Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume VIII. Receptors — Fish, Littoral, Benthos

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

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Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

March 1977

U.S. DEPARTMENT OF COMMERCE
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Bureau of Land Management

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VOLUME VIII

RECEPTORS - FISH

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* indicates final report

BASELINE/RECONNAISSANCE CHARACTERIZATION, LITTORIAL BIOTA, GULF OF ALASKA AND BERING SEA

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

The objective of this study is to locate and describe the dominant species and assemblages of intertidal biota in the Gulf of Alaska and Bering Sea. To achieve this objective, the following questions must be addressed: what is the distribution and percent occurrence of the major intertidal habitat types (sandy, muddy, rocky, etc.), and what are the temporal and spatial distributions of dominant biota at representative habitat types.

Rocky intertidal and nearshore subtidal areas lead all other habitat types in terms of species diversity and density in the Gulf of Alaska and southern Bering Sea. This situation may be reversed in the northern Bering Sea where ice scour has a strong limiting effect on the attached rocky benthic fauna and flora. Muddy intertidal areas are usually located in protected lagoons, and may be protected from effect of ice scour.

The Kodiak Island rocky intertidal and nearshore shallow subtidal is one of the most productive in the world. Attached macrophytes probably contribute a significant percentage, if not a majority, of the primary productivity of the Gulf of Alaska ecosystem in this area. Multispectral scanning may prove to be a valuable tool for the semi-quantitative assessment and mapping of these resources.

The intertidal and shallow nearshore subtidal of the Pribilof Islands includes many endemic and narrowly distributed species. Because of this and the geographical isolation from other reproducing populations, the Pribilof Islands are particularly vulnerable to long term ecological damage resulting from environmental perturbations.

The extremely high variability in distribution and densities of species especially at rocky sites, indicates that it will probably be impossible to predict which populations and densities are to be expected in unstudied areas. In addition, available data indicate that we will not be able to predict environmental damage from a pollution incident using data from a general survey without an actual investigation of the area following the incident. Ex-post-facto reconnaissance will show dead and dying organisms but the long term effect on the intertidal and consequently the whole ecosystem will be impossible to determine from survey data. Research at a few intensive study sites may make it possible to accurately measure long term damage resulting from catastrophic damage as well as monitor sublethal effects related to non-catastrophic increases in pollutants.

II. INTRODUCTION

The purpose of this study is to provide a general baseline reconnaissance characterization of littoral biota of the Bering Sea, Norton Sound, and the Gulf of Alaska, including the Kodiak area.

Specific objectives have been to: 1) determine the distribution and relative abundance of the major intertidal habitat types (sandy, muddy, rocky, etc.) along the coastline; and 2) determine the major plant and animal species present within these habitat types, and make preliminary estimates of their densities and distribution.

There are several phases to each objective. The distribution of habitat types has been determined by visual reconnaissance from fixed wing aircraft. The field section of this phase was completed in July 1976. In cooperation with NASA and the Environmental Research Institute of Michigan, additional information is being produced through use of aerial photography and multi-spectral scanning methods.

The distribution of organisms within habitat types is being determined by field sampling and laboratory analysis by the Auke Bay Laboratory (ABL), with taxonomic assistance from the University of Alaska Marine Sorting Center and with logistical assistance from the Pacific Marine Center. Additional projects include a study of the accumulation of biotic debris in the drift zone, the estimation of variability between sampling areas, and more intensive studies at a few sites which may receive major impact from oil exploration in the Gulf of Alaska.

III. Current State of Knowledge

Relatively little is known of the distribution and composition of intertidal habitats along the Alaskan coast. Hundreds of collections have been made throughout Alaskan coastal waters (for instance the Harriman Alaska Expedition of 1899, Rigg 1915, Bousefield and McAllister 1962, and reviews of previous work by Feder and Mueller 1972, and AEIDC 1974). Unfortunately, most of these are lists of species and stations and are of little value in understanding the distribution, abundance and natural history of the species and the complex set of physical and biological interactions (Connell 1972) which structure marine intertidal communities.

A few recent studies (Nybakken 1969, Hubbard 1971, Nickerson 1975, Dames and Moore 1977, Calvin, in press), and especially those concerned with the Amchitka Bioenvironmental Project (O'Clair and Chew 1971, Weinemann 1969, Lebednick 1971) have taken into account such problems as vertical zonation, temporal and spatial heterogeneity and more briefly, the trophic relationships of some of the intertidal biota.

Although relatively well studied in other areas of the northeast Pacific (Dayton 1971, 1975, Menge and Menge 1974, Paine 1966), little is known of the ecology of Alaskan littoral biota. McRoy (1968, 1970) and Calvin and Ellis (Man. in prep.) have mentioned the high productivity of macrophytes in Alaska and the dependence on this production by a myriad of commercially and aesthetically important species. Estes and Palmisano (1974) considered the trophic dynamics of sea otters and their effect in the structure and productivity of nearshore subtidal and intertidal communities.

IV. Study Area

The area covered in this report extends from Yakutat in the eastern Gulf of Alaska to Cape Prince of Wales in the Bering Straits (Fig. 1). Included in this are the Kodiak Island group and the Pribilof Islands. Not included are Prince William Sound, Cook Inlet, and the Aleutian Islands west of the Islands of Four Mountains.

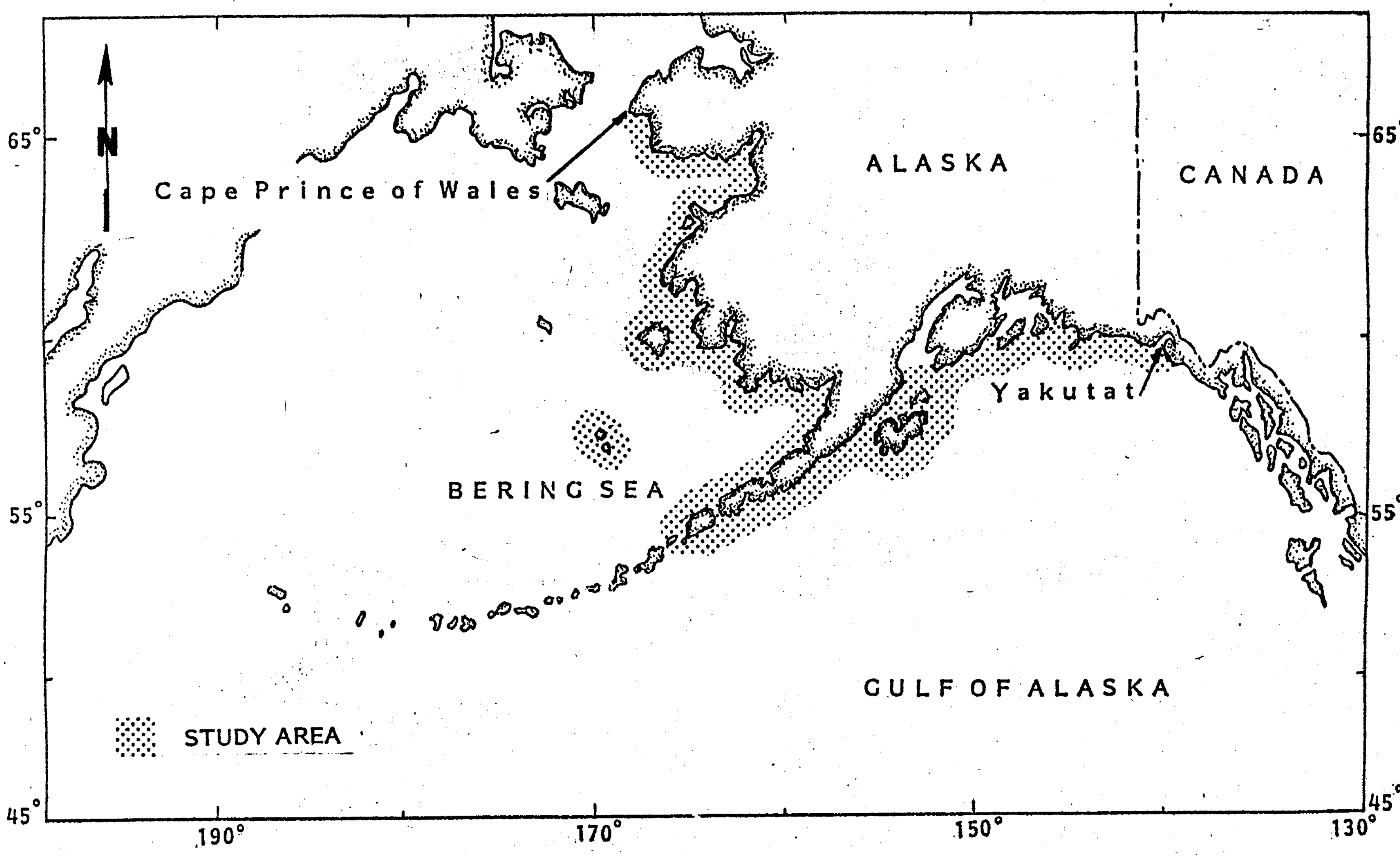


FIGURE 1. Study Area

V. Sources, Methods and Rationale of Data Collection

Methods. Quantitative baseline sampling methods have remained essentially unchanged from those stated in our final report of April 1, 1976. Deviations are as follows: Although samples were usually taken from 1/16 m^2 quadrats, 1 m^2 frames were used at Dolina Pt. and Low Cape during the May 1976 Kodiak cruise. This modification was made because algal cover was distributed in dense but discrete small clumps at these sites. The use of the 1/16 m^2 quadrats would have been inadequate in these instances, since there would have been many empty or near empty quadrats. Variance would have been high and much beach time would have been wasted filling out necessary sample forms. By using one meter frames the clumped algal cover was gathered quite easily from within the larger area.

At Dolina Pt. the 1 m^2 quadrat was used only for sampling algal cover, while invertebrates were sampled from the 1/16 m^2 quadrat as usual. This was done because the invertebrate populations were more evenly distributed than were the algal populations. At Low Cape, both were sampled from the same 1 m^2 quadrat. While the decreasing variance and reducing paperwork may be advantageous, the effort involved in collecting small invertebrates over a larger area (1 m^2) and the likelihood of bias may negate these advantages.

VI. Results

Many of our results have been reported in quarterly reports as follows:

Subject	Report date
EGOA Drift Zone Study	July 1, 1976
Kodiak Subtidal Study	January 1, 1977
Kodiak Atlas Study	January 1, 1977
Kodiak Intertidal Study	
Zonation on Rocky Shores	January 1, 1977

The following results have not previously been reported and are included in this section:

A. Multispectral scanning overflights-Gulf of Alaska.

B. Miles and percentage of intertidal habitat types by basin.

C. Subtidal surveys in and near Norton Sound, August 1976.

D. The Pribilof Islands-a unique biological situation.

E. Kodiak Island macrophytes and primary productivity.

F. Kodiak Island intertidal study-beach descriptions and comparisons.

G. A discussion of variability in the data.

H. Appendix

   1. Reconnaissance of the Yukon-Kuskokwim River delta intertidal.
   2. Data summaries-average densities (in grams per square meter) of Kodiak Island rocky intertidal organisms presented by site.
   3. Data summaries of average densities (in grams per square meter) of Kodiak Island rocky intertidal organisms presented by selected species:

A. Use of multispectral scanning (MS) imagery to describe the density and distribution of littoral macrophytes.

During June 1976, the Environmental Research Institute of Michigan made trial flights to determine if MS techniques could be used in describing the broad scale distribution, zonation and density of dominant littoral species. Three sites (Zaikof Bay, LaTouche Point, and Cape Yakataga) were overflown following an assessment of each area by marine biologists.

The necessary software for analyzing the spectral records was developed by fall, and preliminary output (Fig. 2) was available by December. This first result was produced by training the computer on a selected area, computing the spectral signature of that area and then printing all other areas (called pixels) which have a similar signature. This process was repeated several times for each site and the colored bands in Figure 2

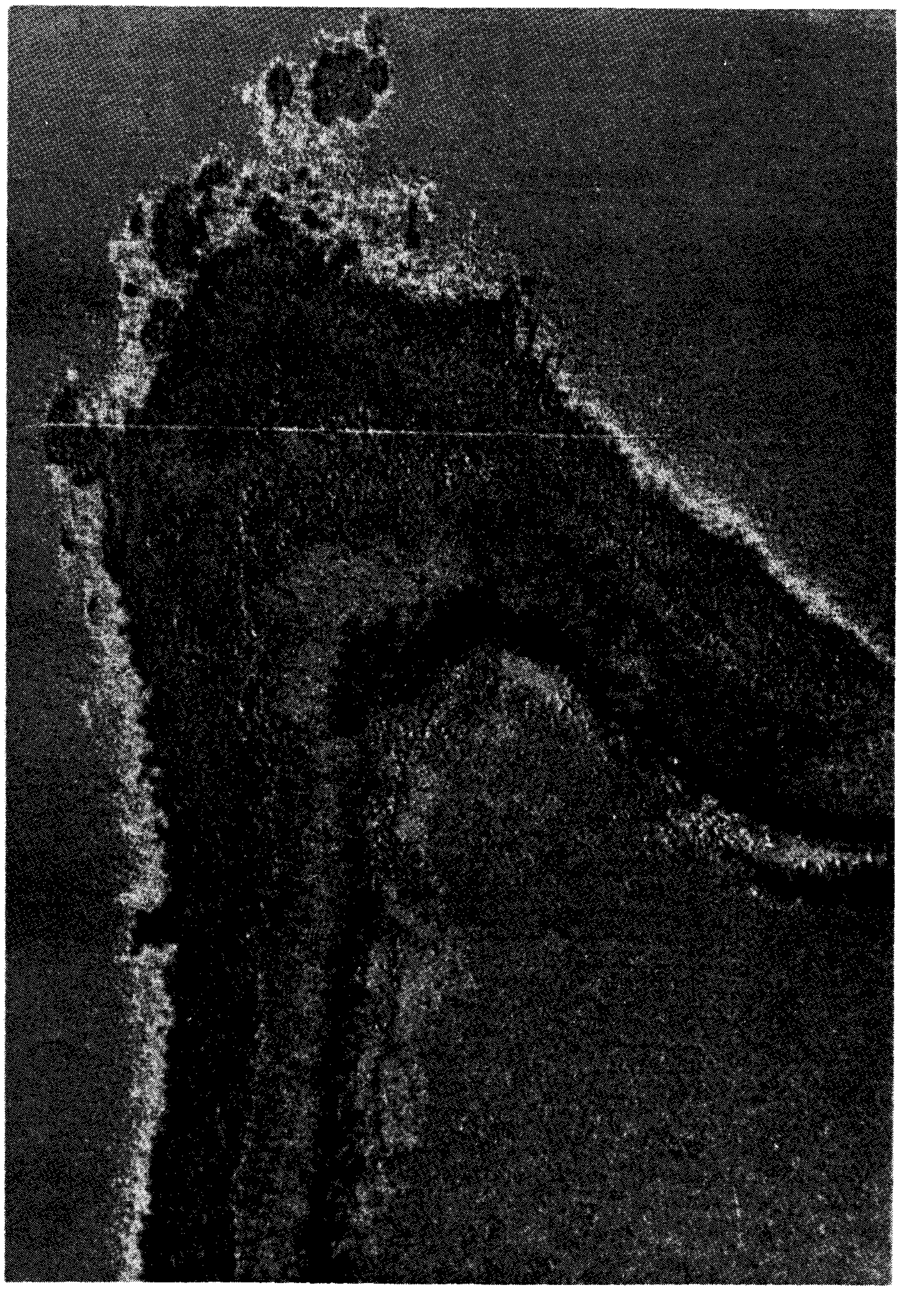


Figure 2. Photograph of sampling site in Zaikof Bay interpreted with MS imagery. 7:23 local time, 27 June 1976. Approximate scale 1:1,300.

indicate the distribution of areas with similar spectral signatures. The results were then sent to Auke Bay to determine if this method of choosing signatures had been able to separate the littoral area into zones which correspond to the known biology.

Preliminary analysis indicates that several of the more dominant features (spruce forest, grassland, water) are correctly represented. It is apparent, however, that further work will be necessary to correctly describe the different algal zones. This will be undertaken in the near future when the computer will be retrained using areas of known species dominance.

B. Coastline survey of intertidal habitat types

The following section (Tables 1-6) contains a breakdown of several of the lease basin areas into major intertidal beach types (sandy, rocky, muddy, etc.). Presently completed sections include the eastern Gulf of Alaska (Table 1); Kodiak (Table 2); Aleutian Islands (Table 3); St. George Basin (Table 4); Bristol Bay (Table 5); and Norton Sound (Table 6). Data are taken from observations made from fixed wing aircraft flown at approximately 200 foot elevations. The data are currently being used to produce an atlas of the study area which will also include information on beach slope and biological cover.

NE Gulf of Alaska

Table 1. Number of miles and percentage of major intertidal substratum types from Point Carew (Yakutat Bay) to Cape Puget. Includes Russel Fiord to entrace of Nunatak Fiord.

Type	Miles	Percentage
Bedrock	185.0	19.9
Boulder	136.0	14.6
Gravel	200.0	21.5
Sand	336.0	36.1
Mud	73.0	7.8
TOTAL	930.0	99.9

Kodiak Area

Table 2. Number of miles and percentage of major intertidal substratum types in the Kodiak Area.

	Kodiak	Barren Islands	Trinity Islands	Chirikof Island	Total	Percentage
Bedrock	1078	56	9.5	16.5	116.0	47.58
Boulder	297.5	1.5	3.5	2	304.5	12.49
Gravel	740.5	1.5	34		776	31.83
Sand	79	4	94	14.5	191.5	7.8
Mud	5.75				5.75	.2
Totals	2200.75	63	141	33	2437.75	99.9

Aleutian Islands

Table 3. Number of miles and percentage of major intertidal substratum types in the Aleutian Islands area, from Ugamak Island on Unimak Pass westward, to and including the Islands of Four Mountains.

Type	Statute Miles	Percentage
Bedrock	656.0	56.0
Boulder	355.0	30.0
Gravel	75.0	6.0
Sand	85.0	7.0
Mud	-0-	-0-
TOTAL	1171.0	100.0

St. George Basin

Table 4. Number of miles and percentage of major intertidal substratum types, from Unimak Island north to Port Moller, and including the Pribilof Islands.

Type	Statute Miles	Percentage
Bedrock	52.0	8.0
Boulder	106.0	16.0
Gravel	104.5	16.0
Sand	236.5	36.0
Mud	158.0	24.0
Total	657.0	100.0

Bristol Basin

Table 5. Number of miles and percentage of major intertidal substratum types from Port Moller north to Sheldon's Point of the Yukon Delta.

Type	Statute Miles	Percentage
Bedrock	107.0	7.0
Boulder	109.5	7.0
Gravel	194.0	12.0
Sand	516.5	32.0
Mud	698.0	43.0
Total	1625.0	100.0

Norton Sound

Table 6. Number of miles and percentage of major intertidal substratum types from Sheldon's Point of the Yukon Delta north to Cape Prince of Wales.

Type	Statute Miles	Percentage
Bedrock	149.5	11.0
Boulder	242.0	18.0
Gravel	320.00	24.0
Sand	206.0	16.0
Mud	340.5	26.0
Not categorized	* 54.0	4.0
Total	1312.0	100.0

*Approximately 54.0 miles on Nunivak Island, were ice-bound.

C. Subtidal surveys in and near Norton Sound, August 1976 - by Louis Barr

Subtidal surveys were carried out at ten general locations in and near Norton Sound, Alaska, during the period of August 6-14, 1976. The locations visited included eight (Stuart Island, Egg Island, Cape Denbigh, Cape Darby, Rocky Point, Bluff, Cape Nome, Sledge Island) within Norton Sound and two (Cape Wooley, King Island) slightly northwest of Norton Sound (Figure 3). The surveys were conducted entirely by scuba-equipped divers. Information was gathered in three basic forms at each survey location: extensive collections of plants, invertebrates, and vertebrates were made; detailed field notes were prepared based on observations of oceanographic and geomorphic features, indications of ice scouring, and community and ecological relationships of organisms; photographs were taken of biological assemblages and communities and individual organisms representative of those seen during the surveys.

Although some major differences existed among the eight locations surveyed within Norton Sound, a generalized description of the Sound, as a whole, can be made. Descriptions of King Island and Cape Wooley will be given separately because of their differences from the Norton Sound locations and from each other.

All of the sites surveyed in Norton Sound were closely adjacent to mainland or island shorelines. Survey sites were most often selected off sections of coast with high bedrock cliffs or boulder beaches. Two sites (Rocky Point, Bluff), however, were selected along sections of sandy shore.

Subtidally, the substrate off rocky shores sloped gently (usually less than 15°) into deeper water. Even where vertical cliffs extended into the water, such vertical surfaces rarely reached depths of 10 feet. The shallow water substrate was typically composed of medium to large boulders set in a matrix of gravel and sand. As depth increased, there were fewer and smaller

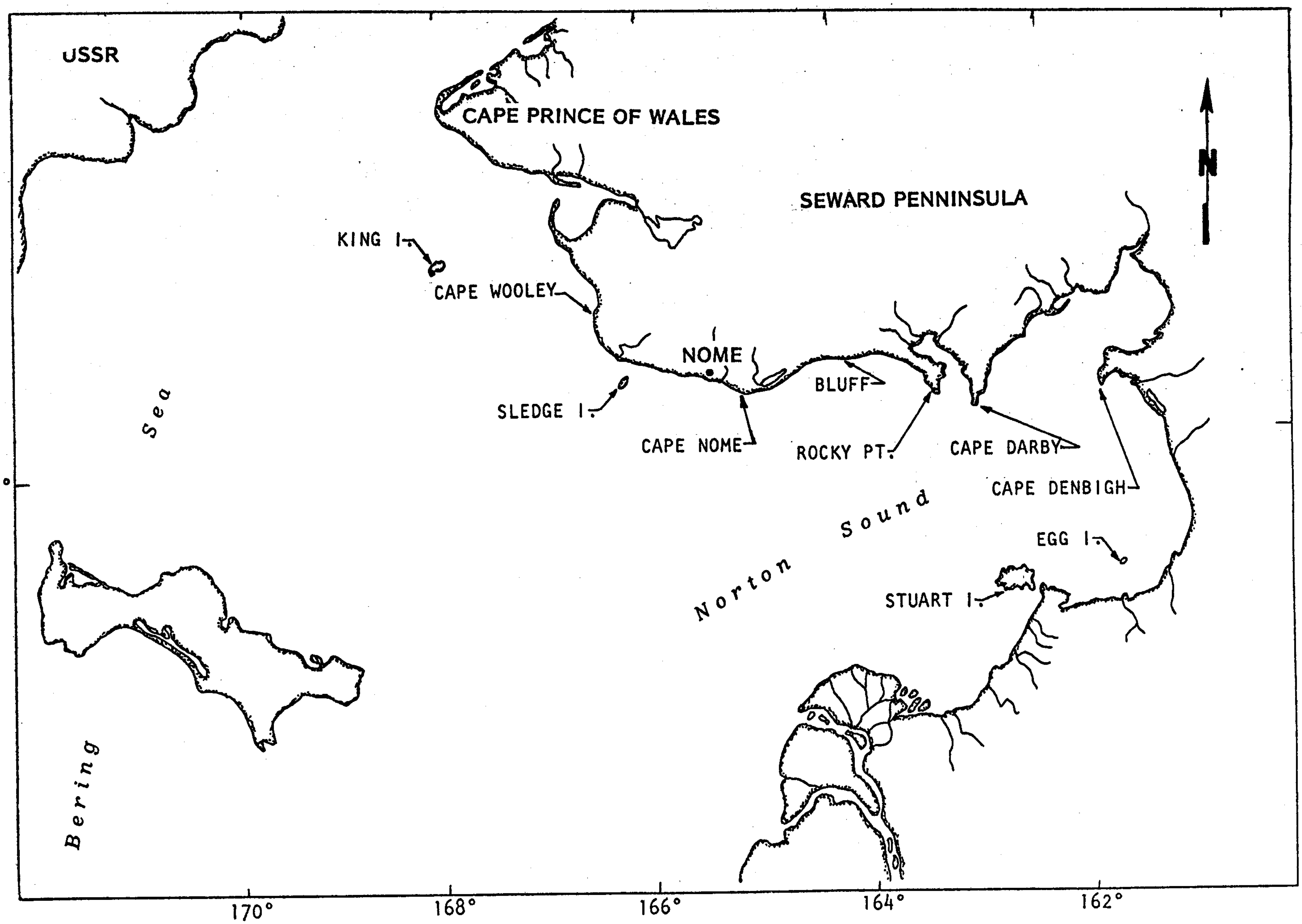


FIGURE 3. NORTON SOUND SHOWING LOCATION OF SAMPLING SITES

boulders and the matrix material became finer, with increasing proportions of fine sand, clay, and silt toward deeper water.

The water mass within Norton Sound was distinctly stratified in terms of temperature and turbidity. Surface temperatures, probably reflecting the warm, calm weather during the survey period, generally ranged between 55° F and 65° F. Temperature at 20 feet was usually 52° F to 56° F, and at 40 feet, or deeper, was usually 40° F to 42° F. Water turbidity, as estimated by lateral visibility, was generally much greater below the 20 foot depth. Visibility in the upper 20 feet of water was usually 15- to 20-feet, visibility below 20 feet was usually only 2- to 4-feet, apparently due to a heavy silt content in those deeper waters.

Evidence of ice scouring was apparent at several sites in the form of deep gouges in the soft substrate at 40- to 45-feet of depth. Ice wear on the boulder tops in shallower water could be inferred from the uniformly small size of the Mytilus populations covering the uppermost parts of those rocks. Those small mussels (most about 0.5-inch) were apparently all young-of-the-year and had set and grown after the departure of the ice in the spring of 1976. Larger, and probably older, Mytilus were present in crevices and on the more protected sides of boulders.

Although the subtidal biological communities within Norton Sound comprise a large number of species, certain organisms and assemblages were dominant. One of the most obvious assemblages was that of mussels, barnacles, filamentous red algae, and caprellid amphipods. This combination of organisms was seen frequently, especially in the southern and eastern parts of Norton Sound. A starfish, probably Asterias sp., was abundant in a wide variety of habitats and was utilizing many different prey organisms. Also common and occupying a variety of habitats was the brachyuran crab, Telmessus sp.. Unlike the behavior of this crab in more southern parts of its range, those in northern

Norton Sound, when found on sand, are often partially or completely buried. Other common invertebrates were hydroids, sponges, anemones, soft corals, bryozoans, green urchins, cucumbers, nudibranchs, limpets, gastropods, and tunicates. Less common, or only common at a single site, were king crabs (both red and blue), phoronids, and shrimps (pandalids, crangonids, and hippolytids). Sandy areas had abundant annelid worms, clams, and sand dollars. Among the fishes seen, cottids, stichaeids, gadids, and agonids were most common. In sand areas sand lances and flatfish (mostly small juveniles) were abundant. Collections of dead fish in the water beneath bird rookeries included sand lances and juvenile salmon. Several wolf fish were collected and found to be feeding mostly on blue mussels.

Among midwater organisms seen, the jellyfish Cyanea sp. and Aurelia sp. were most prominent at several locations in the northwest part of Norton Sound. The Cyanea were seen capturing very small fish larvae, yet also safely harboring inch-long young-of-the-year gadids near and among the tentacles.

One of the most prominent biological features of Norton Sound was the near-total absence of kelps. With the exception of a few small Alaria sp. at Sledge Island and some very small Laminaria-like algae at Bluff, no broad blade brown algae were seen in the entire Sound.

The site inspected near Cape Wooley was located about 4 miles offshore in 55 feet of water. Surface and bottom temperatures were 56° F and 46° F, respectively. The bottom was generally level, silty gravel with occasional small boulders. Ice scour grooves were present in the bottom.

The only algae seen at the Cape Wooley site were coralline forms. Sponges, anemones, hydroids, soft corals, bryozoans, nudibranchs, clams, and gastropods were present. Echinoderms were more heavily represented than at sites in Norton Sound; four species of stars, one species of cucumber and one species of urchin were seen. Two brachyuran crabs (Hyas sp. and Telmessus sp.) and

:ing crab (red) and hermit crabs were present. Other crustaceans included caprellids and other amphipods, pandalid and crangonid shrimps, and barnacles. Solitary and colonial tunicates and a few cottids were also present.

King Island was unique in several respects. The surface water was considerably colder than at the other sites: surface temperature was 47° F; at 20 feet it was 44° F; at 85 feet it was 37° F. The water was also less turbid than at the other sites (although the general pattern of increasing turbidity with increasing depth did hold); lateral visibility in the upper 50 feet of water was 20- to 30-feet and deeper than 50 feet was about 15 feet.

The substrate off the south side of King Island is mostly large boulders along a very gradual slope. Off the southeast corner of the island, however, the bottom is mostly bedrock sloping at about 30- to 45°.

Biologically, the most unique feature at King Island were the abundant kelps growing mostly from the ice-sheltered crevices and sides of boulders. The kelps were represented by three genera: *Laminaria*, *Alaria*, and *Agarum*.

Other organisms seen at King Island but not at other locations in Norton Sound were at least two species of starfish (*Crossaster* sp. and *Leptasterias* sp.), basket stars (one small individual was seen at Sledge Island), the brachyuran crab, *Hyas coarctatus*, and the solitary tunicate, *Boltenia* sp.. Many adult blue king crabs were also present in the deeper areas surveyed.

The midwater environment was more richly populated with prominant organisms than it was in Norton Sound. *Cyanea* sp., *Aurelia* sp., and at least one other species of scyphozoan were present. Three genera of ctenophores were abundant. At least two species of pteropods, one species of chaetognath and one species of appendicularian were also present. Near the bottom were very dense swarms of large mysids.

Evidence of ice scouring was present at King Island from the shallowest depths down to at least 85 feet, the deepest area surveyed. Boulder tops in shallow water were devoid of perennial populations of organisms, and patches of sand and gravel in the deeper water showed deep furrows that could only have come from ice gouging. In spite of the effects of ice, however, King Island still supports dense and varied populations of sessile organisms in addition to the many mobile and pelagic animals in its subtidal environment.

D. Pribilof Islands

The Pribilofs present a unique and peculiarly vulnerable biological situation. While the ice scour makes the intertidal area appear relatively barren to the casual eye, many plants and animals occur in cracks and crevices intertidally, and the subtidal biota is rich and varied. In many respects, the Pribilofs could be considered a Bering Sea Galapagos. Some of the algal and invertebrate species such as Onchidiopsis hannai are endemic to the islands. Others such Cirrulicarpus gmelini, Zinovaea acanthocarpa, Pleuroblepharis japonica, Laingia aleutica, Yendonia crassifolia, and Membranoptera spinulosa, occur elsewhere only in Japan, Russia or the Aleutian Islands. The vulnerability of the islands lies in their small size and the lack of nearby areas to provide larvae and spores for repopulation. On long coastlines, even brooding species with nonplanktonic larvae can eventually repopulate a devastated area. This is not possible for offshore islands. The red algae have no motile or floating spores; they would move only a few meters before settling. One major incident could permanently affect the entire shoreline of these small islands.

E. Kodiak area macrophytes

The major growth of macrophytes (the main source of primary productivity) at Kodiak occurs in the band from approximately the ten fathom curve to mean high water of the intertidal zone. This band varies from about 1/4 mile to 6 miles in width. A glance at the navigation chart of the Kodiak area will show that this is an exceptionally large area. The intricate coastline with its many bays, straits, islands, and reefs results in a great length of shoreline in a small area. Sears and Zimmerman (MS in prep. Table 2) as p . of these studies, estimate that this small island area has approximately 2500 miles of coastline (4025 Km), which is about 1,000 miles more than the length of the coast of California and Oregon combined.

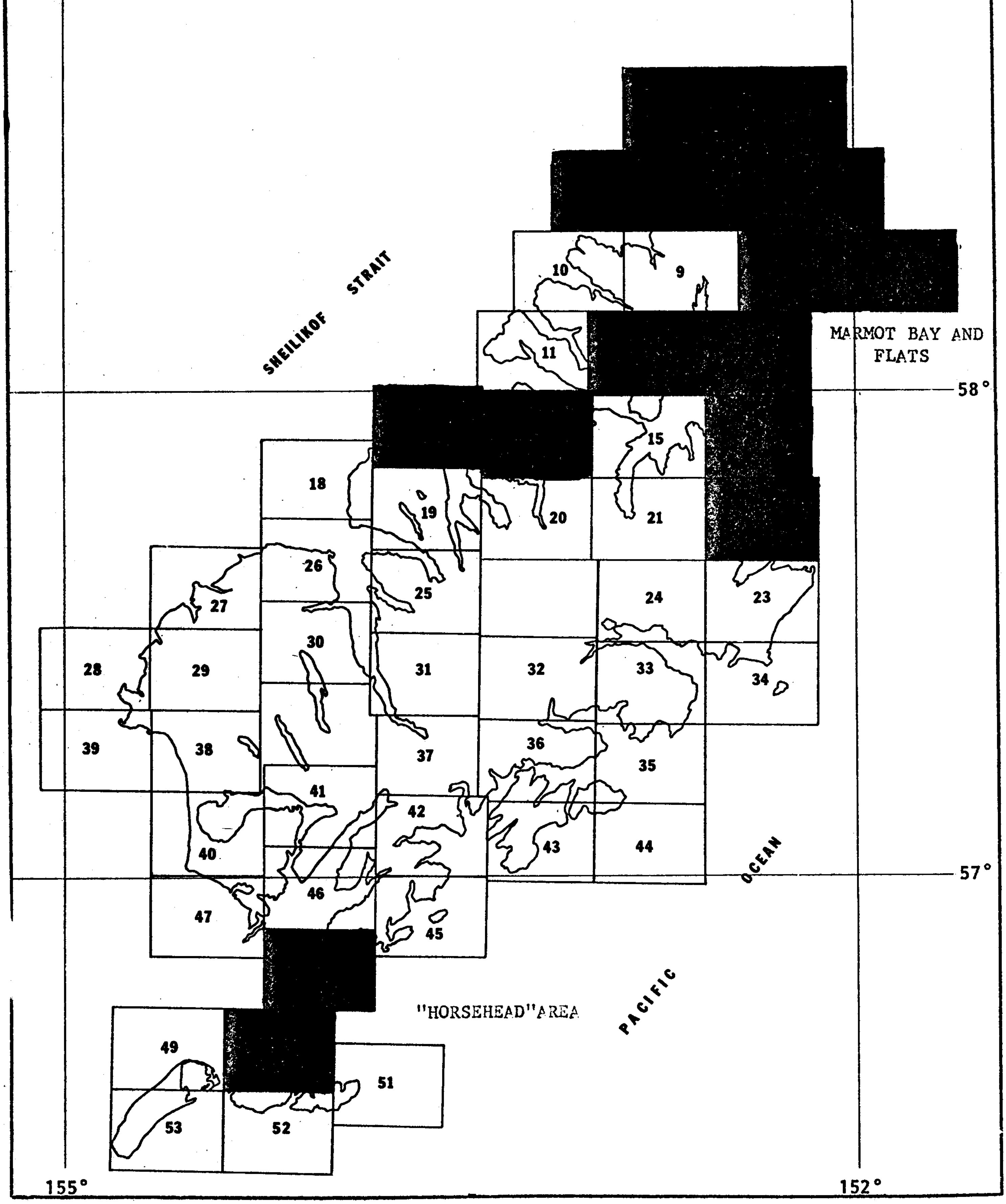
The average standing crop of subtidal brown algae at the Kodiak sites we studied is similar to the highest values reported from other areas. The greatest previously reported weight for an individual quadrat was 46 Kg/m^2 (MacFarlane 1952) for Laminaria longicruris, in Nova Scotia, one of the richest seaweed producing areas in the world (Michanek 1975). The greatest quadrat weight from our Kodiak samples was 35 Kg/m^2, of which 99% was Laminaria dentigera.

Mann (1972) in studies in Nova Scotia, estimated the standing crop of the intertidal and subtidal seaweeds to equal 1481.5 Kg wet weight (almost 1.5 metric tons) per running meter of shoreline. We do not have adequate information to extrapolate our figures to Kg wet weight per running meter of shoreline, but it appears that the Kodiak value could exceed the figure for Nova Scotia. We believe this because not only are the values for individual quadrats of Laminaria similar but also because Kodiak has extensive beds of the floating kelps, Alaria fistulosa and the bull kelp, Nereocystis luetkeana which do not occur in Nova Scotia. These beds are so thick that small boats have trouble pushing through them. Two individuals of the bull kelp weighed about 90 pounds each, or more than three times as much as individual plants in the Washington and British Columbia area. In short, combining the high density of the seaweeds and the wide area over which they occur, the primary productivity contributed by the seaweeds likely makes the Kodiak area one of the most productive in the world.

It is also interesting to note that the areas of highest intertidal macrophyte cover appear to correspond to areas which are highly productive shellfish regions. During a recent OCSEAP synthesis meeting concerned with the Kodiak lease sale, it was pointed out (P. Jackson, ADF&G, Kodiak) that the two most productive shellfish areas are the "horsehead" area east of the Trinity and Geese Islands, and the Marmot Bay area in the northeastern region. Using our aerial observations on biological cover we determined which areas had been classified as having "heavy" cover on more than half of the rocky coastline. These areas are shown in Figure 4. Using this criterion, heavy coverage is seen to occur in the Trinity Islands-Geese Islands area, the area south of Kupreanof Strait, and the northeastern side of the Island mass which includes Marmot Bay.

We also calculated the ratio between the number of kelp bed sightings and the miles of coastline for each plate in the Kodiak atlas series (for instance, if 5 kelp beds were noted along 50 miles of beach the ratio would be 0.10). The data, shown in Figure 5 indicate the greatest number of kelp beds are on the southeastern section of the island. This part of the island had a generally wider shelf (Capps 1934) than the northern section which is quite vertical. Thus, the greater number of kelp beds in the southern portion may reflect the wider shelf which would provide a greater area for attachment of the macrophytes. Again, it is interesting to note that the Trinity Islands-Geese Islands area is a rich area from the standpoint of kelp growth.

Figure 4 . Shaded areas represent coastline for which 50% or more of the rocky intertidal beaches are heavily covered with biota.



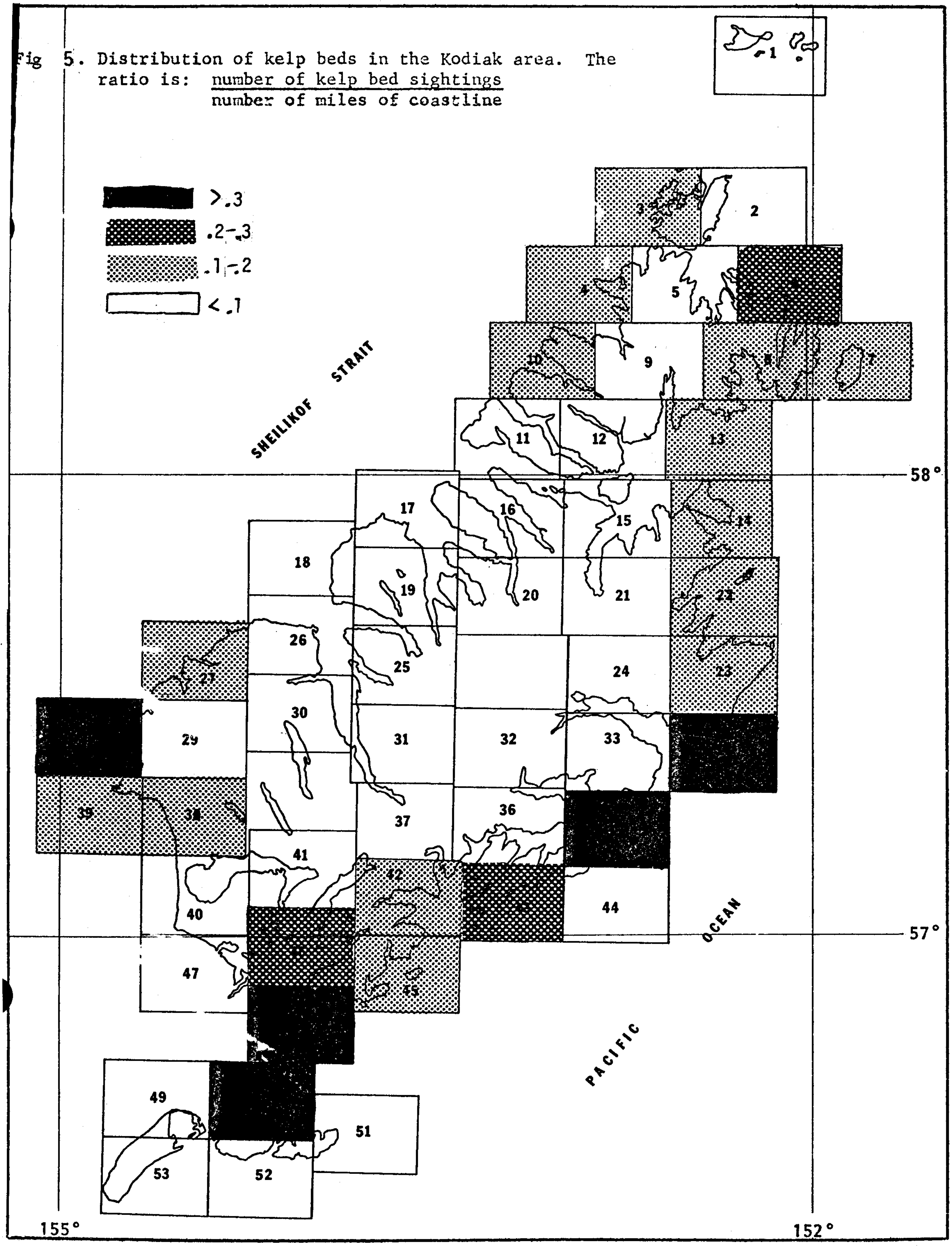


Fig 5. Distribution of kelp beds in the Kodiak area. The ratio is: number of kelp bed sightings / number of miles of coastline

F. Kodiak Intertidal Beach Descriptions

We visited and made quantitative collections at ten sites in the Kodiak area (Fig. 6). For each site we are presenting:

1. A map showing the sampling site.
2. A narrative report on the site including descriptions of the transect line and of the general area as taken from field notes and sampling data.
3. A figure of horizontal and vertical distribution of selected algae and invertebrates from $1/16m^2$ quadrat collections (excluding south Sitkalidak Lagoon which was a mud sampling site).
4. Photographs of the site.

Computer plots and species lists for these sites were included in the January 1, 1977 quarterly report. All of these data will eventually be combined into a full report on the Kodiak area.

Some of these beaches (Low Cape, Cape Sitinak, Chirikof Island, and the upper part of Dolina Point) are extensive benches of unusually uniform habitat. These beaches appear to be somewhat similar to beaches at Amchitka and our figures of distribution are similar to those designed by O'Clair and Chew for that area (O'Clair and Chew 1971). We have not attempted to describe a comprehensive zonation scheme for the beaches we visited because most of our samples were collected along one transect line during one visit to the site. We feel it would be necessary to visit a beach three to four times a year over a period of years before attempting to describe zonation or interrelationships in an area.

Sud Island

Sud Island is one of the Barren Islands (Figure 7). This group of precipitous and windswept islands lies just below the entrance to Cook Inlet, where they are highly exposed to the mixing of atmospheric and oceanic forces between Cook Inlet, Shelikof Strait, and the northeastern Gulf of Alaska. Winds there are stronger than nearby areas and heavy tide rips and ocean

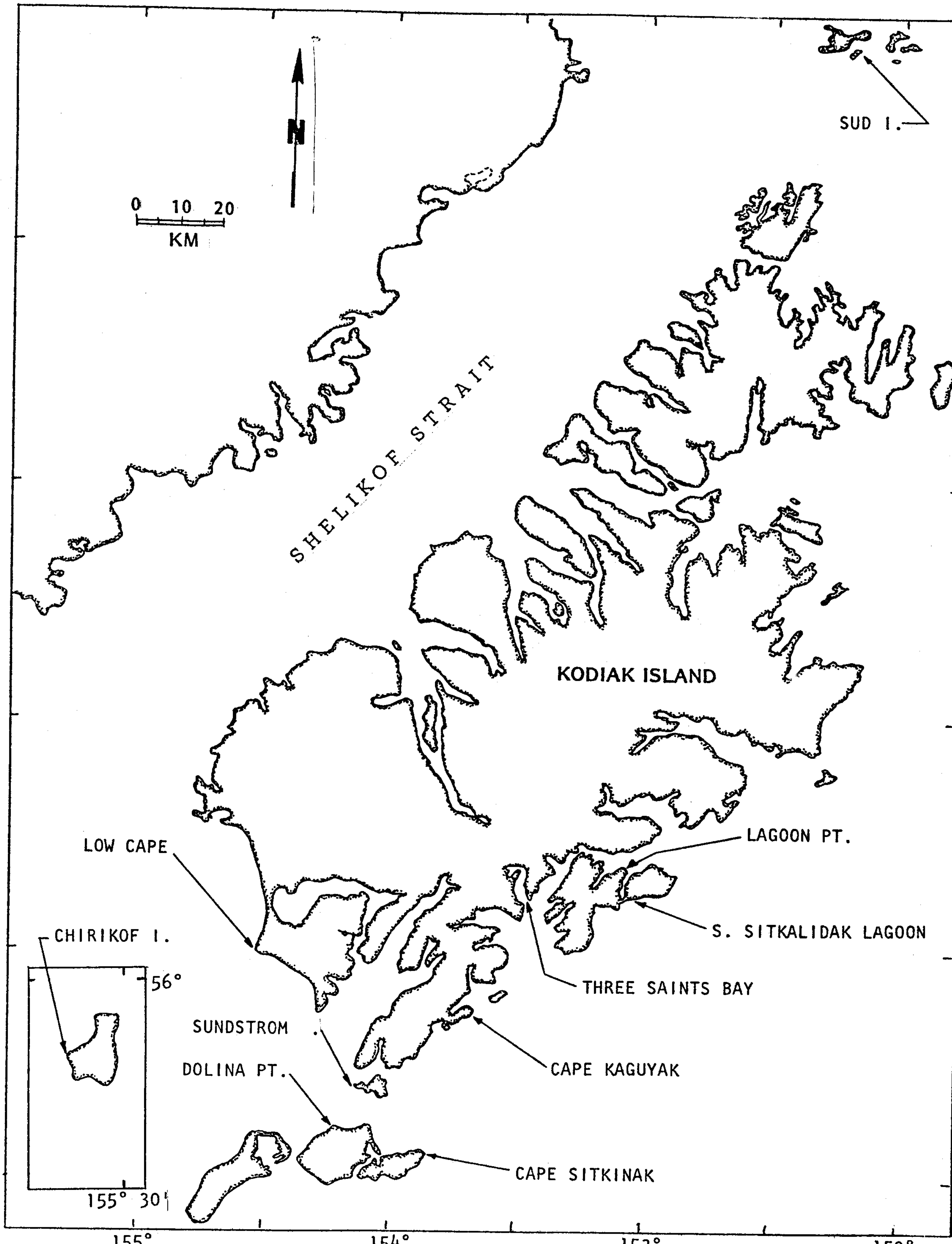


FIGURE 6. KODIAK ISLAND GROUP SHOWING LOCATION OF SAMPLING SITES

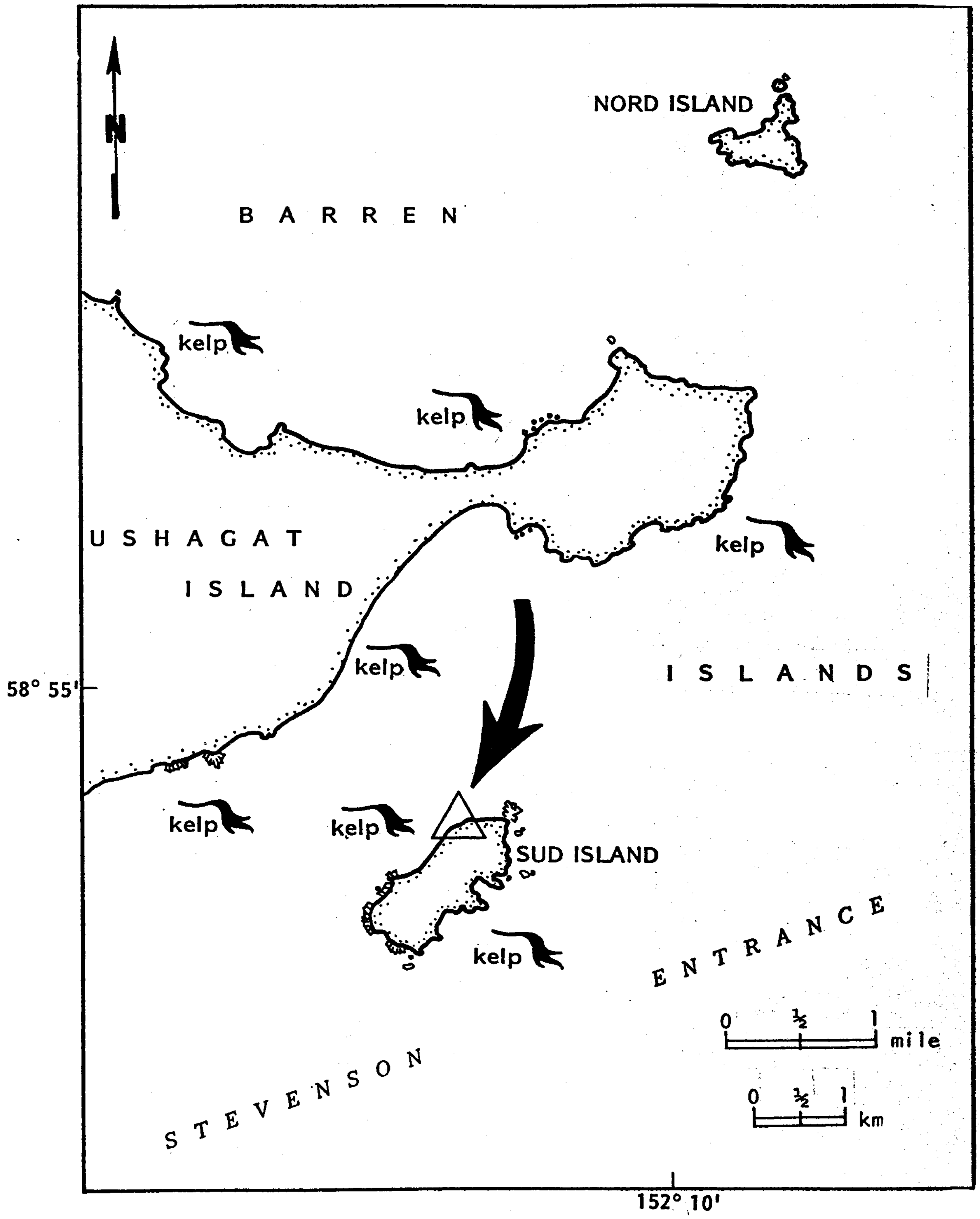


FIGURE 7. SUD ISLAND SITE

Fig. A. Sud Island, Barren Islands. View of transect line with Ushagat Island in background.

Fig. B. Sud Island, Barren Islands. Lower end of transect line. Note floating kelp offshore.

Fig. C. Sud Island, Barren Islands. Sampling a vertical face using the Myren-Pella arrow method.

currents occur throughout the Barren Island group (Coast Pilot pg. 66-67). NMFS divers commented that some of the densest subtidal algal communities encountered in Alaska have developed in this highly mixed and turbulent area (Louis Barr, personal communication).

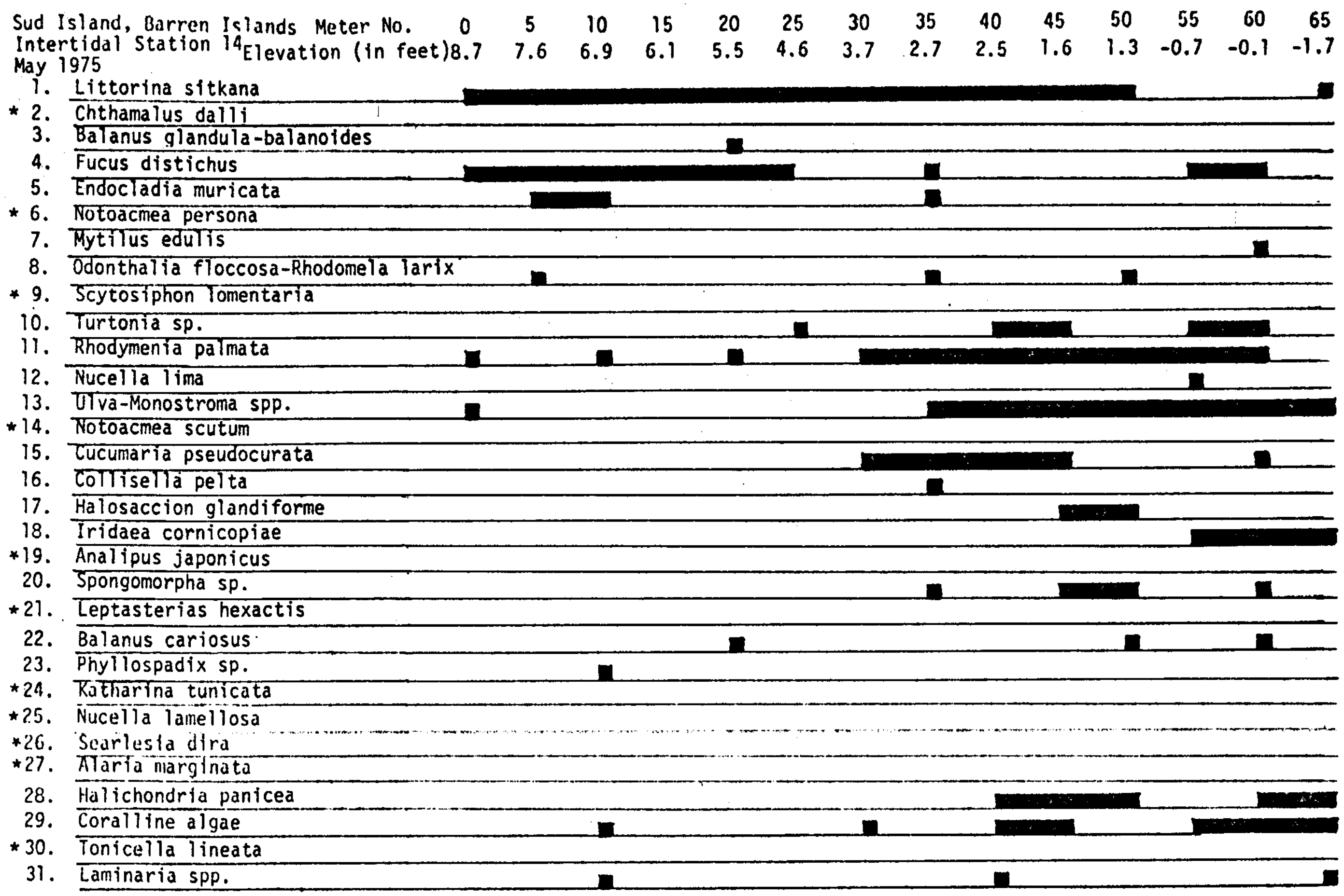
Much of the littoral area is either bedrock or bedrock overlain by large boulders. The site we sampled, on the northern side of Sud Island, was composed of large boulders which almost completely overlay a moderately sloping bedrock substrate. Sampling was done in May and August, 1975. One transect line and the Myren-Pella arrow method were used to collect twenty quantitative samples in May (Figure 8); two transect lines were used to collect forty nine quantitative samples in August (Figures 9 & 10).

Algal cover was very dense in the intertidal areas. The mid- and upper-areas were dominated by heavy growths of Fucus, the lower by well developed growths of the red algae Rhodymenia, Callophyllis (or possibly R. palmata sariensis) and Iridaea. The sublittoral fringe had lush populations of Alaria and Laminaria.

Among the invertebrates littorine snails (Littorina sitkana) was common in the upper zones, barnacles (Balanus cariosus) and sponges (Halichondria panicea) were abundant in the lower zones. Otherwise, invertebrate populations were generally low. Mussels (Mytilus edilus) were confined to the protected sides of large boulders or bedrock outcroppings and did not generally occur where the transect lines were laid. Limpets, chitons, predatory snails, and starfish were either absent or present in relatively small numbers. A factor which may have contributed to the small numbers of invertebrates was the presence of sea otters which were observed feeding just offshore at low tide.

Lagoon Point

Three transect lines were laid in the vicinity of Lagoon Point on Sitkalidak Island, Sitkalidak Straits (Figure 11). Transect 1 was laid near



* Species not present in quadrat collections on this transect line.

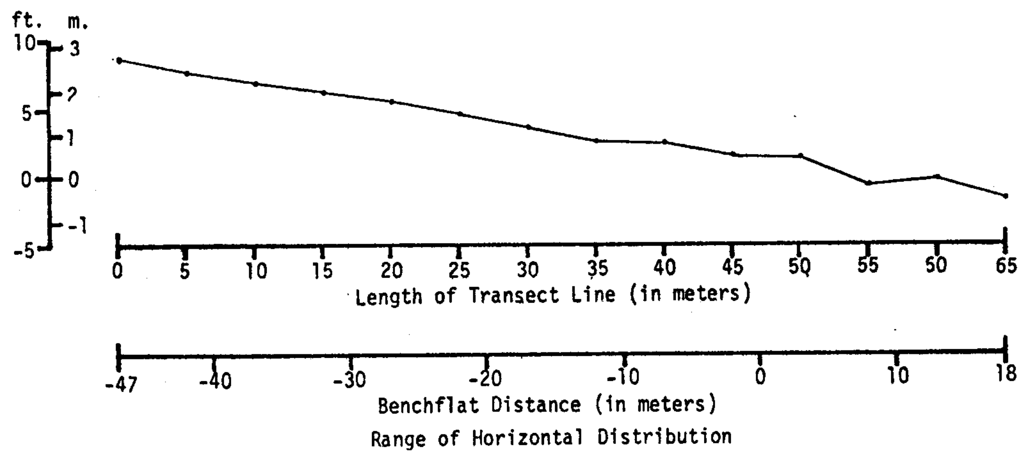
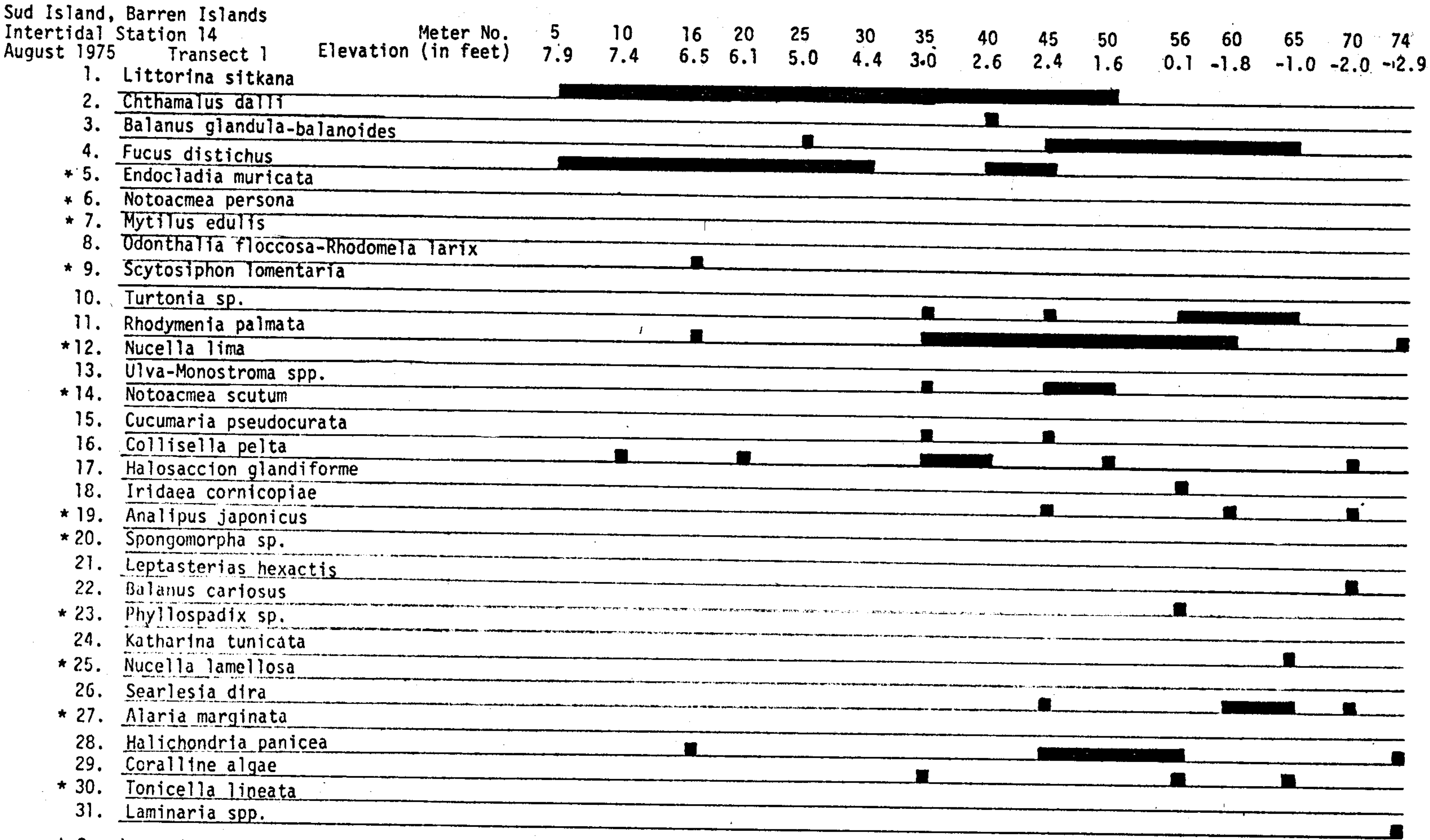


Fig. 8. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrat collections along a transect line.



* Species not present in quadrat collections on this transect line.

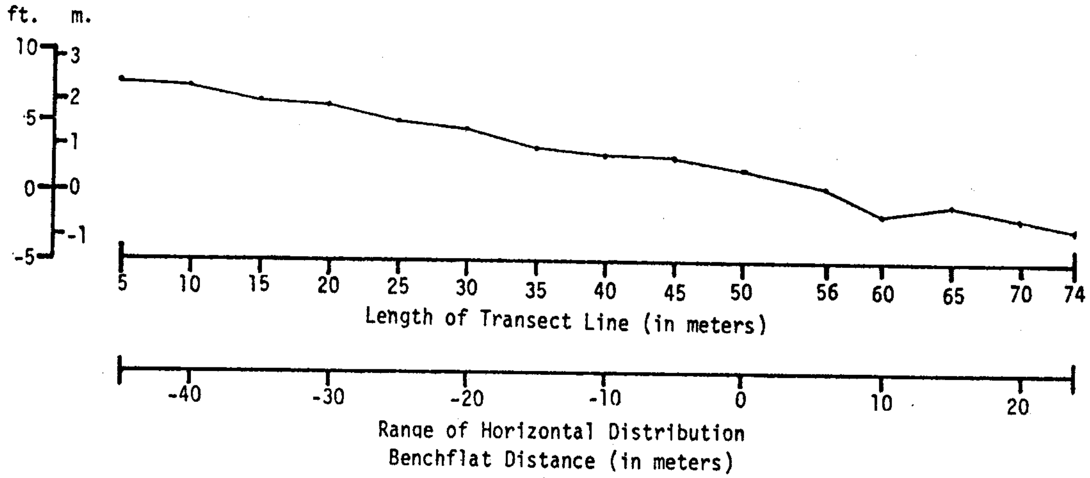
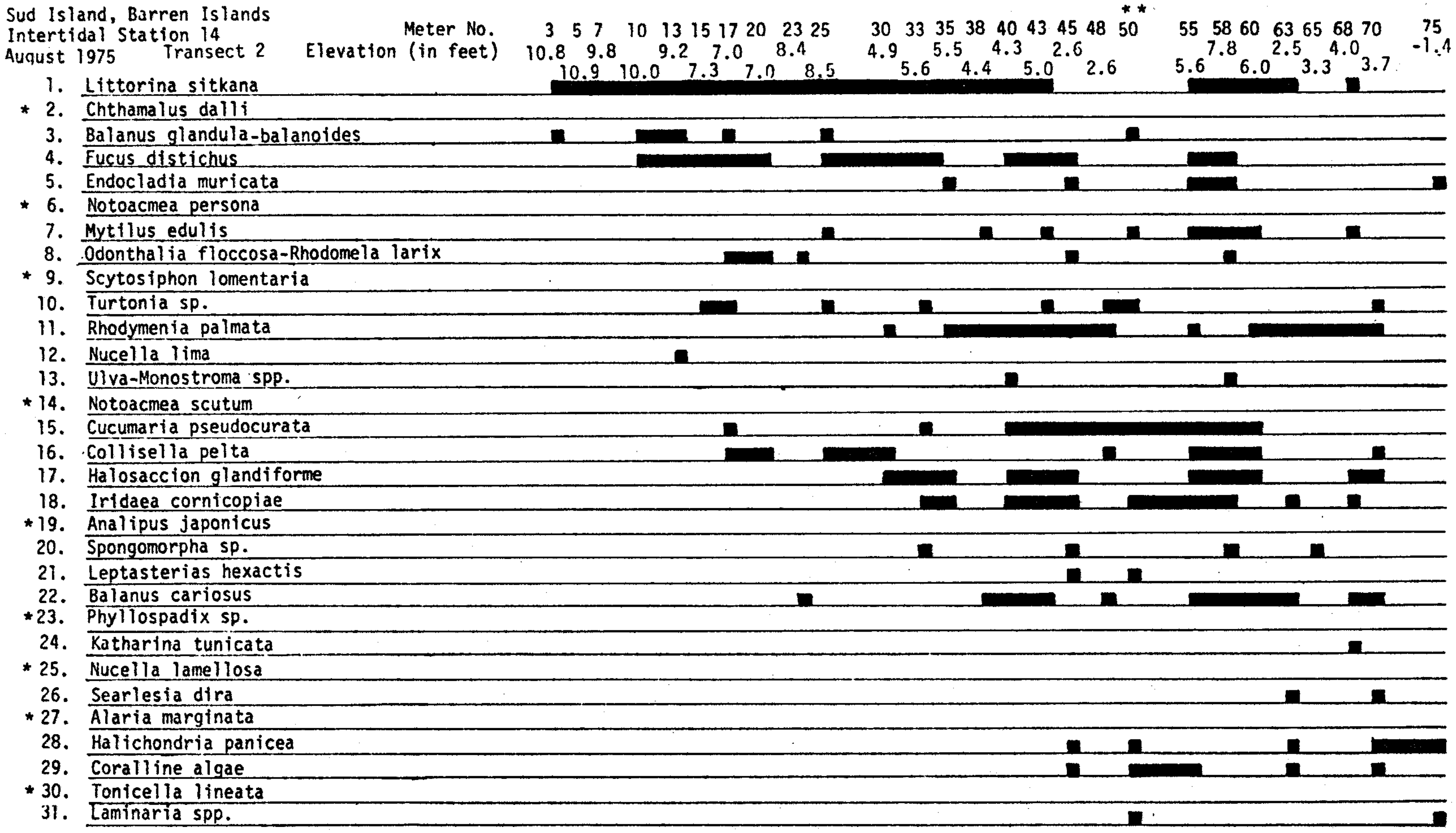


Fig. 9. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.



* Species not present in quadrat collections on this transect line.

**tidepool; half submerged

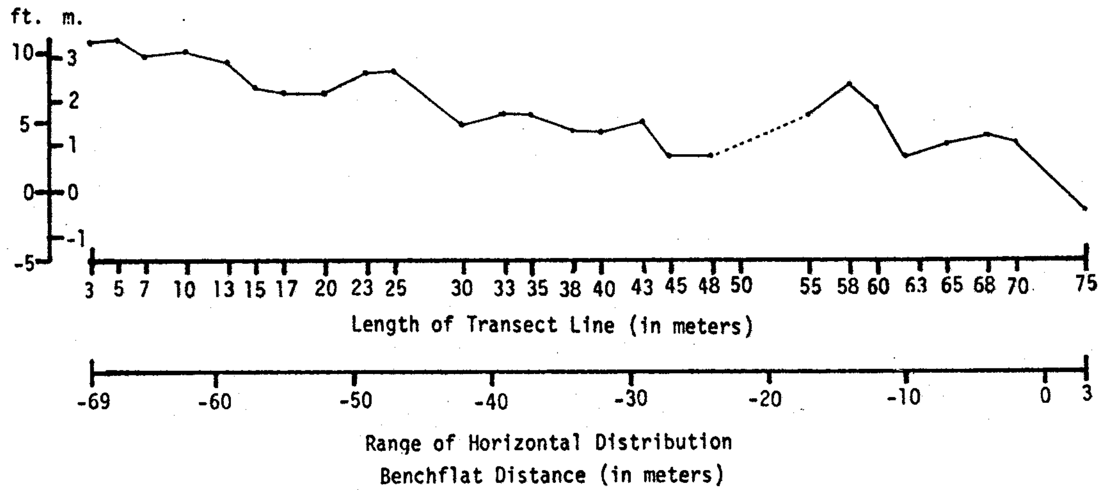


Fig. 10. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

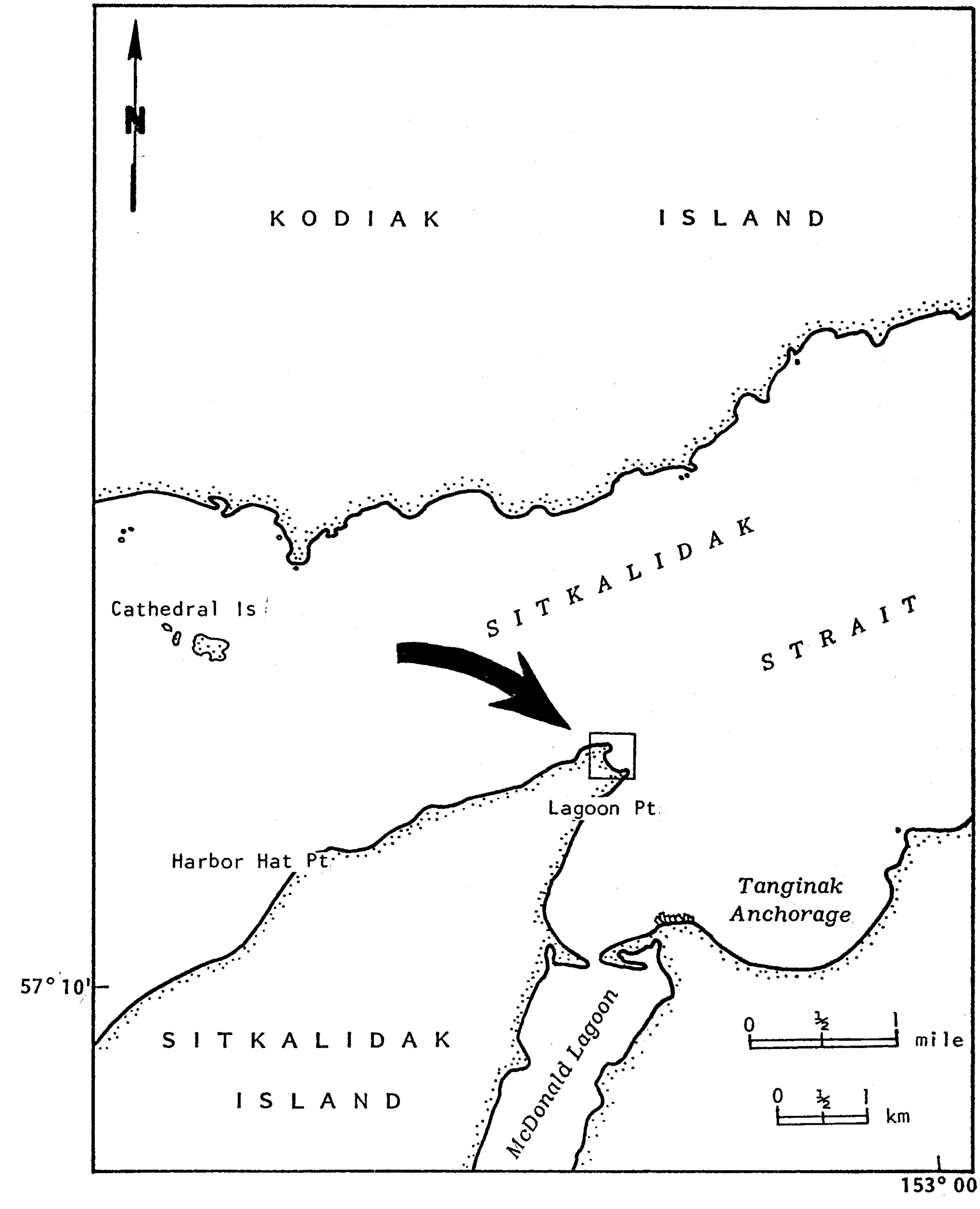


FIGURE 11. LAGOON PT. SITE

Fig. D. Mussel zone at Lagoon Point, Sitkalidak Island. Transect line 1 in area of large boulders.

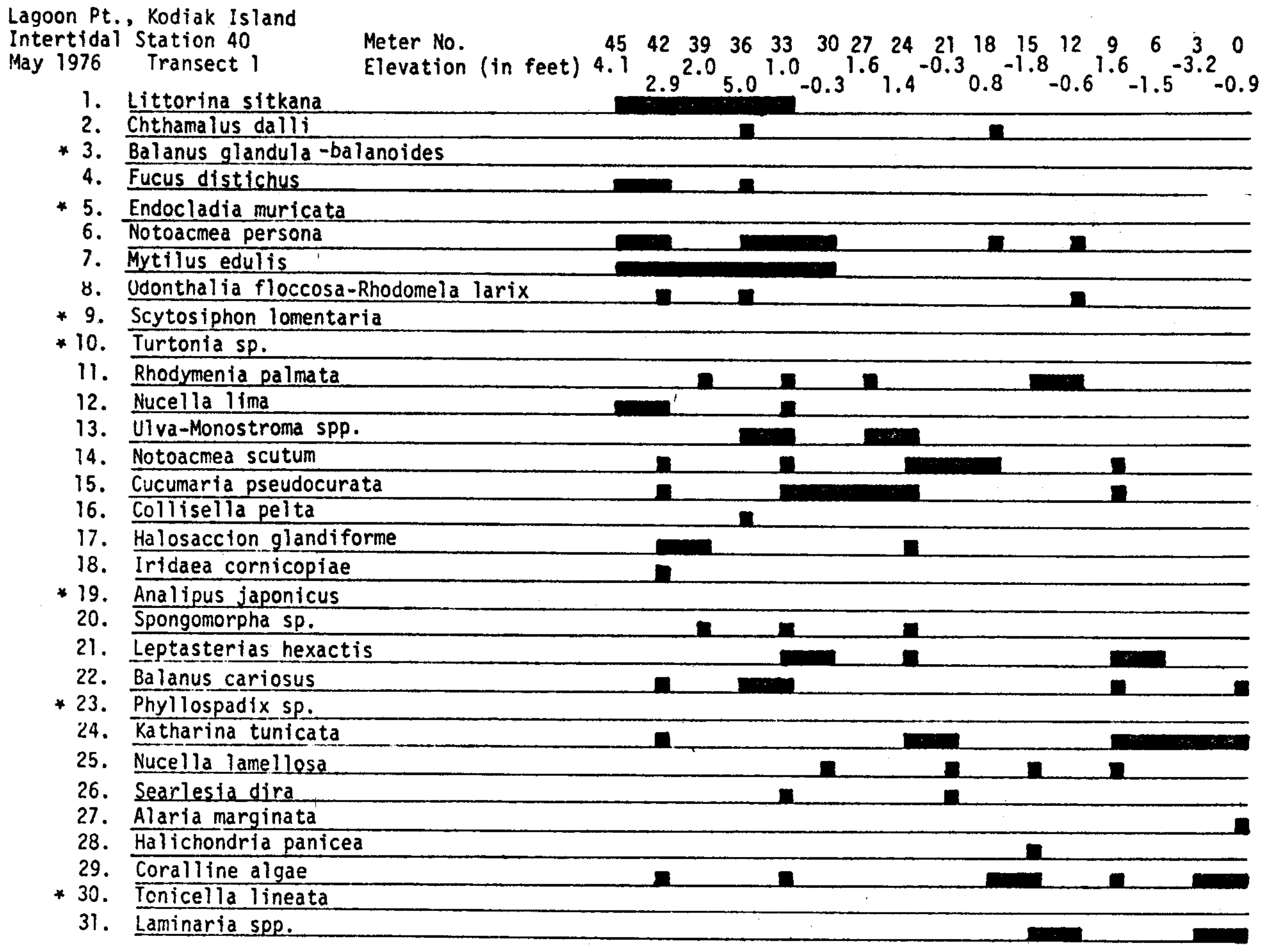
Fig. E. Lagoon Point, Sitkalidak Island. Transect line 2. Boulders are considerably smaller than in transect 1 area.

Fig. F. Lagoon Point, Sitkalidak Island. Area southwest of transect lines. Substratum size and width of beach are less than in sampling area.

the Point on a shore of moderate slope covered with large boulders. Transects 2 and 3 were approximately 100- and 200-yards westward of transect 1 respectively, in areas of progressively smaller boulders.

The area of transect 1 (Figure 12) was rich in vegetative cover and invertebrate populations. Fucus, Odonthalia, Rhodymenia, Alaria, and Laminaria were the most abundant algae. Balanus cariosus, Mytilus edulis, and numerous gastropods are included among the dominant (ranked by wet weight) organisms in the samples. Populations of invertebrates seemed especially rich in this area but this situation is not always reflected in the data. Sea urchins (Strongylocentrotus drobachiensis) were more obvious here than any other site visited. Some species of starfish were not found in the samples but were observed in the immediate area (probably Dermasterias and Pisaster). A small octopus was also observed in the area, as well as many large sea anemones.

Transect 2, (82 meters long sampled at 3 m. intervals) was laid in an area with a few large boulders and many small boulders, and lacked the varied habitat and invertebrate populations present near transect 1 (Figure 13). All observations indicate that the algal cover was in rather well defined zones. These observations are: (1) field notes, (2) quadrat percent cover estimates, (3) quadrat collections. Field notes containing preliminary overall observations indicate: a Laminaria zone beginning at meter 38 with Laminaria on bottom substrate and Alaria on the small rock tops; an Alaria zone between meter 25 and 27; a Rhodymenia and Callophyllis? zone between meter 19 and 24; and a Fucus zone with some Rhodymenia in the lower section at meter 10-to 18. Percent cover estimates within quadrats indicates very similar distribution, except the presence of a Laminaria zone. In addition Balanus cariosus was noted in the Fucus and Rhodymenia zones and littorine snails and small amounts of Fucus and Porphyra were present above meter 10. The quadrat collection data also reflected the same distributions as the first two methods.



* Species not present in quadrat collections on this transect line.

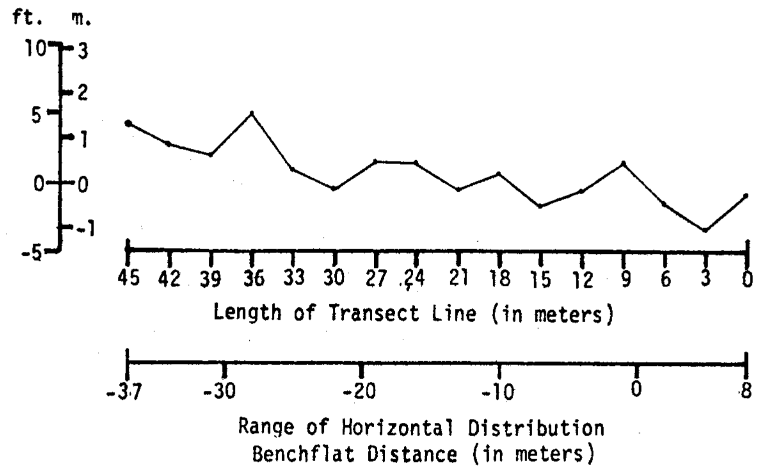
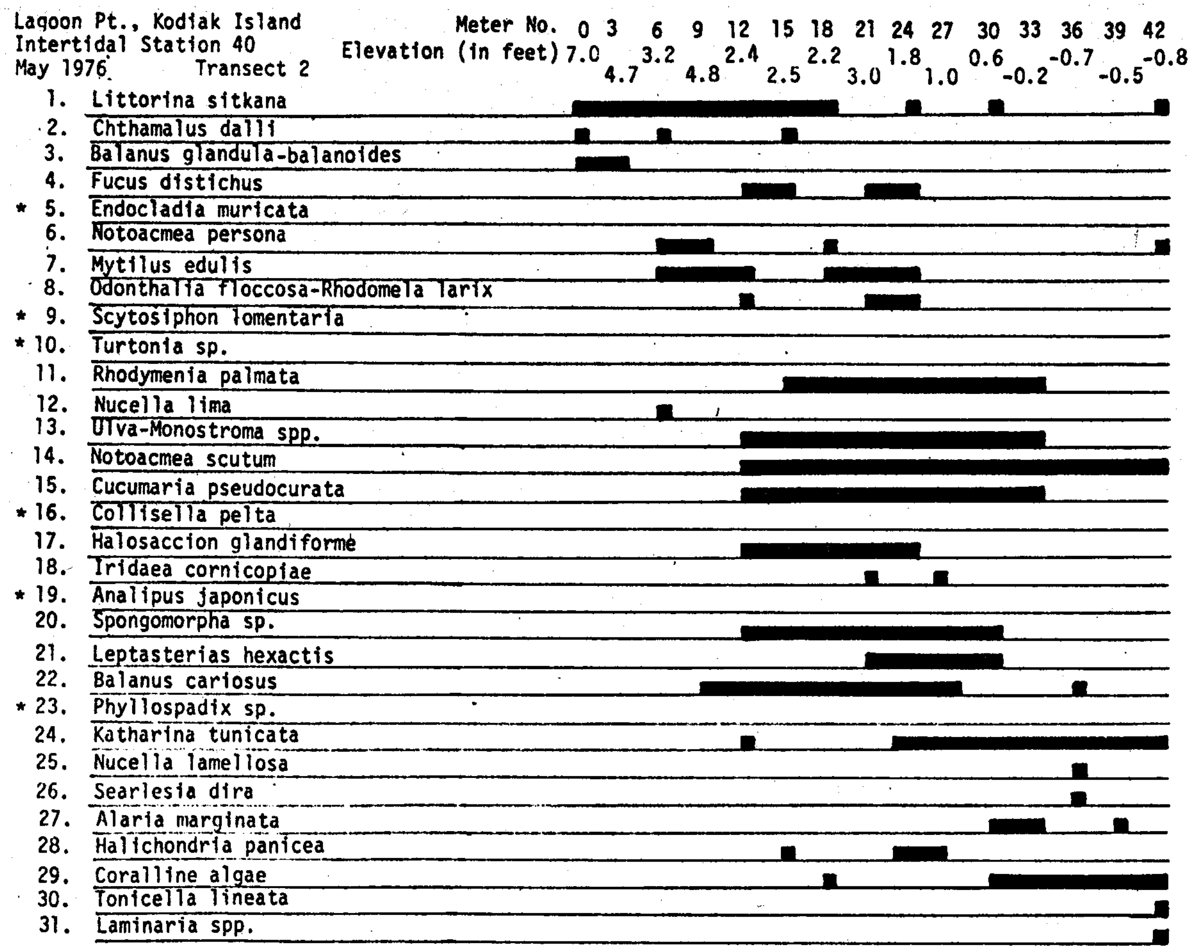


Fig. 12. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.



* Species not present in quadrat collections on this transect line.

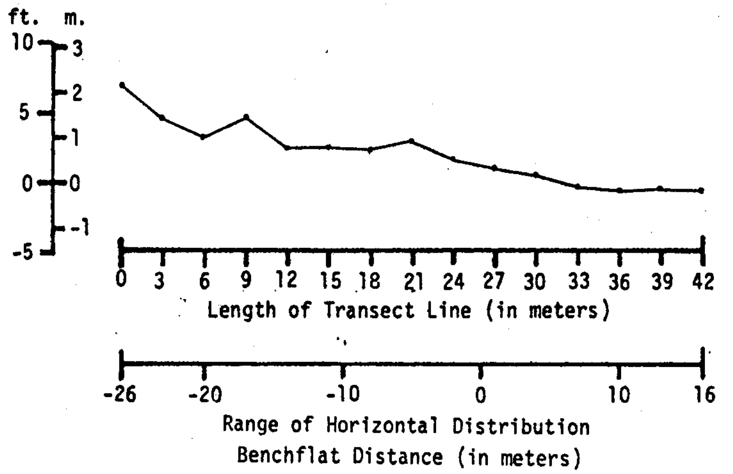


Fig. 13. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

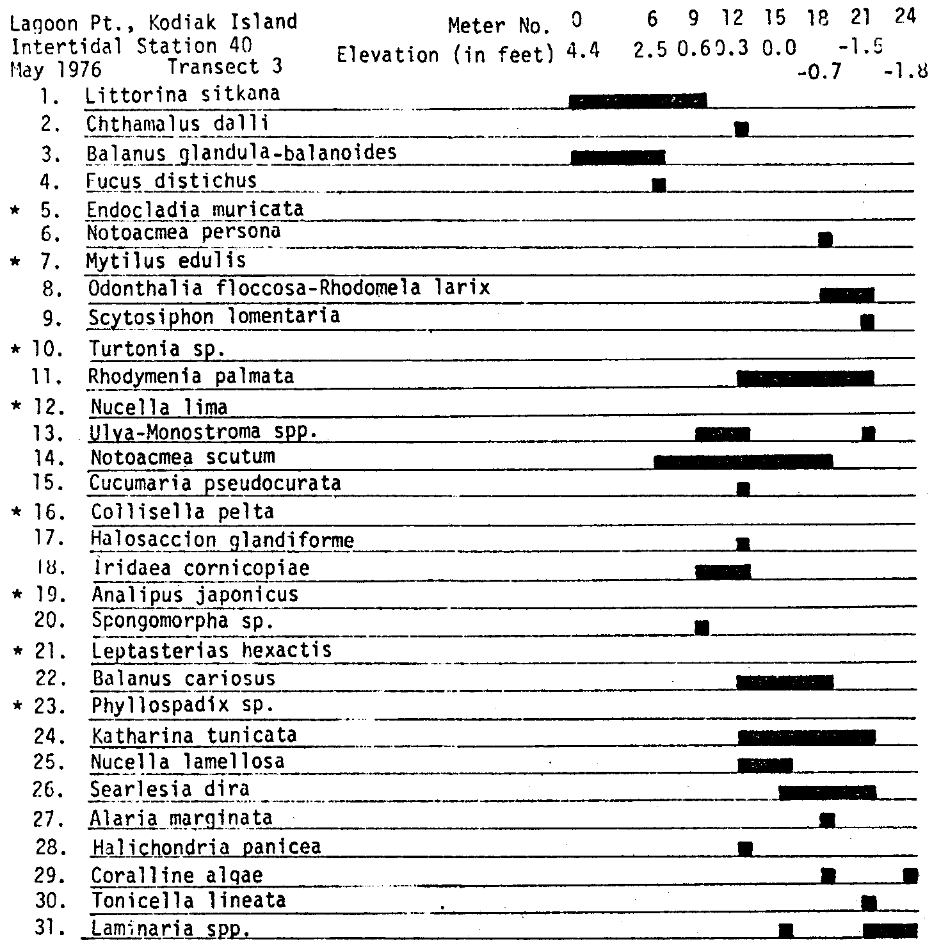
Transect 3 (Figure 14) (a line 24 m. long sampled at 3 m. intervals) was approximately 100 yds. west of transect 2 in an area of even smaller rocks and no large boulders. Again the area under the transect line seemed well defined by vegetative cover. Field notes indicate: meter 0- to 7 was bare rock with very light barnacle cover, and an occasional small cluster of *Mytilus*; meter 8- to 11 was covered with *Fucus* patches of various sizes, with occasional small rock covered with brown noodle-like algae and high rocks having dense concentrations of *Nucella lamellosa* feeding on barnacles; meter 12- to 19 dominated by 100 percent *Alaria* cover; and meter 20+ is 100 percent *Laminaria* cover, except for occasional small rock tops with *Odonthalia*. It was observed that the sample quadrats missed the *Fucus* patches in the *Fucus* zone, and thus the quadrat collection data do not indicate the presence of this zone.

South Sitkalidak Lagoon

South Sitkalidak Lagoon is a large indentation on the Pacific Ocean side of Sitkalidak Island (Figure 15). A sand beach lies outside the lagoon entrance fronting the Pacific Ocean. The entrance to the lagoon is a narrow neck opening into a large (about 2 km^2) area largely filled with mud. At high tide the lagoon is filled with water and even at low tide some areas are filled with tidal run-off or semi-permanent brackish streams.

We sampled an area of soft mud near the entrance of the lagoon using a transect line and a one-liter corer. Analysis of samples showed large numbers of a few species. The most numerous group in our samples is oligochaete worms, a group of bottom feeders living on organic debris. Other groups present include polychaete worms (3 species), clams (3 species), nemertean worms, and amphipods.

We walked over the area and made qualitative observations, digging in the sediment with a shovel. Distribution of organisms appeared to be patchy with species aggregated according to microhabitat. For this reason



* Species not present in quadrat collections on this transect line.

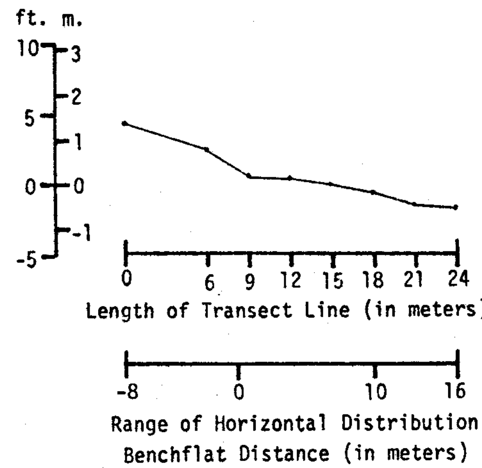


Fig. 14. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

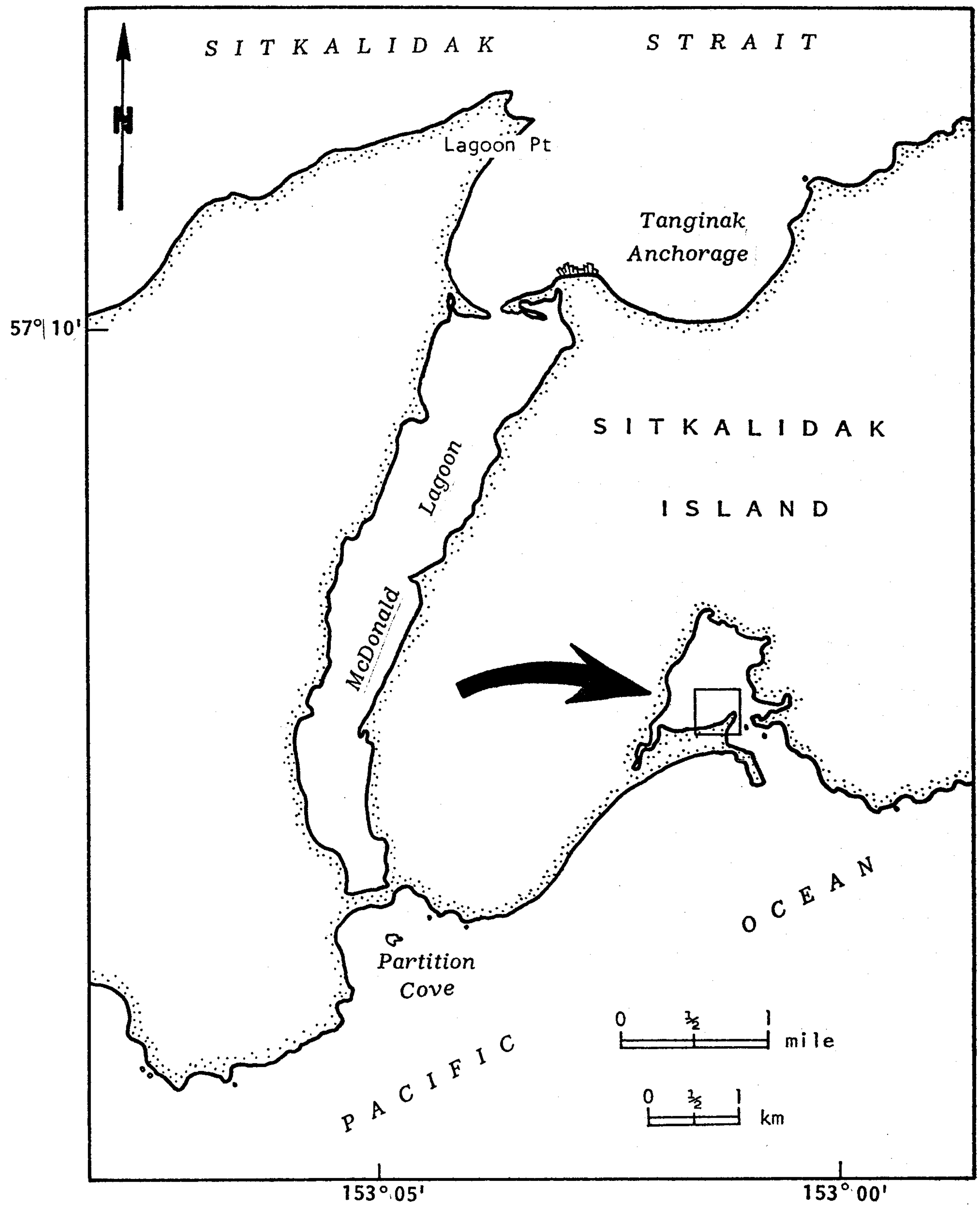


FIGURE 15. SOUTH SITKALIDAK LAGOON SITE

Fig. G1. South Sitkalidak Lagoon, Sitkalidak Island. Taking a one-liter mud sample along transect line.

Fig. G2. South Sitkalidak Lagoon, Sitkalidak Island. Close-up of area where sample has been removed along transect line. Note eelgrass, *Zostera marina*.

Fig. G3. South Sitkalidak Lagoon, Sitkalidak Island. General view of sampling area showing extensive mud flats.

our transect line sampling was an inadequate representation of this extensive and varied area. During our qualitative sampling we found aggregations of several species of polychaete worms and clams, (for instance *Mya arenaria*) many of which could not have been adequately sampled using our standard corer because of their large size or because they occurred deeper than we normally sample. We also found that some of these animals move very quickly and would probably move out of range of the corer before they could be captured. Juvenile starry flounder, small adult shrimp and larval shrimp were found in the tidal streams. Sandy areas along the edges of tidal streams were often populated with sand lance. Algal species in the mud-sand-gravel area were *Fucus distichus*, *Scytosiphon lomentaria*, *Desmarestia* sp., *Polysiphonia* sp., and *Monostroma* sp.. The sea grass, *Zostera marina*, also occurred in small patches in the mud habitat.

At the head of the lagoon on a rock berm we observed littorine snails, *Mytilus edulis*, and *Balanus* sp.. *Odonthalia floccosa* and *Monostroma* sp. were the algal species in this area.

Three Saints Bay

Three Saints Bay is on SE Kodiak Island about 30 miles north of Cape Trinity. The area we sampled, Cape Liakik, is directly exposed to Gulf of Alaska wave action from the SSE (Figure 16). The west, north, and east exposures are semi-protected. Cape Liakik is basaltic bedrock with steep cliffs, spires and a low bedrock outcrop. We ran our transect line across the low bedrock area. The lowest part of the transect runs across an area cut with deep surge channels. Above this zone is an area of low relief ridges and valleys with gradually increasing gradient merging into steep rock cliffs at the head of the transect.

Some species which occurred in fair abundance are not represented in our transect line collections (Figure 17). For instance, a bed of kelp *Nereocystis luetkeana* could be seen floating in the offshore area beyond

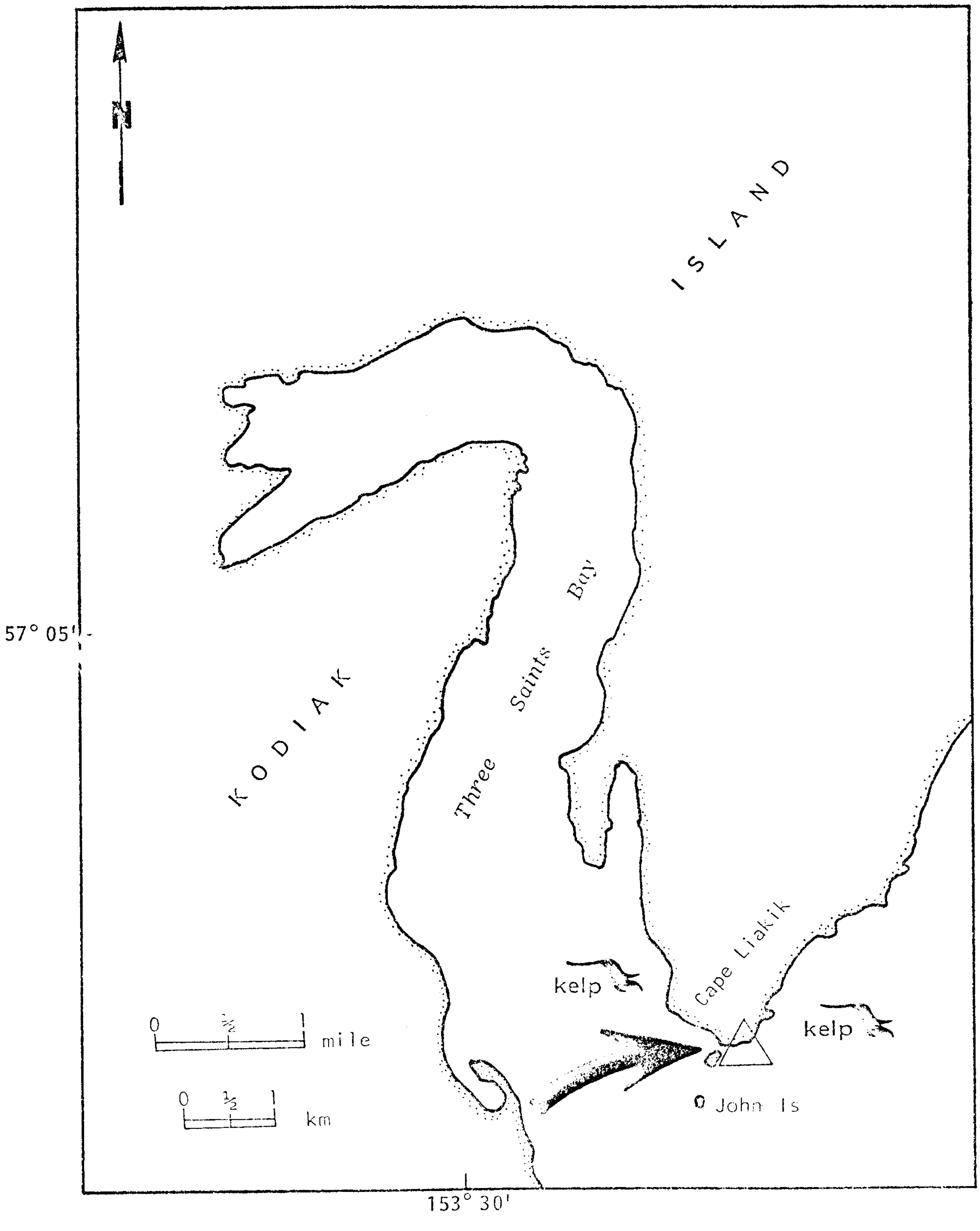


FIGURE 16. THREE SAINTS BAY SITE

Fig. H. Three Saints Bay, Kodiak Island. General view of sampling area; arrow site is in right center of picture.

Fig. I. Three Saints Bay, Kodiak Island. Myren-Pella arrow sampling area on vertical face.

Fig. J. Three Saints Bay, Kodiak Island. Upper end of transect line showing *Mytilus*, barnacle, and *Fucus* cover.

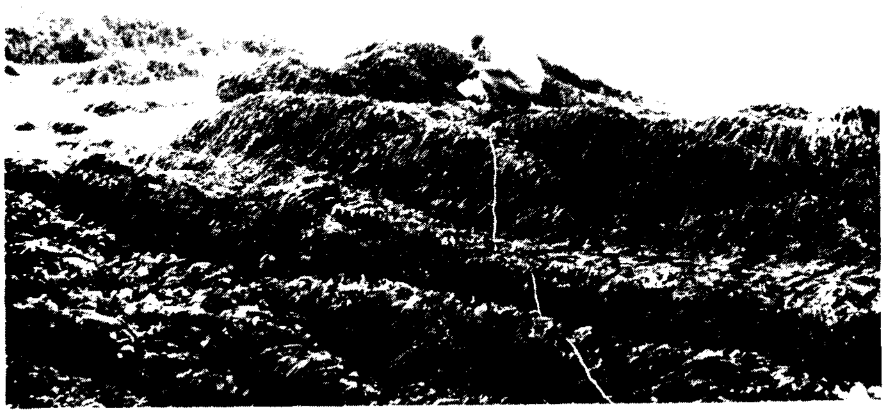
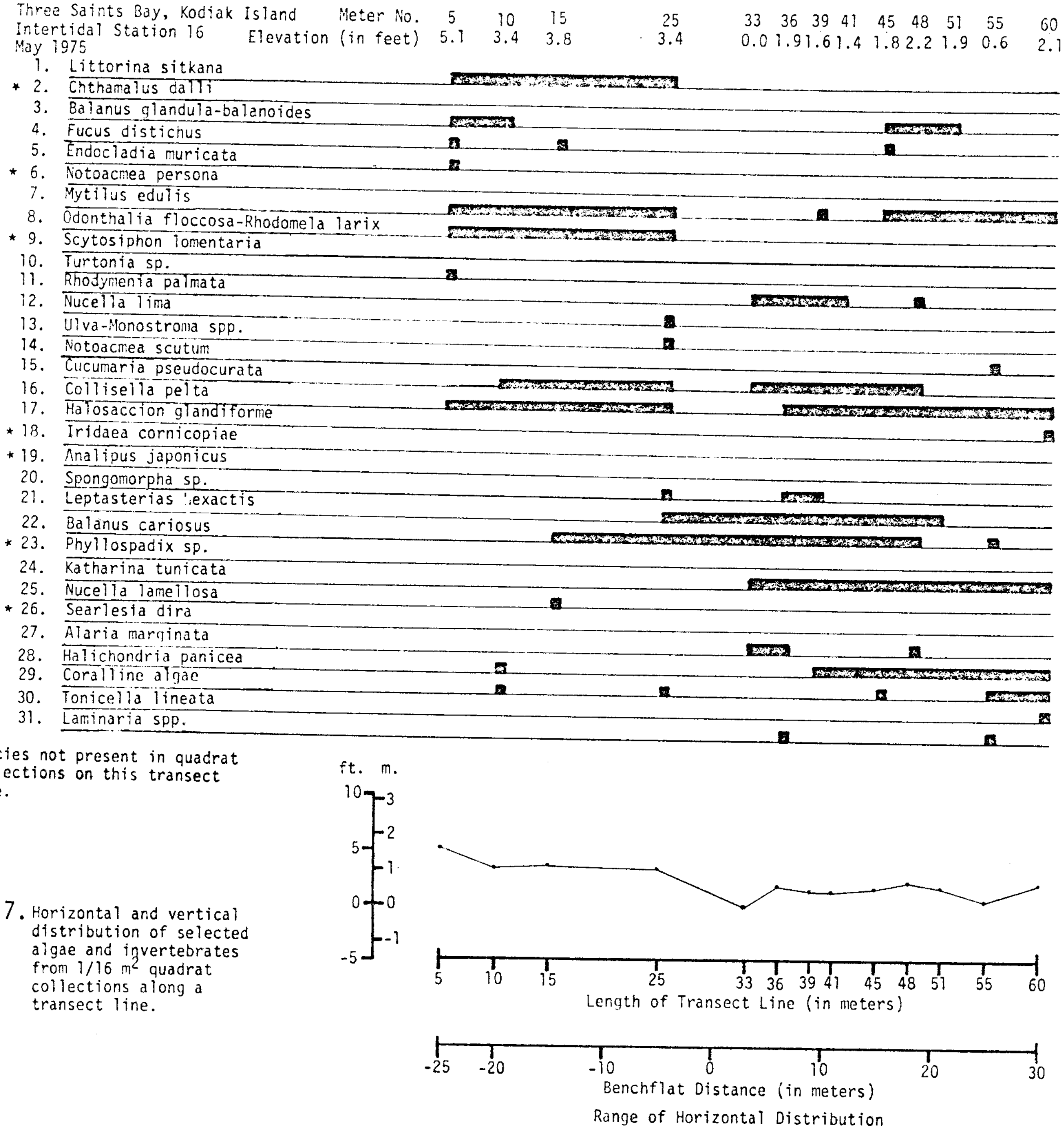


Fig. K. Three Saints Bay, Kodiak Island. Lower end of transect line showing heavy *Alaria* cover.



* Species not present in quadrat collections on this transect line.

Fig. 17. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

the transect. High bedrock outcrops near the low tide line also occurred outside the area of the transect. The highest of these areas had patches of green algae, probably Spongomorpha sp.. The next zone was a band of mixed red algae below the green algae and along the tops of some of the lower ridges. The algae included Odonthalia floccosa, Halosaccion glandiforme, Rhodymenia palmata f. sarniensis, and other small bladed reds. A wide band of mussels occupied the area between the red algae and the Alaria zone.

The lowest area of the transect begban at the low tide line and had a dense cover of the brown algae Alaria, principally Alaria marginata. Much of the Alaria was short, with eroded blades, with or without sporophylls. A heavy layer of Balanus cariosus grew on the bedrock with the Alaria holdfasts growing up, on or between them. The B. cariosus were large, often chimney-form, with heavy walls. Although not apparent on casual observation, and usually not found until a clump of B. cariosus had been pried from the rock, were many small organisms sheltered between the large barnacles. The sheltering animals included the starfish Leptasterias hexactis, small gastropods, various polychaete worms, and ubiquitous amphipods and isopods.

Other conspicuous organisms in the low zone along the transect line were the chitons Katharina tunicata, and Tonicella lineata. K. tunicata was more abundant, with as many as eight per 1/16 m^2 quadrat. A cover of sponge, mostly Halichondria panicea, was abundant with a patchy distribution. Various species of coralline algae, both encrusting and articulated, were also seen throughout this zone.

The dominant animal in the mid-zone was Mytilus edulis, although barnacles were also abundant. A small area between the Alaria and Mytilus zones had a patchy distribution of barnacles, mostly medium to large Balanus cariosus, with a few B. glandula. The lower boundary of the Mytilus zone proper was demarcated by small Mytilus, and large B. cariosus, merging upward into an area of almost solid Mytilus with medium B. cariosus in patchy distribution. Large Mytilus formed only a narrow band on the rock tops near the lower boundary of its distribution on the transect, becoming an almost solid band about a meter wide higher up on the transect. The algae Porphyra sp. and Spongomorpha spinescens were often seen growing on the Mytilus band.

The high zone is characterized by a heavy cover of Fucus distichus. The lower end of the Fucus zone is characterized by M. edulis, small B. cariosus, and short profusely branched fertile Fucus plants. The B. cariosus became interspersed with and was gradually replaced by B. glandula. Higher on the line some Mytilus occurred through most of the zone but in the very highest area only littorines were found with small B. glandula and short sterile Fucus growing in crevices. Patches of Odonthalia floccosa and Endocladia muricata were also common throughout the Fucus area.

Cape Kaguyak

Cape Kaguyak lies near the southern tip of Kodiak Island. Our sampling site, which lies slightly inside the Cape on the north side, is partially protected from the full force of oceanic turbulence (Figure 18).

The beach is somewhat irregular, grading from large boulders near the point, to gravel part way inside Kaguyak Bay. The large boulder area which is only a short distance from our site appears to be influenced by wave force from the Pacific side. Storm surf in this area appears able to roll across the land into Kaguyak Bay. The large boulders appear to have been shifted about recently and several large tide pools at the highest elevations indicate that waves from the Pacific side inundate the area with spray.

The upper part of our sampling site was composed of sand, gravel, and small boulders which graded into larger boulders nearer the water. The beach had a moderate and fairly regular slope generally unbroken by large boulders or bedrock hummocks.

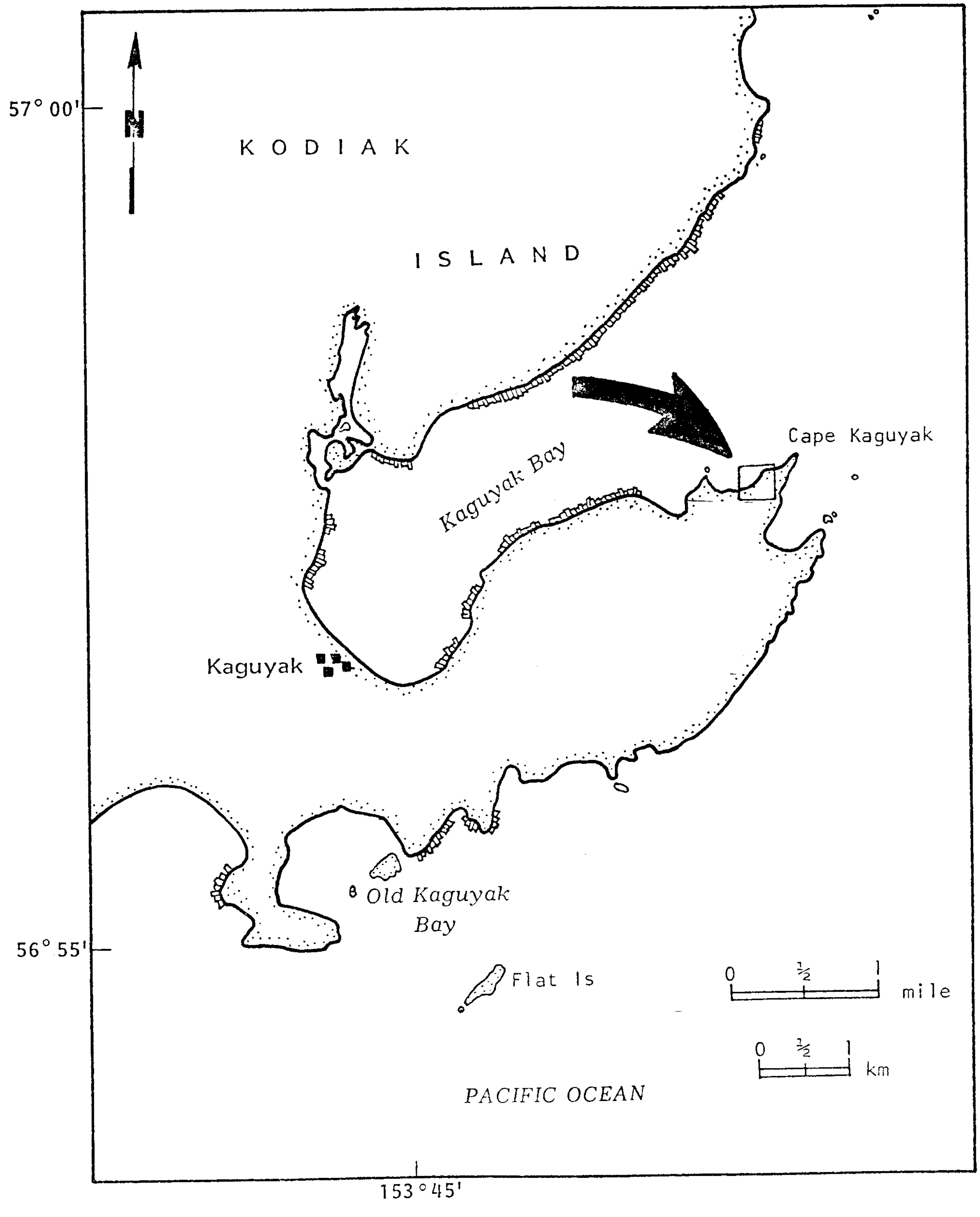


FIGURE 18 CAPE KAGUYAK SITE

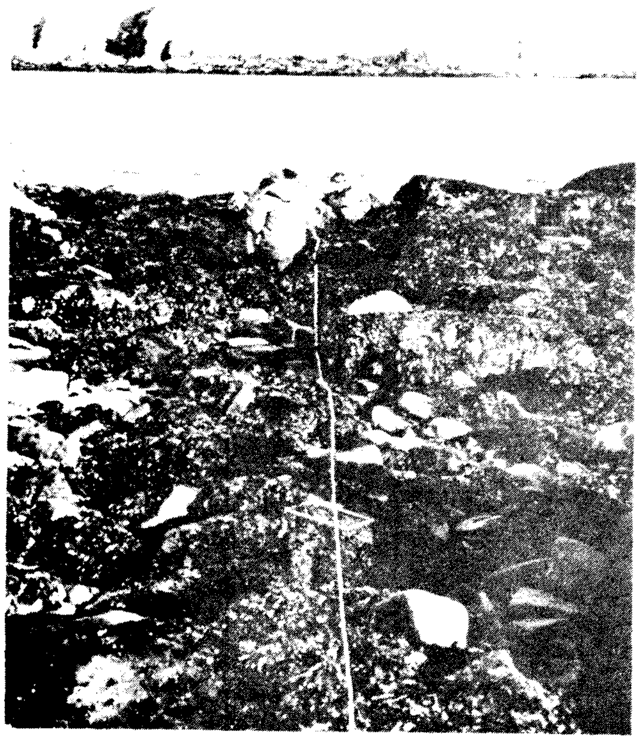


Fig. L.

Cape Kaguyak, Kodiak Island.

View of transect line.

Fig. M. Cape Kaguyak, Kodiak Island. Sampling area showing transect lines 1 and 2.

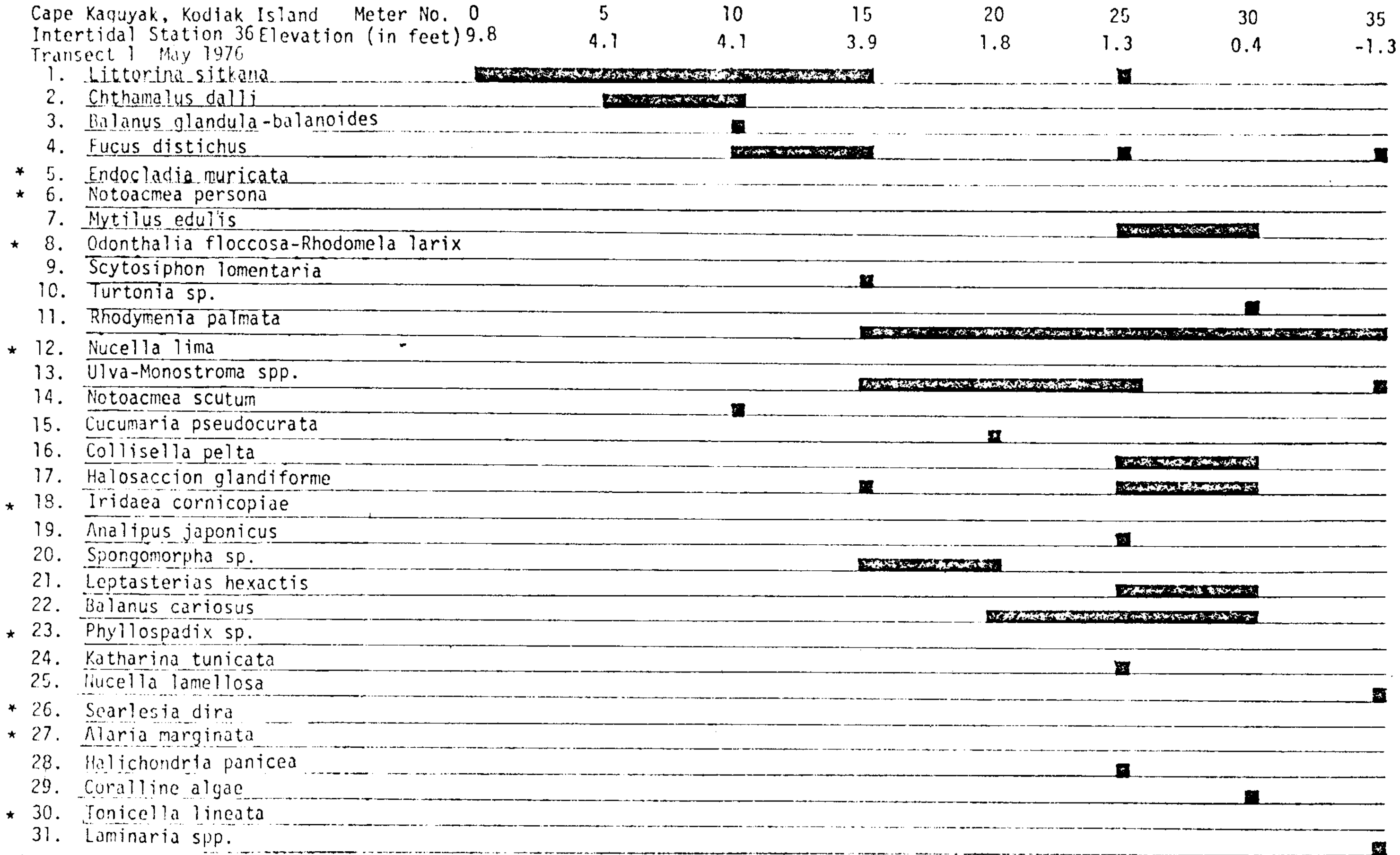
Two parallel transect lines were used at Cape Kaguyak (Figures 19 & 20). Both were used to enumerate algal and invertebrate cover, and also to make 15 quantitative collections. Algal cover along the lines was generally heavy. The upper area was dominated by Fucus, Gloiopeltis, and Pophyra. Lower levels were dominated by Rhodymenia and Alaria.

Invertebrate populations were small. Mussels (Mytilus edulis) and predatory molluscs and sea stars were largely absent. The upper area of the beach was characterized by littorine snails, barnacles, (Chthamalus dalli, Balanus glandula), limpets (Notoacmaca scutum, Collisella digitalis). Lower levels were characterized by barnacles (Balanus cariosus) several species of gastropods (Margarites helicinus, Lacuna marmorata), sponge (Halichondria panicea), bryozoa, and serpulid worms (Spirorbis). Most of the non-colonial forms were small in size and except for sponges the biomass of invertebrates was generally small throughout both lines.

Low Cape

Low Cape is a flat, small boulder and cobble beach lying on the west shore of Kodiak Island, and is exposed from the south and west (Fig. 21). Surf action probably tends to move the boulders and vegetation was sparse along the transect (Fig. 22). Rhodomela and Odonthalia, lying in small discrete clumps were the most visible algae. Fucus was sparse and Rhodymenia and Alaria were absent in quadrat collections, although, small amounts of bleached Rhodymenia were noted in the vicinity of the transect line. Littorina sitkana and polychaete worms were the only organisms which were found in all 11 samples, while Mytilus edulis was found in 10 of 11 samples. The seaward samples had more unique species (occurring in only one sample) and also had more species.

We also made qualitative observations in an area lying beyond the transect



* Species not present in quadrat collections on this transect line.

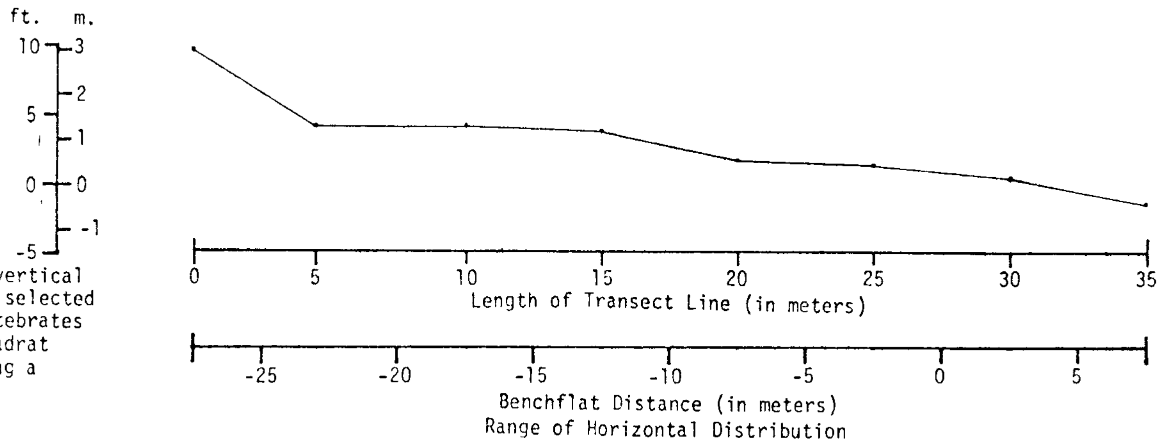


Fig. 19. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

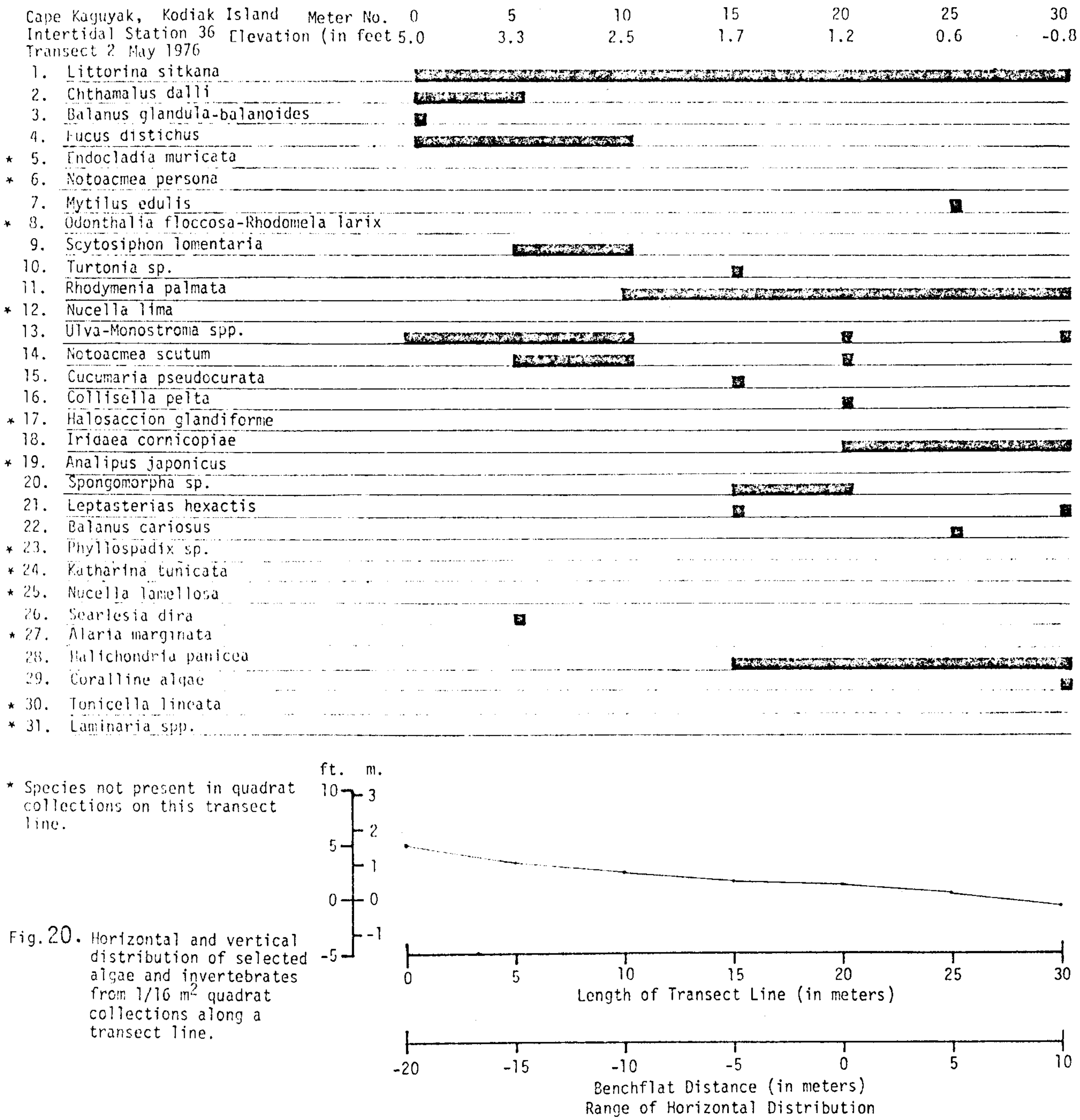


Fig. 20. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

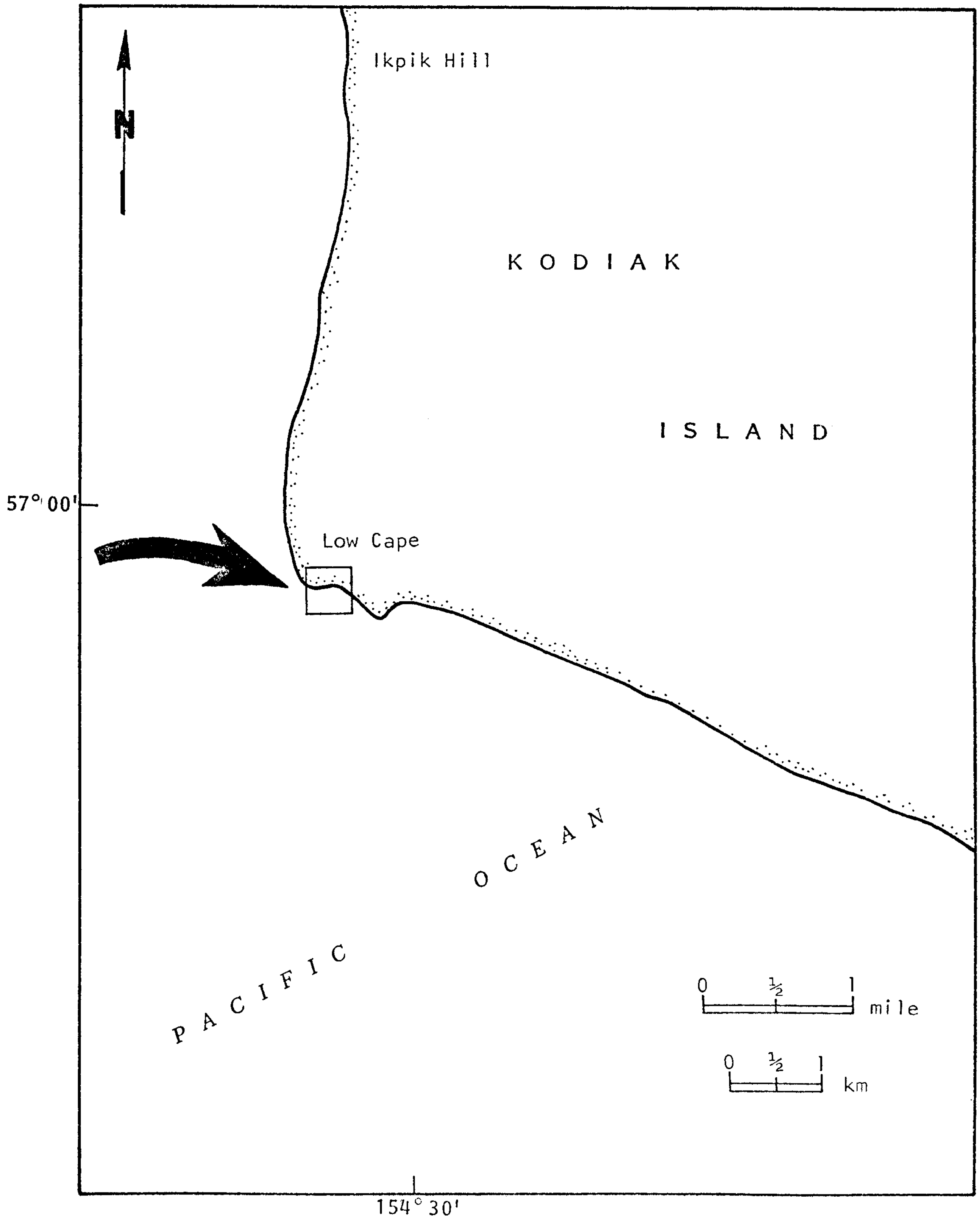


FIGURE 21. LOW CAPE SITE

Fig. N. Low Cape, Kodiak Island. General view of sampling area looking north.

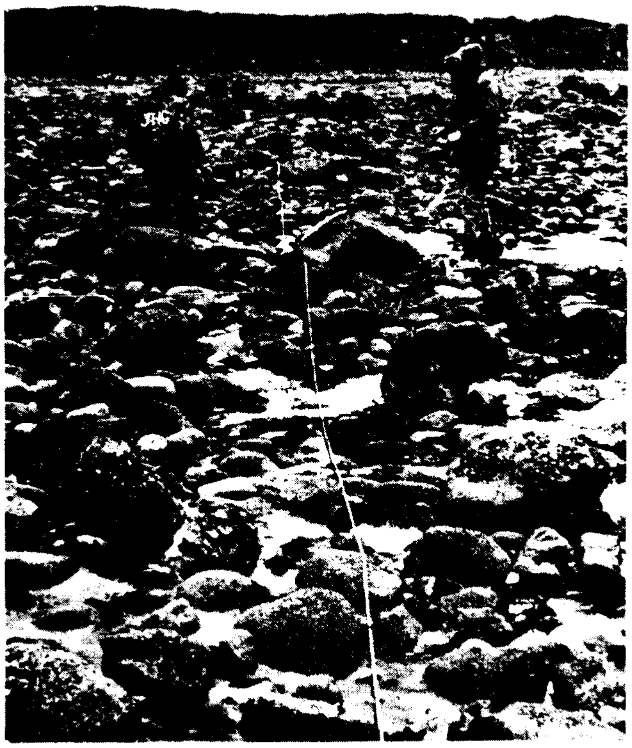
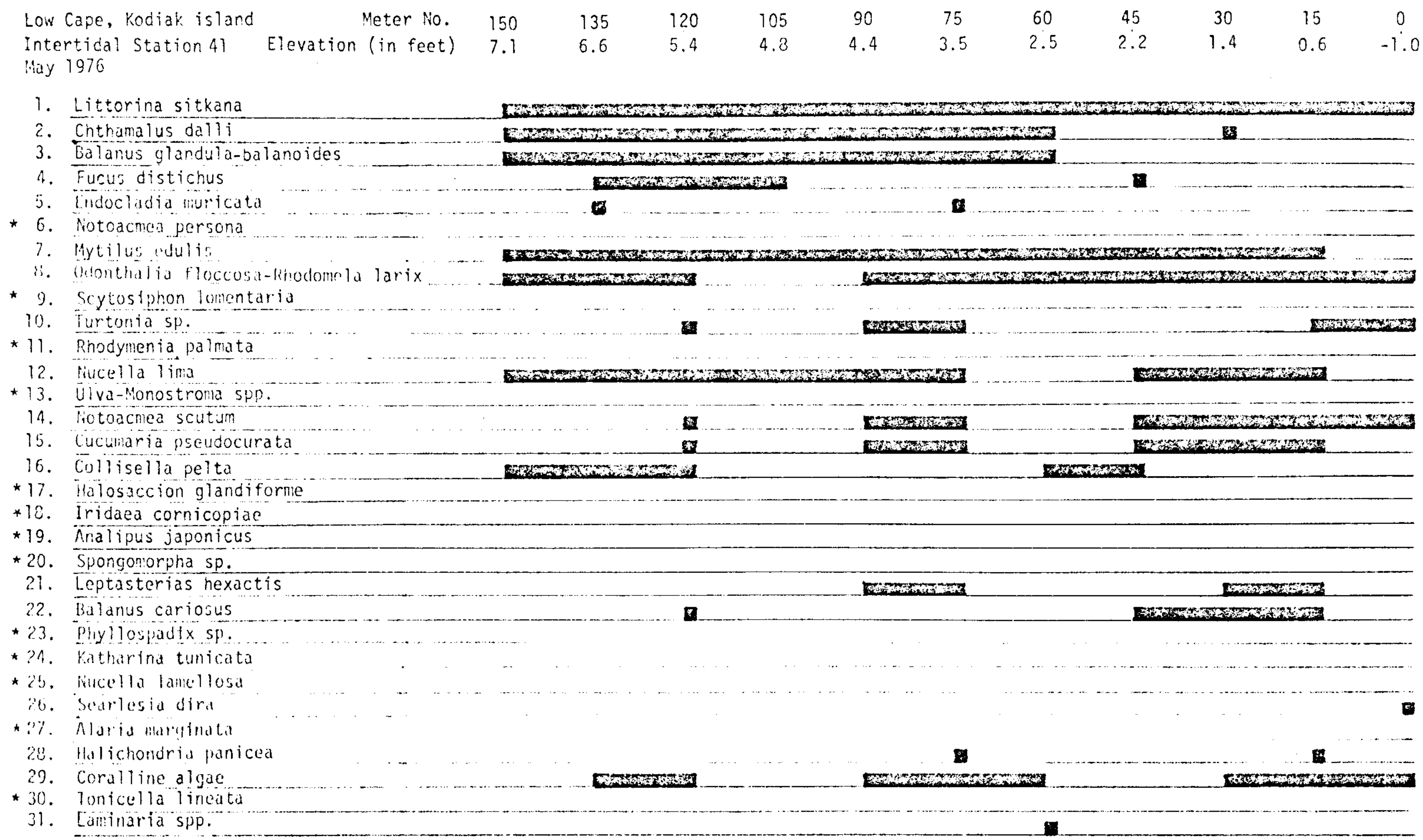


Fig. O. Low Cape, Kodiak Island.
Upper end of transect line.

Fig. P. Low Cape, Kodiak Island.
Lower end of transect line.



* Species not present in quadrat collections on this transect line.

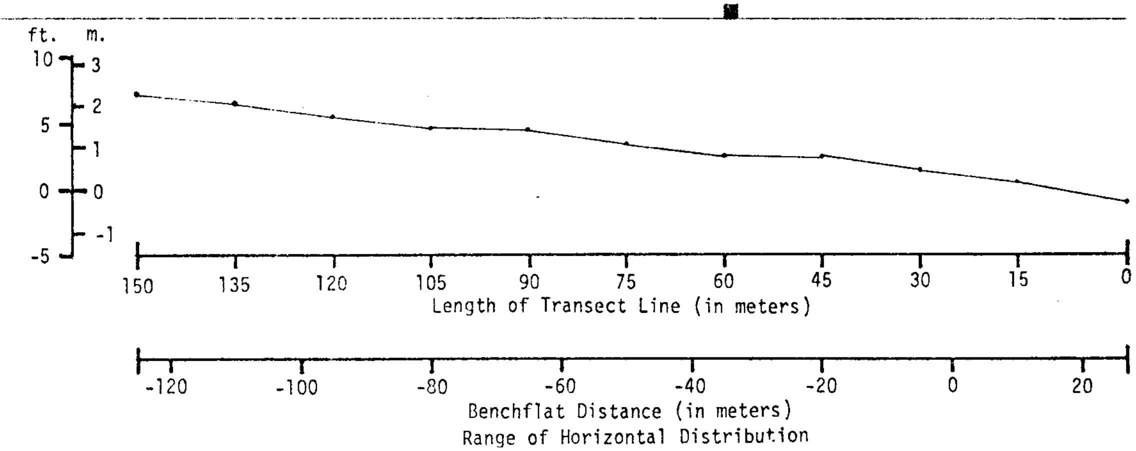


Fig. 22. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

line. Aerial reconnaissance showed that the flat slope of the beach ctoninues for some distance into the subtidal, and much of the area we looked at is covered with very large, shallow, tidepools. In this area there are a few large and apparently immovable boulders which have different assemblages of organisms than those seen on the transect line. For instance, we saw small-medium Balanus cariosus on the boulders, often covered with aggregations of the predatory snail Nucella lamellosa. The chiton, Katharina tunicata was also observed in this area. Neither Nucella lamellosa or Katharina tunicata was found in the transect line collections. Many species of red algae were found in the tidepools; these algae were often bleached. Most of the tidepool bottom was covered with coralline algae species, and Constaninea rosa-marina, which generally occurs subtidally, was abundant in tidepools. Clumps of Ptilota sp. were also common. Brown algae included Desmarestia sp., Laminaria yezoensis, and a good stand of mature Alaria sp.

The low beach between the tidepools and the end of the transect line was similar to the terrain along the transect line. Sponge and bleached Lithothamnion covered much of the rock surfaces. Eroded Alaria stipes, but no mature Alaria were common. Other algae in the area were Laminaria sp., Halosaccion glandiforme, Bangia sp., Ulva, and Fucus.

Sundstrom Island

Sundstrom Island is a small island lying south of Kodiak Island between the Trinity Islands and Cape Trinity (Figure 23). The coastal substrate is basaltic bedrock with deep indentations. At the head of the rocky area there is a narrow strip of black sand beach, rising abruptly to steep rocky bluffs which are occasionally covered with grass.

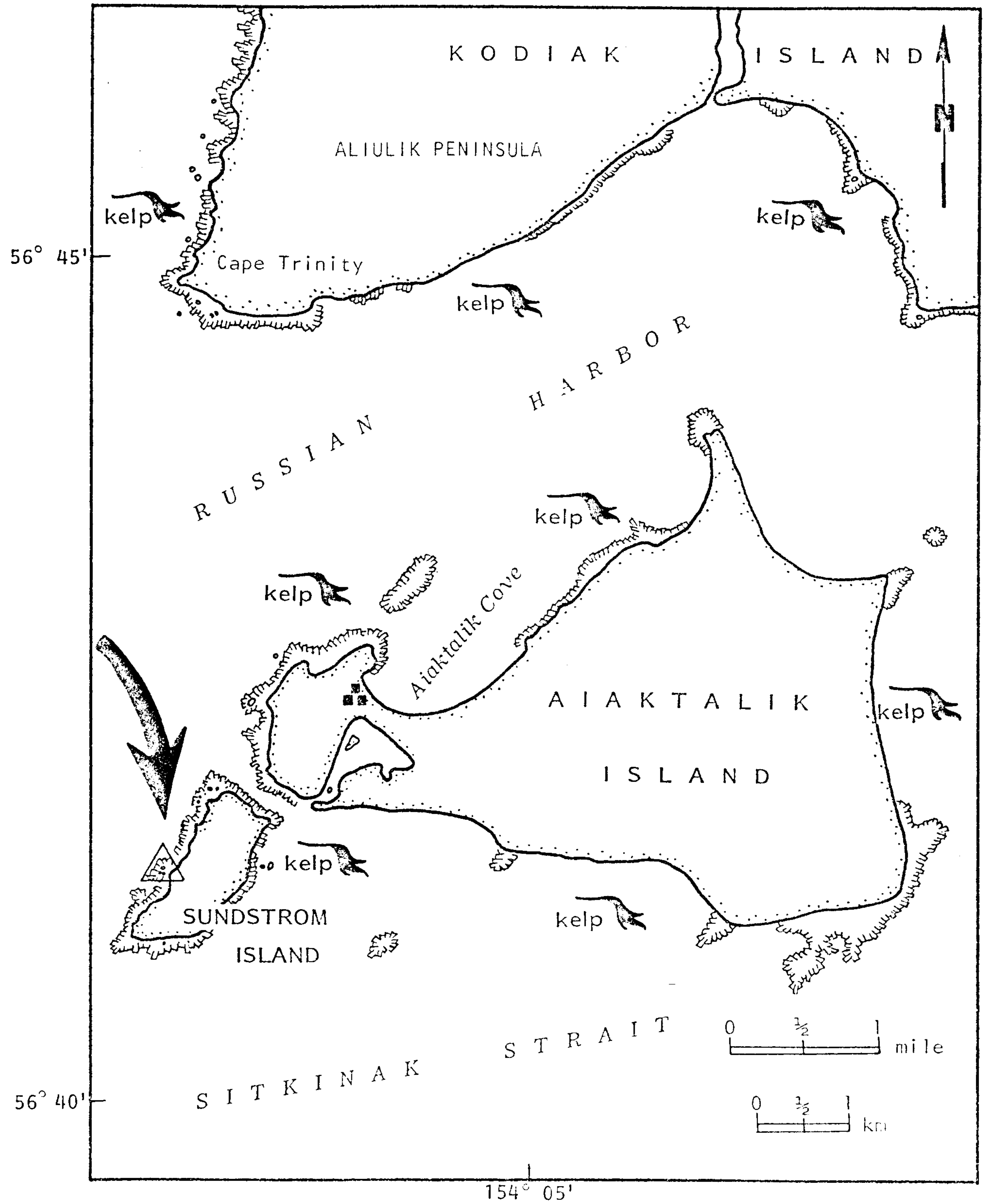


FIGURE 23. SUNDSTROM ISLAND SITE

Fig. Q. Sundstrom Island. Middle of transect line showing *Fucus* cover.

Fig. R. Sundstrom Island. Sampling using Myren-Pella arrow sampling method on vertical face. Most visible cover is *Alaria*.

Fig. S. Sundstrom Island. Odonthalia floccosa and Littorina sitkana.

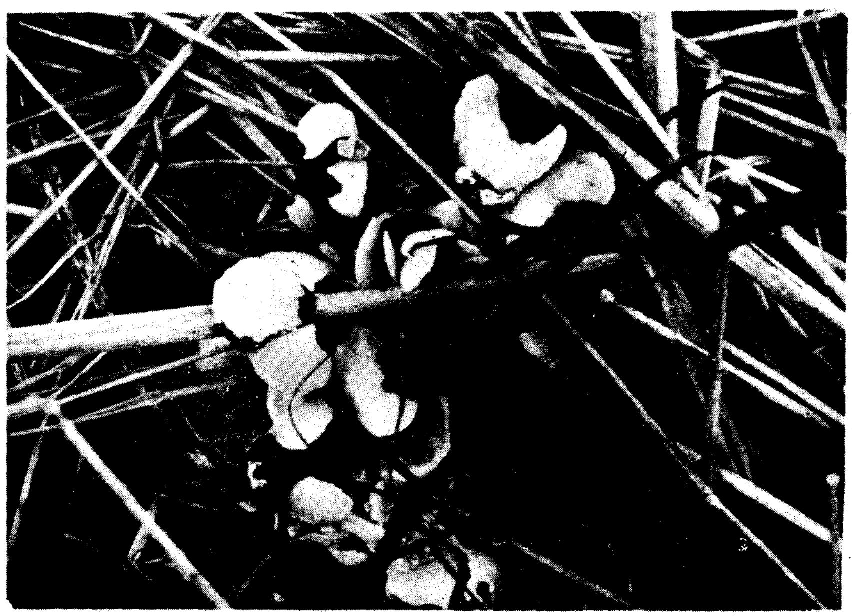
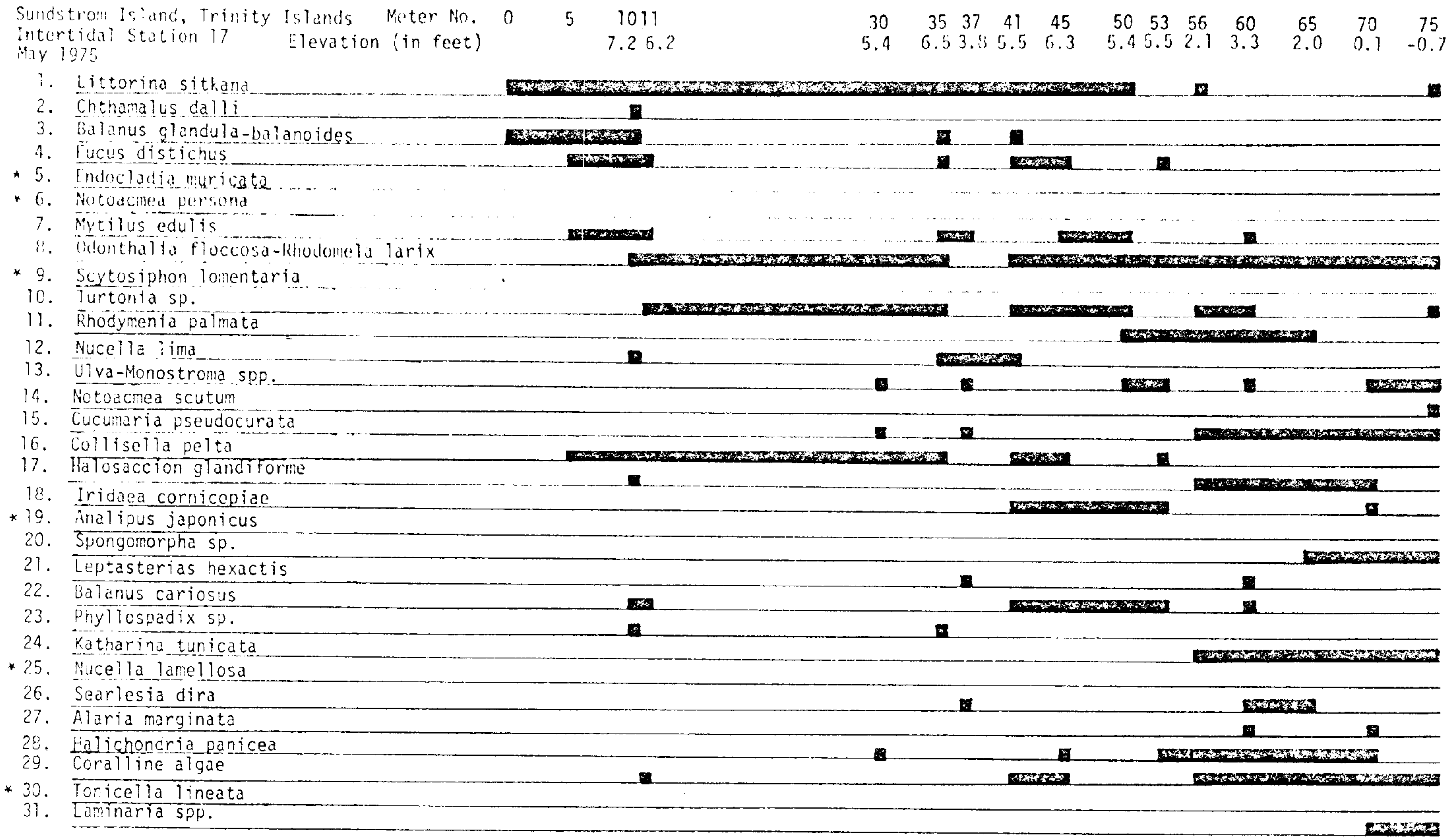


Fig. T. Sundstrom Island. Plates of the chiton, Katharina tunicata were common in the gull nesting areas on Sundstrom Island.

The lowest zone in our sampling area was almost entirely covered with long strands of fertile Alaria (Figure 24). The substrate there was basaltic bedrock with deeply cut surge channels. Biota differed between rock tops and channels. Laminaria longipes was often found filling the low channels. In low tidepool areas it was accompanied by Hedophyllum sessile. The area outside the channels and tidepools was characterized by Alaria marginata, Balanus cariosus, and several species of coralline algae, both encrusting and articulated. Often seen were several large Katharina tunicata wedged in among the B. cariosus. The Katharina were being heavily preyed on by sea birds, principally oyster catchers and gulls. Large patches of Halichondria panicea and another sponge also covered much of the low area. There were occasional Henricia leviuscula and Tonicella lineata as well. The red algae were represented by Rhodymenia palmata and Pterosiphonia bipinnata; in addition, Odonthalia sp. was found on the sides of some of the higher channels in the low zone. Spongomorpha spinescens and Monostroma sp. were the green algal species of the low zone. The kelp species probably made up over 90 percent of the low zone algal cover.

The mid-zone was variable and difficult to define. In general it may be characterized as the red algal belt, for several red algal species were found in their greatest abundance here. Two forms of Rhodymenia, (R. palmata, and R. palmata f. sarniensis) occurred throughout the zone; R. palmata intergraded downward into the low zone as well. Various species of the Odonthalia-Rhodomela group were found along almost the entire length of the transect; the most abundant species was O. floccosa. Odonthalia occurred principally on the sides of channels in the low zone; in the mid-zone it was found principally on the bottom of channels or in very shallow areas of standing water. Often the Odonthalia plants were heavily covered with littorine snails. Halosaccion glandiforme was also found in this zone. In areas where it was most abundant,



* Species not present in quadrat collections on this transect line.

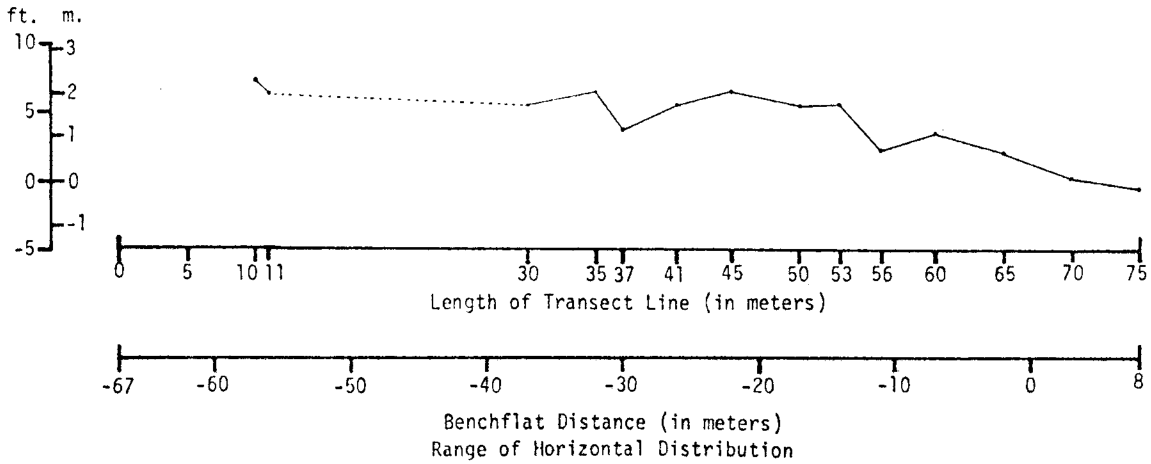


Fig. 24. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

it covered medium-gradient rock surfaces with plants of uniform size. On rock tops it often intergraded with Fucus distichus. In May 1976, we observed a heavy cover of epiphytic parenchymatous green algae growing on Rhodymenia and Halosaccion.

Balanus cariosus was found in the middle zone as well as in the low zone. In the middle zone it occurred principally in shaded or moist situations under overhangs or at the base of rocks. The common barnacle in the mid-zone was Balanus glandula which was quite abundant on rock sides and tops. Groups of limpets were seen on irregularities in the rock surface. Collisella pelta was the common species there. Mytilus edulis was seldom seen; it occurred only in very small clumps in protected locations.

The three dominant organisms of the high zone were Fucus distichus, Balanus glandula, and Littorina sitkana. O. floccosa was found in areas of standing water. F. distichus occurred on rock tops in the mid-zone, grew abundantly through most of the high zone, and was found as isolated sprigs where the bedrock graded into pebbles and sand. Balanus glandula was found throughout the high zone and grew above the limit of the Fucus. In the upper part of the zone it was mixed with Chthamalus dalli. In several quadrats as much as 25 percent of the barnacles were dead and only the empty plates remained on the rock. Littorina sitkana was found along the entire length of the transect and even beyond. Although their greatest concentrations were on O. floccosa plants, we observed a few littorines on patches of lichens above the tide line.

We had the opportunity to observe condensed vertical zonation on two vertical faces of a huge, high bedrock boulder near the low tide line. One side was exposed to the sea from a SW direction; the other side faced the land, and was shaded and fairly protected from waves.

The exposed side had virtually 100 percent cover of organisms. The base of the area was a flat shelf, which bared only during the lowest tides. This shelf was covered with a carpet of large B. cariosus which in turn was covered with several varieties of coralline algae. Some of these corallines were bleached at the edges. Alaria plants were found wherever there was room for their holdfasts to remain attached.

The lowest zone of the exposed vertical face had a cover of B. cariosus, Alaria sp., Rhodymenia plamata, and Odonthalia floccosa. The O. floccosa often completely covered the barnacles; it has a short, tuft-like form. The next higher zone was covered with R. palmata, Halosaccion glandiforme, Fucus distichus, and B. glandula. Both the fucus and Halosaccion grew in large clusters of short, dense plants. Above this zone was a zone of F. distichus and B. glandula. A broad band of Porphyra sp. grew just below the summit of the boulder. Sundstrom Island has a large population of sea birds; the top of the boulder was crowned with a luxurient growth of Prasiola meridionalis nourished by guano.

The landward, protected side of the boulder had a very patchy distribution of organisms; everything grew in clumps with bare rock in between. The lowest zone had patches of Alaria sp. and B. cariosus. Odonthalia sp. grew between and above this zone. The next zone was composed of clumps of Fucus and Mytilus edulis. In an area where the rock formed a ridge and flattened out a little before the next vertical rise, the Mytilus had a more continuous distribution and formed a narrow band. The zone below the summit had a patchy distribution of B. glandula and F. distichus. As on the exposed side of the boulder, the summit was covered with P. meridionalis.

Cape Sitkinak

Cape Sitkinak, on Sitkinak Island, is the eastern most point in the Trinity Island group. It lies in a highly exposed location, being subject to the full force of southerly and easterly Pacific storms (Figure 25). Heavy tide rips in Sitkinak Strait (Coast Pilot 9, ph 105) and the full exposure to waves and winds make it a turbulent area oceanographically.

Geologically the beach is bounded by high bluffs which terminate in a sandy slope above high water. The intertidal area is part of an extensive, almost flat reef area which extends far offshore. The upper part of the intertidal is covered with large and small boulders. The lower part is exposed bedrock which may be covered with pockets of sand in some places. Owing to the very small gradient almost the entire lower area is covered by water to some extent, even when the tide is out. Large tide pools abound. Extensive beds of surf grasses (Phyllospadix scouleri) and kelps (Alaria, Laminaria) occupy the tide pools.

During May 1976 we studied the area using two transect lines (Figure 26). Quadrats along both lines were visually enumerated to determine percent coverage of algae. The first line was also used to collect 22 quantitative samples. At the time the lines were laid, only the upper portions of the intertidal were exposed. As the tide continued to recede another half mile of beach was exposed. This was investigated qualitatively but it was not possible to make systematic quantitative collections during the short period of time the lower areas were exposed. Thus, the area which was dominated by kelp was not sampled.

A comparison of the two lines indicated that similar organisms were present at both locations. Since neither of the lines passed through the

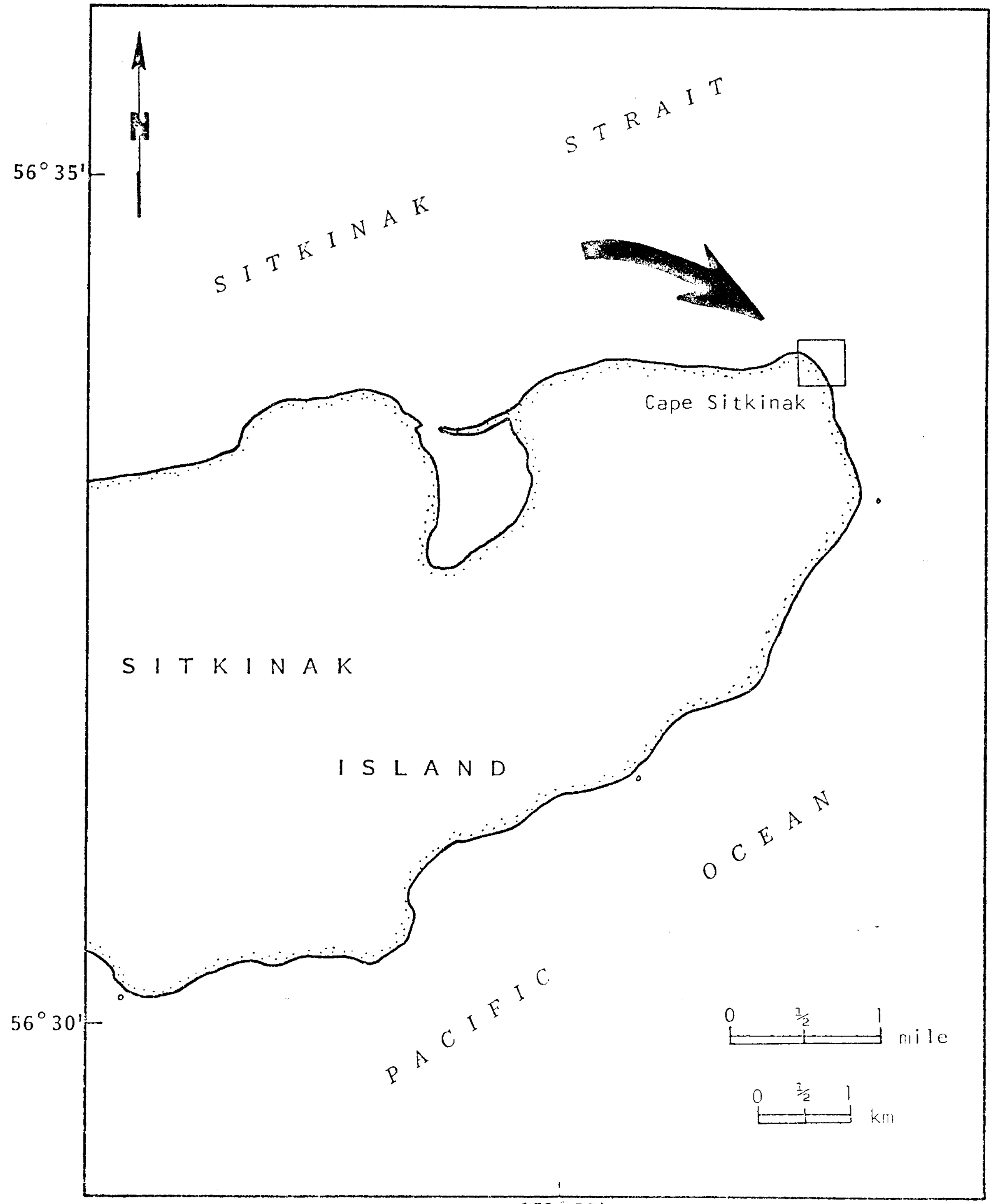


FIGURE 25. CAPE SITKINAK SITE

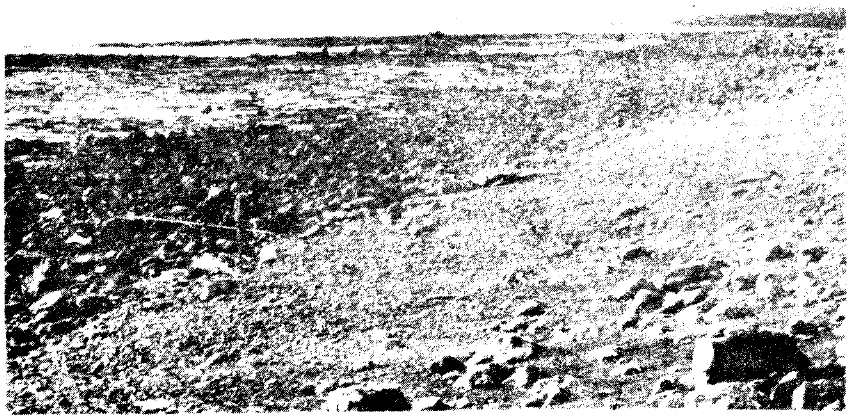
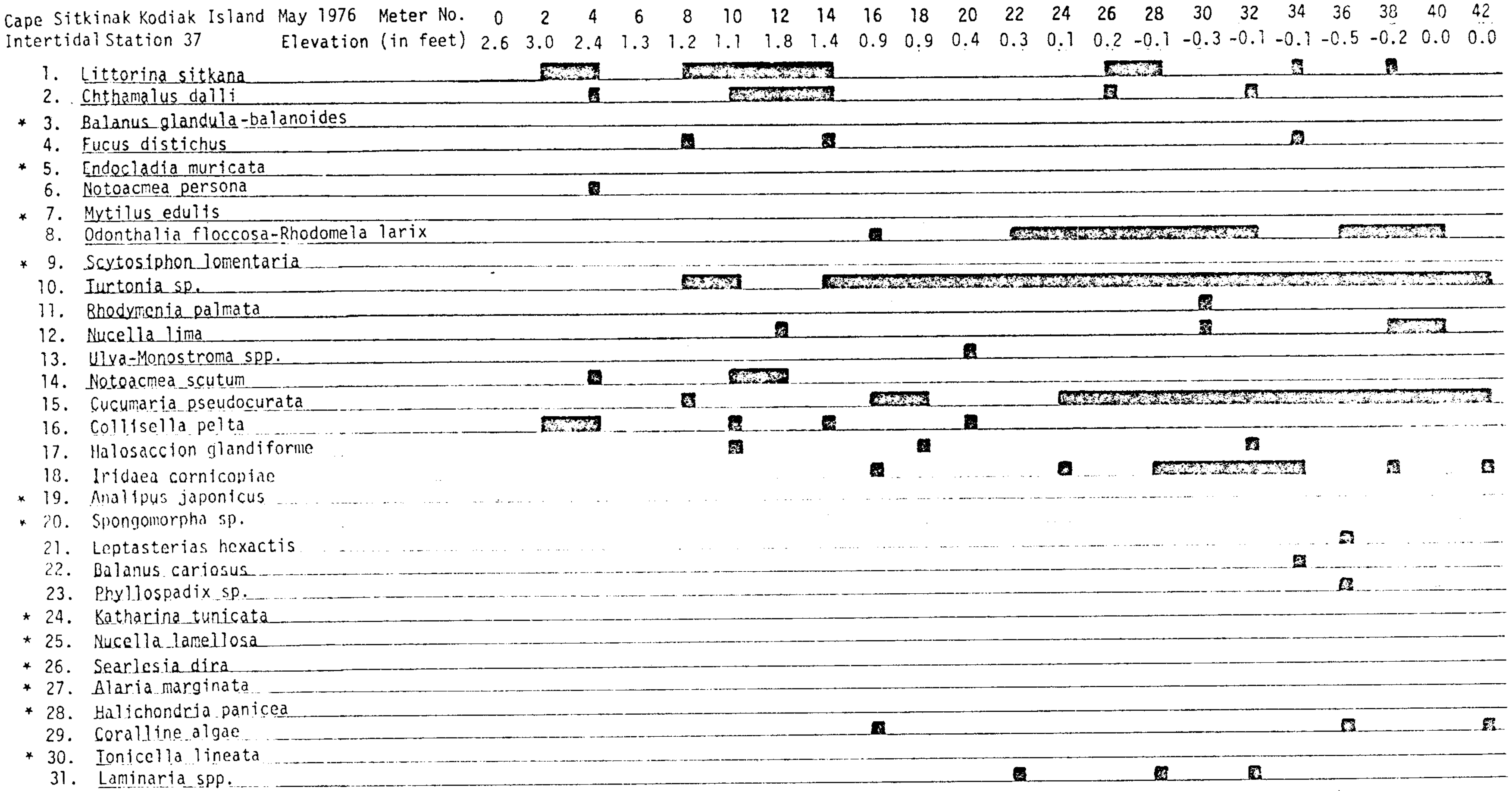


Fig. U. Cape Sitkinak, Sitkinak Island. General view of sampling area. Intertidal area begins where surveyors are standing in left center of picture.

Fig. V. Cape Sitkinak, Sitkinak Island. General view of sampling area looking toward beach. Note standing water and Laminaria in foreground.

Fig. W. Cape Sitkinak, Sitkinak Island. Transect line.



* Species not present in quadrat collections on this transect line.

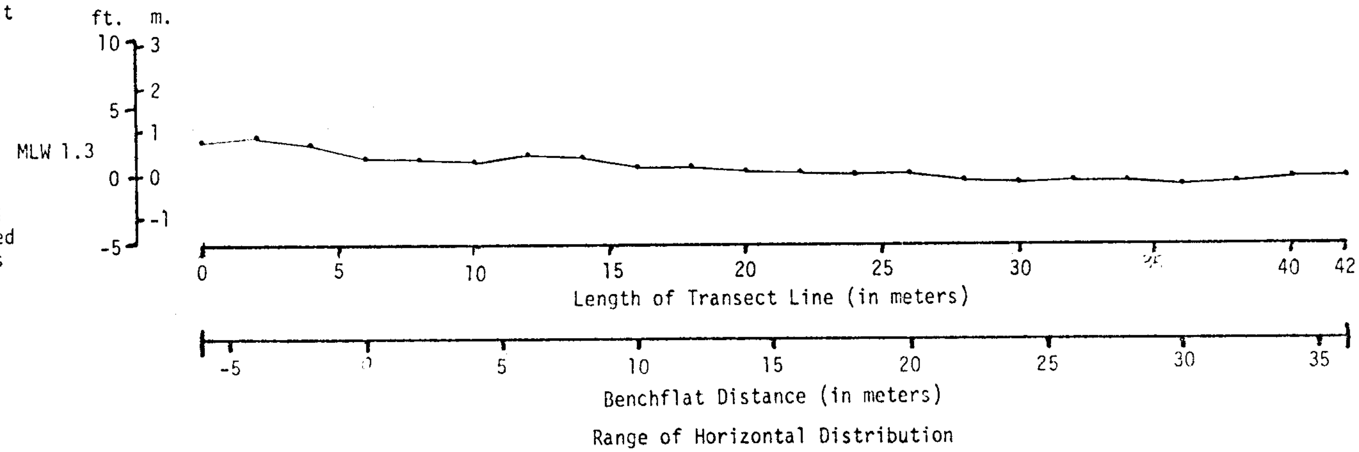


Fig. 26. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

large area of Phyllospadix, however, there were several sources of variability which were not sampled.

Algal cover was not heavy. Much of the cover on the upper intertidal area was caused by Fucus distichus and Halosaccion glandiforme. Slightly lower, Rhodymela larix, a form which we have found to be most common on exposed flat bedrock, and Odonthalia floccosa were more common. The lowest intertidal areas were quite densely covered by growths of Laminaria sp., Hedophyllum sessile and Phyllospadix scouleri. Rhodymela palmata was abundant in some areas but did not furnish a distinquishable band. Because of the flatness of the beach and the presence of standing water, zonation was not clearly defined and low and high intertidal fauna were often found grouped together. Invertebrate populations were quite low. Mussels (Mytilus edulis) were almost entirely absent. Predatory snails, (Nucella, Searlesia), starfish, and urchins were also missing. Even forms such as chitons, sponges, and Balanus cariosus which were present at almost all of our sampling sites were absent or uncommon at Cape Sitkinak. Invertebrates which were relatively common included limpets, hermit crabs (Pagurus), sea cucumbers (Cucumaria) and amphipods.

Dolina Point

Dolina Point is a flat bedrock point lying along gravel sand beaches on the north coastline of Sitkinak Island (Figure 27). The point was separated from the beach by gravel and small cobble bar of lower elevation than the top of the bench. The transect line extended 190 meters shoreward from the center of the bench across the cobble bar. Thus habitat at the lower elevations on the perimeter of the bedrock bench were not sampled by the transect line. The outer portion of the transect line crossed rough bedrock covered mainly with Balanus cariosus (Figure 28). Vegetation was light, most commonly Alaria and Odonthalia. The middle portion of the line ran through a mixed area

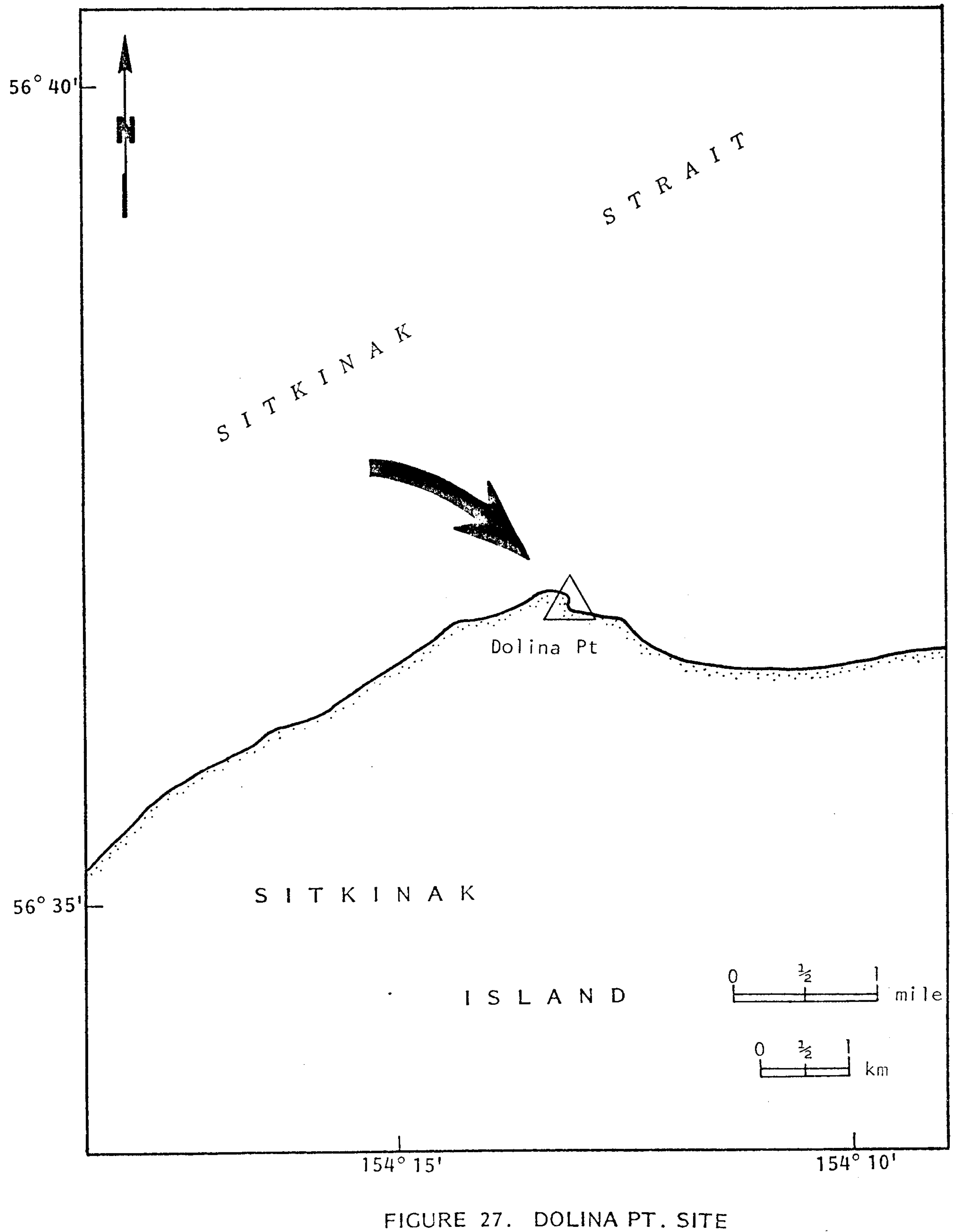


FIGURE 27. DOLINA PT. SITE

Fig. X.

Dolina Point, Sitkinak Island. Upper end of transect line. Samples along this portion of the line were 1 m^2.

Fig. Y. Dolina Point, Sitkinak Island. Lower end of transect line. Samples along this portion of the line were 1/16 m^2.

Fig. Z. Dolina Point, Sitkinak Island. Beach immediately east of sampling area. The boulders at the left had a wide band of Mytilus edulis not represented in our samples.

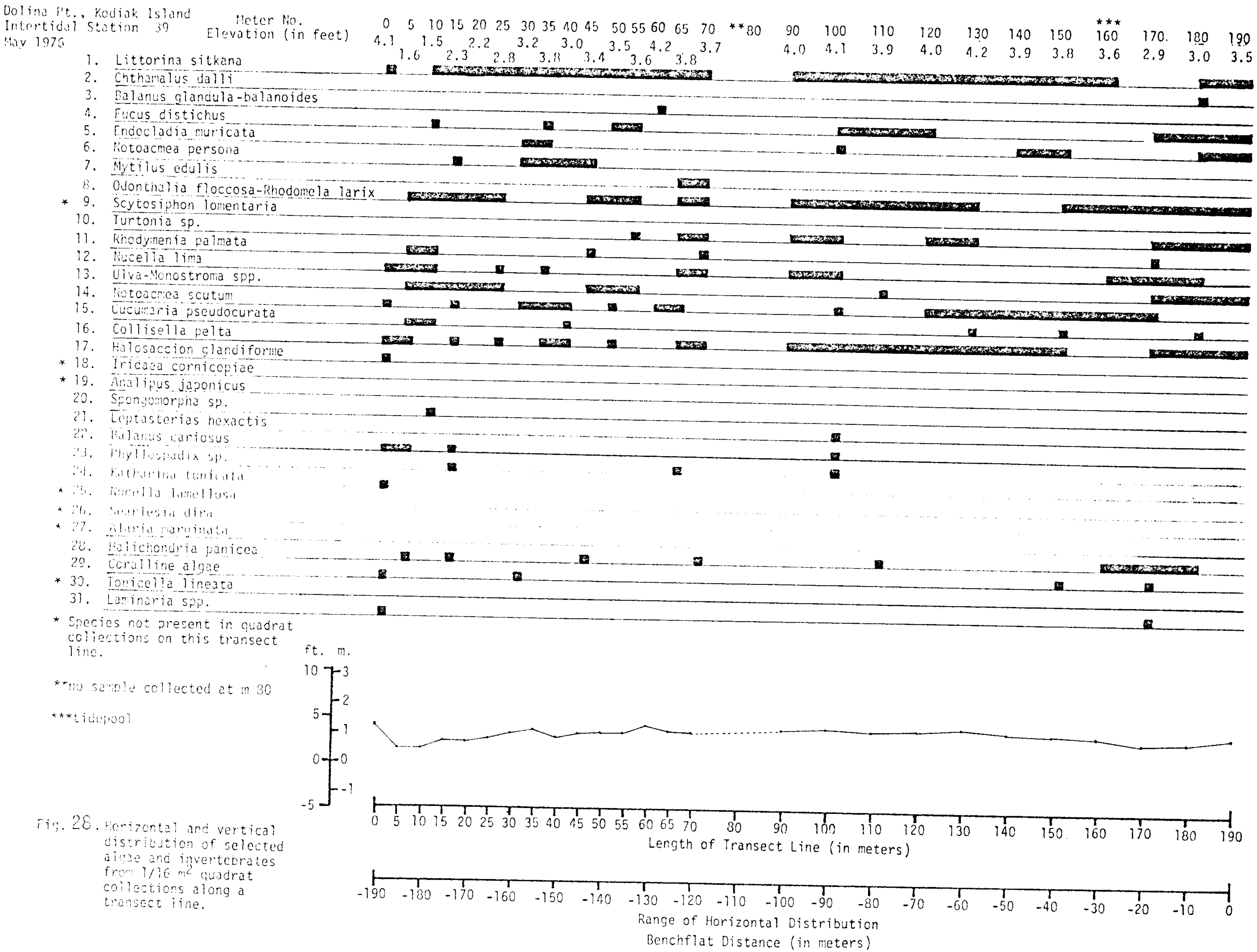


Fig. 28. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

of bedrock, gravel, sand, and standing water. Phyllospadix was growing in small patches in this area. The shoreward portion of the line was cobble beach. Vegetation was small dense, discrete clumps of Fucus, Rhodomela, and Odonthalia. One meter square sample quadrats were used for sampling algae in this section.

Both quadrat collections and visual enumerations show the dominance of Fucus, Odonthalia, and Rhodomela, as well as the significant presence of Endocladia, Phyllospadix, and parenchymentous green algae. Alaria was dominant in the quadrats lying in the bedrock portion of the transect line. Littorina sitkana and B. cariosus were also present in significant amounts in the samples.

Chirikof Island

Chirikof Island is in the Gulf of Alaska, about 80 miles east of the Alaska Peninsula, and about 80 miles southwest of Kodiak Island. It is highly exposed to wave action (Figure 29). The area we sampled at West Point, is characterized by a long, low reef system, much of it lying below MLW. The beach above the tideline is also low gradient and is entirely sand. The upper side of the sand beach is covered with a jumble of large weathered logs, showing evidence of strong wave action during storms.

We sampled a part of the large reef area using two methods. A high relief area with elevations ranging from 3.6 feet to -1.4 feet was sampled using the Myren-Pella arrow method. An area near the arrow site, but lying entirely below MLW, was sampled using the transect line. The arrow site is bedrock without any overlaying material and thus is more stable than the transect line site which has small cobbles and sand over bedrock. The stable bedrock and greater range of elevation found at the arrow site provide an additional range of habitats in the form of crevices and overhangs giving some protection for motile invertebrates; these habitats are not found along the low-lying transect line. Because of its low elevation the transect line

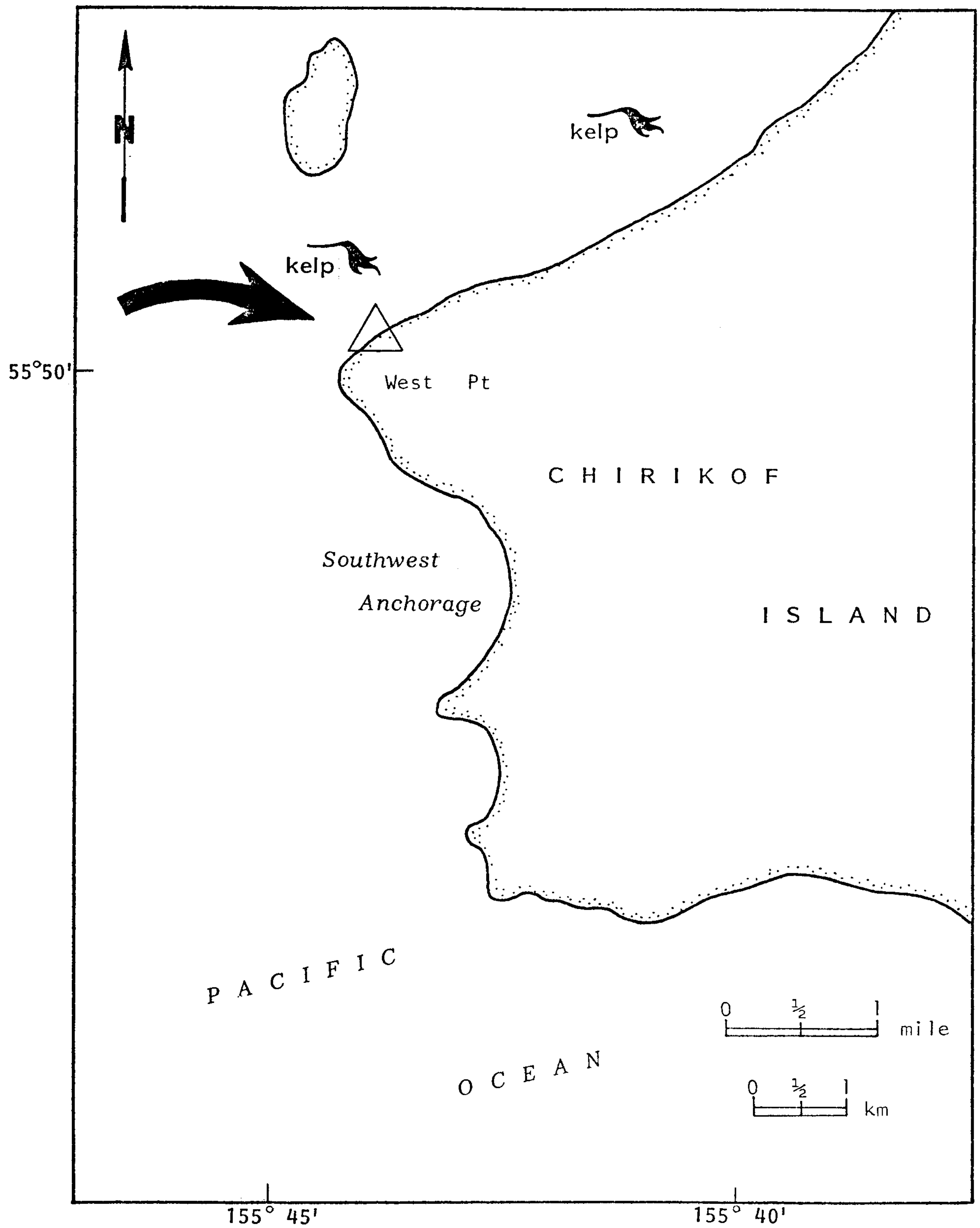


FIGURE 29. CHIRIKOF ISLAND SITE

Fig. AA. Chirikof Island. View along transect line looking shoreward toward sand beach.

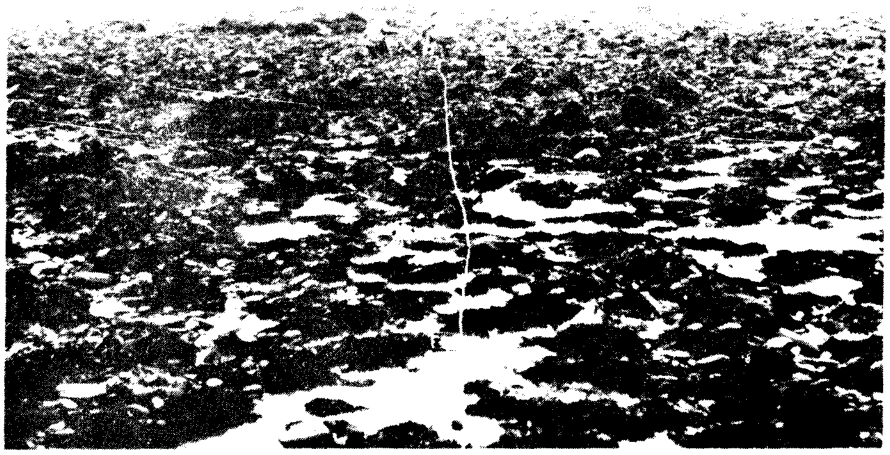


Fig. BB. Chirikof Island. View along transect line looking toward water.

Fig. CC. Chirikof Island. Sampling part of the reef using the Myren-Pella arrow method.

area has many small tidepools and areas of standing water, even at low tide.

The arrow site was an area of the bedrock reef which had been eroded, presumably by wave action, and presented a rock face perpendicular to the waves. The arrows were placed on the top, side and overhangs of this face in an area about 10 meters long. Much of the arrow site area had a heavy cover of large Balanus cariosus which in turn was covered with sponge, coralline algae, small bladed red algae such as Iridaea cornicopiae, and large fertile Alaria plants. The Alaria were uneroded, with large, entire blades. Laminaria longipes was also seen in the arrow site. In addition to Balanus cariosus we saw Henricia leviuscula, Katharina tunicata, Collisella pelta, and large littorine snails.

The beach at the low end of the transect line was a bedrock substrate somewhat similar to the arrow site area and was covered with sponge, fertile, uneroded Alaria, Rhodomela larix, and Iridaea cornicopiae (Figures 28 & 29). Higher on the line, in an area of cobbles, large pebbles, and standing water, we observed a large amount of Odonthalia floccosa and Rhodomela larix in low areas, with Alaria sp. and Fucus distichus growing on the boulders. In this area some of the Alaria had eroded blades with only midribs and sporophyllis persisting. Farther along the line in an area with fewer cobbles, but with pebbles and sand, the Alaria began to thin out and most of it was eroded. Much of the Fucus was sterile. The distribution of all organisms was patchy.

Only a few differences were obvious between the May and August sampling periods. In May we saw a very heavy cover of drift material, mostly decaying algae, at the high tide line. In August the drift material was approximately 10 percent of what it had been in May. In August we found more species of non-kelp brown algae (e.g. Analipus, Melanosiphon) than in May, and noted a heavy cover of parenchymatous green algae* at the upper end of the transect line.

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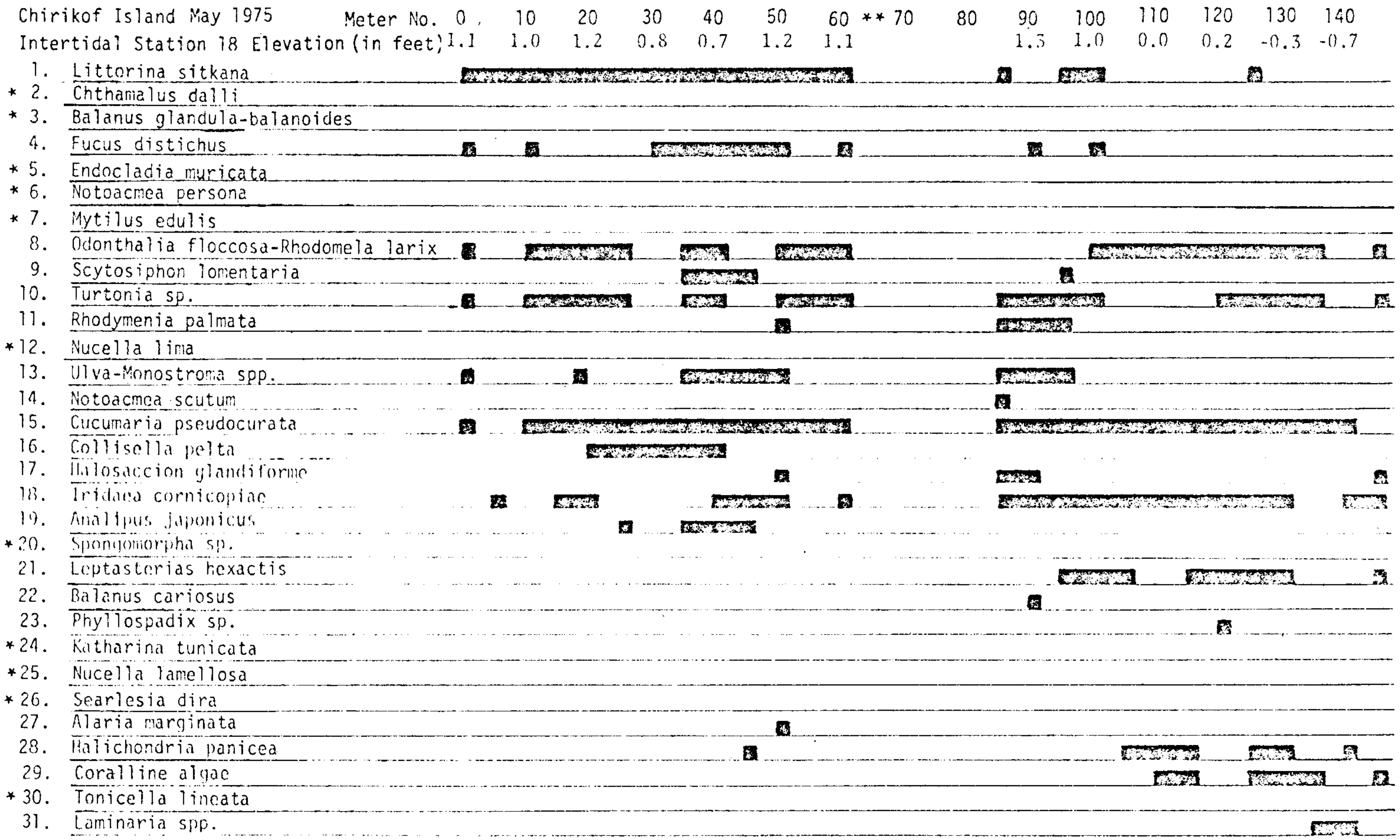
*Parenchymatous green algae refers to a number of species which have a sheet-like form.



* Species not present in quadrat collections on this transect line.

**no samples collected for meters 65, 70, 75, and 80.

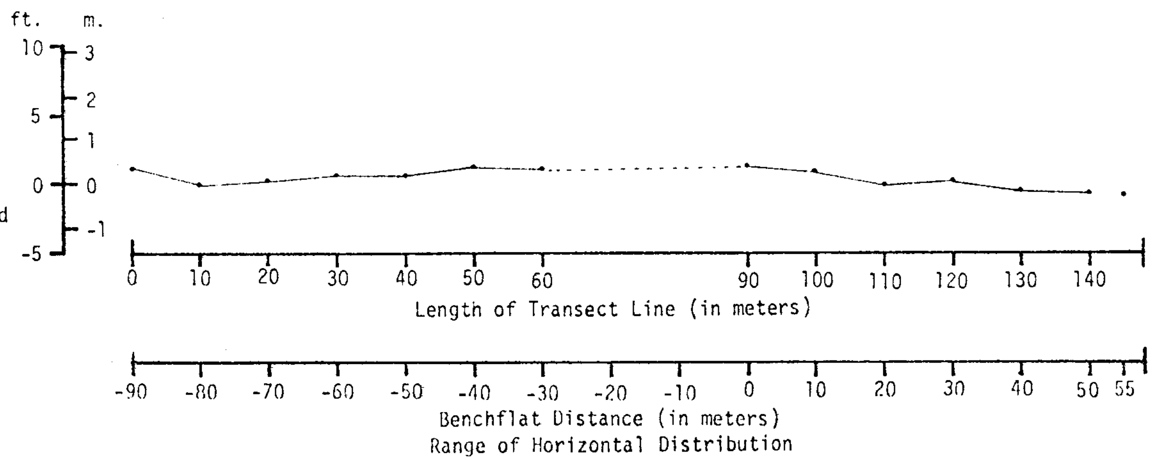
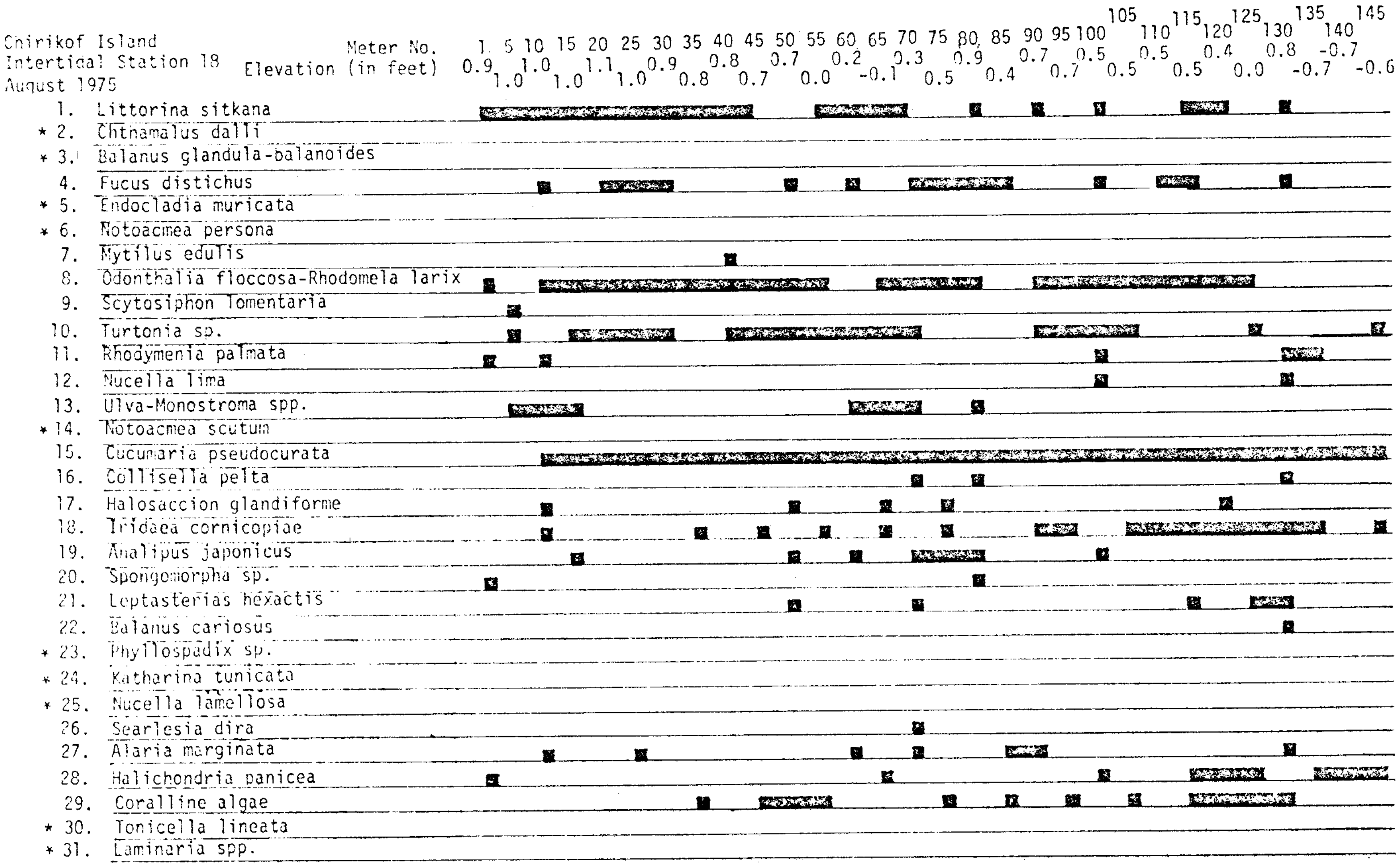


Fig. 30. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.



* Species not present in quadrat collections on this transect line.

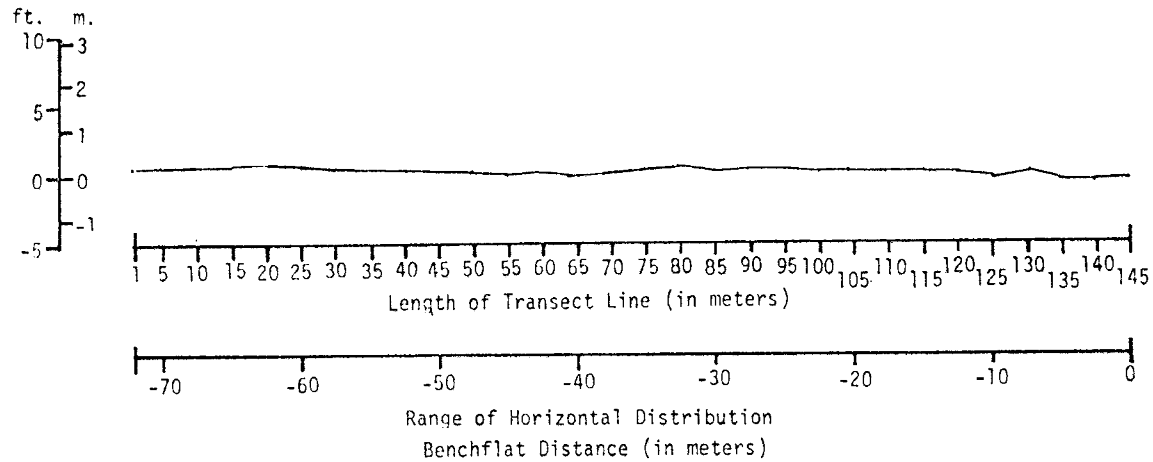


Fig. 31. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrat collections along a transect line.

Species Diversity

Measures of diversity were calculated for most rocky transect line samples. Class diversity [H (C) as described in project annual report April 1976] for animal-type organisms and species diversity [H (C) + H_c (S) as in April 1976 report] for plant-type organisms are plotted versus sample elevation. Calculations from gravel, sand, or mud samples have not been done.

Very little of interpretable significance is readily apparent. It does appear however, that samples from Three Saints Bay had significantly higher animal diversity measures, and that Lagoon Pt. and C. Sitkinak had a greater than average proportion of samples with zero plant diversity. Comparisons between stations are confounded by elevation effects, although relationships between elevation and diversity measure are not obvious in the data.

Within station analyses also indicated that little new information was gained by calculating diversity data. For instance, at Sud Island, (Table 7) as would be expected, be expected, plant diversity and number of species were low above the zone of Fucus dominance (greater than 2.1 m.). Below the 2.1 m. level the number of species and the diversity values were relatively the same although two of the lines showed slightly higher values in the zones dominated by red algae.

Table 7. Plant [H(CW)] and animal [H(C)] diversity values for different tidal elevations at Sud Island. Samples were collected during May and August, 1976. Pooled values for all samples collected during both trips are also given.

May 1976

Heights (M)	Plant Diversity	Number of Plant Species	Animal Diversity	Number of Animal Species	Number of Samples	Algal Dominance
> 2.10	.04	---	.26	---	--- (1)	
1.01-2.10	.19	8	.82	11.4	--- (5)	Fucales
0.00-1.00	1.03	11.4	1.59	27.0	(6)	Rhodyphyceae
< 0.00	.54	9	1.0	3.3	(2)	Laminariaceae

August, 1976 Transect 1

Heights (M)	Plant Diversity	Number of Plant Species	Animal Diversity	Number of Animal Species	Number of Samples	Algal Dominance
> 2.10	.40	4.5	.24	6	(2)	
1.01-2.10	.31	4.0	.86	8.3	(4)	Fucales
0.00-1.00	1.11	7.0	1.20	32	(5)	Rhodyphyceae
< 0.0	.59	8.8	1.32	50	(4)	Laminariaceae

August, 1976 Transect 2

Heights (M)	Plant Diversity	Number of Plant Species	Animal Diversity	Number of Animal Species	Number of Samples	Algal Dominance
> 2.10	.13	2.5	.54	8.9	(11)	
1.01-2.10	.94	8.0	1.29	22.7	(10)	Fucales
0.00-1.00	.60	8.6	1.49	29.6	(5)	Rhodyphyceae
< 0.00	.04	7.0	1.58	78	(1)	Laminariaceae

Pooled Values

Heights (M)	Plant Diversity	Number of Plant Species	Animal Diversity	Number of Animal Species	Number of Samples
> 2.1	.16	2.7	.44	8.5	(14)
1.0-2.1	.61	7.2	1.08	16.7	(19)
2-1.0	.92	9.0	1.44	29.5	(16)
<0	.50	8.6	1.27	49.1	(7)

Variability in Data - Results

Spatial Variability

The two adjacent transect lines sampled in May, 1976, at Cape Kaguyak contained a combined total of 74 species, 42 of which were common to both lines (Table 8a). Transect line 1 contained 64 species (or 86% of the total) while transect line 2 contained 52 species (or only 70% of the total). Some common rocky intertidal species present in transect line 1 but missing from transect line 2 were *Katharina tunicata*, *Halosaccion glandiforme*, and *Laminaria* spp.. Some common rocky intertidal species present in transect line 2 but missing from transect line 1 were *Balanus glandula* and *Iridaea cornucopia*. None of the species missing from one line were dominant in the other.

The two adjacent transect lines sampled in August, 1975, at Sud Island contained a combined total of 211 species, 116 of which were common to both lines (Table 8b). Transect line 2 contained 171 species (or 81% of this total) while transect line 1 contained 156 species (or only 74% of this total). Some common rocky intertidal species present in transect line 2 but missing from transect line 1 were *Balanus glandula*, *Mytilus edulis*, *Rhodomela larix*, and *Alaria* sp.. Some common rocky intertidal species present in transect line 1 but missing from transect line 2 were *Chthamalus dalli* and *Laminaria yezoensis*. With the possible exception of *B. glandula* no dominant species were missed by either transect line.

Temporal Variability

Transect line 1 sampled in May and in August 1975 at Sud Island had a combined total of 208 species, 87 of which were common to both months (Table 8c). The August sample contained 156 species (or 75% of the total) while the May sample had 133 species (or only 64% of the total). Some common rocky intertidal species present in August but missing in May were *Katharina*

Table 8. Spatial and temporal variability of total species numbers from transect lines sampled at two selected stations in the Kodiak Island area, 1975, 1976.

Table 8a.

Species *	Spatial Variability Cape Kaguyak, Two Adjacent Transect Lines, 1976 Line 1	Line 2	Lines 1 and 2
Total	64	52	74
Common	42	42	42
% Missing	14	30	--

Table 8b

Species*	Spatial Variability Sud Island, Two Adjacent Transect Lines, 1975 Line 1	Line 2	Lines 1 and 2
Total	156	171	211
Common	116	116	116
% Missing	26	19	---

Table 8c

Species*	Temporal Variability Sud Island, Transect Line 1, May and August, 1975 May	August	May and August
Total	133	156	208
Common	87	87	87
% Missing	36	25	---

* Includes marine algae, sea grass, invertebrates (including insects), fish, and fish eggs.

tunicata, Chthamalus dalli, and Leptasterias hexactis. Some common rocky intertidal species present in May but missing in August were Balanus glandula, Mytilus edulis, Phyllospadix sp., Spongomorpha spp., and Nucella sp.. None of the species missing from one month's sample were dominant in the other's.

Differences were also observed between these two months in mean wet weight (i.e. biomass) per m^2 for the 16 most dominant species (Table 9). For example, ten species had lower mean weights in August, 3 species had higher mean weights in August, and 3 species showed no major differences in mean weight between May and August.

Station Variability

Table 10 shows the ranked order (from most dense, 1, to least dense, 10) of the mean weight per m^2 along transect lines for the 16 most dominant species from ten selected stations. We have arranged these along gradients of wave exposure and topography, (i.e. from sheltered, sloping areas, which usually had much relief in the form of hummocks, surge channels or large boulders, to exposed flat areas, which usually had little relief and were often covered with tide pools and standing water). Although no significant relationships were noted between mean weight and habitat type for algal or invertebrate groups, mean weights did tend to vary along these gradients for many individual species. A Mann-Whitney test (Conover 1971) showed these trends to be significant ($p < 0.05$) for five genera. The mean weights of Spongomorpha and Alaria were greater per m^2 along transect lines in sheltered and in nonflat areas than in exposed or flat areas, the mean weights of Rhodomyenia and Katharina were also greater per m^2 along transect lines in nonflat areas than in flat areas while the mean weight of Rhodomela was greater per m^2 along transect lines in exposed and in flat areas than in sheltered or nonflat areas. No significant ($p < 0.05$) differences were

Table 9. Mean wet weights in grams per m^2 of 16 dominant organisms from transect lines sampled at two selected stations in the Kodiak Island area, 1975, 1976.

Selected Species	Sud Island 1975 May Transect 1	Sud Island 1975 August Transect 1	Sud Island 1975 August Transect 2	Cape Kaguyak 1976 May Transect 1	Cape Kaguyak 1976 May Transect 2
Littorina	505.4	286.1	184.2	25	147
Mytilus	0	0	55.5	0	0.2
Fucus	1375.7	1098.6	816.9	917	594
Odonthalia	0.5	3.8	23.1	0	0.5
Rhodomyenia	642.9	501.1	703.1	77	170
Alaria	1842.1	598.2	96.0	1272	2271
Porifera	115.3	177.3	25.6	3.2	332
Rhodomela	0	0	0.1	0	0
Laminaria	124.4	0	379	112	0
Katharina	0	4.1	24.8	37	0
Parenchymatous greens	11.4	1.5	0.0	70.6	62.4
Spongomorpha	62.4	0	3.6	6	112
Balanus cariosus	177.4	5.5	382.5	69	2.9
Collisella pelta	14.1	2.9	4.5	0.8	0
Phyllospadix	0	0	0	0	0
Halosaccion	1.1	0.4	65.2	8	0

Table 10.--Ranked order (from 1, most dense to 10, least dense; read horizontally) of mean wet weight in grams per m^2 along transect lines for 16 dominant organnisms from ten selected stations in the Kodiak Island area, 1975, 1976. Stations are arranged from sheltered, nonflat areas to exposed, flat areas.

	Nonflat Bedrock Three St. Bay	Nonflat Boulders-S Lagoon #3	Nonflat Boulders Lagoon #1,2	Nonflat Boulders-L Kaguyak	Nonflat Bedrock Sudstrom
SPONGOMORPHA	3	4	1	2	6
RHODOMYENIA	6	5	3	4	2
KATHARINA	1	4	3	5	2
ALARIA	3	1	2	4	7
LAMINARIA	8	1	3	6	2
BALANUS CARIOSUS	1	6	2	8	3
PORIFERA	1	6	8	3	2
MYTYLUS	1	10	2	7	3
MYTYLUS	1	10	2	7	3
MYTILUS	1	10	2	7	3
HALOSACCION	7	5	2	6	4
PARENCHYMATOUS GREENS	8	1	3	4	5
FUCUS	7	10	5	2	4
LITTORINA	5	10	9	3	2
ODONTHALIA	3	6	5	10	2
COLLESELLA PELTA	2	9	10	7	4
RHODOMELA	8.5	8.5	8.5	8.5	5
PHYLOSPADIX	7.5	7.5	7.5	7.5	1
ALL SPECIES*	4	5	**	6	2
ALL PLANT SPECIES*	4	5	**	7	3
ALL INVERTEBRATE SP.**	3	5	**	6	1

Table 10.--Continued.

	Nonflat Boulders-L Sud	Flat Bedrock Chirikof	Flat Cobble-S Dolina	Flat Bedrock Sitkwak	Flat Cobble-S Low Cape
SPONOGOMORPHA	5	9	7	9	9
RHODOMYENIA	1	8	7	9	10
KATHARINA	6	9	7	8	10
ALARIA	6	5	8	9.5	9.5
LAMINARIA	4	7	5	10	9
BALANUS CARIOSUS	5	10	4	9	7
PORIFERA	7	5	4	10	9
MYTYLUS	5	9	6	8	4
HALOSACCION	3	1	9.5	8	9.5
PARENCHYMATOUS GREENS	7	6	2	9.5	9.5
FUCUS	1	3	6	8	9
LITTORINA	1	4	8	6	7
ODONTHALIA	9	1	4	7	8
COLLESELLA PELTA	5	6	1	3	8
RHODOMELA	6	4	2	1	3
PHYLOSPADIX	7.5	4	2	3	7.5
ALL SPECIES*	1	3	7	9	8
ALL PLANT SPECIES*	1	2	6	8	9
ALL INVERTEBRATE SP.**	2	4	8	9	7

*Includes all species sampled and not only those listed above.

** Data for Lagoon Point have been pooled.

noted in mean weights per m^2 between transect lines in boulder areas or between transect lines in nonflat bedrock areas for any species or groups of species.

Similar analysis between species numbers (richness) and habitat type (Tables 11, 12), showed no significant ($p < 0.05$) relationships between these two parameters. However, the highest species richness for both algal and invertebrate groups occurred along transect lines at exposed, nonflat sites while the lowest species richness for these groups occurred along transect lines at exposed, flat sites.

To continue this analysis the ten rocky sites were categorized into three two-level factors (exposure, slope, and substratum) as shown in Table 13. Comparisons between factors were made on the average density per sample (expressed as wet weight in grams per square meter) of 16 selected organisms taken at each site.

Rudimentary examination and consideration indicate that only four of the organisms had consistent differentiation between factors for any of the categories; Katharina, Rhodomela, Rhodymenia, and Spongomorpha. In each case, the most definite differentiation was based on the amount of local vertical relief (flat vs. nonflat).

Percent cover data

Organisms selected were those in which percent cover was considered a potentially meaningful method of quantification. These were usually macrophytes, sponges, and bryozoans. Percent cover variables did not require involved processing and were prepared and summarized soon after the trip's completion (Table 14).

In addition to the comparisons made from density of selected organisms in quadrat collections we also compared data from field estimations of percent cover of selected groups.

Some of the differences between habitat classifications noted when comparing average wet weight are indicated in Table 13. Rhodomela was dominant on the flat beaches and Spongomorpha ranked high on the nonflat

Table 11. Number of species identified in each major phylogenetic category from transect lines sampled at 9 selected stations in the Kodiak Island area, 1975, 1976.

	Sheltered Nonflat Bedrock Three St. Bay	Sheltered Nonflat Boulders-S Lagoon #3	Sheltered Nonflat Boulders Lagoon #1,2	Sheltered Nonflat Boulders-L Kaguyak	Exposed Nonflat Bedrock Sundstrom
Chlorophyta	9	7	*	3	9
Phalophyta	7	10	*	6	15
Rhodophyta	25	18	*	14	34
Porifera **	1	1	*	1	1
Cnidaria **	3	2	*	1	1
Turbellaria **	1	1	*	1	1
Rhynchocoela **	1	1	*	1	1
Nematoda **	1	1	**	1	1
Annelida ***	44	4**	*	1**	57
Polyplacophora	5	3	*	2	7
Pelecypoda	6	6	*	5	9
Gastropoda	22	30	*	16	29
Arachnida **	1	1	*	1	1
Pycnogonida **	1	0	*	2	2
Crustacea ***	23	15**	*	10**	20
Bryozoa **	1	1	*	1	3
Asteroidea	1	1	*	2	3
Ophiuroidea	1	1	*	1	2
Holothuroidea	1	2	*	1	0
Echinoidea	1	1	*	0	0
Total Species ****	155	106	*	70	196
Plant Species ****	41	35	*	23	58
Invertebrate Species****	114	71	*	47	138

Table 11.--Continued.

	Exposed Nonflat Boulders-L Sud	Exposed Flat Bedrock Chirikof	Exposed Flat Cobble-S Dolina	Exposed Flat Bedrock Sitkinak	Exposed Flat Cobble-S Low Cape
Chlorophyta	9	9	2	1	0
Phalophyta	18	23	5	3	2
Rhodophyta	41	33	22	17	12
Porifera **	1	1	1	1	1
Cnidaria **	2	1	1	1	1
Turbellaria **	1	1	1	1	1
Rhynchocoela **	1	1	1	1	1
Nematoda **	1	1	0	0	1
Annelida ***	56	43	1**	1**	1**
Polyplacophora	3	2	1	0	1
Pelecypoda	7	7	6	1	5
Gastropoda	22	18	14	11	14
Arachnida **	1	1	0	0	0
Pycnogonida **	2	2	1	3	2
Crustacea ***	26	23	9**	9**	14**
Bryozoa **	3	1	0	0	0
Asteroidea	1	2	1	1	2
Ophiuroidea	1	1	0	0	0
Holothuroidea	2	1	1	1	1
Echinoidea	0	0	0	0	0
Total Species ****	198	171	66	52	59
Plant Species ****	68	65	29	21	14
Invertebrate Species****	130	106	37	31	45

Table 12. Ranked order from 1, most dense to 9, least dense; read horizontally) of species numbers in selected categories (i.e. those with the "easiest" species to identify) from transect lines sampled at 9 selected stations in the Kodiak Island area, 1975, 1976.

	Sheltered Nonflat Bedrock Three St. Bay	Sheltered Nonflat Boulders-S Lagoon #3	Sheltered Nonflat Boulders Lagoon #1,2	Sheltered Nonflat Boulders-L Kaguyak	Exposed Nonflat Bedrock Sundstrom
Chlorophyta	2.5	5	*	6	2.5
Phalophyta	5	4	*	6	3
Rhodophyta	4	6	*	8	2
Annelida **	3	5***	*	7.5***	1
Polyplacophora	2	3.5	*	5.5	1
Pelecypoda	5	5	*	7.5	1
Gastropoda	3.5	1	*	6	2
Crustacea **	2.5	5***	*	7***	4
Total Species ****	4	5	*	6	2
Plant Species ****	4	5	*	7	3
Invertebrate Species****	3	5	*	6	1

Table 12.--Continued.

	Exposed Nonflat Boulders-L Sud	Exposed Flat Bedrock Chirikof	Exposed Flat Cobble-S Dolina	Exposed Flat Bedrock Sitkinak	Exposed Flat Cobble-S Low Cape
Chlorophyta	2.5	2.5	7	8	9
Phalophyta	2	1	7	8	9
Rhodophyta	1	3	5	7	9
Annelida **	2	4	7.5***	7.5***	7.5***
Polyplacophora	3.5	5.5	7.5	9	7.5
Pelecypoda	2.5	2.5	5	9	7.5
Gastropoda	3.5	5	7.5	9	7.5
Crustacea **	1	2.5	8.5***	8.5***	6***
Total Species ****	1	3	7	9	8
Plant Species ****	1	2	6	8	9
Invertebrate species****	2	4	8	9	7

* All data from Lagoon Point have been pooled.
** Organisms were not identified to species level at all stations.
*** Most organisms were not identified to species level.
**** Includes all species sampled and not only those listed above.

Table 13.--Average densities (wet weight/sq. meter) of selected species from quadrat samples along transect lines at avarious rocky sites in the western Gulf of Alaska. Sites are categorized by three two-level factors (exposed vs. unexposed, flat vs. nonflat, boulders vs. bedrock).

	Flat		Non-flat	
	Boulders	Bedrock	Boulders	Bedrock
Exposed	Dolina Low Cape	Chirikof Sitkinak	Sud Island	Sundstrom
Unexposed			Lagoon Pt.1&2 Lagoon Pt.3 Kaguyak	Three Sts. Bay
<u>Ulvoids</u>				
Exposed	133.40	32.47		
	0.00	0.00	3.20	57.34
Unexposed			77.60	
			156.80	
			66.78	1.72
<u>Halosaccion</u>				
Exposed	0.00	56.02	32.30	23.78
	0.00	1.82		
Unexposed			50.22	
			10.13	2.11
<u>Odonthalia</u>				
Exposed	178.19	1023.71	12.43	917.24
	56.61	86.62		
Unexposed			138.45	
			124.09	182.79
			0.21	
<u>Rhodomela</u>				
Exposed	289.30	113.87	0.07	43.88
	197.07	782.33		
Unexposed			0.00	0.00
			0.00	
			0.00	
<u>Spongomorpha</u>				
Exposed	1.13	0.00	17.06	9.52
	0.00	0.00		
Unexposed			119.65	
			23.11	46.67
			55.57	
<u>Alaria</u>				
Exposed	200.00	1209.68	656.85	578.90
	0.00	0.00		
Unexposed			3016.55	
			4801.42	2977.60
			1738.24	

Table 13.--Continued

	Flat		Non-flat	
	Boulders	Bedrock	Boulders	Bedrock
Laminaria				
Exposed	72.97	11.85	216.11	1253.52
	0.21	0.00		
Unexposed			1123.80	6.91
			1820.62	
			59.73	
Phyllospadix				
Exposed	65.56	0.00	0.00	512.06
		21.24		
Unexposed			0.00	
			0.00	0.00
			0.00	
Littorina				
Exposed	68.45	147.73	7.16	11.20
	10.66	11.20		
Unexposed			6.45	
			0.53	15.26
			82.56	
Mytilus				
Exposed	0.71	0.00	27.20	33.21
	28.15	0.00		
Unexposed			1007.35	1299.76
			0.00	
			0.11	
Collisella pelta				
Exposed	13.46	4.06	6.45	10.88
	0.18	11.56		
Unexposed			0.00	
			0.00	11.61
			0.43	
Balanus cariosus				
Exposed	321.72	0.12	232.25	898.88
	105.34	1.75		
Unexposed			1036.30	
			189.51	12,210.70
			38.51	
Katharina				
Exposed	0.00	0.00	13.24	249.43
	0.00	0.00		
Unexposed			88.75	
			27.02	714.45
			19.95	

Table 13.--Continued

	Flat		Non-flat	
	Boulders	Bedrock	Boulders	Bedrock
Porifera				
Exposed	152.20	149.18	87.84	511.04
	1.54	0.00		
Unexposed			28.20	
			97.78	1536.34
			157.01	
Fucus				
Exposed	184.84	671.19	1028.45	588.17
	0.39	11.71		
Unexposed			278.85	
			0.00	30.06
			766.93	
Rhodymenia				
Exposed	7.03	2.30	634.78	409.41
	0.00	0.80		
Unexposed			297.02	26.91
			69.89	
			120.53	

Table 14.--Plant species and bryozoa ranked by in-the-field percent cover estimates at stations visited in May 1976. (Asterisk indicates dominance and/or consistency (subjective designation)).

	Medium Slope					
Habitat Class		Boulder			Boulder	
Site		(C. Kaguyak)			(Lagoon Pt.)	
Transect within site	1	2	3	1	2	3
-2.0 to 0.0	*Alaria Ulva-Mon Laminaria Coralline algae	*Iridea Alaria Coralline algae	No. obs.	*Alaria Bryozoa Laminaria Lithothamnion	*Alaria Lithothamnion Bryozoa	*Alaria Odonthalia Lithothamnion Bryozoa
0.1 to 2.0	*Alaria *Rhodymenia Iridea Spongomorpha	*Alaria *Rhodymenia Spongomorpha Ulva-Mon	*Fucus (1 obs.)	*Alaria Rhodymenia Ulva-Mon Spongomorpha	*Alaria Rhodymenia Ulva-Mon Spongomorpha	*Rhodymenia Bryozoa Alaria Ulva-Mon
2.1 to 4.0	*Porphyra Fucus Rhodymenia Enteromorpha	*Fucus *Porphyra *Ulva-Mon Rhodymenia	*Fucus (patchy) Gloiopeltis	Odonthalia Fucus Iridea (1 obs.)	*Halosaccion *Rhodymenia Fucus Ulva-Mon	Fucus (sparse)
4.1 to 6.0	no algae	Porphyra Fucus (both sparse) (1 obs.)	no algae	*Fucus	no algae	no algae
6.1 +	no algae (1 obs.)	no. obs.	no algae	no. obs.	Porphyra (sparse) (1 obs.)	no algae

Table 14.--Continued.

	Flat Slope			
Habitat Class	Bedrock		Cobble	
Site	(C. Sitkinak)		(Low Cape)	(Dolina Pt.)
Transect within site	1	2	1	1
-2.0 to 0.0	*Odonthalia *Rhodmela *Gigartina *Iridea	*Odonthalia Rhodymenia Gigartina	*Rhodomela Rhodymenia Lithothamnion Bossiella	no. obs.
0.1 to 2.0	*Odonthalia Gigartina Iridea Fucus	*Gigartina *Iridea Rhodymenia	*Odonthalia Bossiella Rhodymenia	*Alaria Odonthalia *Rhodomela Ulva-Mon
2.1 to 4.0	no algae	Halosaccion Endocladia (sparse)	*Odonthalia Bossiella Lithothamnion Rhodymenia	*Odonthalia Rhodomela Fucus Ulva-Mon
4.1 to 6.0	no algae	no algae	*Odonthalia Fucus	*Odonthalia (sparse)
6.1 to 8.0	no algae	no algae	Odonthalia (sparse)	no obs.

beaches in both types of comparisons. Difference in distribution of Rhodymenia is not as evident in Table 13 because it was found to be ranked on each type of beach.

Variability in Data-Discussion

Marine biological communities are complex and varied. Distribution and abundance of species vary in time and space and are determined by many environmental factors. To describe a community completely requires knowledge of the dynamic interactions of its components and knowledge of the internal temporal and spatial variability.

In general, most of our knowledge of the intertidal communities in the vicinity of Kodiak Island comes from data collected at a few specific geographic locations which were usually sampled only once in time and space. While not complete, this approach appears adequate to describe gross characteristics of communities and it has been used in this and other baseline studies. To gain information on the spatial and temporal variability that may exist in our study locations we compare data collected for this purpose from sites visited more than once and from sites where replicate transect lines were used. To determine if the degree of exposure and type of substratum are correlated with specific biological communities in the Kodiak area we will compare data between all locations studied.

Comparisons within sites. Communities exhibit spatial and temporal differences in numbers and abundance of species (Krebs 1972, Pianka 1974). Although these differences are related, spatial differences are due primarily to the heterogeneity of the environment and to distributional patterns of organisms, while temporal differences are due primarily to biotic and abiotic seasonal changes, longevity of organisms, and stochastic events (i.e. storms, food shortages, etc.). Thus it is usually impossible to describe a community completely, especially one not previously studied, by sampling it only once in time and space. Other information, such as data on feeding, growth, movement, fecundity and mortality of organisms present, remain unknown when a community is inadequately sampled.

Spatial variability. To learn of spatial variation in the Kodiak area, we compared replicate data from Cape Kaguyak and from Sud Island where samples were collected simultaneously along two adjacent transect lines. Depending on which line and which location were chosen, 14 percent to 30 percent of the species known to be present were missed when only one line was considered at each location sampled. This comparison shows that a significant number of species present can remain undetected when an area is sampled by one transect line only.

Of the possible habitats present, i.e. outer surfaces of rocks, cracks, crevices, channels, tide pools and under surfaces of rock, the outer rock surfaces were sampled most often by our sampling techniques. Thus, benthic and sessile species characteristic of outer rock surfaces were well represented in our samples, while motile and more hidden species characteristic of the other habitat types mentioned were rarer in our samples.

Temporal variability. Temporal differences occur at Kodiak but they have been more difficult to document. A comparison of samples collected at Sud Island in May and in August showed that 84 additional species were found in the August samples. Samples were collected along different transect lines, and thus we are not sure whether the additional species collected in August were present but not sampled in May, or whether these species settled or moved into the area after May. The large individual size (and implied age) of the additional species present in the August samples suggests that they were present in May but not along the transect line sampled.

Differences in species biomass were observed between the May and August samples. Because most species showed a decrease in biomass during this time (rather than an increase which would be expected as an indication of seasonal growth) these differences also appear to be spatial differences. For example, ten of the 16 most dominant species had lower weights per 1/16 m^2 in August than in May. One of the few verifications of temporal changes in biomass was the increase in weight per 1/16 m^2 from May to August of Halosaccion glandiforme, an annual species of algae which settles in spring and reaches maximum biomass during summer (Lebednik and Palmisano, in press).

Comparions between sites. The distribution and abundance of species are determined by dispersion, behavior, and biotic and abiotic environmental factors (Krebs 1974). Although exposure to waves is difficult to quantify (Bascom 1964), it and substratum type are often used to characterize intertidal communities (Ricketts and Calvin 1968) because they are easily described. However, biotic factors and other abiotic factors such as predation, competition, tidal exposure, temperature, light, salinity, turbidity, and humidity, also greatly influence community composition (Lewis 1964, Ricketts and Calvin 1968, Dayton 1971, Paine 1969, Connell 1970, 1972, Paine and Vadas 1969, Estes and Palmisano 1974). Thus, it may be misleading to account for community types solely on the basis of exposure or substratum. For example, two locations with identical substratum may have different communities if each has a different level of salinity, an abiotic factor which strongly effects species distribution. Also, two factors that appear positively correlated at one location may appear negatively correlated at a similar location in the presence of an additional factor; e.g. barnacles may be abundant at an area sheltered from wave exposure if predators were absent, but barnacles may be scarce or even absent at an equally sheltered location if predators were abundant.

Because organisms have both tolerances and requirements for exposure and substratum, many researchers have attempted to use this information to explain the composition of intertidal communities. Certain intertidal organisms tolerate wave shock, while others depend on it to create bare areas needed for larval settling or to prevent accumulation of smothering silt; still other organisms can survive only in sheltered areas (Ricketts and Calvin 1968). Lewis (1964) observed that along the rocky coasts of Great Britain sessile invertebrate associations predominate in areas exposed to direct wave action, whereas algal associations occur in more protected areas. Dayton (1973) found that along the open coast of Washington algae are competitive dominants over sessile invertebrates. Ricketts and Calvin (1968) noted along the Pacific coast of the United States that animals are most abundant along partially protected shores and least abundant along completely sheltered and entirely unprotected shores. The findings of Ricketts and Calvin tend to reconcile the seemingly different findings of Lewis and Dayton and also seem to explain the distributions we often encountered in the Kodiak area.

Macroscopic intertidal organisms cannot ordinarily survive water movement unless they are capable of securely attaching to the substratum (or unless they can grip or burrow into it). Thus, unstable substratum (i.e. sand, gravel, cobble, boulder) usually support fewer or different organisms than do stable substrata (i.e. bedrock). Even when unstable substrata occur in sheltered areas they often have depauperate or different communities when compared to areas of bedrock. This occurs because the movement of water, which is needed to provide nutrients and dissolved gasses and to remove waste products and silt, is greatly reduced or absent. Even though the degree of wave exposure and type of substratum are, at times, highly correlated with the occurrence of certain species or community type (Lewis 1964, Ricketts and

and Calvin 1968) the most characteristic organism of one of these factors may occasionally be found in totally unexpected association because of the infinite variety in nature and because no area is influenced solely by one or the other of these factors. Thus, because correlation is not proof of cause and effect, care must be taken when accounting for community composition solely on the basis of exposure or substratum, especially in areas of limited data.

CONCLUSIONS

1. Multispectral scanning imagery may prove to be a powerful tool for the semi-quantitative assessment of intertidal assemblages for resource evaluation studies. (Tentative).

2. The intertidal and subtidal areas of the Kodiak Island area are among the most highly productive in the world. (Firm).

3. Much of the Pribilof Island biota may be unique to the islands, and due to the small area of the islands and their geographical isolation from reproducing populations, may be particularly vulnerable to long term damage. (Tentative).

4. Ice scouring may strongly affect the distributions of many sublittoral organisms in and around Norton Sound. (Tentative).

5. King Island, northwest of NOrton sound, supports dense and varied populations of attached organisms in addition to the many mobile and pelagic animals in in the sublittoral environment. (Firm).

6. The intertidal zone of <u>much</u> of the Yukon delta appears to be void of any sessile benthic marine macrophytes and invertebrates. This may be attributed to the small tidal amplitude and the absence of saline water conditions. Drift evidence indicates the presence of offshore molluscan communities (Appendix I). (Tentative).

7. High variability as well as temporal and spatial heterogeneity indicates that it will not be possible to predict which populations and densities are to be expected in unstudied areas (i.e. extrapolation). (Firm).

Needs for further study--Long-term intensive studies

The goal is to understand the communities well enough so that we can possibly predict results of perturbations such as oil spills. For this, just knowing what is there is not enough, though it is a beginning.

Marine biologists are only beginning to understand the incredible complexities of what goes on in the intertidal zone. Edges of ecosystems which overlap tend toward higher complexity, and the intertidal and immediate subtidal areas, where land and sea meet are the edge par excellence.

Plants and animals of beach and subtidal areas respond to many physical environmental factors, those of both air and water. They interact with each other, competing for space, shelter, light, and food. They interact with the ocean itself, filtering plankton and detritus from the water column, and in return contribute significantly to the food web of the sea through their planktonic larval stages if present and through their contribution to the detrital system.

Though there are obvious similarities between beaches, for a real understanding each must be considered as an entity in itself. Paradoxically, an understanding in depth of one or two beaches will contribute more to an overall understanding of all beaches than will a more superficial look at a hundred beaches.

The need now is for intensive studies at a few sites to gain understanding of community structure; to examine not only species present, abundance and distribution, but also the dynamic interactions taking place within those communities.

To achieve this we will focus our attention on three broad areas; (1) physical environment, (2) species life histories including reproductive phases, and (3) community parameters (e.g. species richness, succession, etc.

Our approach will include both descriptive (observations and collections) and manipulative (field and laboratory experiments) studies. Our techniques will probably include; general observations, photography, SCUBA observations at high tide, marking studies, settling studies, introduction and exclusion studies, and selective and systematic collections. Our observations will not be restricted to "typical" intertidal biota but will include bird, fish, and mammal species found in or adjacent to the intertidal area. We will attempt to determine natural variation in species composition, abundance, distribution, life history stage, size, age, food habitats, growth, recruitment, etc. due to changes in elevation, wave exposure, substratum, habitat, season, and year. It will be important to determine exact position or habitat (e.g. on algae, in tide pools, under rocks, etc.) where feeding, reproduction, settling, resting, etc. occur for each species observed. Finally, we will attempt to determine energy pathways (i.e to construct food chains and webs), and possibly productivity in each major food guild (i.e. autotrophs, herbivores, predators, scavengers, etc.).

Summary of Fourth Quarter Operations

A. Field and laboratory activities.

1. Several sites have been examined near Auke Bay for the purpose of selecting a local site on which to test intensive study methods.

2. Scientific party--not applicable.

3. Methods--laboratory analysis.

Pribilof algae study. Algae from the Pribilof samples are being processed by Auke Bay personnel. Because of the uniqueness of the lack of a previous thorough study, the algae from the Pribilofs are being permanently preserved and catalogued. As is usually the case with one-time quadrat sampling, many of the algae are not in the reproductive state that is required for their definite identification. In addition, there are some special problems involved with their identification. Many do not occur on the American continent, and so are not included in taxonomic studies of American and Canadian algae. The one fairly comprehensive work on algal species distribution in the Bering Sea (Kjellman 1889), is in Swedish, and has never been translated. We are having it translated, but it will not be available for several months. Other information is scattered through Japanese and Russian literature, which is being acquired.

It is likely that many species collected are unknown to science, and will have to be described. To this end, one of our biologists consulted with Dr. Michael Wynne at the University of Michigan in January. Dr. Wynne, who described many of the new algal species collected in the course of the Amchitka Bioenvironmental Program, has consented to assist with the more difficult algae.

Izembeck Lagoon study. Quantitative samples from Izembeck Lagoon collected during the 1976 cruise to the Bering Sea are being processed. This work is being done at Auke Bay to insure a relatively rapid return of data.

Earlier work in Izembeck Lagoon (McRoy 1966, 1970) was concerned with the ecology of eelgrass (*Zostera marina*) and did not include the associated invertebrate fauna. Our samples indicate a significant number and variety of invertebrates associated with the eelgrass.

Pribilof Invertebrates study. The geographical isolation of the Pribilof Islands has resulted in some morphological variations of some organisms that may represent undescribed species or just variations of existing descriptions. These variations would be expected to occur within species having non-planktonic or abbreviated planktonic larval stages. Our observations tend to support this. Three species from the Pribilofs that are new to science have been found by our investigation. These include a sponge, a gastropod, and a tanaid. The sponge is currently being described.

4. Not applicable (tracklines, etc.).
5. Data collected or analyzed.

Since January 1, 1977, 89 samples have been received from the University of Alaska Marine Sorting Center. A partial schedule for completion of the remaining 247 samples collected in 1975 is as follows:

Number of samples	Projected Completion
30 - WGOA/EGOA	April 1, 1977
34 - EGOA	May 1, 1977

A $10,000 "precontract cost" was awarded the Marine Sorting Center in February 1977. This is to provide for continued sorting of quantitative intertidal samples and amassing of a voucher collection, which is not yet complete.

One data submission (magnetic tape) has been made to the Juneau Project Office which includes Cruise 1, 1974 (EGOA) enumerations and 70 percent of quantitative data from Cruise 4, 1975 (WGOA).

The major obstacles to data processing continue to be turn around time on sorting, decreased availability of key punching and other hardware facilities, and the problem of time sharing with the Forest Service computer facility.

Publications. A paper on the subtidal Laminariaceae of Kodiak has been completed and is ready for submission to a journal.

6. Milestone chart and data submission schedules

Milestone chart

1.	Submission of annual report	April 1
2.	Selection of intensive study sites and methodology	April 1-June 1
3.	Completion of processed report on Kodiak littoral	June 1
4.	Completion of aerial survey atlas	July 1
5.	Initiate intensive studies at one to three sites	June 1-October
6.	Submission of quarterly report	July 1
7.	Submission of quarterly report	October 1

Justifications of slippages

Work to date has generally been completed according to the schedule given in the milestone chart submitted with the work statement for FY 77. Data submission is lagging, however, due to the erratic and incomplete reception of data from the Sorting Center. Complete data for each cruise will be submitted when completed by the Sorting Center and assembled by ABL personnel.

The Norton Sound cruise scheduled for June 27-July 6 has tentatively been cancelled. It is generally felt by ABL littoral staff, that our survey of the area in 1976 was complete enough that the expense of another sampling trip can not be justified because it would not significantly increase our knowledge of the area. Personnel would be better used to compile data not as yet submitted and to begin the intensive studies.

B. Problems encountered/recommended changes

We have no recommendations for changes at this time. However, budget cutbacks and the greatly increased cost of sorting samples mean that without financial assistance from the OCSEAP Office we will be unable to complete the sorting of samples collected in 1975 and 1976. Memos outlining the problem were sent to the Juneau Project Office in December and January but we have received no reply to them.

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APPENDIX I

Littoral Reconnaissance of the Yukon-Kuskokwim Delta Region

July 1976

by

John MacKinnon

Reconnaissance of the Littoral Benthos of the Yukon-Kuskokwim Delta Region

Introduction

The Yukon-Kuskokwim delta area includes a long coastline that is of unknown biological significance. It has received, up to the present, little or no scientific investigation. The purpose of this work was to examine and describe the littoral and nearshore benthic macro-invertebrates and provide data for the Outer Continental Shelf Environmental Assessment Project. The objectives were to: 1) describe and document the biotic establishment of a coastal monitoring station. This work was done in conjunction with the Yukon Delta coastal processes study of Dr. William Dupre, USGS during July 13-29, 1976. Personnel included Drs. Dupre, and Thomas Ager, USGS, and Mr. John MacKinnon, ABL-NMFS.

Methods

Sampling consisted primarily of non-quantitative beach drift zone collecting. Both recent and storm-deposited drift piles were examined until thorough collections of relatively non-beachworm items were made. These consisted almost exclusively of molluscan and crustacean hard parts. Relative abundance of each species was rated. Sediment samples from both onshore and nearshore locations were sieved through mesh from 6.3 to 2.0 mm. Samples were brought back, sorted, and identified and are currently in storage at Auke Bay.

Results

Nine coastal sites in the delta area were investigated. Locations visited and pertinent data are given in Table 1. Their respective locations are shown in Figure 1.

The coastal area investigated can be divided into four general types; 1) peat-mud bluffs and flats; 2) open coast sandy beaches; 3) protected lagoons; 4) rocky intertidal beaches. Peat-mud bluffs and flats comprise approximately 80 percent of the area with the other 20 percent divided equally amon the remaining beach types.

Discussion

The delta coast from Pikmiktalik south to the Black River appeared to be homogenous. It consisted of eroding peat bluffs from 1 to 4 meters high. The intertidal zone consisted of these bluffs, and the sloughed off peat hummocks which lay below them on a shallow soft sandy substrate. This latter ran offshore at least 300 meters with very little slope. Intertidally at these places, no animals were found alive or in the drift. The salinity of the nearshore water was less than 3 °/oo.

Table 1. Delta coastal sites and pertinent data.

Location	Saline Water	Substrate	Intertidal Orgs.	Dominant Drift Remains
1. Pikmiktalik River	no	peat-mud	none found	none found
2. Pt. Romanof	no	shingle	none found	*Lunatia pallida*, *Amauropsis purpurea*, *Mytilus edulus* *Macoma balthica*, *Macoma sp.*
3. Okshokwewhik Pass	no	peat-mud	none found	none found
4. Bugomowik Pass	no	peat-mud	none found	none found
5. Black River	no	mud	none found	*Amauropsis purpurea*, *Lunatia pallida*, *Mytilus edulus*, *Mya arenaria*, *Macoma balthica*, *Cyrtodaria Kurriana*
6. Dall Point	yes	sand	amphipods	*A. purpurea*, *L. pallida*, *Neptunea heros*, *Natica Clausa*, *Mya arenaria*, *Mya truncata*, *Macoma balthica*, *Macoma* sp., *Siliqua alta*, *Tellina lutea*, *Zirfaea pilsbryi*, Foraminifera, *Sadura entomon*
7. Hooper Bay Airport area	yes	sand	amphipods	Same as Dall Pt. (above)
8. Issortulik Slough	yes	sand	none found	Same as Dall Pt. (above)
9. Tununak	yes	cobble-bedrock	*Balanus Balanoides*, *Chthamalus dalli* *Littorina sitkana*, *Mytilus edulus* *Anthopleura artemissa*, *Fucus*, *Enteromorpha*, *Odonthalia*, *Monostroma*	Bryozoa, *Mytilus edulus*, *Macoma balthica*, *Mya arenaria*

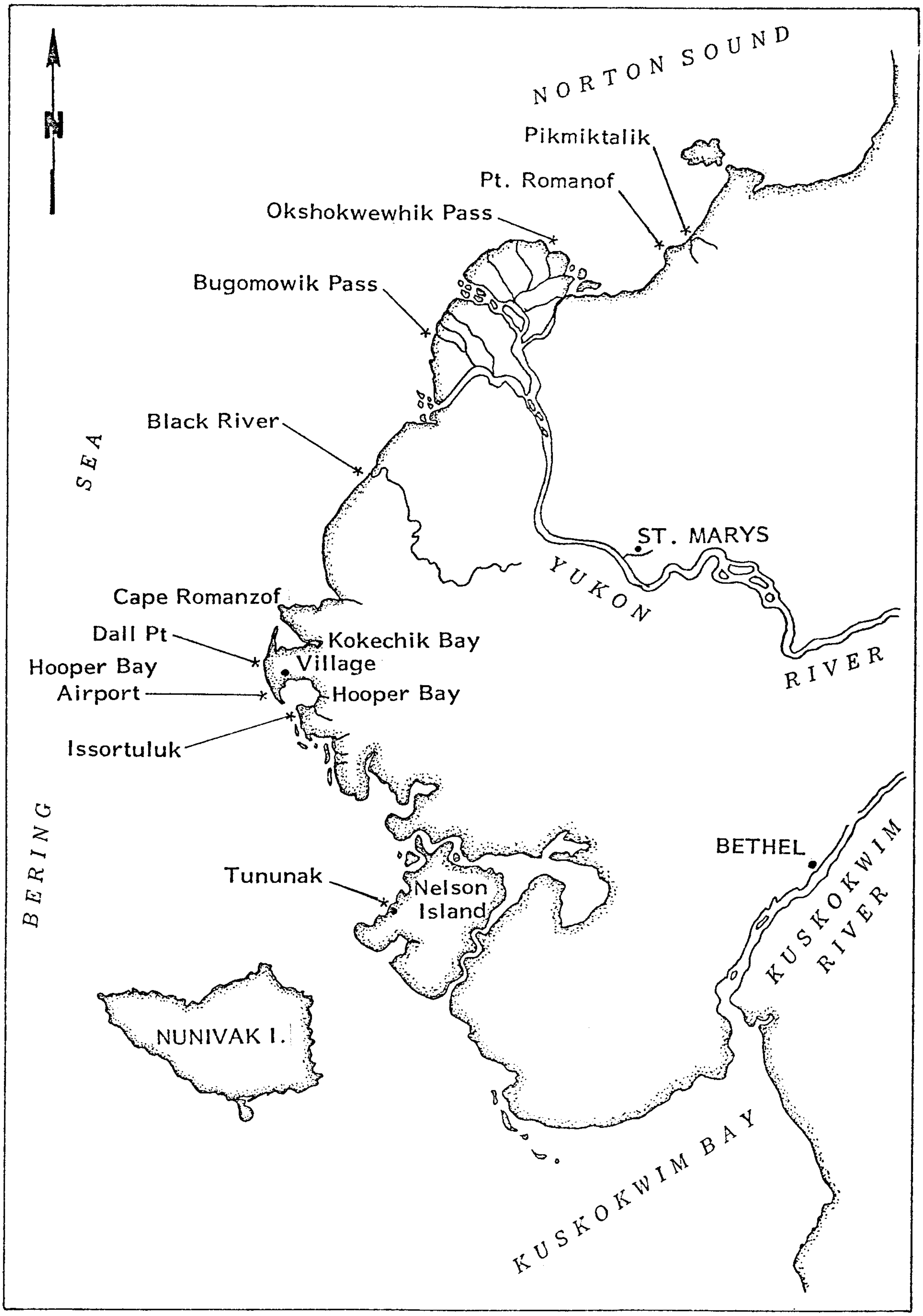

FIGURE 1. THE YUKON-KUSKOKWIM DELTA REGION

The shingle beach at Pt. Romanof was atypical of the area. It had a slope of approximately 20 degrees and was 10-15 meters wide. Just offshore the bottom became soft sand similar to that which is characteristic of most of the northern delta region. Here too, there were no animals found live intertidally, but the presence of a relatively stable beach allowed for the accumulation of drift. The drift probably does not represent anything peculiar to this particular coastal site but instead is a sample of the offshore benthic community (exclusive of animals without hard parts) which can accumulate when beach conditions favor drift accumulation. Of interest worth noting, in the drift was the presence of a number of washed out peat clumps containing numbers of fairly large settled mussels (Mytilus edulus). Evidently the hummocks which break off the peat bluffs can be suitable settling substrate.

Immediately south of the Black River was a large beach composed of fine sand. It too allowed for the accumulation of drift remains and they were investigated. Because this location was visited during a high tide, information pertaining to the intertidal community is lacking.

The sandy beaches in the Hooper Bay area including Dall Pt. and Issortuluk were found to be inhabited intertidally only by vagile animals (amphipods). This may be a result of the effect of ice on the shoreline during the winter months. Drift remains were very numerous, turning the brown sandy beaches white in places. Analysis of the species present indicates a number of different offshore biotic communities related to substrate type. These are tentatively divided in the following manner:

Biotic Assemblage	Substrate Type
Zirfaea pilsbryi	clay
Macoma balthica, Mya arenaria Mya truncata, Lunatia pallida, Amauropsis purpurea	fine sand-mud
Siliqua alta, Tellina lutea Macoma sp, Natica clausa	sand

Foraminifera were occasionally found in the drift in great piles containing thousands of organisms. The individuals, which grow up to 4 mm in diameter, are of unknown origin.

Evidence of predation of snails of the family Naticidae (Lunatia, Amauropsis, Natica) on the pelecypods Macoma balthica, Macoma sp, Tellina lutea and Siliqua alta was noted at all locations where these animals were found.

Logistics would not permit a look at either of the protected lagoons (Hooper Bay proper and Kokechik Bay). However, people of Hooper Bay village said they dug clams (probably Mya arenaria based on a description) in the flats of Hooper Bay for food. There were also "small round clams (Macoma balthica) and worms" in their diggings. Mya shells were found in a recent campsite midden along with eggs and bones of birds.

The rocky intertidal area near Tununak, Nelson Island was composed of: 1) Fucus, Enteromorpha, Odonthalia, and Monostroma as dominant primary producers; consumers included Balanus balanoides, Chthamalus dalli, Littorina sitkana, Mytilus edulus, and Anthopleura artemisia. Percent coverage was about 50% by the algae and less than 10% by the invertebrate consumers.

An aerial reconnaissance of rocky coastal intertidal areas around Cape Romanzof showed light coverage by an algal band which possibly represents a similar community assemblage. Presence of fucus in the drift near Dall Pt. may support this.

The lack of spring tides during the reconnaissance may be a reason for the absence of marine invertebrates in most of the intertidal area sampled. Thus it may be too soon to draw conclusions concerning the lower intertidal zones. However, lower intertidal populations may also be low because winter ice may exert a limiting effect on the intertidal biota of much of the delta area. Lack of saline water in the area north of the Black River is also no doubt a limiting factor.

Another difficulty arises in drawing inferances about offshore biotic assemblages from drift remains. Although similarities exist geographically between dominant molluscs, biotic associates (generic level) and substrate types, a couple of questions still remain: 1) what are the differences between these community types and those we have knowledge of elsewhere; 2) where offshore are these communities located?

Summary

1. The delta coastline from Pikmiktalik south to Black River is almost entirely a low peat bluff which grades abruptly into a fine sand and peat hummock substrate. This intertidal zone appears to be void of any sessile benthic macro-invertebrates.

2. The presence and absence of drift remains over the norther part of the delta is probably more a result of the hydrodynamics of the coast and lack of suitable beach types for accumulation than an indicator of the presence or absence of sublittoral biotic communities. Drift remains do indicate the presence offshore of a Macoma balthica-Mya arenaria community.

3. Exposed coastline in the Hooper Bay area consists of wide flat sandy beaches. Amphipods were the only intertidal animals found. Drift remains indicate the presence offshore of a number of different biotic assemblages which are probably related to substrate types.

4. Rocky intertidal areas near Tununak, Nelson Island exhibited sparce populations of fairly typical rocky intertidal animals. Aerial reconnaissance of rocky headlands at Cape Romanzof showed evidence of similar communities.

5. A protected lagoon at Hooper Bay is a habitat for shellfish resources utilized by people of the nearby village.

APPENDIX II

CALCULATION OF DENSITY

Raw data from project files were reformatted and processed via the SPSS CROSSBREAK program. Sample densities (no. or grams of wet weight) for selected organisms were transformed, if necessary, to expressions in units per sq. meter. CROSSBREAK then summarizes by 2 foot elevation intervals within transect lines and outputs the mean, number of observations, and standard deviation for each interval. This is the data presented in the Appendix II tables. Only transect line data is presented in these tables.

Data for Appendix III tables are extracted from the Appendix II tables and summarized by station.

An elevation coding oversight has caused the placement of two samples into the wrong elevation strata for the transect line taken at Sundstrom Island, May 1975. The number of observations for intervals 0.00-1.99 ft. and 6.00-7.99 ft. should be 2 and 6 respectively rather than 4 and 4 as given in the series of tables. The correct cell means for a given variable can be obtained by applying the original mean and appropriate value from Table I to the following formulae:

Interval 6.00 to 7.99 ft:

$$M_{6,8\ (corrected)} = M_{6,8\ (original)} \times \frac{2}{3} + 16\delta/6$$

Interval 0.00 to 1.99 ft:

$$M_{0,2\ (corrected)} = M_{0,2\ (original)} \times (2) - 16\delta/2$$

Where M's are the means of the variable (organism wet wt. or count) and δ is the appropriate value for that variable as read from the following table. Standard deviations for the two cells will likely be wrong and should not be used without reference to the original data.

Table 1 . Values for calculating correct elevation strata means for transect line data from Sundstrom Island, May 28, 1975 (only non-zero values are given).

Taxonomic category of variable	S for counts	S for wet weight
Parenchymentous green algae		
Spongomorpha		
Laminaria		
Alaria		
Fucus		162.200
Porphyra		
Endocladia		
Corallines algae		
Lithothamnion		
Gigartina		
Iridea		
Halosaccion		
Rhodymenia sp.		
Polysiphonia		
Pterosiphonia		
Rhodomela sp.		
Odonthalia		
Phyllospadix		
Zostera sp.		
Porifera sp.		
Cnidaria sp.		
Polychaete sp.	6	.004
Oligochaete sp.	4	.001
Tonicella sp.		
Katharina sp.		
Mytilus edulis	1	.012
Turtonia sp.		
Acmaeidae		
Collisella pelta	4	1.148
Notoacmea scutum		
Notoacmea persona		
Margarites		
Littorina sp.	221	34.025
Littorina sitkana	221	34.025
Nucella lamellosa		
Nucella lima		
Balanus balanoides		
Balanus cariosus		
Balanus glandula	156	21.093
Isopods		
Amphipods		
Pagurus		
Leptasterias		
Hiatella		
Holothuroidea		

Table 2. Means, number of observations, and standard deviations of the grams/sq. meter of Parenchymentous green algae at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	.16 4 .32	.08 8 .23	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	.01 8 .02	.01 10 .02	0. 2 0.	0. 1 0.	8.35 5 12.30	
3.99 ft. to 2.00 ft.	6.11 3 6.20	0. 5 0.	2.29 8 4.58	37.22 3 29.04	5.16 4 10.33	89.43 3 115.05	
1.99 ft. to 0.00 ft.	.50 2 .70	0. 1 0.	.33 3 .57	0. 1 0.	0. 7 0.	165.62 4 331.24	38.37 22 69.26
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	6.33 4 12.00		2.26 1 0.	0. 4 0.
	1.49 13 3.66	.03 24 .13	.54 37 2.23	11.41 12 21.04	1.72 12 5.96	57.34 17 164.77	32.47 26 65.03

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	4.80 2 6.79	0. 2 0.	0. 1 0.	0. 2 0.	1.60 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	327.29 6 316.22	0. 2 0.	121.60 1 0.	117.60 2 50.91	0. 3 0.	8.[illegible] 21 14.[illegible]	0. 3 0.
1.99 ft. to 0.00 ft.	50.14 6 66.78	35.21 3 46.56	440.53 3 657.91	131.20 3 191.06	54.93 3 95.15	.00 13 .00	12.05 2 14.35	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	26.00 4 52.00	29.87 3 51.73	49.60 1 0.	35.20 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	19.40 16 45.79	135.83 16 240.32	156.80 9 392.85	70.60 8 120.72	62.40 7 72.34	.00 22 .00	7.41 27 13.23	0. 11 0.

Table 3. Means, number of observations, and standard deviations of the grams/sq. meter of Spongomorpha sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975			Sud Id.	Three Sts. Bay	Sundstrom Id.	Chirikof Id.
	tr. 1	tr. 2	total	May 1975	May 1975	May 1975	May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	.04 4 .07	.02 8 .05	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	2.14 8 6.05	1.71 10 5.41	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	13.91 5 31.11	8.70 8 24.60	10.02 3 14.37	75.40 4 150.80	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	6.99 1 0.	36.91 7 94.32	23.99 4 46.80	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	177.93 4 282.36		62.50 1 0.	0. 4 0.
	0. 13 0.	3.62 24 14.47	2.35 37 11.70	62.40 12 170.52	46.67 12 107.77	9.32 17 26.58	0. 26 0.

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	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	186.40 6 174.67	0. 2 0.	24.00 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	376.00 6 618.33	151.47 3 262.35	69.33 3 120.09	8.53 3 14.78	261.33 3 418.48	0. 13 0.	15.20 2 21.50	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	141.00 16 403.47	98.30 16 165.91	23.11 9 69.33	6.20 8 11.49	112.00 7 279.08	0. 22 0.	1.13 27 5.65	0. 11 0.

Table 4 . Means, number of observations, and standard deviations of the grams/sq. meter of Laminaria sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	209.66 2 296.51		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	334.51 3 579.38	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	9097.07 1 0.	3032.36 3 5252.20	0. 1 0.	11.84 7 31.34	29.45 4 58.90	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	17.39 4 34.78		21192.00 1 0.	77.01 4 122.72
	0. 13 0.	379.04 24 1856.93	245.87 37 1495.55	124.37 12 301.83	6.91 12 23.93	1253.52 17 5138.11	11.85 26 51.09

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .01	0. [illegible] 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	93.82 21 429.95	.77 3 1.3[illegible]
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	5376.00 3 9311.51	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	1446.14 6 2241.51	2190.40 4 4380.80	85.87 3 148.73	896.00 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	18524.80 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	1700.10 16 4722.94	547.60 16 2190.40	1820.62 9 5365.94	112.00 8 316.78	0. 7 0.	0. 22 0.	72.97 27 379.18	.21 11 .69

Table 5. Means, number of observations, and standard deviations of the grams/sq. meter of Alaria sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	16.96 2 16.81		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	13.50 2 19.09	0. 1 0.	94.56 5 211.44	
3.99 ft. to 2.00 ft.	0. 3 0.	460.83 5 963.83	288.02 8 766.63	678.95 3 1138.11	2458.81 4 3242.67	1392.81 3 2412.41	
1.99 ft. to 0.00 ft.	3168.40 2 4480.79	0. 1 0.	2112.27 3 3658.55	1737.79 1 0.	3699.42 7 3078.38	1297.53 4 2595.06	564.65 22 1092.36
-0.01 ft. to -2.00 ft.	720.00 2 1018.23		720.00 2 1018.23	4567.32 4 8864.56		0. 1 0.	4757.30 4 8193.20
	598.22 13 1769.57	96.01 24 445.09	272.46 37 1108.80	1842.07 12 5094.20	2977.60 12 3045.01	578.90 17 1559.71	1209.68 26 3381.95

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .01	0. 3 0.
3.99 ft. to 2.00 ft.	238.40 1 0.	6.67 6 10.44	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.00 21 .00	0. 3 0.
1.99 ft. to 0.00 ft.	3714.13 6 6003.46	4522.13 3 6691.12	1708.80 3 2959.73	3229.87 3 4190.28	4968.00 3 5281.47	0. 13 0.	2700.00 2 3775.38	0. 2 0.
-0.01 ft. to -2.00 ft.	2147.20 6 2387.58	11879.20 4 9722.25	12695.47 3 19377.78	486.40 1 0.	993.60 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	2212.90 16 4007.06	3820.20 16 7143.37	4801.42 9 11474.53	1272.00 8 2769.88	2271.09 7 3973.11	0. 22 0.	200.00 27 1033.17	0. 11 0.

Table 6. Means, number of observations, and standard deviations of the grams/sq. meter of Fucus sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. --August 1975 tr. 1	Sud Id. --August 1975 tr. 2	Sud Id. --August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		989.81 5 1395.72	989.81 5 1395.72				
7.99 ft. to 6.00 ft.	974.57 4 1457.98	2515.78 4 2142.10	1745.17 8 1885.80	3792.00 2 1787.57		1593.28 4 1622.13	
5.99 ft. to 4.00 ft.	4716.26 2 6649.82	523.43 8 575.09	1362.00 10 2880.26	1726.25 2 243.03	349.49 1 0.	206.10 5 436.00	
3.99 ft. to 2.00 ft.	314.22 3 514.92	80.96 5 165.40	168.43 8 325.52	1800.65 3 3118.82	1.48 4 2.96	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	22.88 1 0.	.76 7 2.01	648.80 4 1297.60	793.23 22 2265.23
-0.01 ft. to -2.00 ft.	3.85 2 5.44		3.85 2 5.44	11.78 4 20.10		0. 1 0.	0. 4 0.
	1098.55 13 2646.08	816.85 24 1325.48	915.83 37 1864.12	1375.70 12 2010.10	30.06 12 100.62	588.17 17 1114.53	671.19 26 2096.53

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.25 2 .35
5.99 ft. to 4.00 ft.	2820.00 2 2438.10	0. 2 0.	0. 1 0.	225.60 2 319.05	40.00 1 0.	0. 0 0.	10.20 [illegible] 20.55	1.00 3 1.00
3.99 ft. to 2.00 ft.	1228.80 1 0.	326.93 6 443.90	.01 2 .01	3758.40 1 0.	2060.80 2 481.96	0. 3 0.	234.25 21 580.49	.27 3 .46
1.99 ft. to 0.00 ft.	0. 6 0.	30.93 3 53.58	0. 3 0.	894.40 3 1549.15	0. 3 0.	10.09 13 24.64	15.20 2 21.50	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	449.60 1 0.	0. 1 0.	21.07 6 51.60		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	429.30 16 1166.49	128.40 16 302.36	.00 9 .01	917.80 8 1463.46	594.51 7 1020.91	11.71 22 32.05	184.84 27 524.73	.39 11 .65

Table 7. Means, number of observations, and standard deviations of the grams/sq. meter of Porphyra sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	3.15 2 4.46		0. 4 0.	
5.99 ft. to 4.00 ft.	.07 2 .10	.03 8 .09	.04 10 .09	0. 2 0.	0. 1 0.	.01 5 .03	
3.99 ft. to 2.00 ft.	0. 3 0.	2.44 5 5.45	1.52 8 4.30	.43 3 .75	.00 4 .01	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	.90 1 0.	.30 3 .52	0. 1 0.	3.56 7 8.70	0. 4 0.	.07 22 .28
-0.01 ft. to -2.00 ft.	1.01 2 1.43		1.01 2 1.43	0. 4 0.		.27 1 0.	1.07 4 2.14
	.17 13 .56	.56 24 2.48	.42 37 2.02	.63 12 1.82	2.08 12 6.68	.02 17 .07	.22 26 .86

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	84.80 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	3.20 2 4.53	0. 2 0.	0. 1 0.	0. 2 0.	147.20 1 0.	0. 0 0.	.00 4 .01	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	13.07 6 26.24	0. 2 0.	38.40 1 0.	88.80 2 23.76	0. 3 0.	.15 21 .70	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	.01 3 .01	61.87 3 28.19	13.33 3 23.09	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	.00 6 .01	0. 4 0.	0. 3 0.	0. 1 0.	4.80 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	.40 16 1.60	10.20 16 25.81	.00 9 .01	28.00 8 34.38	52.80 7 57.90	0. 22 0.	.12 27 .62	0. 11 0.

Table 8. Means, number of observations, and standard deviations of the grams/sq. meter of Endocladia sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	2.10 4 4.19	1.05 8 2.96	.74 2 1.04		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	8.69 8 24.19	6.95 10 21.65	0. 2 0.	214.24 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	2.82 5 6.30	1.76 8 4.98	9.63 3 16.68	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	3.83 24 14.17	2.49 37 11.48	2.53 12 8.31	17.85 12 61.85	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		2.85 2 4.03
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	[illegible].60 [illegible] [illegible]	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	23.46 21 94.51	.00 3 .00
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	18.50 27 83.44	.52 11 1.72

Table 9. Means, number of observations, and standard deviations of the grams/sq. meter of Coralline algae at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	4.03 2 5.70		12.10 4 23.78	
5.99 ft. to 4.00 ft.	0. 2 0.	.05 8 .15	.04 10 .13	0. 2 0.	0. 1 0.	3.20 5 7.15	
3.99 ft. to 2.00 ft.	0. 3 0.	.96 5 1.08	.60 8 .96	2.67 3 3.25	21.87 4 25.21	1039.25 3 1098.03	
1.99 ft. to 0.00 ft.	26.38 2 37.30	0. 1 0.	17.58 3 30.46	0. 1 0.	3.55 7 9.24	319.57 4 638.10	7.59 22 27.44
-0.01 ft. to -2.00 ft.	24.64 2 34.85		24.64 2 34.85	30.76 4 58.16		103.14 1 0.	4.95 4 5.88
	7.85 13 19.17	.22 24 .60	2.90 37 11.68	11.59 12 33.61	9.36 12 17.50	268.44 17 615.91	7.18 26 25.25

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	.02 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	.00 3 .00
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	.00 6 .01	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	.00 16 .01	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	.00 11 .00

Table 10. Means, number of observations, and standard deviations of the grams/sq. meter of Lithothamnion sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		7.76 4 15.10	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	3.20 5 7.15	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	2.76 4 5.52	8.67 3 15.02	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	8.84 4 17.69	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		4.99 1 0.	1.93 4 3.80
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	.92 12 3.19	6.67 17 12.19	.30 26 1.50

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	.02 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	.00 3 .00
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	.00 6 .01	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	.00 16 .01	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	.00 11 .00

Table 11. Means, number of observations, and standard deviations of the grams/sq. meter of Gigartina sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	5.54 4 11.08	66.82 4 133.64	36.18 8 93.70	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	398.47 8 728.89	318.78 10 664.41	.85 2 1.20	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	107.65 3 136.81	15.60 5 34.88	50.12 8 91.17	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	26.64 1 0.	8.88 3 15.38	0. 1 0.	0. 7 0.	0. 4 0.	10.19 22 23.11
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	26.55 13 72.76	148.32 24 444.26	105.54 37 362.40	.14 12 .49	0. 12 0.	0. 17 0.	8.62 26 21.51

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	107.20 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	56.53 3 97.92	53.33 3 52.81	88.00 13 151.62	0. [illegible] 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	133.87 6 211.49		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	6.70 16 26.80	0. 16 0.	0. 9 0.	21.20 8 59.96	22.86 7 41.74	88.51 22 159.67	0. 27 0.	0. 11 0.

Table 12. Means, number of observations, and standard deviations of the grams/sq. meter of Iridea sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975			Sud Id.	Three Sts. Bay	Sundstrom Id.	Chirikof Id.
	tr. 1	tr. 2	total	May 1975	May 1975	May 1975	May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	2.52 4 3.36	681.34 4 1362.68	341.93 8 963.05	2.42 2 3.42		59.74 4 119.49	
5.99 ft. to 4.00 ft.	5.45 2 7.70	356.09 8 733.81	285.96 10 663.84	12.00 2 16.97	.14 1 0.	60.44 5 127.22	
3.99 ft. to 2.00 ft.	115.22 3 132.48	1493.03 5 1484.32	976.35 8 1331.34	7.09 3 1.29	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	80.06 2 80.55	13.62 1 0.	57.91 3 68.67	0. 1 0.	0. 7 0.	6.97 4 12.91	124.02 22 210.14
-0.01 ft. to -2.00 ft.	388.71 2 506.98		388.71 2 506.98	51.44 4 56.84		0. 1 0.	1079.00 4 1338.94
	100.32 13 208.73	543.87 24 1044.05	388.03 37 870.07	21.32 12 37.63	.01 12 .04	33.48 17 87.24	270.94 26 612.94

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	483.20 1 0.	5.07 6 12.41	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.68 21 .36	0. 3 0.
1.99 ft. to 0.00 ft.	8.80 6 21.56	24.53 3 42.49	66.67 3 60.13	212.27 3 367.66	339.73 3 559.59	96.75 13 301.50	0. [illegible] 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	542.40 1 0.	157.87 6 173.53		37.00 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	33.50 16 120.64	6.50 16 19.43	22.22 9 44.89	79.60 8 225.14	223.09 7 391.23	100.23 22 248.00	.66 27 .31	3.36 11 11.16

Table 13. Means, number of observations, and standard deviations of the grams/sq. meter of Halosaccion sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	10.76 4 21.53	5.38 8 15.22	0. 2 0.		.70 4 1.40	
5.99 ft. to 4.00 ft.	0. 2 0.	186.19 8 293.88	148.95 10 270.81	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	6.43 5 12.27	4.02 8 9.86	2.30 3 3.98	.02 4 .03	112.12 3 134.57	
1.99 ft. to 0.00 ft.	2.39 2 3.38	0. 1 0.	1.59 3 2.76	6.05 1 0.	3.60 7 8.97	16.27 4 22.68	64.10 22 134.33
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	11.56 4 23.13
	.37 13 1.33	65.20 24 184.46	42.42 37 150.74	1.08 12 2.53	2.11 12 6.88	23.78 17 64.67	56.02 26 124.88

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .01	0. 3 0.
3.99 ft. to 2.00 ft.	35.20 1 0.	245.69 6 259.72	0. 2 0.	8.00 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	13.34 6 32.66	5.87 3 10.16	30.40 3 52.65	19.74 3 34.17	0. 3 0.	3.08 13 11.09	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	7.20 16 21.31	93.23 16 193.34	10.13 9 30.40	8.40 8 20.72	0. 7 0.	1.82 22 8.53	.00 27 .00	0. 11 0.

Table 14. Means, number of observations, and standard deviations of the grams/sq. meter of Rhodymenia sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	10.48 4 20.26	.14 4 .29	5.31 8 14.37	19.71 2 27.88		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	891.51 8 1338.85	713.21 10 1239.14	1.14 2 1.62	0. 1 0.	1387.73 5 2114.40	
3.99 ft. to 2.00 ft.	996.75 3 566.51	1948.44 5 798.62	1591.56 8 835.92	1765.53 3 1499.99	7.98 4 15.97	3.19 3 4.01	
1.99 ft. to 0.00 ft.	1712.92 2 1087.46	0. 1 0.	1141.95 3 1252.72	1278.59 1 0.	41.57 7 63.25	2.94 4 5.89	2.47 22 11.17
-0.01 ft. to -2.00 ft.	28.28 2 39.99		28.28 2 39.99	274.60 4 282.92		0. 1 0.	1.40 4 2.81
	501.12 13 [illegible]	703.12 24 1114.61	632.15 37 1004.60	642.94 12 1003.12	26.91 12 50.84	409.41 17 1241.53	2.30 26 10.29

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
5.99 ft. to 4.00 ft.	16.00 2 22.63	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	[illegible] [illegible] [illegible]	0. 3 0.
3.99 ft. to 2.00 ft.	64.00 1 0.	818.75 6 884.56	0. 2 0.	72.00 1 0.	24.00 2 33.94	0. 3 0.	[illegible] [illegible] [illegible]	0. 3 0.
1.99 ft. to 0.00 ft.	434.41 6 819.61	618.67 3 1023.08	194.67 3 330.27	180.27 3 279.63	336.00 3 400.86	0. 13 0.	[illegible] 2 [illegible]	0. 2 0.
-0.01 ft. to -2.00 ft.	5.60 6 12.95	.00 4 .01	.01 3 .01	4.80 1 0.	134.42 1 0.	2.93 6 7.19		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	171.00 16 518.29	423.03 16 744.43	64.89 9 191.68	77.20 8 173.78	170.06 7 282.25	.80 22 3.75	[illegible] 27 24.77	0. 11 0.

Table 15. Means, number of observations, and standard deviations of the grams/sq. meter of Polysiphonous red algae at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. -- August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		.00 5 .01	.00 5 .01				
7.99 ft. to 6.00 ft.	0. 4 0.	5.45 4 10.90	2.73 8 7.71	2.04 2 2.88		19.16 4 38.33	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	14.68 5 32.33	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	13.51 4 27.02	.09 3 .15	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	3.98 22 11.32
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		.02 1 0.	0. 4 0.
	0. 13 0.	.91 24 4.45	.59 37 3.59	.34 12 1.18	4.50 12 15.60	8.84 17 24.76	3.37 26 10.47

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. [illegible] 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. [illegible] 0.	.00 3 .00
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. [illegible] 0.	2.59 2 3.61
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	.46 11 1.54

Table 16. Means, number of observations, and standard deviations of the grams/sq. meter of Rhodomela sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	.84 4 1.68	.42 8 1.19	0. 2 0.		.25 4 .50	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	149.00 5 333.18	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	122.57 22 448.02
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	65.97 4 131.94
	0. 13 0.	.14 24 .69	.09 37 .55	0. 12 0.	0. 12 0.	43.88 17 180.68	113.87 26 413.68

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	60.[illegible] [illegible] 10[illegible]	7.1[illegible] [illegible] [illegible]
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	223.3[illegible] 21 362.[illegible]	300.27 3 200.26
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	589.78 13 1372.66	14[illegible].[illegible] [illegible] 850.79	215.25 2 53.39
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	1590.67 6 1591.32		809.10 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	782.33 22 1405.94	269.30 27 493.3[illegible]	197.07 11 270.04

Table 17. Means, number of observations, and standard deviations of the grams/sq. meter of Odonthalia sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	11.26 4 22.51	138.26 4 225.44	74.76 8 163.11	.49 2 .69		1053.41 4 1337.73	
5.99 ft. to 4.00 ft.	0. 2 0.	.01 8 .03	.01 10 .03	0. 2 0.	6.13 1 0.	810.15 5 1314.58	
3.99 ft. to 2.00 ft.	0. 3 0.	.20 5 .37	.12 8 .30	1.71 3 2.97	531.58 4 1014.09	1197.10 3 2069.24	
1.99 ft. to 0.00 ft.	1.86 2 2.64	0. 1 0.	1.24 3 2.15	.29 1 0.	8.72 7 23.06	933.64 4 1124.33	1111.61 22 1409.92
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		2.86 1 0.	540.26 4 586.61
	3.75 13 12.44	23.09 24 96.94	16.29 37 78.38	.53 12 1.48	182.79 12 589.17	917.24 17 1270.84	1023.71 26 1324.87

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		8.3 2 4.8
5.99 ft. to 4.00 ft.	159.20 2 225.14	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	320.05 4 [illegible]	67.7 3 64.1
3.99 ft. to 2.00 ft.	2952.00 1 0.	63.20 6 151.69	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	163.72 21 313.11	108.9 3 86.4
1.99 ft. to 0.00 ft.	83.20 6 203.80	64.00 3 110.85	0. 3 0.	.01 3 .01	0. 3 0.	132.92 13 290.54	56.00 2 65.62	37.5 2 53.0
-0.01 ft. to -2.00 ft.	9.87 6 24.17	7.60 4 15.20	372.27 3 644.78	0. 1 0.	3.20 1 0.	29.60 6 72.50		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	239.30 16 737.21	37.60 16 101.39	124.09 9 372.27	.00 8 .01	.46 7 1.21	86.62 22 229.82	178.19 27 355.67	56.51 11 65.71

Table 18. Means, number of observations, and standard deviations of the grams/sq. meter of Phyllospadix sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		.24 4 .47	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	2901.33 3 5025.26	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	4.40 22 20.10
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	0. 12 0.	512.06 17 2111.02	3.72 26 18.49

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	418.23 4 [illegible]	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	4.65? 21 14.66	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	.00 13 .00	.01 2 .01	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	77.87 6 190.73		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	21.24 22 99.61	65.56 27 321.[illegible]	0. 11 0.

Table 19. Means, number of observations, and standard deviations of the grams/sq. meter of Zostera sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	0. 12 0.	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. [illegible] 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	0. 11 0.

Table 20. Means, number of observations, and standard deviations of the grams/sq. meter of Porifera at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	24.32 4 48.64	0. 4 0.	12.16 8 34.39	0. 2 0.		6.40 4 12.80	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	35.58 5 48.74	
3.99 ft. to 2.00 ft.	9.31 3 16.12	71.36 5 100.20	48.09 8 82.72	90.68 3 157.07	761.44 4 1412.14	1618.70 3 2389.72	
1.99 ft. to 0.00 ft.	1090.09 2 1524.92	258.58 1 0.	812.92 3 1180.32	683.78 1 0.	2198.61 7 2158.89	907.01 4 1697.09	94.12 22 263.12
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	106.94 4 72.88		0. 1 0.	452.02 4 694.03
	177.34 13 598.84	25.64 24 71.23	78.94 37 358.01	115.30 12 200.84	1536.34 12 1948.88	511.04 17 1293.77	149.18 26 365.24

	Lagoon Pt. - May 1976			C. Kaguyak - May 1976		C. Sitkinak	Dolina Pt.	Low Cape
	tr. 1	tr. 2	tr.3	tr. 1	tr. 2	May 1976	May 1976	May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	30.13 6 73.81	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	126.48 21 572.30	1.70 3 2.94
1.99 ft. to 0.00 ft.	0. 6 0.	232.00 3 338.80	293.33 3 508.07	8.53 3 14.78	310.93 3 500.26	0. 13 0.	186.40 2 263.61	5.90 2 8.34
-0.01 ft. to -2.00 ft.	4.27 6 10.45	0. 4 0.	0. 3 0.	0. 1 0.	1396.80 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	1.60 16 6.40	54.80 16 158.26	97.78 9 293.33	3.20 8 9.05	332.80 7 572.47	0. 22 0.	112.18 27 507.09	1.54 11 3.73

Table 21. Means, number of observations, and standard deviations of the grams/sq. meter of Cnidaria at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	.00 4 .01	0. 4 0.	.00 8 .01	1.01 2 1.43		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	.07 5 .16	
3.99 ft. to 2.00 ft.	.33 3 .57	10.86 5 8.46	6.91 8 8.41	1.42 3 2.47	32.86 4 42.37	0. 3 0.	
1.99 ft. to 0.00 ft.	.50 2 .26	23.15 1 0.	8.05 3 13.08	0. 1 0.	32.83 7 42.23	14.12 4 21.69	.07 22 .29
-0.01 ft. to -2.00 ft.	.12 2 .17		.12 2 .17	1.76 4 3.51		5.42 1 0.	0. 4 0.
	.17 13 .32	3.23 24 7.11	2.15 37 5.87	1.11 12 2.27	30.10 12 39.40	3.66 17 11.21	.06 26 .27

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	.00 3 .00
3.99 ft. to 2.00 ft.	27.20 1 0.	.00 6 .01	0. 2 0.	.02 1 0.	0. 2 0.	11.20 3 19.40	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	.53 6 1.31	0. 3 0.	8.00 3 13.86	.01 3 .01	.01 3 .01	.00 13 .00	.01 2 .01	.00 2 0.
-0.01 ft. to -2.00 ft.	.54 6 1.30	.01 4 .01	27.73 3 48.04	0. 1 0.	0. 1 0.	0. 6 0.		.00 1 0.
-2.01 ft. to -4.00 ft.	179.22 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	13.30 16 44.76	.00 16 .01	11.91 9 27.89	.00 8 .01	.00 7 .01	1.53 22 7.16	.00 27 .00	.00 11 .00

Table 22. Means, number of observations, and standard deviations of the grams/sq. meter of Polychaete sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		.21 5 .48	.21 5 .48				
7.99 ft. to 6.00 ft.	.20 4 .39	1.34 4 1.36	.77 8 1.11	.17 2 .24		6.64 4 12.95	
5.99 ft. to 4.00 ft.	.08 2 .11	5.29 8 6.55	4.25 10 6.18	0. 2 0.	3.39 1 0.	5.11 5 6.95	
3.99 ft. to 2.00 ft.	4.96 3 1.11	17.07 5 14.64	12.53 8 12.73	2.21 3 1.90	14.31 4 11.39	39.62 3 21.84	
1.99 ft. to 0.00 ft.	7.15 2 6.15	74.66 1 0.	29.65 3 39.22	1.22 1 0.	21.43 7 13.20	20.26 4 24.76	6.31 22 5.41
-0.01 ft. to -2.00 ft.	1.54 2 1.67		1.54 2 1.67	2.98 4 2.24		39.30 1 0.	23.67 4 20.17
	2.55 13 3.41	8.70 24 16.95	6.54 37 14.01	1.67 12 1.92	17.55 12 12.73	17.14 17 20.46	8.98 26 10.69

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.00 2 0.
5.99 ft. to 4.00 ft.	1.60 2 2.26	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.01 4 .01	.06 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	.00 6 .01	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.16 21 .70	.13 3 .06
1.99 ft. to 0.00 ft.	0. 6 0.	4.81 3 8.31	.01 3 .01	.01 3 .01	1.08 3 1.83	.01 13 .01	.02 2 0.	.10 2 .14
-0.01 ft. to -2.00 ft.	8.80 6 14.37	.81 4 .91	1.08 3 1.84	0. 1 0.	6.40 1 0.	.81 6 1.95		.00 1 0.
-2.01 ft. to -4.00 ft.	67.20 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	7.70 16 18.39	1.10 16 3.59	.36 9 1.06	.00 8 .01	1.38 7 2.51	.23 22 1.02	.13 27 .61	.06 11 .08

Table 23. Means, number of observations, and standard deviations of the grams/sq. meter of Oligochaete sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		1.79 1 0.	1.79 1 0.				
9.99 ft. to 8.00 ft.		.05 5 .07	.05 5 .07				
7.99 ft. to 6.00 ft.	.01 4 .01	1.85 4 1.94	.93 8 1.61	1.23 2 1.74		1.04 4 1.45	
5.99 ft. to 4.00 ft.	.01 2 .01	.75 8 .89	.60 10 .84	.01 2 .01	3.06 1 0.	2.46 5 2.58	
3.99 ft. to 2.00 ft.	.68 3 .59	1.56 5 2.00	1.23 8 1.61	.94 3 .71	1.94 4 2.58	21.29 3 33.33	
1.99 ft. to 0.00 ft.	.01 2 .01	.13 1 0.	.05 3 .07	.06 1 0.	.69 7 .46	2.13 4 4.17	.37 22 .57
-0.01 ft. to -2.00 ft.	.04 2 .06		.04 2 .06	.01 4 .02		0. 1 0.	.34 4 .52
	.17 13 .38	.97 24 1.38	.69 37 1.19	.45 12 .81	1.30 12 1.61	5.23 17 14.26	.36 26 .56

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. [illegible] 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	0. 11 0.

Table 24. Means, number of observations, and standard deviations of the grams/sq. meter of Tonicella sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	1.72 7 4.56	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	1.01 12 3.48	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. [illegible] 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	3.20 4 6.40	8.00 3 13.86	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	.80 16 3.20	2.67 9 8.00	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	0. 11 0.

Table 25. Means, number of observations, and standard deviations of the grams/sq. meter of Katharina sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. --August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	119.04 5 266.18	74.40 8 210.43	0. 3 0.	458.98 4 751.02	497.69 3 857.64	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	962.49 7 988.87	359.62 4 415.86	0. 22 0.
-0.01 ft. to -2.00 ft.	26.74 2 37.82		26.74 2 37.82	0. 4 0.		1308.00 1 0.	0. 4 0.
	4.11 13 14.83	24.80 24 121.49	17.53 37 98.00	0. 12 0.	714.45 12 892.46	249.43 17 493.97	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	[illegible]	0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .01	0. 3 0.
3.99 ft. to 2.00 ft.	33.60 1 0.	2.40 6 5.88	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	213.33 6 331.11	346.13 3 504.98	28.27 3 25.11	99.73 3 172.74	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	13.60 6 22.39	94.80 4 177.03	52.80 3 55.36	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	12.80 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	88.00 16 216.37	89.50 16 241.03	27.02 9 38.04	37.40 8 105.78	0. 7 0.	0. 22 0.	.00 27 .00	0. 11 0.

Table 26. Means, number of observations, and standard deviations of the grams/sq. meter of Mytilus edulis at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. --August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		7.39 5 16.51	7.39 5 16.51				
7.99 ft. to 6.00 ft.	0. 4 0.	282.23 4 564.46	141.11 8 399.13	0. 2 0.		31.50 4 29.89	
5.99 ft. to 4.00 ft.	0. 2 0.	20.03 8 56.25	16.02 10 50.32	0. 2 0.	6570.80 1 0.	.00 5 .01	
3.99 ft. to 2.00 ft.	0. 3 0.	.60 5 1.33	.37 8 1.05	0. 3 0.	2236.98 4 4281.43	146.12 3 252.67	
1.99 ft. to 0.00 ft.	0. 2 0.	3.68 1 0.	1.23 3 2.12	0. 1 0.	11.21 7 13.97	.05 4 .10	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	.00 4 .01		0. 1 0.	0. 4 0.
	0. 13 0.	55.53 24 230.99	36.02 37 186.58	.00 12 .00	1299.76 12 2983.48	33.21 17 106.02	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		2.[illegible] 2 [illegible]
5.99 ft. to 4.00 ft.	15867.21 2 22439.60	187.20 2 264.74	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	.67 3 .58
3.99 ft. to 2.00 ft.	12.80 1 0.	3.20 6 3.65	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.92 21 4.19	160.[illegible] 3 174.04
1.99 ft. to 0.00 ft.	12.00 6 20.48	.01 3 .01	0. 3 0.	.01 3 .01	.53 3 .92	0. 13 0.	.01 2 .01	.05 2 .07
-0.01 ft. to -2.00 ft.	3.73 6 9.14	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	1990.10 16 7931.83	24.60 16 93.32	0. 9 0.	.00 8 .01	.23 7 .60	0. 22 0.	.71 27 3.69	28.15 11 90.71

Table 27. Means, number of observations, and standard deviations of the grams/sq. meter of Turtonia sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. -- August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		.08 5 .17	.08 5 .17				
7.99 ft. to 6.00 ft.	0. 4 0.	.38 4 .67	.19 8 .48	0. 2 0.		.09 4 .08	
5.99 ft. to 4.00 ft.	0. 2 0.	.09 8 .23	.07 10 .21	.01 2 .01	.14 1 0.	.55 5 .66	
3.99 ft. to 2.00 ft.	.13 3 .17	.12 5 .25	.13 8 .21	.21 3 .36	0. 4 0.	.09 3 .10	
1.99 ft. to 0.00 ft.	.61 2 .86	.02 1 0.	.41 3 .70	0. 1 0.	0. 7 0.	0. 4 0.	.33 22 .48
-0.01 ft. to -2.00 ft.	72.59 2 65.55		72.59 2 65.55	75.94 4 151.68		.08 1 0.	1.50 4 2.93
	11.29 13 33.14	.13 24 .32	4.05 37 19.88	25.37 12 87.58	.01 12 .04	.20 17 .42	.51 26 1.19

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .00	.00 3 .00
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.00 21 .00	.00 3 .00
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	.01 3 .01	.01 3 .01	.25 13 .89	0. 2 0.	.00 2 .00
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	.00 6 .01		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	.00 8 .01	.00 7 .01	.15 22 .68	.00 27 .00	.00 11 .00

Table 28. Means, number of observations, and standard deviations of the grams/sq. meter of Acmaeidae at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	2.53 4 3.30	4.90 4 5.18	3.71 8 4.22	0. 2 0.		65.54 4 56.84	
5.99 ft. to 4.00 ft.	0. 2 0.	3.41 8 5.97	2.73 10 5.45	0. 2 0.	5.92 1 0.	10.06 5 14.82	
3.99 ft. to 2.00 ft.	7.19 3 9.44	12.27 5 19.41	10.36 8 15.74	56.44 3 97.76	15.00 4 4.18	0. 3 0.	
1.99 ft. to 0.00 ft.	3.31 2 4.68	0. 1 0.	2.21 3 3.82	0. 1 0.	11.62 7 18.13	4.59 4 9.18	6.13 22 23.06
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		15.84 1 0.	0. 4 0.
	2.95 13 5.19	4.51 24 9.98	3.96 37 8.55	14.11 12 48.88	12.27 12 13.81	20.39 17 36.89	5.19 26 21.25

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	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	.02 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.70 2 .99
5.99 ft. to 4.00 ft.	12.01 2 5.67	2.40 2 3.39	0. 1 0.	13.60 2 16.97	3.20 1 0.	0. 0 0.	11.62 4 14.62	.67 3 .56
3.99 ft. to 2.00 ft.	3.22 1 0.	14.67 6 28.25	.01 2 .01	33.60 1 0.	61.60 2 16.97	26.67 3 44.81	23.79 21 44.72	2.03 3 1.00
1.99 ft. to 0.00 ft.	8.54 6 14.79	.01 3 .01	.54 3 .91	11.74 3 10.14	8.01 3 9.99	19.45 13 34.64	16.00 2 22.63	3.45 2 1.06
-0.01 ft. to -2.00 ft.	.81 6 1.96	26.80 4 24.50	38.41 3 37.62	1.60 1 0.	.02 1 0.	0. 6 0.		1.20 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	5.20 16 9.84	12.51 16 22.33	12.98 9 26.79	12.21 8 13.19	21.49 7 29.00	15.13 22 31.19	21.41 27 40.05	1.60 11 1.29

Table 29. Means, number of observations, and standard deviations of the grams/sq. meter of Collisella pelta at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. --August 1975 tr. 1	Sud Id. --August 1975 tr. 2	Sud Id. --August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	2.53 4 3.30	4.90 4 5.18	3.71 8 4.22	0. 2 0.		29.05 4 27.07	
5.99 ft. to 4.00 ft.	0. 2 0.	3.41 8 5.97	2.73 10 5.45	0. 2 0.	5.92 1 0.	10.06 5 14.82	
3.99 ft. to 2.00 ft.	7.19 3 9.44	12.27 5 19.41	10.36 8 15.74	56.44 3 97.76	15.00 4 4.18	0. 3 0.	
1.99 ft. to 0.00 ft.	3.31 2 4.68	0. 1 0.	2.21 3 3.82	0. 1 0.	10.49 7 18.60	4.59 4 9.18	4.79 22 22.49
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	2.95 13 5.19	4.51 24 9.98	3.96 37 8.55	14.11 12 48.88	11.61 12 14.19	10.88 17 18.17	4.06 26 20.68

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.05 2 .07
5.99 ft. to 4.00 ft.	.01 2 .01	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	7.21 4 14.39	.33 3 .56
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	13.87 3 22.65	14.41 21 42.50	.03 3 .06
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	2.14 3 3.69	.01 3 .01	16.37 13 32.62	16.00 2 22.63	.40 2 .42
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	.00 16 .00	0. 16 0.	0. 9 0.	.80 8 2.26	.00 7 .01	11.56 22 26.65	13.46 27 37.95	.18 11 .34

Table 30. Means, number of observations, and standard deviations of the grams/sq. meter of Notoacmea scutum at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. --August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	1.13 7 2.99	0. 4 0.	1.34 22 6.27
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		15.84 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	.66 12 2.29	.93 17 3.84	1.13 26 5.77

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	12.00 2 16.97	0. 1 0.	0. 0 0.	4.41 4 7.76	.00 3 .00
3.99 ft. to 2.00 ft.	3.20 1 0.	13.34 6 28.81	.01 2 .01	33.60 1 0.	60.80 2 18.10	3.20 3 5.54	3.51 21 8.20	.00 3 .00
1.99 ft. to 0.00 ft.	6.94 6 13.22	.01 3 .01	.54 3 .91	9.07 3 8.81	1.60 3 2.77	3.08 13 8.33	0. 2 0.	1.05 2 1.34
-0.01 ft. to -2.00 ft.	.80 6 1.96	15.60 4 9.27	.01 3 .01	1.60 1 0.	0. 1 0.	0. 6 0.		1.20 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	3.10 16 8.33	8.90 16 18.58	.18 9 .53	10.80 8 12.96	18.06 7 30.17	2.25 22 6.67	3.38 27 7.73	.30 11 .67

Table 31. Means, number of observations, and standard deviations of the grams/sq. meter of Notoacmea persona at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	0. 12 0.	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	12.00 2 5.66	2.40 2 3.39	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	.02 1 0.	1.34 6 3.26	0. 2 0.	0. 1 0.	0. 2 0.	9.60 3 16.63	2.82 21 11.22	0. 3 0.
1.99 ft. to 0.00 ft.	1.60 6 2.48	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	.01 6 .01	.00 4 .01	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	2.10 16 4.44	.80 16 2.26	0. 9 0.	0. 8 0.	0. 7 0.	1.31 22 6.14	2.19 27 9.92	0. 11 0.

Table 32. Means, number of observations, and standard deviations of the grams/sq. meter of Margarites sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	1.60 4 2.98	.80 8 2.13	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	.12 5 .16	
3.99 ft. to 2.00 ft.	1.69 3 2.93	.08 5 .11	.69 8 1.77	.41 3 .40	.00 4 .01	1.13 3 1.95	
1.99 ft. to 0.00 ft.	0. 2 0.	.29 1 0.	.10 3 .17	.05 1 0.	2.73 7 2.62	8.20 4 12.96	2.19 22 3.44
-0.01 ft. to -2.00 ft.	.21 2 .23		.21 2 .23	.00 4 .01		8.50 1 0.	2.92 4 5.55
	.42 13 1.40	.30 24 1.23	.34 37 1.28	.11 12 .25	1.59 12 2.39	2.66 17 6.78	2.30 26 3.70

	Lagoon Pt. - May 1976 tr. 1	tr. 2	tr. 3	C. Kaguyak - May 1976 tr. 1	tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.00 4 .01	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	4.81 6 7.50	2.68 3 4.61	.01 3 .01	.54 3 .91	6.41 3 9.73	2.22 13 7.99	.01 2 .01	.00 2 .00
-0.01 ft. to -2.00 ft.	3.47 6 8.49	.00 4 .01	0. 3 0.	6.40 1 0.	4.80 1 0.	.00 6 .01		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	3.10 16 6.83	.50 16 2.00	.00 9 .01	1.00 8 2.25	3.43 7 6.49	1.31 22 6.14	.00 27 .00	.00 11 .00

Table 33. Means, number of observations, and standard deviations of the grams/sq. meter of Littorina sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	Sud Id. - August 1975 tr. 2	Sud Id. - August 1975 total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		1718.40 1 0.	1718.40 1 0.				
9.99 ft. to 8.00 ft.		44.84 5 36.97	44.84 5 36.97				
7.99 ft. to 6.00 ft.	925.27 4 866.25	581.95 4 839.90	753.61 8 810.93	2815.48 2 3114.02		263.18 4 109.18	
5.99 ft. to 4.00 ft.	.26 2 .09	18.69 8 13.15	15.01 10 13.96	212.22 2 240.17	54.69 1 0.	180.48 5 235.53	
3.99 ft. to 2.00 ft.	5.35 3 7.72	.32 5 .57	2.21 8 4.90	2.95 3 1.62	34.08 4 67.29	3.91 3 6.43	
1.99 ft. to 0.00 ft.	.50 2 .70	0. 1 0.	.33 3 .57	0. 1 0.	0. 7 0.	136.10 4 171.32	8.46 22 13.10
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	.03 4 .06		.06 1 0.	0. 4 0.
	286.05 13 619.96	184.23 24 494.70	220.01 37 535.63	505.37 12 1434.45	15.92 12 40.65	147.73 17 174.80	7.16 26 12.40

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	123.20 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	27.20 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		10.75 2 5.16
5.99 ft. to 4.00 ft.	45.60 2 44.12	13.60 2 19.23	0. 1 0.	40.00 2 20.36	931.20 1 0.	0. 0 0.	30.40 4 38.99	19.10 3 5.99
3.99 ft. to 2.00 ft.	24.02 1 0.	7.21 6 16.12	1.60 2 2.26	.02 1 0.	52.00 2 71.28	50.67 3 83.63	82.21 21 82.49	12.57 3 16.18
1.99 ft. to 0.00 ft.	1.61 6 2.49	.01 3 .01	.53 3 .92	.01 3 .01	.01 3 .01	7.26 13 14.26	.01 2 .01	.05 2 .07
-0.01 ft. to -2.00 ft.	0. 6 0.	.00 4 .01	0. 3 0.	0. 1 0.	.02 1 0.	.01 6 .01		.00 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	7.80 16 19.59	6.10 16 12.89	.53 9 1.13	25.40 8 44.13	147.89 7 347.49	11.20 22 32.41	68.45 27 78.39	10.60 11 10.89

Table 34. Means, number of observations, and standard deviations of the grams/sq. meter of Littorina sitkana at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		1718.40 1 0.	1718.40 1 0.				
9.99 ft. to 8.00 ft.		44.84 5 36.97	44.84 5 36.97				
7.99 ft. to 6.00 ft.	925.27 4 866.25	581.95 4 839.90	753.61 8 810.93	2815.48 2 3114.02		263.18 4 109.18	
5.99 ft. to 4.00 ft.	.26 2 .09	17.74 8 13.22	14.24 10 13.80	212.22 2 240.17	54.69 1 0.	180.48 5 235.53	
3.99 ft. to 2.00 ft.	5.35 3 7.72	.32 5 .57	2.21 8 4.90	2.95 3 1.62	32.10 4 63.33	3.91 3 6.43	
1.99 ft. to 0.00 ft.	.50 2 .70	0. 1 0.	.33 3 .57	0. 1 0.	0. 7 0.	136.10 4 171.32	8.46 22 13.10
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	.03 4 .06		.06 1 0.	0. 4 0.
	286.05 13 619.96	183.91 24 494.81	219.80 37 535.71	505.37 12 1434.45	15.26 12 38.55	147.73 17 174.80	7.16 26 12.40

Table 35. Means, number of observations, and standard deviations of the grams/sq. meter of Nucella lamellosa at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		1.88 5 4.21	1.88 5 4.21				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	.39 24 1.92	.25 37 1.55	0. 12 0.	0. 12 0.	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. [illegible] 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	0. 3 0.
1.99 ft. to 0.00 ft.	58.67 6 143.70	0. 3 0.	216.00 3 215.20	0. 3 0.	0. 3 0.	0. 13 0.	0. [illegible] 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	184.80 6 225.06	154.00 4 308.00	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	91.30 16 172.95	38.50 16 154.00	72.00 9 152.45	0. 8 0.	0. 7 0.	0. 22 0.	0. 27 0.	0. 11 0.

Table 36. Means, number of observations, and standard deviations of the grams/sq. meter of Nucella lima at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975			Sud Id.	Three Sts. Bay	Sundstrom Id.	Chirikof Id.
	tr. 1	tr. 2	total	May 1975	May 1975	May 1975	May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		.80 4 1.57	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	16.55 5 37.00	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	27.95 4 55.90	6.74 3 11.68	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	9.32 12 32.27	6.25 17 20.31	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		1.[illegible] 2 .[illegible]
5.99 ft. to 4.00 ft.	5.60 2 7.92	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	69.70 4 57.46	17.65 3 6.[illegible]
3.99 ft. to 2.00 ft.	9.60 1 0.	.00 6 .01	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	7.92 21 19.72	11.97 5 11.13
1.99 ft. to 0.00 ft.	1.60 6 3.92	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	.74 13 2.23	0. 2 0.	19.10 2 28.60
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	.54 6 1.31		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	1.90 16 4.10	.00 16 .00	0. 9 0.	0. 8 0.	0. 7 0.	.58 22 1.82	13.45 27 30.25	11.95 11 12.99

Table 37. Means, number of observations, and standard deviations of the grams/sq. meter of Balanus balanoides at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975			Sud Id.	Three Sts. Bay	Sundstrom Id.	Chirikof Id.
	tr. 1	tr. 2	total	May 1975	May 1975	May 1975	May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	2509.71 7 6640.08	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	0. 24 0.	0. 37 0.	0. 12 0.	1464.00 12 5071.44	0. 17 0.	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	.02 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		65.20 2 92.21
5.99 ft. to 4.00 ft.	0. 2 0.	.01 2 .01	0. 1 0.	.80 2 1.13	0. 1 0.	0. 0 0.	.00 4 .01	167.47 3 94.3[illegible]
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	3.20 2 4.53	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	315.10 3 429.87
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	1.00 2 1.41
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	.00 16 .01	.71 9 2.13	.20 8 .57	0. 7 0.	0. 22 0.	.00 27 .00	143.65 11 236.52

Table 38. Means, number of observations, and standard deviations of the grams/sq. meter of Balanus cariosus at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		37.72 5 84.35	37.72 5 84.35				
7.99 ft. to 6.00 ft.	0. 4 0.	365.88 4 731.77	182.94 8 517.44	0. 2 0.		1624.64 4 3193.65	
5.99 ft. to 4.00 ft.	0. 2 0.	130.80 8 308.17	104.64 10 277.32	11.49 2 16.25	0. 1 0.	1150.35 5 1830.77	
3.99 ft. to 2.00 ft.	0. 3 0.	1296.44 5 1426.84	810.28 8 1270.26	0. 3 0.	14327.59 4 19104.55	1010.21 3 1749.74	
1.99 ft. to 0.00 ft.	35.53 2 50.24	0. 1 0.	23.69 3 41.02	606.88 1 0.	12745.43 7 9013.08	0. 4 0.	.14 22 .67
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	374.68 4 739.35		0. 1 0.	0. 4 0.
	5.47 13 19.71	382.53 24 834.44	250.05 37 691.58	177.38 12 446.47	12210.70 12 12618.14	898.88 17 1881.30	.12 26 .61

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. [illegible] 0.
5.99 ft. to 4.00 ft.	79.20 2 112.01	296.00 2 418.61	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	1152.40 4 2222.38	1.17 3 2.02
3.99 ft. to 2.00 ft.	308.80 1 0.	3063.20 6 5242.48	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	183.70 21 830.14	291.83 3 505.47
1.99 ft. to 0.00 ft.	395.20 6 621.92	3677.87 3 4909.45	536.53 3 472.33	185.61 3 307.71	6.93 3 12.01	0. 13 0.	109.60 2 155.00	139.85 2 186.46
-0.01 ft. to -2.00 ft.	31.20 6 76.42	32.80 4 65.60	32.00 3 55.43	0. 1 0.	0. 1 0.	6.40 6 15.68		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	189.10 16 404.51	1883.50 16 3882.52	189.51 9 352.81	69.60 8 190.48	2.97 7 7.86	1.75 22 8.19	321.72 27 1107.21	105.34 11 268.02

Table 39. Means, number of observations, and standard deviations of the grams/sq. meter of Balanus glandula at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		516.71 5 1152.77	516.71 5 1152.77				
7.99 ft. to 6.00 ft.	0. 4 0.	.04 4 .09	.02 8 .06	0. 2 0.		21.24 4 30.64	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	.50 2 .71	163.49 1 0.	4.84 5 10.83	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	0. 4 0.	0. 3 0.	
1.99 ft. to 0.00 ft.	0. 2 0.	93.81 1 0.	31.27 3 54.16	0. 1 0.	1.41 7 3.58	84.37 4 127.59	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	111.56 24 525.88	72.37 37 423.79	.08 12 .29	14.45 12 47.01	26.27 17 66.51	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		103.45 2 112.78
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	490.69 1 0.	0. 0 0.	0. 4 0.	73.87 3 56.77
3.99 ft. to 2.00 ft.	0. 1 0.	0. 6 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	17.25 3 18.05
1.99 ft. to 0.00 ft.	0. 6 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	0. 4 0.	0. 3 0.	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	0. 16 0.	0. 16 0.	0. 9 0.	0. 8 0.	70.10 7 185.46	0. 22 0.	0. 27 0.	43.65 11 61.25

Table 40. Means, number of observations, and standard deviations of the grams/sq. meter of Isopod sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	7.49 4 7.09	7.22 4 12.44	7.36 8 9.37	0. 2 0.		.21 4 .42	
5.99 ft. to 4.00 ft.	3.77 2 5.33	23.41 8 17.42	19.48 10 17.55	0. 2 0.	0. 1 0.	7.22 5 12.17	
3.99 ft. to 2.00 ft.	38.13 3 14.14	10.74 5 11.05	21.01 8 18.10	33.57 3 19.06	1.66 4 1.52	1.52 3 1.97	
1.99 ft. to 0.00 ft.	9.95 2 4.07	133.49 1 0.	51.13 3 71.38	1.76 1 0.	4.90 7 4.99	2.54 4 4.83	.68 22 .70
-0.01 ft. to -2.00 ft.	24.17 2 2.66		24.17 2 2.66	14.51 4 14.48		.74 1 0.	.02 4 .04
	16.93 13 15.43	16.81 24 28.96	16.85 37 24.80	13.38 12 17.67	3.41 12 4.22	3.08 17 7.08	.58 26 .68

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	.02 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.00 2 .00
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.40 4 .81	.50 3 .87
3.99 ft. to 2.00 ft.	0. 1 0.	2.94 6 7.18	.01 2 .01	0. 1 0.	0. 2 0.	0. 3 0.	4.27 21 17.40	.00 3 .00
1.99 ft. to 0.00 ft.	6.67 6 11.73	.02 3 .02	.02 3 .02	1.08 3 1.85	1.08 3 1.84	.14 13 .44	.02 2 .01	.00 2 0.
-0.01 ft. to -2.00 ft.	0. 6 0.	.01 4 .02	.02 3 .02	0. 1 0.	0. 1 0.	.04 6 .01		10.70 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	2.50 16 7.55	1.11 16 4.40	.01 9 .02	.41 8 1.13	.46 7 1.21	.09 22 .34	3.39 27 15.35	1.11 11 3.21

Table 41. Means, number of observations, and standard deviations of the grams/sq. meter of Pagurus sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	2.13 4 4.26	.10 4 .20	1.11 8 2.99	0. 2 0.		29.32 4 49.10	
5.99 ft. to 4.00 ft.	0. 2 0.	1.02 8 2.89	.82 10 2.59	0. 2 0.	0. 1 0.	10.84 5 20.56	
3.99 ft. to 2.00 ft.	5.78 3 10.01	4.46 5 7.17	4.96 8 7.65	0. 3 0.	12.85 4 25.46	55.26 3 78.07	
1.99 ft. to 0.00 ft.	0. 2 0.	0. 1 0.	0. 3 0.	0. 1 0.	0. 7 0.	0. 4 0.	5.12 22 8.00
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	1.99 13 5.18	1.29 24 3.80	1.53 37 4.28	0. 12 0.	4.28 12 14.72	19.84 17 41.54	4.33 26 7.57

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.00 2 .00
5.99 ft. to 4.00 ft.	.01 2 .01	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.40 4 .00	.67 3 .58
3.99 ft. to 2.00 ft.	.02 1 0.	6.40 6 9.33	0. 2 0.	.02 1 0.	4.81 2 2.27	0. 3 0.	.00 21 .01	.03 3 .06
1.99 ft. to 0.00 ft.	22.14 6 49.66	.01 3 .01	2.67 3 3.33	4.81 3 6.98	9.07 3 11.79	.26 13 .60	.02 2 0.	.10 2 .14
-0.01 ft. to -2.00 ft.	.54 6 1.31	2.81 4 3.77	1.61 3 2.76	.02 1 0.	1.60 1 0.	1.09 6 1.30		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	8.50 16 30.69	3.10 16 6.33	1.43 9 2.46	1.81 8 4.48	5.49 7 7.83	.45 22 .88	.06 27 .31	.21 11 .40

Table 42. Means, number of observations, and standard deviations of the grams/sq. meter of Amphipod sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		.00 5 .01	.00 5 .01				
7.99 ft. to 6.00 ft.	.93 4 .76	.78 4 1.39	.86 8 1.04	3.05 2 4.22		1.46 4 2.07	
5.99 ft. to 4.00 ft.	.20 2 .28	8.73 8 9.79	7.02 10 9.35	0. 2 0.	0. 1 0.	5.99 5 4.36	
3.99 ft. to 2.00 ft.	15.59 3 12.19	4.02 5 7.95	8.36 8 10.70	85.98 3 123.03	3.33 4 2.13	13.96 3 18.27	
1.99 ft. to 0.00 ft.	12.98 2 7.03	39.12 1 0.	21.70 3 15.89	8.90 1 0.	5.12 7 2.95	3.79 4 6.20	20.58 22 25.02
-0.01 ft. to -2.00 ft.	93.93 2 25.65		93.93 2 25.65	33.63 4 19.89		2.74 1 0.	17.17 4 27.29
	20.36 13 34.56	5.51 24 10.27	10.73 37 22.74	33.96 12 63.56	4.10 12 2.90	5.62 17 8.56	20.06 26 24.83

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkina May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		.00 2 [illegible]
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	.01 2 .01	0. 1 0.	0. 0 0.	7.60 4 [illegible]	1.65 3 1.76
3.99 ft. to 2.00 ft.	102.40 1 0.	12.53 6 24.17	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	10.37 21 20.69	2.40 3 2.12
1.99 ft. to 0.00 ft.	29.07 6 65.86	4.27 3 3.70	.53 3 .92	2.67 3 4.61	5.33 3 9.24	2.83 13 10.21	16.80 2 23.76	.50 2 .14
-0.01 ft. to -2.00 ft.	14.40 6 32.98	0. 4 0.	0. 3 0.	0. 1 0.	36.80 1 0.	28.27 6 49.29		.00 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	22.70 16 48.77	5.50 16 15.19	.18 9 .53	1.00 8 2.83	7.54 7 14.21	9.38 22 27.91	10.43 27 19.55	1.25 11 1.61

Table 43. Means, number of observations, and standard deviations of the grams/sq. meter of Leptasterias sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	10.88 5 24.33	6.80 8 19.23	0. 3 0.	279.49 4 325.44	34.54 3 59.56	
1.99 ft. to 0.00 ft.	0. 2 0.	42.56 1 0.	14.19 3 24.57	0. 1 0.	118.36 7 81.43	0. 4 0.	4.65 22 15.46
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	15.06 4 23.40
	0. 13 0.	4.04 24 13.80	2.62 37 11.20	0. 12 0.	162.21 12 202.78	6.10 17 25.05	6.26 26 16.77

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	4.80 4 9.60	.00 5 .00
3.99 ft. to 2.00 ft.	0. 1 0.	6.40 6 15.68	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	0. 21 0.	.00 3 .00
1.99 ft. to 0.00 ft.	62.67 6 116.19	102.41 3 163.70	0. 3 0.	.54 3 .92	.01 3 .01	0. 13 0.	0. 2 0.	1.35 2 1.91
-0.01 ft. to -2.00 ft.	14.40 6 35.27	0. 4 0.	0. 3 0.	0. 1 0.	1.60 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0. 0.		
	28.90 16 75.35	21.60 16 72.60	0. 9 0.	.20 8 .56	.23 7 .60	0. 22 0.	.71 27 3.70	.25 11 .81

Table 44. Means, number of observations, and standard deviations of the grams/sq. meter of Hiatella sp. at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	0. 4 0.	0. 8 0.	0. 2 0.		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	0. 8 0.	0. 10 0.	0. 2 0.	0. 1 0.	0. 5 0.	
3.99 ft. to 2.00 ft.	0. 3 0.	0. 5 0.	0. 8 0.	0. 3 0.	9.49 4 16.47	3.20 3 5.54	
1.99 ft. to 0.00 ft.	0. 2 0.	12.77 1 0.	4.26 3 7.37	0. 1 0.	17.06 7 30.13	0. 4 0.	0. 22 0.
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	0. 4 0.		0. 1 0.	0. 4 0.
	0. 13 0.	.53 24 2.61	.35 37 2.10	0. 12 0.	13.11 12 24.48	.56 17 2.33	0. 26 0.

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	.01 2 .01	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	0. 4 0.	0. 3 0.
3.99 ft. to 2.00 ft.	1.60 1 0.	.80 6 1.96	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.00 21 .00	.37 3 .68
1.99 ft. to 0.00 ft.	.54 6 1.31	1.07 3 1.85	0. 3 0.	0. 3 0.	0. 3 0.	0. 13 0.	0. 2 0.	0. 2 0.
-0.01 ft. to -2.00 ft.	.80 6 1.96	.00 4 .01	.54 3 .91	0. 1 0.	0. 1 0.	0. 6 0.		0. 1 0.
-2.01 ft. to -4.00 ft.	.02 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	.60 16 1.41	.50 16 1.40	.18 9 .53	0. 8 0.	0. 7 0.	0. 22 0.	.00 27 .00	.10 11 .33

Table 45. Means, number of observations, and standard deviations of the grams/sq. meter of Holothuroidea at 2 foot elevations intervals along transect lines at selected locations in the Western Gulf of Alaska.

	Sud Id. - August 1975 tr. 1	tr. 2	total	Sud Id. May 1975	Three Sts. Bay May 1975	Sundstrom Id. May 1975	Chirikof Id. May 1975
11.99 ft. to 10.00 ft.		0. 1 0.	0. 1 0.				
9.99 ft. to 8.00 ft.		0. 5 0.	0. 5 0.				
7.99 ft. to 6.00 ft.	0. 4 0.	11.83 4 21.78	5.91 8 15.60	4.71 2 6.66		0. 4 0.	
5.99 ft. to 4.00 ft.	0. 2 0.	5.22 8 6.97	4.17 10 6.52	0. 2 0.	0. 1 0.	.01 5 .02	
3.99 ft. to 2.00 ft.	27.30 3 22.38	19.29 5 40.62	22.29 8 33.21	12.78 3 12.01	125.70 4 225.46	42.83 3 60.54	
1.99 ft. to 0.00 ft.	.04 2 .06	492.13 1 0.	164.07 3 284.11	0. 1 0.	16.59 7 26.91	8.96 4 16.16	43.71 22 50.59
-0.01 ft. to -2.00 ft.	0. 2 0.		0. 2 0.	3.60 4 6.24		.24 1 0.	15.52 4 16.85
	6.31 13 15.06	28.23 24 100.88	20.53 37 81.79	5.18 12 8.06	51.58 12 131.44	9.68 17 27.77	39.37 26 47.87

	Lagoon Pt. - May 1976 tr. 1	Lagoon Pt. - May 1976 tr. 2	Lagoon Pt. - May 1976 tr. 3	C. Kaguyak - May 1976 tr. 1	C. Kaguyak - May 1976 tr. 2	C. Sitkinak May 1976	Dolina Pt. May 1976	Low Cape May 1976
9.99 ft. to 8.00 ft.	0. 0 0.	0. 0 0.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.		
7.99 ft. to 6.00 ft.	0. 0 0.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		0. 2 0.
5.99 ft. to 4.00 ft.	0. 2 0.	0. 2 0.	0. 1 0.	0. 2 0.	0. 1 0.	0. 0 0.	.40 4 .80	.00 3 .00
3.99 ft. to 2.00 ft.	336.00 1 0.	26.67 6 59.91	0. 2 0.	0. 1 0.	0. 2 0.	0. 3 0.	.00 21 .01	.30 3 .30
1.99 ft. to 0.00 ft.	4.27 6 8.97	133.87 3 177.16	.01 3 .01	.01 3 .01	5.33 3 9.24	.62 13 1.04	80.00 2 40.73	6.75 2 2.47
-0.01 ft. to -2.00 ft.	2.67 6 6.53	.00 4 .01	0. 3 0.	0. 1 0.	0. 1 0.	41.60 6 61.99		0. 1 0.
-2.01 ft. to -4.00 ft.	0. 1 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.	0. 0 0.		
	23.60 16 83.57	35.10 16 89.08	.00 9 .01	.00 8 .01	2.29 7 6.05	11.71 22 35.59	5.99 27 22.78	1.31 11 2.61

APPENDIX III

Average densities (g/m^2) of selected organisms estimated along transect line at Kodiak intertidal sites.

Data were extracted from tables, Appendix II.

Table 1. Average densities (g./sq.m.) of selected organisms estimated along transect line at Three Saints Bay in May 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongomorpha	Halosaccion	Mytilus edulis	Ondonthalia
4	1	54.69	349.49	.00	5.92	.00	.00	6570.80	6.13
2	4	32.10	1.48	5.16	15.00	75.40	.02	2236.98	531.58
0	7	.00	.76	.00	10.49	36.91	3.60	11.21	8.72

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllospadix	Alaria	Laminaria
4	1	.00	.00	.00	.00	.00	.00	.00	.00
2	4	7.98	.00	14327.59	761.44	458.98	.00	2458.81	.00
0	7	41.57	.00	12745.43	2198.61	962.49	.00	3699.42	11.84

Table 2. Average densities (g./sq.m.) of selected organisms estimated along transect line. at Chirikof Island in May 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No.of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
0	22	8.46	793.23	38.37	4.79	.00	64.10	.00	1111.61
-2	4	.00	.00	.00	.00	.00	11.56	.00	540.26

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
0	22	2.47	122.57	.14	94.12	.00	.00	564.65	.00
-2	4	1.40	65.97	.00	452.02	.00	.00	4757.30	77.01

Table 3 . Average densities (g./sq.m.) of selected organisms estimated along transect line at Sundstrom Island in May 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
6	4	353.19	1494.72	.00	22.43	.00	.43	21.03	702.27
4	5	180.48	206.10	8.35	10.06	.00	.00	.00	810.15
2	3	3.91	.00	89.43	.00	.00	112.12	146.12	1197.10
0	4	.00	.00	331.24	.00	47.98	32.54	.00	1867.28
-2	1	.06	.00	2.26	.00	62.50	.00	.00	2.86

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	4	.00	.17	1083.09	4.27	.00	.00	.00	.00
4	5	1387.73	149.00	1150.35	35.58	.00	.00	94.56	.00
2	3	3.19	.00	1010.21	1618.70	497.69	.00	1392.81	.00
0	4	5.88	.00	.00	1814.02	719.64	.00	2595.06	58.90
-2	1	.00	.00	.00	.00	1308.00	.00	.00	21192.00

Table 4. Average densities (g./sq.m.) of selected organisms estimated along transect line at Sud Island in May 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
6	2	2815.48	3792.00	.00	.00	.00	.00	.00	.49
4	2	212.22	1726.25	.00	.00	.00	.00	.00	.00
2	3	2.95	1800.65	37.22	56.44	10.02	2.30	.00	1.71
0	1	.00	22.88	.00	.00	6.99	6.05	.00	.29
-2	4	.03	11.78	6.33	.00	177.93	.00	.00	.00

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	2	19.71	.00	.00	.00	.00	.00	16.96	209.66
4	2	1.14	.00	11.49	.00	.00	.00	13.50	.00
2	3	1765.53	.00	.00	90.68	.00	.00	678.95	334.51
0	1	1278.59	.00	606.88	683.78	.00	.00	1737.79	.00
-2	4	274.60	.00	374.68	106.94	.00	.00	4567.32	17.39

Table 5. Average densities (g./sq.m.) of selected organisms estimated along transect lines at Sud Island in August 1975. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
6	4	925.27	974.57	.00	2.53	.00	.00	.00	11.26
4	2	.26	4716.26	.00	.00	.00	.00	.00	.00
2	3	5.35	314.22	6.11	7.19	.00	.00	.00	.00
0	2	.50	.00	.50	3.31	.00	2.39	.00	1.86
-2	2	.00	3.85	.00	.00	.00	.00	.00	.00
10	1	1718.40	.00	.00	.00	.00	.00	.00	.00
8	5	44.84	989.81	.00	.00	.00	.00	7.39	.00
6	4	581.95	2515.78	.16	4.90	.04	10.76	282.23	138.26
4	8	17.74	523.43	.01	3.41	2.14	186.19	20.03	.01
2	5	.32	80.96	.00	12.27	13.91	6.43	.60	.12
0	1	.00	.00	.00	.00	.00	.00	3.68	1.24

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	4	10.48	.00	.00	24.32	.00	.00	.00	.00
4	2	.00	.00	.00	.00	.00	.00	.00	.00
2	3	996.75	.00	.00	9.31	.00	.00	.00	.00
0	2	1712.92	.00	35.53	1090.09	.00	.00	3168.40	.00
-2	2	28.28	.00	.00	.00	26.74	.00	720.00	.00
10	1	.00	.00	.00	.00	.00	.00	.00	.00
8	5	.00	.00	37.72	.00	.00	.00	.00	.00
6	4	.14	.84	365.88	.00	.00	.00	.00	.00
4	8	891.51	.00	130.80	.00	.00	.00	.00	.00
2	5	1948.44	.00	1296.44	71.36	119.04	.00	460.83	.00
0	1	.00	.00	.00	258.58	.00	.00	.00	9097.07

Table 6. Average densities (g./sq.m.) of selected organisms estimated along transect line #1 C. Kaguyak in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Odonthalia
8	1	123.20	.00	.00	.00	.00	.00	.00	.00
6	0	-	-	-	-	-	-	-	-
4	2	40.00	225.60	.00	.00	.00	.00	.00	.00
2	1	.02	3758.40	121.60	.00	24.00	8.00	.00	.00
0	3	.01	894.40	131.20	2.14	8.53	19.74	.01	.01
-2	1	.00	449.60	49.60	.00	.00	.00	.00	.00

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
8	1	.00	.00	.00	.00	.00	.00	.00	.00
6	0	-	-	-	-	-	-	-	-
4	2	.00	.00	.00	.00	.00	.00	.00	.00
2	1	72.00	.00	.00	.00	.00	.00	.00	.00
0	3	180.27	.00	185.61	8.53	99.73	.00	3229.87	.00
-2	1	4.80	.00	.00	.00	.00	.00	486.40	896.00

Table 7 . Average densities (g./sq.m.) of selected organisms estimated along transect line #2 at Cape Kaguyak in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
4	1	931.20	40.00	1.60	.00	.00	.00	.00	.00
2	2	52.00	2060.80	117.60	.00	.00	.00	.00	.00
0	3	.01	.00	54.93	.01	261.33	.00	.53	.00
-2	1	.02	.00	35.20	.00	.00	.00	.00	3.20

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
4	1	.00	.00	.00	.00	.00	.00	.00	.00
2	2	24.00	.00	.00	.00	.00	.00	.00	.00
0	3	336.00	.00	6.93	310.93	.00	.00	4968.00	.00
-2	1	134.42	.00	.00	1396.80	.00	.00	993.60	.00

Table 8 . Average densities (g./sq.m.) of selected organisms estimated along transect line at Cape Sitkinak in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
2	3	50.67	.00	.00	13.87	.00	.00	.00	.00
0	13	7.26	10.09	.00	16.37	.00	3.08	.00	132.92
-2	6	.01	21.07	.00	.00	.00	.00	.00	29.60

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
2	3	.00	.00	.00	.00	.00	.00	.00	.00
0	13	.00	589.78	.00	.00	.00	.00	.00	.00
-2	6	2.93	1590.67	6.40	.00	.00	77.87	.00	.00

Table 9. Average densities (g./sq.m.) of selected organisms estimated along transect line at Dolina Pt. in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
4	4	30.40	10.25	.00	7.21	.00	.00	.00	320.05
2	21	82.21	234.25	8.38	14.41	.00	.00	.92	163.72
0	2	..01	15.20	12.05	16.00	15.20	.00	.01	46.40

Elev.	No. of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
4	4	.00	60.83	1152.40	.00	.00	418.23	.00	.00
2	21	.35	223.38	183.70	126.48	.00	4.63	.00	93.82
0	2	91.20	1438.40	109.60	186.40	.00	.01	2700.00	.00

Table 10. Average densities (g./sq.m.) of selected organisms estimated along transect line #1 at Lagoon Pt. in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Ondonthalia
4	2	45.60	2820.00	4.80	8.00	.00	.00	15867.21	159.20
2	1	24.00	1228.80	.00	.00	.00	35.20	12.80	2952.00
0	6	1.60	.00	50.14	.00	376.00	13.34	12.00	83.20
-2	6	.00	.00	.00	.00	.00	.00	3.73	9.87
-4	1	.00	.00	.00	.00	.00	.00	.00	.00

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
4	2	16.00	.00	79.20	.00	.00	.00	.00	.00
2	1	64.00	.00	308.80	.00	33.60	.00	238.40	.00
0	6	434.41	.00	395.20	.00	213.33	.00	3714.13	.00
-2	6	5.60	.00	31.20	4.27	13.60	.00	2147.20	1446.14
-4	1	.00	.00	.00	.00	12.80	.00	.00	18524.80

Table 11. Average densities (g./sq.m.) of selected organisms estimated along transect line #2 at Lagoon Pt. in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Odonthalia
6	1	27.20	.00	.00	.00	.00	.00	.00	.00
4	2	13.60	.00	.00	.00	.00	.00	187.20	.00
2	6	7.21	326.93	327.29	.00	186.40	245.69	3.20	63.20
0	3	.01	30.93	35.21	.00	151.47	5.87	.01	64.00
-2	4	.00	.00	26.00	.00	.00	.00	.00	7.60

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	1	.00	.00	.00	.00	.00	.00	.00	.00
4	2	.00	.00	296.00	.00	.00	.00	.00	.00
2	6	818.75	.00	3063.20	30.13	2.40	.00	6.67	.00
0	3	618.67	.00	3677.87	232.00	346.13	.00	4522.13	.00
-2	4	.00	.00	32.80	.00	94.80	.00	11879.20	2190.40

Table 12. Average densities (g./sq.m.) of selected organisms estimated along transect line #3 at Lagoon Pt. in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Odonthalia
4	1	.00	.00	.00	.00	.00	.00	.00	.00
2	2	1.60	.01	.00	.00	.00	.00	.00	.00
0	3	.53	.00	440.53	.00	69.33	30.40	.00	.00
-2	3	.00	.00	29.87	.00	.00	.00	.00	372.27

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
4	1	.00	.00	.00	.00	.00	.00	.00	.00
2	2	.00	.00	.00	.00	.00	.00	.00	.00
0	3	194.67	.00	536.53	293.33	28.27	.00	1708.80	5376.00
-2	3	.01	.00	32.00	.00	52.80	.00	12695.47	85.87

Table 13. Average densities (g./sq.m.) of selected organisms estimated along transect line at Low Cape in May 1976. Data are summarized by 2 foot elevation intervals.

Elev.	No. of Obs.	Littorina sitkana	Fucus	Parenchy. Greens	Collisella pelta	Spongo-morpha	Halosaccion	Mytilus edulis	Odonthalia
6	2	10.75	.25	.00	.05	.00	.00	2.85	8.35
4	3	19.10	1.00	.00	.33	.00	.00	.67	67.70
2	3	12.57	.27	.00	.03	.00	.00	100.63	108.93
0	2	.05	.00	.00	.40	.00	.00	.05	37.50
-2	1	.00	.00	.00	.00	.00	.00	.00	.00

Elev.	No.of Obs.	Rhodymenia	Rhodomela	Balanus cariosus	Sponges	Katharina tunicata	Phyllo-spadix	Alaria	Laminaria
6	2	.00	.00	.00	.00	.00	.00	.00	.00
4	3	.00	9.13	1.17	.00	.00	.00	.00	.00
2	3	.00	300.27	291.83	1.70	.00	.00	.00	.77
0	2	.00	215.25	139.85	5.90	.00	.00	.00	.00
-2	1	.00	809.10	.00	.00	.00	.00	.00	.00

Annual Report for the Period April 1, 1976, to March 31, 1977
RU-174, Baseline Studies of Demersal Resources of the Gulf of Alaska Shelf and Slope: A Historical Review

I. Summary of Objectives and Conclusions

A. Objectives

To review and analyze existing baseline data sources on the distribution, abundance, and productivity of demersal fish and shellfish from Unimak Pass to Cape Spencer.

B. Conclusions

Not applicable at present.

II. Introduction

A. General nature and scope of study

1. Analysis of existing historical survey data at Northwest and Alaska Fisheries Center to provide (a) species composition and biomass estimates by area, depth, and time; (b) charts showing the distribution and relative abundance (catch in weight per unit area) of the major fish and shellfish species; and (c) average length and length composition of major species.

2. Domestic and foreign fisheries statistics will be examined for historical changes in the magnitude of catches by species and fishing grounds and the location of important fishing areas.

3. Exploratory fishing records will be analyzed to determine the location and relative abundance of commercially important marine fish and shellfish resources.

B. Specific objectives

1. Charts will be prepared to show:

a. The distribution and relative abundance of prominent species as determined from baseline survey data

b. The historical distribution of commercial catches by species and species groups.

2. Biomass estimates will be prepared for important species including, insofar as data are available:

a. Walleye pollock (*Theragra chalcogramma*)
b. Rock sole (*Lepidopsetta bilineata*)
c. Flathead sole (*Hippoglossoides elassadon*)
d. Pacific halibut (*Hippoglossus stenolepis*)

e. Arrowtooth flounder (turbot) (Atheresthes stomias)
f. King crabs (Paralithodes, Lithodes)
g. Snow crabs (Chionoecetes)

C. Relevance to problems of petroleum development

The study area, which spans approximately 2,000 kilometers, is an important area for commercial fishing. The results of this study will be presented to BLM/OCSEAP in September 1977 as a contribution toward the preparation of an environmental impact statement by the Bureau of Land Management on the effects of petroleum development.

III. Current State of Knowledge

A comprehensive systematic survey of demersal resources in the Northern Gulf of Alaska was completed from 1961 through 1963 by the International Pacific Halibut Commission with cooperation by the (then) U.S. Bureau of Commercial Fisheries. During the years since 1963, large fisheries by Japan and the U.S.S.R. have brought considerable fishing pressure upon the demersal resources. Fishery scientists from the United States, Japan, and the U.S.S.R. have agreed informally that some of these resources have been endangered by the increased fishing effort during the past 15 years.

IV. Study Area

The study area includes that part of the northern Gulf of Alaska between Unimak Pass (165°30'W long) and Cape Spencer (136°30'W long). Bottom depths included in the study area range from nearshore to approximately 400 m and are being considered by three zones:

0-100 m (0-54 fathoms), 101-200 m (55-109 fathoms), and 201-400 m (110-218 fathoms).

V. Sources, Methods, and Rationale of Data Collection

No new data or samples are to be collected in this study.

Existing literature and data on the distribution, abundance, and productivity of demersal fishes and shellfishes from the study area will be reviewed and analyzed. Data sources will include trawl survey data and exploratory fishing results from National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries) and the International Pacific Halibut Commission (IPHC) cruises as well as domestic and foreign catch records.

The entire study area from Unimak Pass (165°30'W) to Cape Spencer (136°30'W) has come under consideration for the final report and will be analyzed according to the following subareas:

Name	Limits
Fairweather	136°30'W to 140°W
Yakutat	140°W to 144°30'W
Prince William	144°30'W to 148°W
Kenai	148°W to 151°W
Kodiak	151°W to 154°W
Chirikof	154°W to 158°W
Shumagin	158°W to 161°W
Sanak	161°W to 165°30'W
Shelikof	N of 57°N and W of 152°20'W

VI. Results

A comprehensive report summarizing the distribution, relative abundance, and biomass estimates of the principal species of demersal fish and shellfish in the Gulf of Alaska from the Semidi Islands to Yakutat Bay was completed and submitted to the OCSEAP Juneau Office during October 1976. The results of the above report will be incorporated with the 1977 data analysis and submitted as the final RU 174 report in September 1977.

Four interim reports have also been prepared and copies are attached. The titles of these reports are as follows:

1. Areas of importance to commercial fisheries by the United States and Japan in the vicinity of Kodiak Island, Alaska.

2. Japanese fish catches in the area of the test site at 59°45'N-143°00'W.

3. The age composition and growth of seven species of demersal fish from the eastern Gulf of Alaska.

4. Japanese fishing catch, effort, and catch per unit of effort by $1^\circ x \frac{1}{2}^\circ$ squares in the NEGOA lease area.

IPHC and NMFS survey data have been checked for accuracy, keypunched, and the punched data verified. Ninety percent of these data are now loaded onto disk files for analysis. Exploratory fishing survey data are 80 percent analyzed for species composition and mean catch rates. Computer plots of species concentrations located during exploratory fishing survey are just beginning. Species composition, distribution, relative abundance, biomass, and size composition data analysis for the IPHC and NMFS surveys are 60 percent completed. Species distributional plots are 40 percent completed and size composition plots just starting.

Records of commercial catches by U.S. and Japanese fishermen have been reanalyzed according to new and revised area designations and are 75 percent complete. Specific areas of particular importance to fisheries have been determined and now need to be plotted on charts for graphic presentation.

VII. Discussion

None at this time.

VIII. Conclusions

Not appropriate at this time.

IX. Need for Further Study

A recent NMFS survey during the winter of 1977 in the Kodiak area will not be included in the data analyzed in the final report.

X. Summary of Fourth Quarter Operations

A. Ship or laboratory activities

1. Ship or field trip schedule

   Not appropriate.

2. Scientific party

   Not appropriate.

3. Methods

Historical survey data on ADP cards were transferred to disk for compiling and analysis. Computer programs were used to provide (a) species composition and biomass estimates by area, depth stratum, and season (where practicable); (b) charts showing the distribution and relative abundance (catch in weight per unit of area) of the major fish and shellfish species; and (c) mean length and length composition of major species.

Biomass estimates will be made using the "area swept" technique described by Alverson and Pereyra (1969).

Domestic and foreign fisheries catch statistics have been examined to determine changes in magnitude of catches by species and area and to determine important locations to commercial fisheries.

4. Sample localities

   Not appropriate.

5. Data collected or analyzed

Eighty percent of the data for the Unimak Pass to Semidi Islands and Yakutat Bay to Cape Spencer areas were loaded onto disk files. Species composition, distribution, abundance, biomass, and size composition data analysis are 60 percent completed; species distribution plots are 40 percent completed.

Completion of the domestic and foreign catch statistics analysis is at 75 percent, and specific areas of high fisheries yield have been determined.

6. Milestone chart and data submission scheduled

   a. Milestone chart is attached.

   b. Final report will be submitted in September 1977.

B. Problems encountered

   None.

C. Estimate of funds expended will be given elsewhere.

Figure 1.--Major task activities and milestones, October 1, 1976 - September 30, 1977[1/]

		1976			1977								
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept
Historical Data Inventory	A	X----	----	----	----	----	----	----X					
Data Preparation & Analysis	A	X----	----	----	----	----	----	----	----	----	----X		
Final Report Preparation	A									X----	----	----	----X
Completion of Historical Data Report	E												X
Submission of Quarterly Reports[2/]	E		X			X			X				X

*1/ This chart will be updated quarterly.

*2/ Reports will be submitted to the OCSEAP office by the first day of January, April, July, and October.

References

Alverson, D.L., and W.T. Pereyra

1969. Demersal fish explorations in the northeastern Pacific Ocean--an evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecasts. J. Fish. Res. Bd. Canada, 12(8): 1985-2001.

Research Unit RU 174
July 1-September 30, 1976

BASELINE STUDIES OF DEMERSAL RESOURCES OF THE NORTHERN GULF OF ALASKA SHELF AND SLOPE:

1. AREAS OF IMPORTANCE TO COMMERCIAL FISHERIES BY THE UNITED STATES AND JAPAN IN THE VICINITY OF KODIAK ISLAND, ALASKA

By

Dr. Walter T. Pereyra

and

Herbert H. Shippen

Areas of Importance to Commercial Fisheries by the United States and Japan in the Vicinity of Kodiak Island, Alaska

I. General Area: Kenai Peninsula to Semidi Islands (148° W. long. to 157° W. long.), excluding Cook Inlet.

II. Period Covered:

   A. United States: 1969-1975

   B. Japan: 1964-1974

III. Fisheries and Species:

   A. United States:

      1. King crabs - *Paralithodes camtschatica*, *P. platypus*, *P. brevipes*, and *Lithodes aequispina*

      2. Snow crabs (Tanner crabs) - *Chionoecetes bairdi* and *C. opilio*

      3. Dungeness crab - *Cancer magister*

      4. Shrimp - *Pandalus borealis*, *P. goniurus*, *Pandalopsis dispar*, etc.

   B. Japan:

      1. Trawl fisheries

         Arrowtooth flounder (turbot)

         Other flatfishes

         Pacific ocean perch

         Other rockfishes

         Sablefish (blackcod)

         Pacific cod

         Walleye pollock

         Other fishes

         Shrimp

2. Longline fisheries

    Sablefish (blackcod)

    Pacific ocean perch

    Other rockfishes

    Other fishes

IV. United States Fisheries

A. Data source

Records of fish and shellfish catches are available for the period from 1969-1975 as collected by the Alaska Department of Fish and Game. The poundage of king crabs, snow crabs, Dungeness crabs, and shrimp has been examined and analyzed. Fisheries not included in this report are U.S. groundfish landings which except for halibut are too insignificant to make their consideration worthwhile. The areas to which halibut catches were assigned by the International Pacific Halibut Commission were too broad to be of use in identifying important areas of production.

Catches (pounds) by the United States of crabs and shrimp for the years from 1969 through 1975 taken from the records of the Alaska Department of Fish and Game (ADF&G) are shown in Table 1. For the 6-year period shrimp (64%) was the leading product of Alaska's demersal fisheries, exceeding by a large margin the production of crabs. The production of king and snow crabs (17% each) was nearly equal during 1969-1974, while Dungeness crabs (3%) were a relatively small component of the catch.

B. Designation of commercially important areas

The ADF&G records assign each catch to a specific geographic sub-area. The most important sub-areas for each species were assumed to be those which produced approximately ½ percent or more of the total catch for the period from 1969-1975. In round numbers the following minimum catches during any one calendar year were used to designate commercially important sub-areas:

Species	Pounds minimum catch	Percent of total catch, 1969-1974	Number of sub-areas designated
Shrimp	2,000,000	0.47	17
King crab	500,000	0.44	24
Snow crab	500,000	0.45	28
Dungeness crab	100,000	0.54	18

The ADF&G sub-areas meeting the minimum catch criterion are listed in Table 2 which indicates the sub-area number, the species that was found there, the mean catch (pounds) for the years with a recorded catch, the number of such years, and the minimum and maximum catches during the six-year period.

In Table 1, last two columns, the amount and percent of the catch for each year by species from the designated important areas is compared with the total catch. For Dungeness crab the percent of total catch from the 18 commercially important sub-areas ranged from 63 to 92 with an overall mean of 86 percent. For king crabs the annual percent of total catch from the 24 designated areas ranged from 61 to 83 with a mean of 77 percent. For the snow crabs, principally C. bairdi, the 28 designated sub-areas provided from 69 to 87 percent of the annual catch with a mean of 83 percent. The percent of total shrimp catch from the 17 important sub-areas ranged from 70 to 83 percent with a mean of 77 percent.

Locations of the important commercial fishing areas for the Dungeness crab, snow crabs, king crabs, and shrimp are shown in Figures 1 through 5. There are 62 such areas in the vicinity of Kodiak Island of which 42 supply a single fishery, 15 areas provided for two fisheries, and five were important to three fisheries. No area was important to more than three fisheries.

Seasons for Alaskan fisheries are established by the Alaska Board of Fish and Game. In the area south of Cape Douglas and west of 151^{o} W. long. to a depth of 356 m and westward to 172^{o} E. long. the following seasons apply to the various fisheries: (source: Alaska 1975 Shellfish Regulations)

a. Dungeness crab - no closed season except that in the waters of Kodiak district south of the latitude of Boot Point and Cape Ikolik they may be taken from June 15 through April 30;

b. King crabs - from August 15 until closed by emergency order;

c. snow (Tanner) crabs - from November 1 through June 30 unless closed earlier by emergency order;

d. Shrimp - no closed season on shrimp fished with pots. In the waters east of the longitude of Kilokak Rocks (about 156^{o} 12' W. long.) shrimp may be taken by trawls from May 1 through February 28.

V. Japanese Fisheries

A. Data source

The Japan Fisheries Agency provides the Northwest and Alaska Fisheries Center with annual catch records of their fisheries in the North Pacific. The data are presented with respect to gear and species by 1^{o} (latitude) by $\frac{1}{2}^{o}$ (longitude) blocks. Data have been reported for the 11-year period from 1964 through 1974. Two classifications of fishing gear are made in this report, trawl and longline. Trawl gears include stern trawl, side trawl, shrimp trawl, and Danish seine. Stern trawls were employed over the entire period; side trawls were used from 1964-1966, shrimp trawls from 1964-1968, and Danish seines from 1965-1967. The longline fishery, directed principally at sablefish, began in 1967 and continues. A minor fishery employing gill nets occurred in 1969, but the species taken were not identified; this fishery took less than 100 metric tons in the single year that it operated.

B. Composition of Japanese fisheries

1. Trawl fishery - For the 11-year period from 1964-1974 the percentage composition by weight is shown in Table 3. More than 80 percent of the catch consisted of Pacific ocean perch (65%) and walleye pollock (17%).

2. Longline fishery - In the 8 years since the beginning of the Japanese longline fishery in 1967, nearly 98 percent of the catch has been sablefish (Table 4).

3. All fisheries - In the 11 years for which catch records are available, the trawl fishery has taken 92 percent of the catch and the longline fishery 8 percent. The weight composition of the total catch by species or group is indicated in Table 5.

C. Distribution of Japanese Demersal fish catches in the vicinity of Kodiak Island

1. The annual mean trawl catch in metric tons (for years with a recorded catch) for each $1^{\circ} \times \frac{1}{2}^{\circ}$ block is shown in Figure 6. The larger trawl catches were made in the blocks where the continental shelf dips down to become the upper slope. It is along this edge that the best catches of Pacific ocean perch are usually made.

2. The annual mean longline catch, predominantly sablefish, is shown in Figure 7. The mean is only for those years in which a catch was

recorded. Like the trawl catch, the blocks with the greatest mean longline catches were those which include the edge of the continental shelf. Sablefish are usually found somewhat deeper than are Pacific ocean perch.

Table 1.--Crab and shrimp catches, 148°-157° W., from 1969-1975, by U.S. fishermen[1]

Year	Species	Total Catch (Pounds)	%	Catch from commercially important areas (Pounds)	% of total
1969	Dungeness	5,861,408	9	5,251,903	90
	King	13,076,292	19	8,034,161	61
	Snow	6,862,516	10	4,723,066	69
	Shrimp	41,353,461	62	33,090,000	80
1970	Dungeness	5,741,438	6	5,288,309	92
	King	12,118,027	14	8,474,017	72
	Snow	7,712,322	9	5,450,858	71
	Shrimp	62,183,569	71	50,208,000	81
1971	Dungeness	1,445,864	1	996,677	69
	King	11,844,514	12	9,535,350	80
	Snow	7,462,784	7	6,312,423	85
	Shrimp	82,166,973	80	68,294,000	83
1972	Dungeness	2,059,536	2	1,781,088	86
	King	15,491,117	18	12,675,526	82
	Snow	12,155,571	14	10,332,220	85
	Shrimp	58,531,712	66	46,879,000	80
1973	Dungeness	2,001,842	2	1,468,826	73
	King	14,452,276	11	11,666,945	81
	Snow	32,438,086	26	28,659,801	79
	Shrimp	77,683,925	61	56,128,000	72
1974	Dungeness	750,057	1	720,091	96
	King	23,013,046	22	19,078,822	83
	Snow	27,385,959	27	22,318,217	82
	Shrimp	52,023,829	50	36,256,000	70
1975[2]	Dungeness	639,813	1	399,953	63
	King	23,997,413	25	18,755,785	78
	Snow	17,515,425	19	15,297,568	87
	Shrimp	51,958,524	55	38,325,000	74
Total (1969-1975)	Dungeness	18,499,958	3	15,906,847	86
	King	113,992,685	17	88,220,606	77
	Snow	111,532,663	17	93,094,153	83
	Shrimp	425,901,993	64	329,180,000	77

1/ Source: Alaska Department of Fish and Game

2/ Preliminary data

Table 2.--Important subareas of production of crabs and shrimp in the Alaska domestic fishery, 1969-1975.

Sub-Area[1/]	Species[2/]	Mean[3/]	No. Years[4/]	Min.[5/]	Max.[5/]
232-30	Snow	132,359	5	1,498	580,456
232-35	Snow	401,038	3	115,139	578,314
252-20	Shrimp	2,956,964	7	14,567	7,010,680
252-30	King	376,472	7	16,698	1,116,209
252-30	Shrimp	1,312,428	7	946,082	1,982,391
252-35	Dungeness	29,914	6	4,364	116,425
252-51	King	305,616	6	24,426	655,806
252-52	King	191,617	7	23,953	693,933
252-52	Snow	390,305	7	234,734	554,452
252-52	Shrimp	6,723,937	7	32,787	16,542,492
252-53	King	138,090	7	3,205	579,525
252-53	Snow	396,520	7	106,604	1,377,014
252-54	Snow	287,550	6	26,256	523,806
252-56	King	211,171	6	55,574	599,839
252-56	Shrimp	4,710,874	5	1,485,192	9,681,993
252-59	King	432,460	7	7,043	1,694,223
252-63	King	305,796	5	41,057	568,332
252-64	Snow	889,969	7	29,984	2,160,054
253-31	King	510,270	7	37,103	1,054,135
254-40	Dungeness	86,908	7	13,742	189,363
256-20	Dungeness	99,100	4	33,285	156,632
257-10	King	371,022	6	53,104	953,000
257-10	Snow	378,424	5	116	1,333,581
257-20	Dungeness	186,103	2	57,730	314,477
257-50	Shrimp	3,020,121	6	47,362	7,736,024
257-70	Dungeness	109,131	2	34,642	183,619
257-70	Snow	342,367	7	6,954	976,360
257-81	King	969,664	7	67,837	2,344,851
257-81	Snow	2,530,339	6	356,171	4,317,232
257-82	King	564,095	6	179,981	946,019
257-82	Snow	1,187,127	4	110,737	3,125,827
257-90	Dungeness	896,422	7	7,540	2,757,628
257-91	King	1,080,582	7	517,169	1,682,194
258-10	Snow	299,458	5	29,440	817,968
258-10	Shrimp	4,007,552	7	2,750,082	5,221,805
258-20	Snow	337,896	4	124,627	751,684
258-20	Shrimp	2,401,760	7	1,068,857	4,199,968
258-51	Shrimp	2,703,444	3	814,252	4,016,545
258-52	Shrimp	2,461,182	3	53,746	7,134,954
258-54	Shrimp	846,882	5	50,954	2,482,674
258-55	Shrimp	10,730,252	7	6,777,405	15,981,116
258-60	King	229,607	7	11,930	562,083
258-60	Shrimp	2,822,956	7	161,884	7,138,818

Table 2.--(continued)

Sub-Area[1/]	Species[2/]	Mean[3/]	No. Years[4/]	Min.[5/]	Max.[5/]
258-80	Dungeness	241,080	5	4,555	671,134
258-80	King	293,074	7	22,688	960,886
258-81	King	2,185,625	7	677,030	3,439,400
258-91	Shrimp	2,007,415	7	25,815	7,895,306
258-92	Dungeness	28,413	5	956	114,651
258-92	King	187,977	7	50,963	362,341
258-92	Snow	1,256,784	7	469,868	2,390,761
258-95	King	458,351	7	34,109	1,433,873
258-96	King	561,336	7	118,250	992,030
258-96	Snow	193,449	6	13,144	605,831
258-97	Snow	264,586	5	540	880,110
259-10	Snow	225,099	6	6,046	752,617
259-21	King	211,851	7	760	756,541
259-30	Dungeness	37,078	7	328	94,633
259-41	Dungeness	329,668	7	104,228	742,264
259-41	Snow	346,557	6	680	992,984
259-41	Shrimp	2,763,976	6	126,334	8,460,042
259-42	Dungeness	167,009	6	2,000	825,642
259-42	Snow	340,808	7	22,276	1,075,404
259-42	Shrimp	3,483,885	5	40,855	7,434,263
259-61	Snow	289,256	7	4,845	695,514
259-62	Snow	156,512	7	22,378	520,348
262-10	Dungeness	314,520	2	141,604	487,435
262-15	Snow	991,331	7	13,364	2,751,006
262-25	Dungeness	65,447	3	32,542	118,197
262-25	Shrimp	1,184,093	3	475,141	2,491,875
262-30	Dungeness	51,741	5	3,152	190,919
262-30	Snow	668,204	5	25,786	1,597,846
262-30	Shrimp	726,133	5	102,167	2,091,960
262-55	Dungeness	132,564	3	22,220	253,399
262-60	Dungeness	176,841	3	2,434	346,164
262-65	Dungeness	136,561	6	21,090	397,153
272-50	Shrimp	1,654,296	3	746,675	2,447,436
291-11	Snow	1,034,278	7	39,184	2,581,366
291-12	King	342,660	7	58,884	1,193,014
291-12	Snow	382,419	7	11,664	1,230,337
291-21	Snow	675,186	7	117,801	1,618,798
291-32	Snow	429,982	7	14,698	809,752
291-42	Snow	167,297	6	14,641	531,940
291-52	King	451,791	6	37,545	1,154,458
291-53	King	1,053,715	7	249,706	2,178,960
291-63	King	989,483	3	207,594	1,940,171
291-73	King	1,119,645	7	407,210	2,648,453
291-73	Snow	219,012	7	81,287	532,584

1/ Locations of these sub-areas (designated by the Alaska Department of Fish and Game) are shown on accompanying charts.

2/ Snow = snow crabs (Chionoecetes species)
King = king crabs (Paralithodes species and Lithodes aequispina)
Dungeness = Dungeness crab (Cancer magister)
Shrimp = Pandalus species, Pandolopsis dispar

Table 2.--(continued)

3/ The mean is only for those years with a recorded catch (pounds).
4/ The number of years with a recorded catch upon which the mean is based.
5/ Pounds.

Table 3.--Composition of the Japanese trawl catch in the vicinity of Kodiak Island, 1964-1974.

Species or group	Total catch (mt)	Percent
Turbot	12,924	4.3
Other flatfishes	6,919	2.3
Pacific ocean perch	195,265	64.9
Other rockfishes	2,179	0.7
Sablefish	15,998	5.3
Pacific cod	6,544	2.2
Walleye pollock	51,441	17.1
Other fishes	5,861	1.9
Shrimp	3,765	1.3
Total	300,896	100.0

Table 4.--Composition of the Japanese long line catch in the vicinity of Kodiak Island, 1967-1974.

Species or group	Total catch (mt)	Percent
Sablefish	25,951	97.9
Pacific ocean perch	68	0.3
Other rockfishes	116	0.4
Other fishes	367	1.4
Total	26,502	100.0

Table 5.--Composition of Japanese fish catches in the vicinity of Kodiak Island, all gears, 1964-1974.

Species or group	Total catch (mt)	Percent
Turbot	12,924	3.9
Other flatfishes	6,919	2.1
Pacific ocean perch	195,333	59.7
Other rockfishes	2,295	0.7
Sablefish	41,949	12.8
Pacific cod	6,544	2.0
Walleye pollock	51,441	15.7
Other fishes	6,228	1.9
Shrimp	3,765	1.1
Total	327,398	99.9

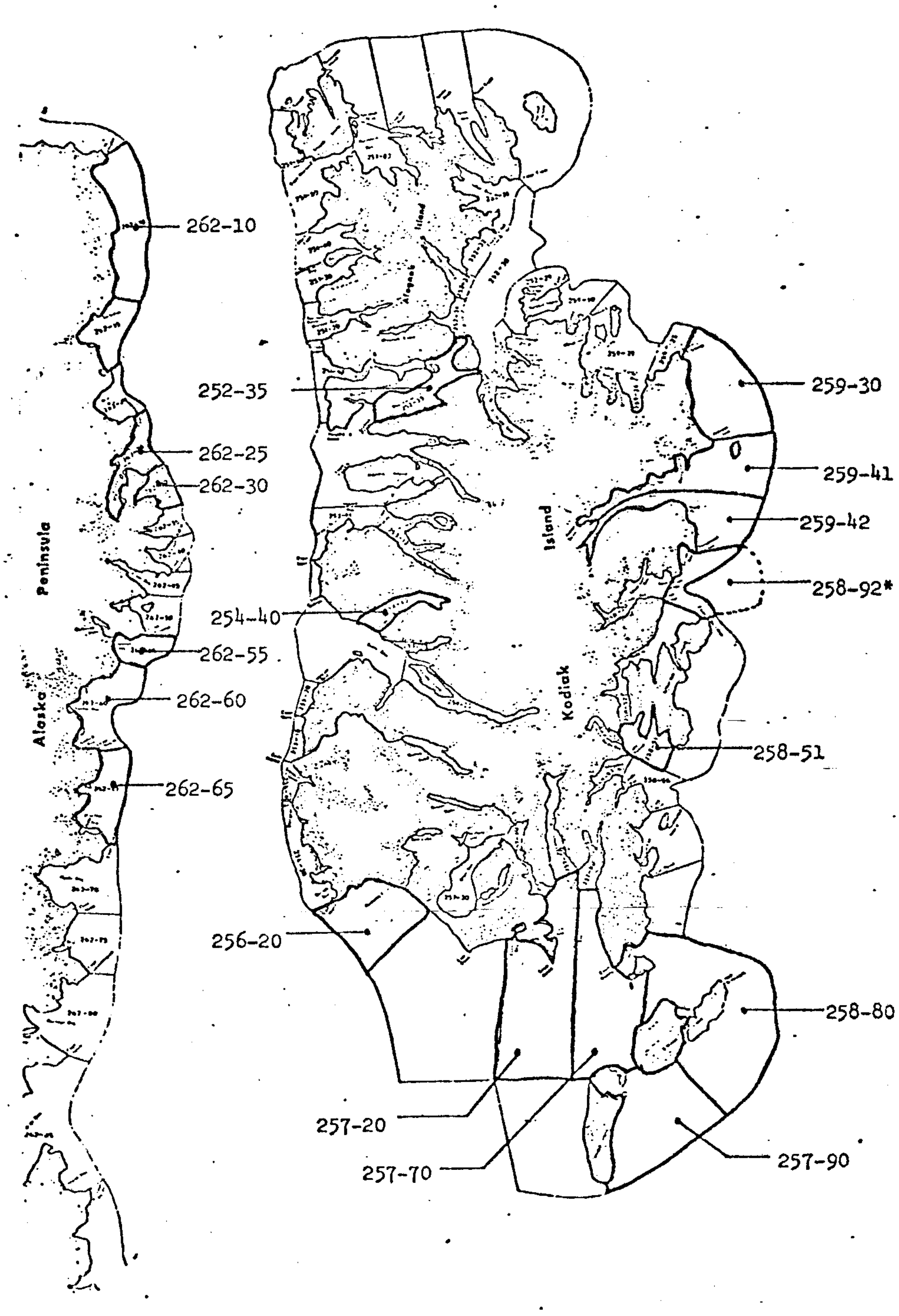

Figure 1 .-- Locations of important commercial fishing areas for Dungeness crabs in the vicinity of Kodiak Island

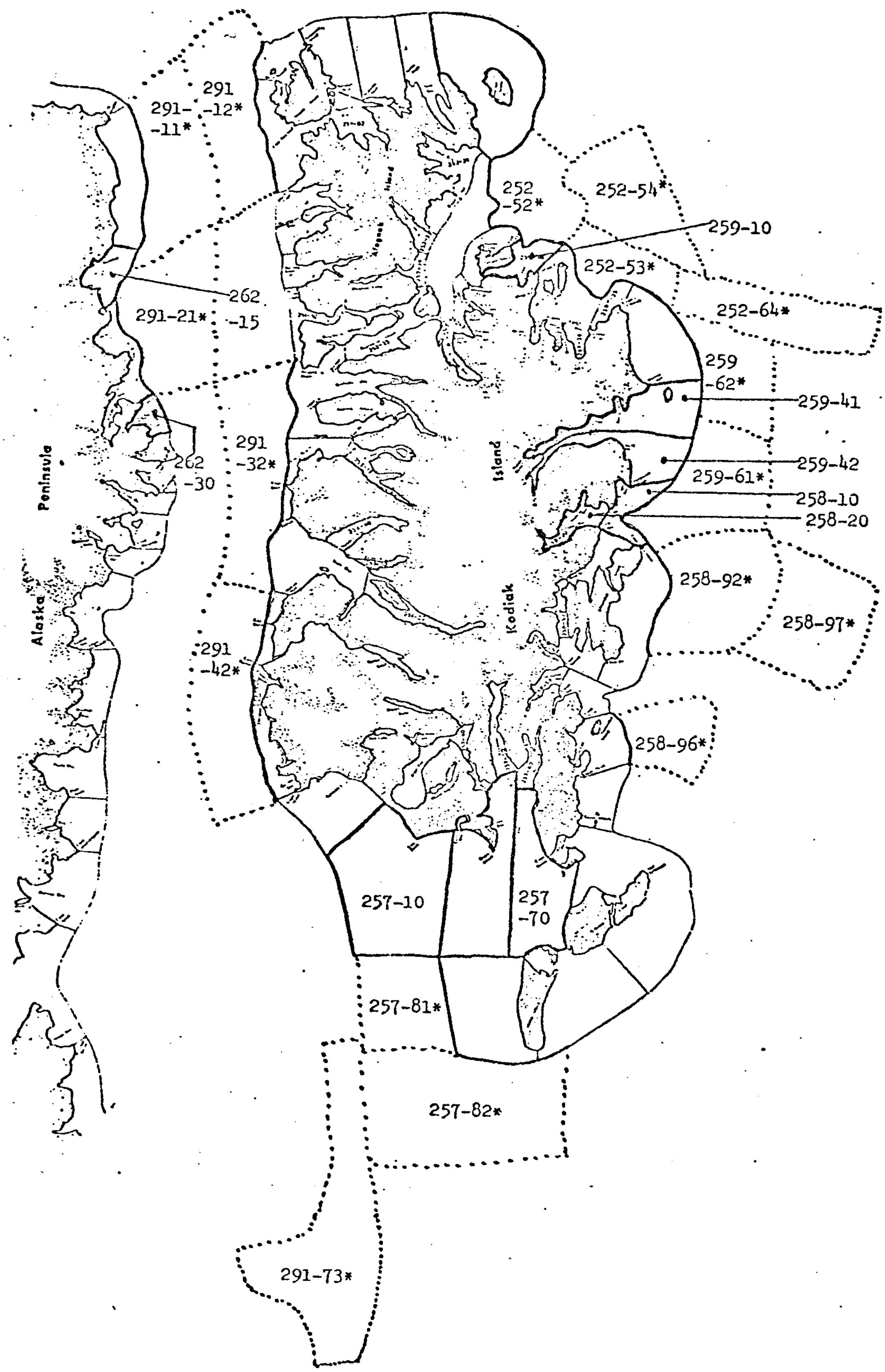

Figure 2 .-- Locations of important commercial fishing areas for snow crabs in the vicinity of Kodiak Island

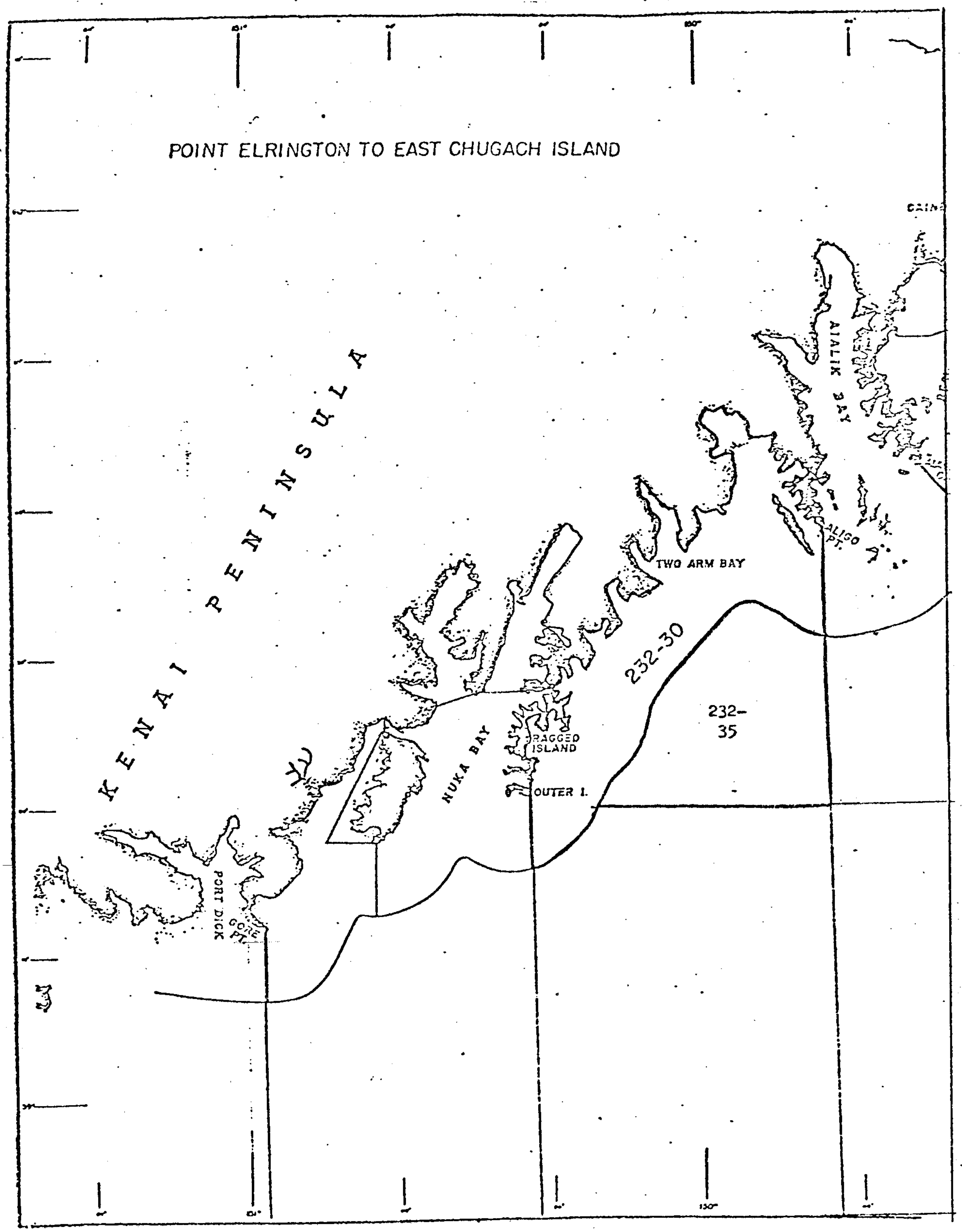

Figure 3 .--Locations of important commercial fishing areas for snow (tanner) crabs on the Kenai Peninsula

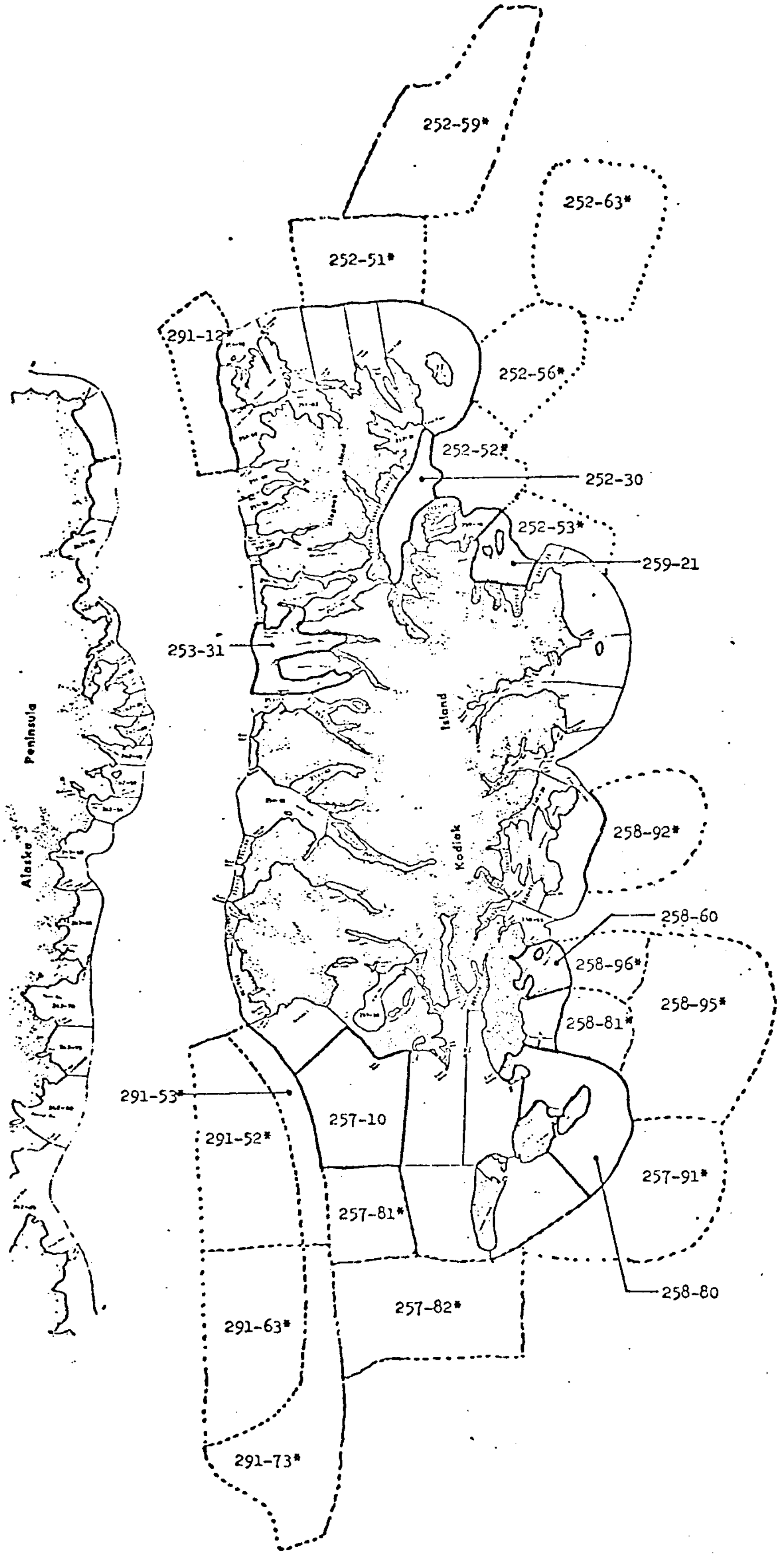

Figure 4 .--Locations of important commercial fishing areas for king crabs in the vicinity of Kodiak Island

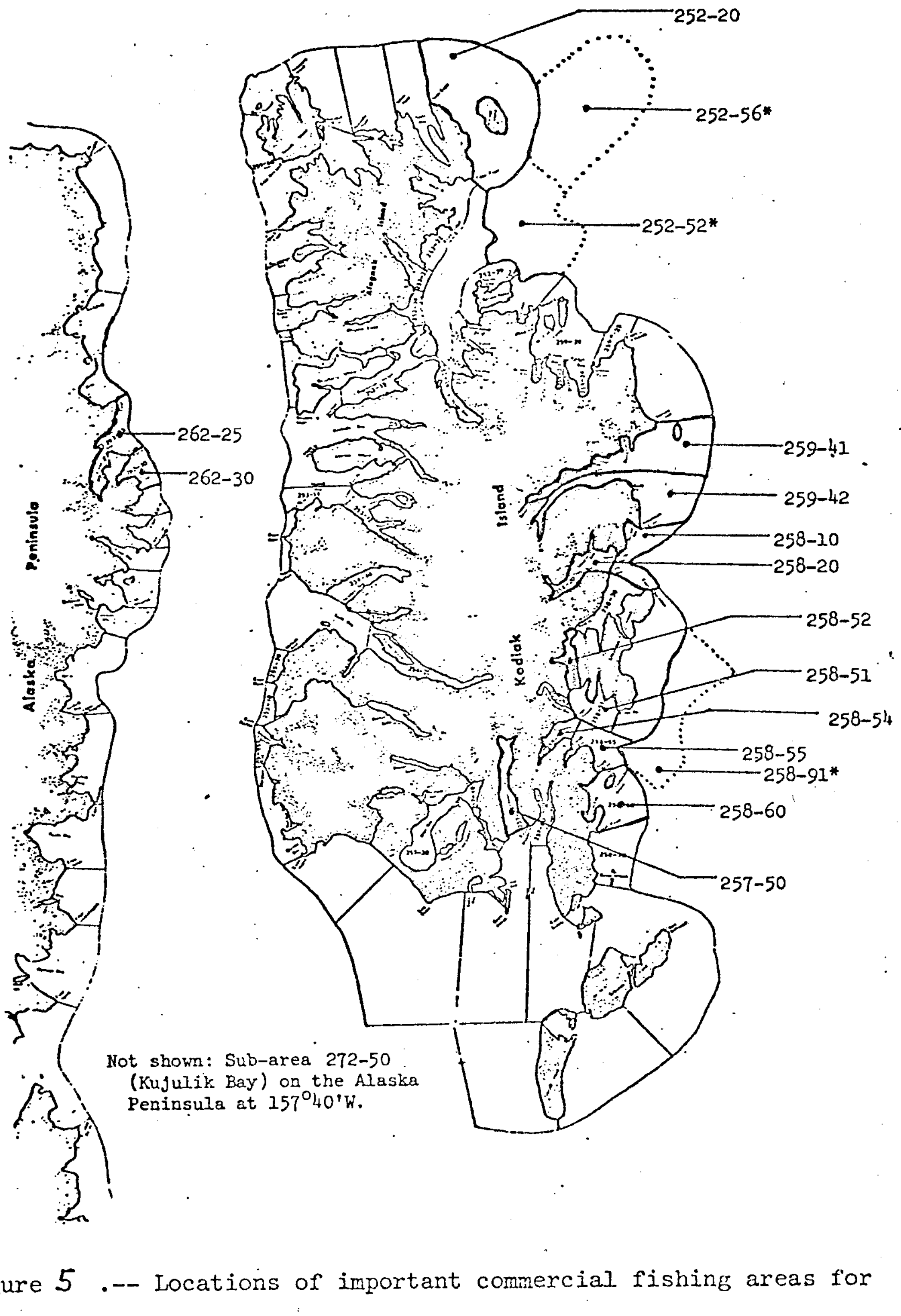

Figure 5 .-- Locations of important commercial fishing areas for shrimp in the vicinity of Kodiak Island

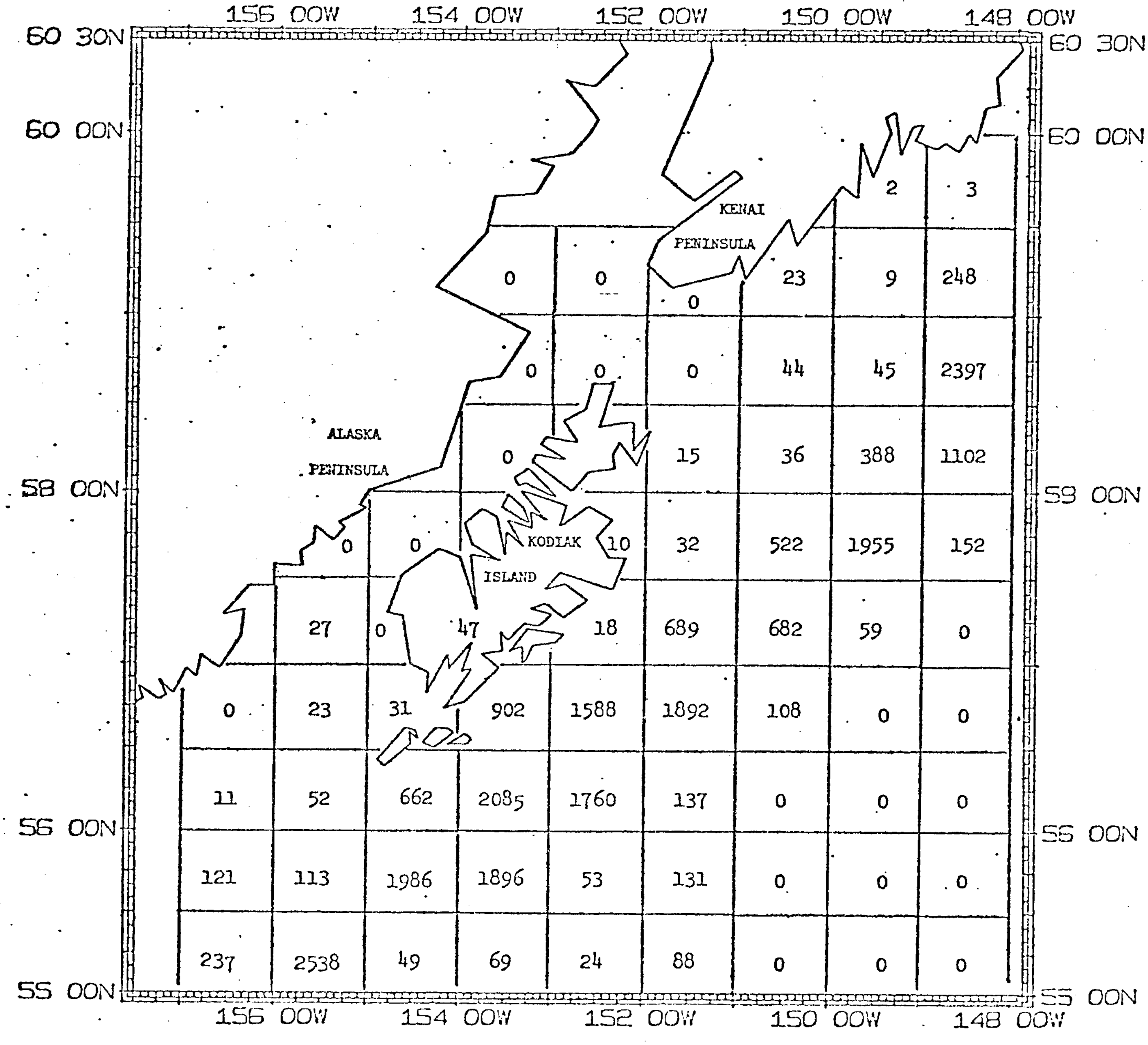

Figure 6 .—Japanese demersal fish catch, trawl gear, in metric tons. Mean for the years 1964-1974.

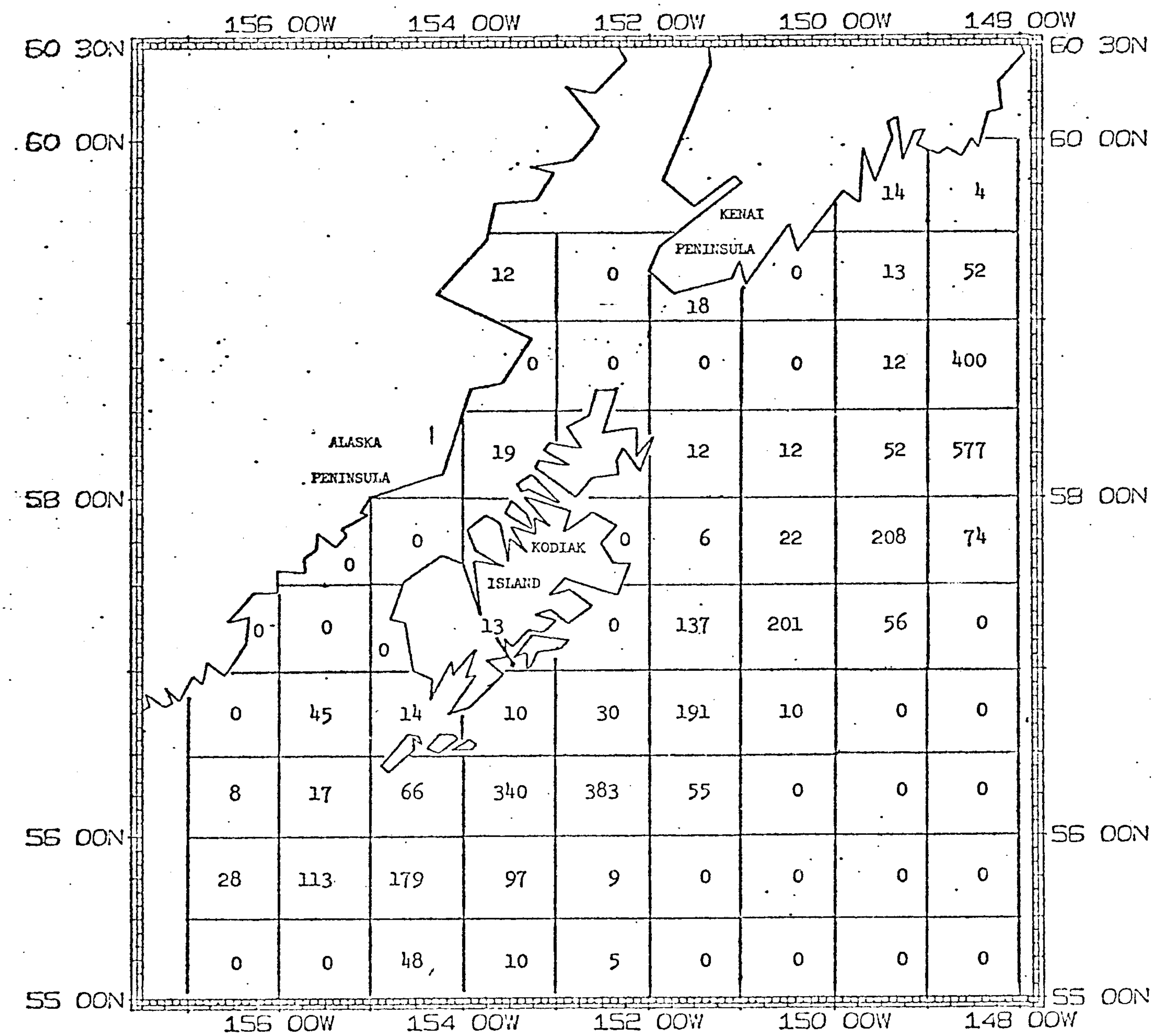

Figure 7 .—Japanese demersal fish catch, longline gear, in metric tons. Mean for the years 1967 -1974.

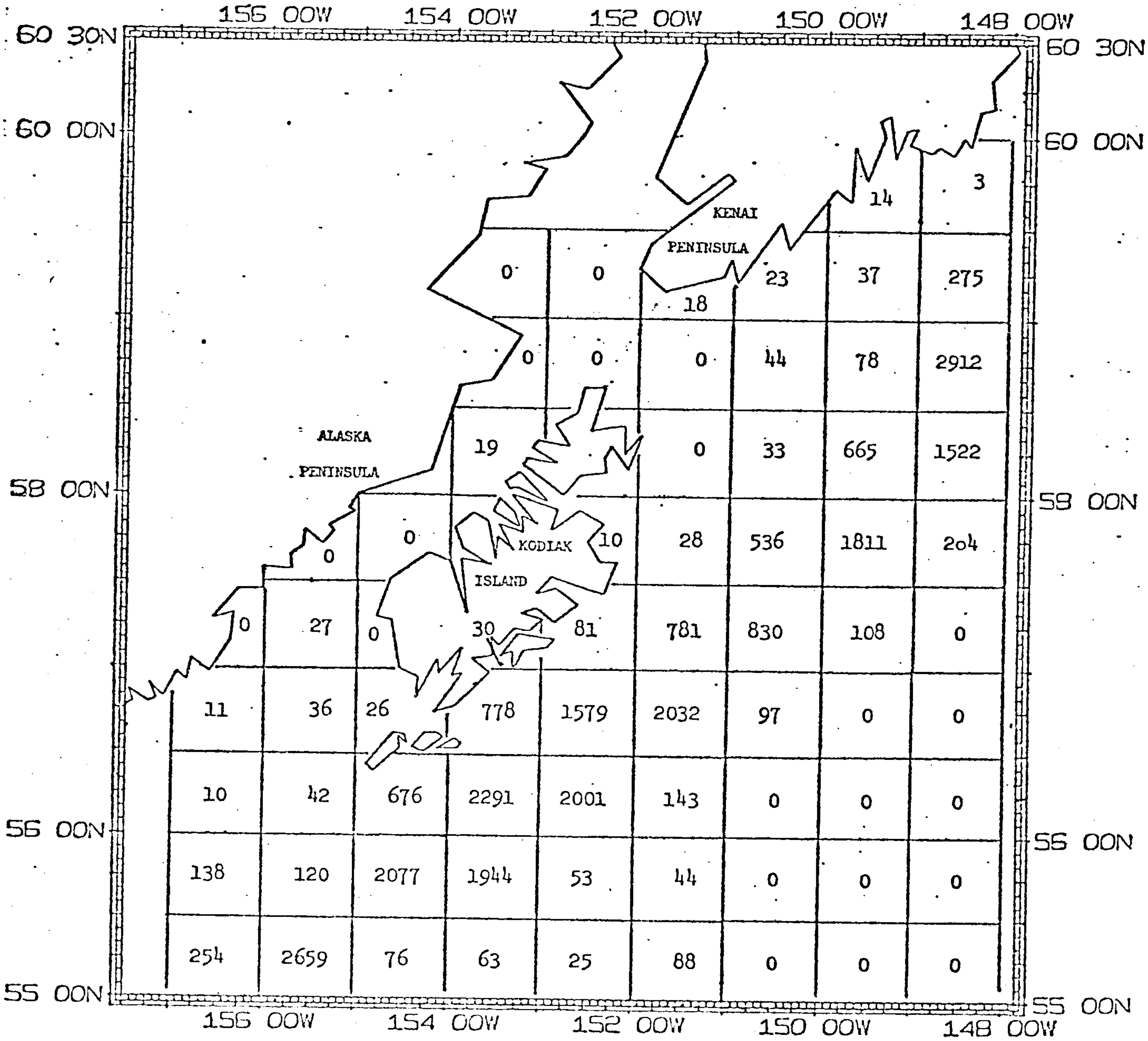

Figure 8 .--Japanese demersal fish catch, all species and gears, in metric tons. Mean for the years 1964-1974.

BASELINE STUDIES OF THE DEMERSAL RESOURCES OF THE EASTERN AND WESTERN GULF OF ALASKA SHELF AND SLOPE: 2. JAPANESE FISH CATCHES IN THE AREA OF THE TEST SITE AT 59°45'N.-143°00'W.

RU 174

by Herbert H. Shippen

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National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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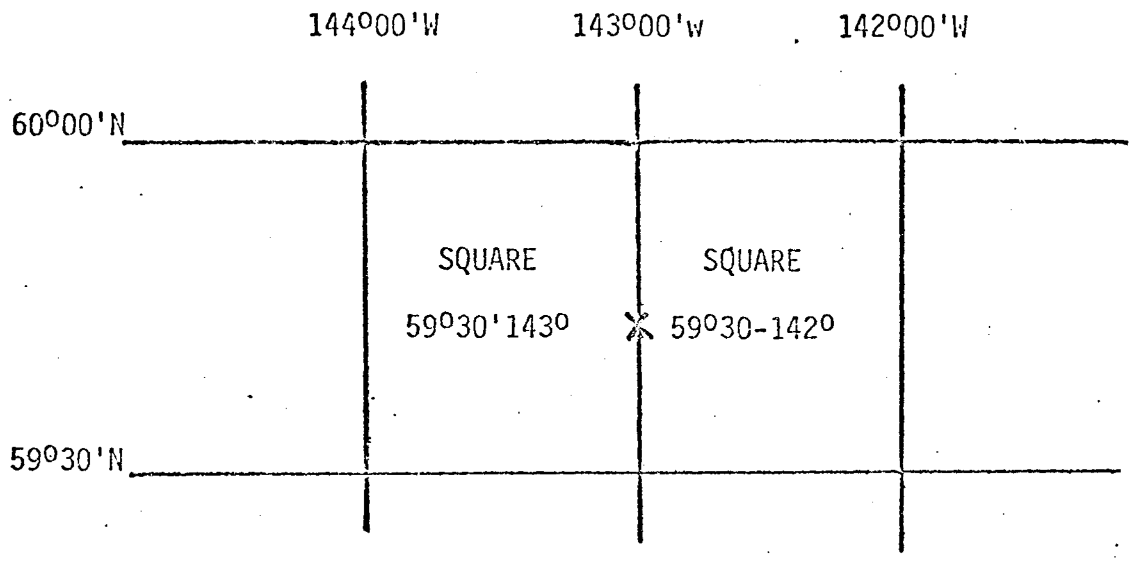
JAPANESE FISH CATCHES IN THE AREA OF THE TEST SITE AT 59°45'N.-143°00'W.

Japanese fish catches are tabulated within 1° (long.) x ½° (lat.) squares. The test site at 59°45'N.-143°00'W. falls on the border between two such squares, 59°30'-142° and 59°30'-143° (Figure 1).

Catches (metric tons) for 11 years from 1964-1974 are presented by the following species or groups: Arrowtooth flounder or turbot (Atheresthes stomias), Table 1; other flatfishes, Table 2; Pacific ocean perch (Sebastes alutus), Table 3; other rockfishes, Table 4; sablefish or blackcod (Anoplopoma fimbria), Table 5; Pacific cod (Gadus macrocephalus), Table 6; and Pacific pollock (Theragra chalcogramma), Table 7.

Summary tables show the species composition by weight for the two squares combined, Table 8 and the distribution of the total catch between the two squares, Table 9.



X = Test Site (59°45'N. - 143°00'W.)

Figure 1.--Relationship of statistical areas to test drilling site.

Table 1.--Japanese catch of turbot (*A. stomias*) by statistical square, 1964-1974.

Year	Square: 59°30'-142° (mt)	Square: 59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	0	0
1966	0	22	22
1967	48	55	103
1968	54	173	227
1969	37	28	65
1970	32	74	106
1971	5	27	32
1972	0	15	15
1973	29	699	728
1974	49	101	150
Total	254	1,194	1,448

Table 2.--Japanese catch of other flatfishes by statistical square, 1964-1974.

Year	Square 59°30'-142° (mt)	Square 59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	15	15
1966	0	3	3
1967	10	11	21
1968	1	5	6
1969	0	1	1
1970	1	14	15
1971	0	0	0
1972	16	7	23
1973	106	666	772
1974	54	108	162
Total	188	830	1,018

Table 3.--Japanese catch of Pacific ocean perch (*S. alutus*) by statistical square, 1964-1974.

Year	Square: 59°30'-142° (mt)	Square: 59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	13	13
1966	0	43	43
1967	530	792	1,322
1968	1,308	4,400	5,708
1969	556	1,882	2,438
1970	230	1,314	1,544
1971	150	758	908
1972	387	1,025	1,412
1973	446	2,322	2,768
1974	317	1,194	1,511
Total	3,924	13,743	17,667

Table 4.--Japanese catch of other rockfishes than POP by statistical square, 1964-1974.

Year	Square: 59°30'-142° (mt)	Square: 59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	0	0
1966	0	0	0
1967	24	0	24
1968	82	102	184
1969	92	44	136
1970	0	12	12
1971	66	14	80
1972	4	56	60
1973	--	--	--
1974	144	153	297
Total	412	381	793

Table 5.--Japanese catch of sablefish or blackcod (*A. fimbria*) by statistical squares, 1964-1974.

Year	Square 59°30'-142° (mt)	59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	1	1
1966	0	4	4
1967	62	99	161
1968	349	547	896
1969	398	272	670
1970	253	380	633
1971	245	234	479
1972	159	542	701
1973	208	772	980
1974	205	307	512
Total	1,879	3,158	5,037

Table 6.--Japanese catch of Pacific cod (*Gadus macrocephalus* by statistical squares, 1964-1974.

Year	Square 59°30'-142° (mt)	59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	0	0
1966	0	0	0
1967	1	8	9
1968	16	79	95
1969	6	7	13
1970	0	19	19
1971	0	5	5
1972	1	5	6
1973	8	137	145
1974	14	45	59
Total	46	305	351

Table 7.--Japanese catch of Pacific pollock (*Theragra chalcogramma*) by statistical square, 1964-1974.

Year	Square 59°30'-142° (mt)	59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	0	0
1966	0	6	6
1967	117	128	245
1968	128	598	726
1969	47	428	475
1970	1	25	26
1971	0	73	73
1972	7	649	656
1973	9	252	261
1974	1	124	125
Total	310	2,283	2,593

Table 8.--Species composition of Japanese catches in statistical squares 59°30'-142° and 59°30'-143°, 1964-1974.

Species	Catch	Percent
	(mt)	
Turbot	1,448	4.8
Other flatfishes	1,018	3.4
Pacific ocean perch	17,667	58.4
Other rockfishes	793	2.6
Sablefish (Blackcod)	5,037	16.7
Pacific cod	351	1.2
Pacific pollock	2,593	8.6
Others	1,325	4.4
Total	30,232	100.1

Table 9.--Japanese total catch for all species, 1964-1974.

Year	Square		
	59°30'-142° (mt)	59°30'-143° (mt)	Total (mt)
1964	0	0	0
1965	0	29	29
1966	0	78	78
1967	792	1,093	1,885
1968	1,983	6,152	8,135
1969	1,157	2,705	3,862
1970	549	1,850	2,399
1971	576	1,298	1,874
1972	594	2,352	2,946
1973	933	5,184	6,117
1974	820	2,087	2,907
Total	7,404 25%	22,828 75%	30,232 100%

Research Unit RU 174
July 1-September 30, 1976

BASELINE STUDIES OF DEMERSAL RESOURCES OF THE NORTHERN GULF OF ALASKA SHELF AND SLOPE:

THE AGE COMPOSITION AND GROWTH OF SEVEN SPECIES OF DEMERSAL FISH FROM THE EASTERN GULF OF ALASKA

by

Dr. Walter T. Pereyra

George Hirschhorn

and

Lael L. Ronholt

Growth information collected during the 1975 Northeastern Gulf of Alaska (NEGOA) survey was analyzed for the following species: turbot (Atheresthes stomias), Dover sole (Microstomus pacificus), rex sole (Glyptocephalus zachirus), flathead sole (Hippoglossoides elassodon), Pacific ocean perch (Sebastes alutus), Pacific cod (Gadus macrocephalus) and walleye pollock (Theragra chalcogramma).

Materials and Methods

The age structures collected for these species were otoliths, except for Pacific cod (scales). The collection was a stratified subsample of the length sample with a target of 5 age structures per cm, sex and stratum. The age length key includes age-length data of fish, 20 cm and over, originating in 9 strata (Figure 1). The length frequency distribution to which each such key was applied represents the sum of estimated numbers of fish over 19 cm present in the fishable biomass in Strata 1-9. However, in sampling these strata during 1975, pollock and Pacific cod were not encountered in Stratum 6 (central area, 201-400 m), nor was Pacific ocean perch found in Strata 1 and 7 (eastern area, 1-100 m and western area, 1-100 m).

Applying the proportions at age by cm from the key to the length frequencies provides estimates of numbers of fish in the fishable population by size and age. Summing these by age provided estimates of age composition by species and sex (Table 1). Departures in the totals shown from 100% are due to rounding. The corresponding values of numbers of fish can be found in Ronholt, Shippen and Brown (1976).

The length frequencies at age also provide estimates of mean lengths at age. These are shown in Table 2 for each age within the observed length range. (Lengths shown as integer numbers were based on a single age-length observation.) All mean lengths at age available for each sex and species were fitted by von Bertalanffy parameters (L_∞, k, t_0) using the fitting procedure of Fabens (1965); these estimates are given in Table 3, part 1, labelled "All data points used." These parameter estimates are likely to be affected by gear selection in the case of incoming age groups; they are additionally affected, at high ages, by very low numbers aged (sometimes a single animal). Visual inspection of Figure 2 suggests that a line fitted through all observed data points (dots) would reach length 0 at some negative age in the majority of cases.

The importance of accurate size data at young ages in von Bertalanffy curve fittings was discussed by Fabens (1965), who suggested use of values near 0 corresponding to age 0 if necessary. In the absence of such information we added a data pair ascribing length 0 to age 0. Further, we omitted mean lengths for ages based on fewer than 10 aged individuals. We also followed the practice of considering age groups comprising the left (ascending) limb of the catch curve (frequencies at age) as incompletely recruited and omitted the size information for such age groups as being possibly biased. The parameters obtained from data sets altered in this manner are shown in Table 3, part 2 labelled "Altered Data Set Used."

The parameter estimates from the altered data sets are shown as smooth curves in Figure 2 against which the means at all ages (dots) can be compared. Modal ages are indicated by circles drawn around dots showing their mean length; to the left of these, the deviations of lengths at younger ages are seen as upward in direction from the fitted curve in the majority of cases.

An additional use of parameters from data sets altered in this manner may lie in relating growth parameters to real time measurements of environmental factors, e.g. population density. In such cases it may be desirable to compare estimates of L_∞ and k, which are unaffected by widely varying values of t_o. As shown in Table 3, the values of t_o are substantially closer to 0 than those computed from the original data sets. Also, the associated standard deviations from fit are generally smaller.

Results

As shown in Table 3, the standard deviations from the fitted curves differ substantially between species and, in many cases, between sexes within species. Their magnitude is generally higher in fittings to the raw data, than to altered data sets. Possible reasons for this were discussed above.

In most comparisons between sexes a dimorphism between males and females is apparent. The females are characterized by higher values of asymptotic length (L_∞) and lower values of growth completion rate (k) than the males of a given species. An exception to this appears from the data collected for Pacific ocean perch; however, the associated departures from fit are among the highest found in any of the 7 species included in Table 3.

Considering the results of fitting the altered data sets, those for Dover sole are based on a very small range of age groups but appear comparable to results from more southerly populations, cf. Demory (1972), Hagermann (1952). Parameter sets for turbot, rex sole and flathead sole are associated with relatively small departures from fit, and the number of individuals aged from each species was ca. 600 or greater. By contrast, the curve fits for Pacific cod and for Pacific ocean perch females were based on fewer than 100 age determinations and were probably less representative on that account. The parameter sets obtained for Pacific cod are comparable to estimates based on Ketchen's (1964) data for Pacific cod males.

The parameter sets for walleye pollock are associated with relatively high standard deviations from fit, although the number sampled of each sex was relatively large (ca. 500). The largest departures in mean length from expectation at (fully recruited) ages appeared highest at age 5 in males, and ages 8 and 9 in females. The associated age composition data were bimodal in both sexes (Table 1).

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Table 1.--Estimated age composition by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age 0														
1											8			
2	1	1[1/]									65	72	9	9
3	21	19	2	1	2	2			1		23	21	44	22
4	30	25	6	1	12	15	7	10	8	18	4	6	17	16
5	31	20	13	8	24	12	12	11	19	34			23	32
6	10	12	24	7	32	30	16	10	20	10			2	5
7	4	7	26	15	13	18	18	19	11	7			2	4
8	2	5	21	14	8	7	15	10	6	8			2	5
9	1	4	5	18	6	3	5	13	2	2			1	2
10		2	4	15	1	6	5	7	8	3				2
11		2		8	1	3	5	8	8	6				1
12		1		9	1	1	2	2	10	7				1
13		1		3		1	2	2	5	4				
14		1		2		1	3	3	2	2				
15							2	2						
16							3	1						
17							1	2						
18							1	1						
19							1	1						
Total %	100	100	101	101	100	99	98	102	100	101	100	99	100	99
Total Aged	530	795	150	251	274	307	304	304	158	97	58	84	452	554

1/ Rounded to nearest percent.

Table 2.--Mean length at age by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age 0														
1											35.12	29.48	22[1]	
2	20.00	21.94									44.49	44.49	26.32	25.95
3	23.49	23.58	26.38	28.03	21.47	21.96			21		56.81	59.63	31.60	32.47
4	29.13	29.14	29.30	26.96	22.79	23.37	21.70	22.50	22.92	22.92	68.16	73.53	35.08	38.23
5	33.78	35.32	28.23	31.80	26.81	26.92	23.57	23.94	25.75	25.60	77		37.43	40.89
6	37.56	40.66	34.36	33.84	28.58	29.43	27.17	30.29	25.92	27.12			43.57	45.91
7	39.99	45.33	36.52	37.34	31.10	30.89	28.31	31.71	27.12	28.80			47.47	52.93
8	42.42	48.67	35.47	38.65	32.89	33.84	29.82	34.54	29.86	29.20			49.73	57.33
9	43.15	51.33	34.61	41.35	33.76	34.82	31.19	35.70	33.82	36.14			51.13	60.29
10	45.00	55.72	38.36	41.82	34.57	35.87	32.57	37.75	37.13	39.10			55.76	58.74
11	43	58.55		42.49	35.92	37.20	33.42	38.64	37.83	37.02		71[2]	52.69	61.30
12		61.20		43.23	35.67	37.77	33.81	40.02	38.51	38.14			56.14	59.20
13		60.15		42.32		38.88	34.32	39.75	37.40	38.65			51	57.42
14		65.09		42.16		36.80	34.01	43.54	38.00	38.93				
15		64.47			39	39.10	35.09	40.81						
16		71.01					35.64	41.72						
17						40	31.73	45.00						
18		66.71					36.02	44						
19		78					36.85	45						

1/ Absence of decimal point indicates 1 observation only.
2/ Believed to be in error.

Table 3.--Von Bertalanffy growth parameters by species and sex.

	Turbot		Dover sole		Rex sole		Flathead sole		Pacific ocean perch		Pacific cod		Pollock	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1. All Data Points Used														
L_∞	47.24	82.29	37.53	45.65	44.98	42.20	35.68	45.54	45.31	41.41	425.50	73.72	55.93	62.62
k	-.22	-.10	-.38	-.16	-.12	-.16	-.26	-.19	-.11	-.19	-.03	-.57	-.20	-.23
t_0	-.44	-.90	.07	-2.73	-2.33	-1.57	.69	.51	-2.50	0.01	-2.03	.12	-1.46	-.37
δ	1.62	2.71	2.15	1.87	.79	.88	1.15	1.18	1.94	2.13	1.38	6.53	2.92	3.08
2. Altered Data Set Used[1]														
L_∞	52.44	82.47	36.36[2]	44.61	39.60	41.33	36.79	45.83	44.21[3]	42.44[4]	95.80[5]	130.21[5]	55.26	73.58
k	-.21	-.11	-.50	-.29	-.21	-.21	-.21	-.17	-.15	-.18	-.31	-.21	-.27	-.16
t_0	.00	-.04	.00	.00	-.02	-.01	.00	-.02	-.09	.06	.01	.01	.06	-.11
δ	0.21	1.07	1.31	0.34	0.41	0.44	0.34	0.41	1.87	3.18	1.18	0.80	1.94	2.39

1/ a. No. at age in age determination date set $n_a \geq$ lo, except as noted.
b. Ages below modal age group excluded.
c. $l_t = 0$, t = 0 included in data set.

2/ No convergence. Substituted set with ages 6, 7, 8; six is premodal.

3/ n = 7, included.

4/ Ages 5, 8 and 12 only.

5/ $n_{min} = 7$.

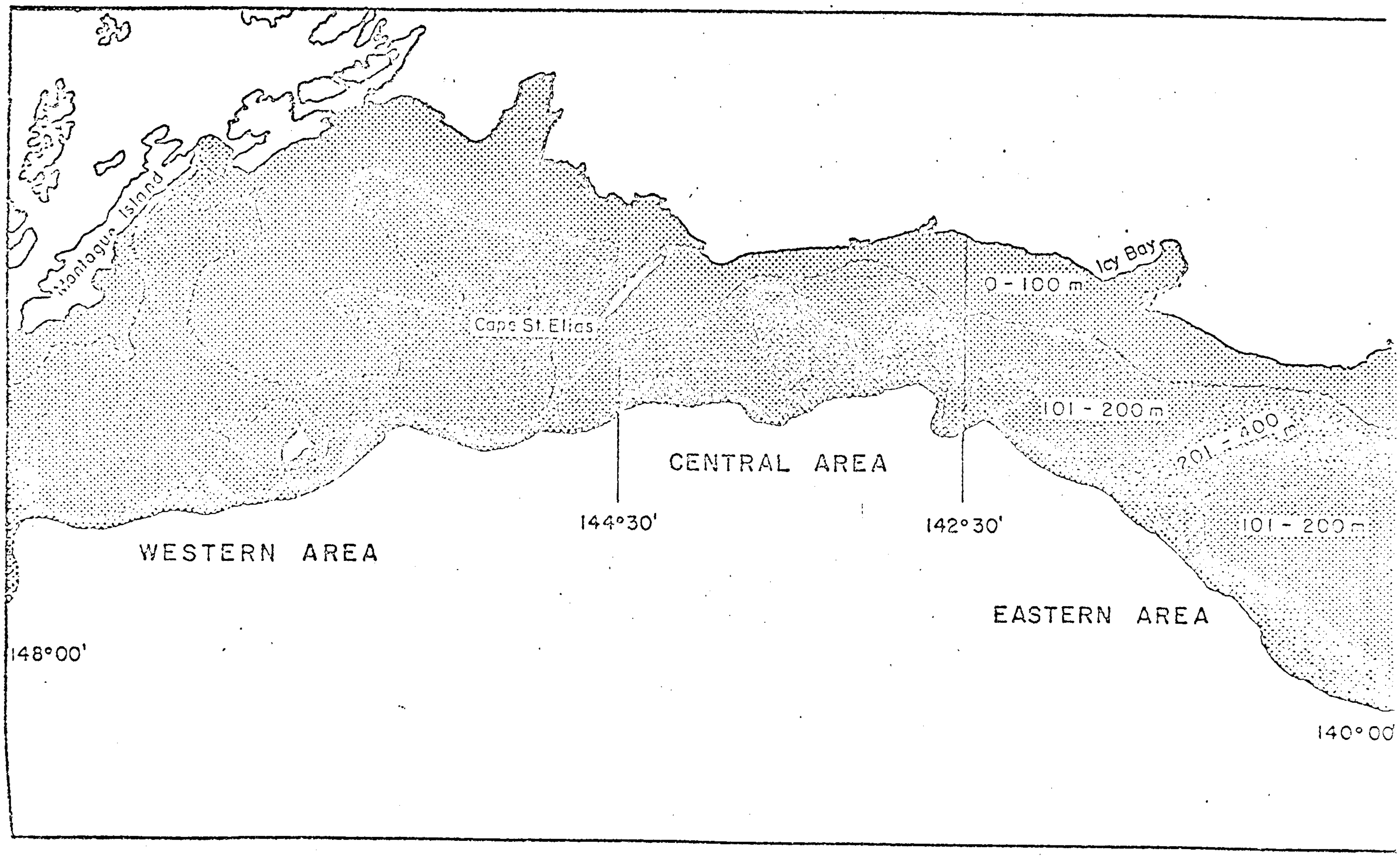

Figure 1.--The NEGOA survey area and the 9 area-depth interval subdivisions.

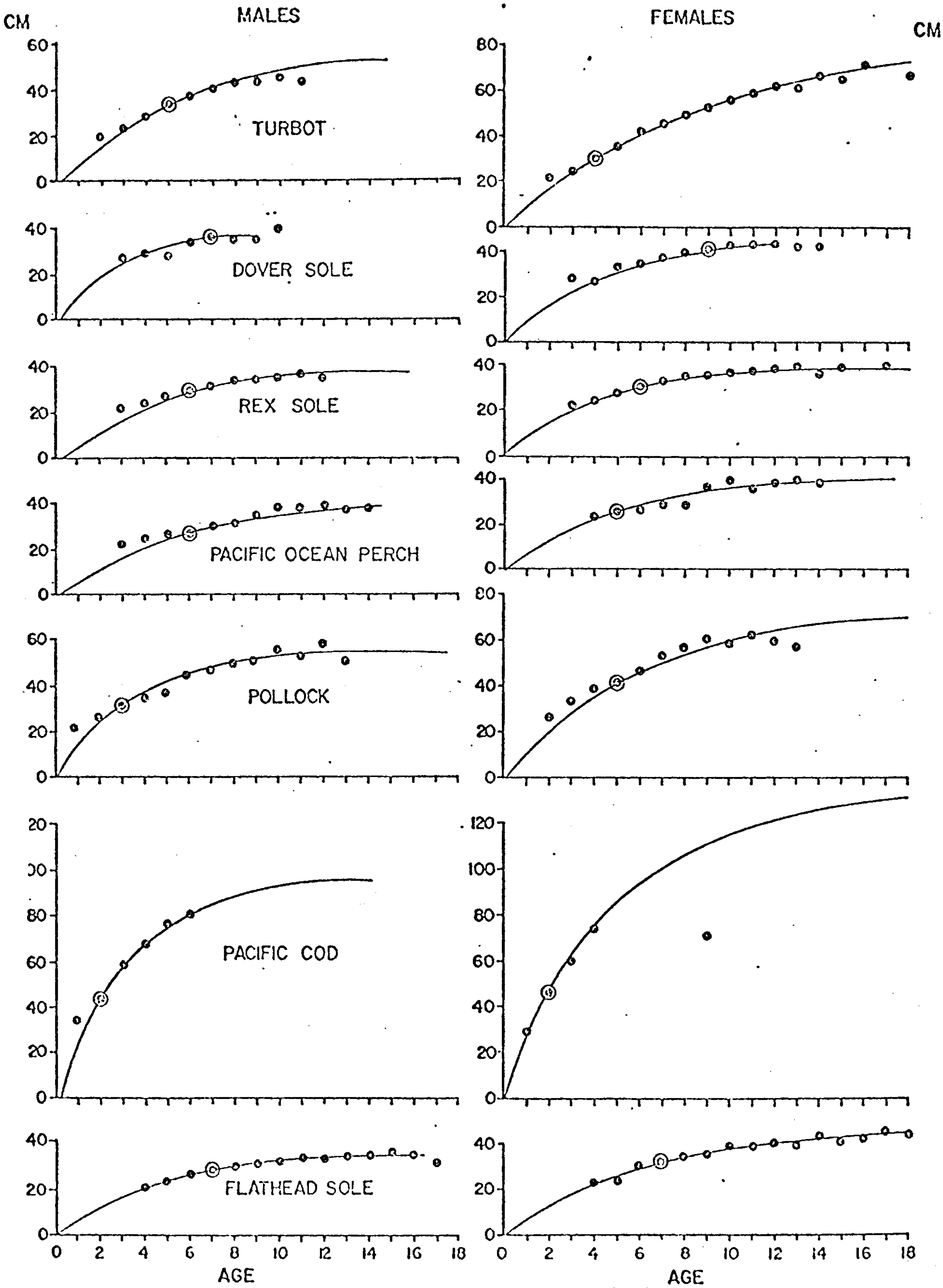

Figure 2.--Mean lengths at age, by sex, for turbot, Dover, rex and flathead sole, Pacific ocean perch, walleye pollock and Pacific cod and growth curves (see text).

RESEARCH UNIT RU 174

January 1977

BASELINE STUDIES OF DEMERSAL RESOURCES OF THE NORTHERN GULF OF ALASKA SHELF AND SLOPE:

4. JAPANESE FISHING CATCH, EFFORT, AND CATCH PER UNIT OF EFFORT BY $1^{\circ} \times \frac{1}{2}^{\circ}$ STATISTICAL BLOCKS IN THE NEGOA LEASE AREA

by

Herbert H. Shippen

FISHERIES: Stern trawl fishery

Longline fishery

PERIOD COVERED: 1969 - 1974

DATA SOURCE: Information supplied to the Northwest and Alaska Fisheries Center by the Japan Fisheries Agency

UNITS: Catches for both fisheries are in metric tons. Stern trawl effort is in hours. Longline effort is in 10-hachi (skate) units [1/]

DESIGNATION OF SQUARES: The south and east borders of each square are designated; thus, 59°00'-138° refers to the block between 59°00' and 59°30' N. lat. and between 138° and 139° W. long.

NUMBER OF YEARS: Since in some quarters there was no fishing in some blocks the number of years, ranging from 0 - 6, providing data are indicated.

[1/] A typical Japanese hachi is 50 m long and has 38 individual hooks. A 10-hachi unit, therefore, has 380 hooks.

BLOCK	QUARTER	STERN TRAWL NUMBER OF YRS.	STERN TRAWL TOTAL CATCH	STERN TRAWL TOTAL EFFORT	STERN TRAWL C.P.U.E.	LONGLINE NUMBER OF YRS.	LONGLINE TOTAL CATCH	LONGLINE TOTAL EFFORT	LONGLINE C.P.U.E.
59°00'-138°	1	0	0	0	—	1	15	50	.30
	2	0	0	0	—	0	0	0	—
	3	1	13	6	2.2	2	20	87	.23
	4	0	0	0	—	0	0	0	—
	TOTAL	1	13	6	2.2	3	35	137	.26
59°00'-139°	1	0	0	0	—	1	12	42	.29
	2	0	0	0	—	2	77	246	.31
	3	1	37	13	2.8	1	133	473	.28
	4	0	0	0	—	0	0	0	—
	TOTAL	1	37	13	2.8	4	222	761	.29
59°00'-140°	1	2	6	10	0.6	2	66	352	.19
	2	2	123	52	2.4	0	0	0	—
	3	3	104	52	2.1	2	75	384	.18
	4	3	75	54	1.4	0	0	0	—
	TOTAL	10	307	167	1.8	4	141	736	.19
59°00'-141°	1	6	4899	2268	2.2	5	411	2511	.16
	2	6	3958	1527	2.6	6	335	1625	.21
	3	6	6951	3454	2.0	6	764	3279	.23
	4	6	4793	1976	2.4	6	830	3386	.25
	TOTAL	24	20,600	9225	2.2	23	2340	10,801	.22
59°00'-142°	1	6	2342	914	2.6	6	376	2030	.19
	2	6	1249	631	2.0	6	273	1405	.19
	3	6	2405	1539	1.6	6	675	2798	.24
	4	6	2257	952	2.4	6	421	2010	.21
	TOTAL	24	8349	4036	2.1	24	1745	8243	.21
59°00'-143°	1	4	536	359	1.5	6	176	1107	.16
	2	6	715	366	2.0	5	115	579	.20
	3	6	870	601	1.4	6	417	1687	.25
	4	5	324	206	1.6	5	121	610	.20
	TOTAL	21	2445	1532	1.6	22	829	3983	.21
59°00'-144°	1	4	331	179	1.8	5	124	725	.18
	2	4	253	192	1.3	6	164	856	.19
	3	6	810	526	1.5	6	507	2126	.24
	4	6	169	147	1.2	6	138	1088	.17
	TOTAL	20	1563	1044	1.5	23	933	4795	.21
59°00'-145°	1	4	305	78	3.9	4	97	562	.17
	2	3	60	45	1.3	6	242	1192	.20
	3	6	948	548	1.7	6	835	3280	.25
	4	6	232	131	1.8	6	206	966	.21
	TOTAL	19	1545	802	1.9	22	1380	6000	.23

BLOCK	QUARTER	STERN TRAWL NUMBER OF YRS.	STERN TRAWL TOTAL CATCH	STERN TRAWL TOTAL EFFORT	STERN TRAWL C.P.U.E	LONGLINE NUMBER OF YRS.	LONGLINE TOTAL CATCH	LONGLINE TOTAL EFFORT	LONGLINE C.P.U.E.
59°00'-145°	1	5	402	79	5.1	5	156	881	.18
	2	4	427	194	2.2	6	360	1843	.20
	3	6	739	535	1.4	6	1108	4266	.26
	4	5	[illegible]	217	1.8	6	415	2012	.21
	TOTAL	20	1967	1025	1.9	23	2039	9002	.23
59°30'-140°	1	1	11	12	0.9	1	9	40	.22
	2	1	41	17	2.4	1	12	40	.30
	3	3	18	26	0.7	0	0	0	—
	4	0	0	0	—	0	0	0	—
	TOTAL	5	70	55	1.3	2	21	80	.26
59°30'-141°	1	1	8	9	0.9	0	0	0	—
	2	3	124	44	2.8	2	35	209	.17
	3	3	58	33	1.8	0	0	0	—
	4	1	49	7	7.0	1	11	60	.18
	TOTAL	8	239	93	2.6	3	46	269	.17
59°30'-142°	1	5	612	298	2.1	4	47	268	.18
	2	6	1007	604	1.7	5	170	779	.22
	3	6	1738	1450	1.2	6	308	1289	.24
	4	6	666	668	1.0	6	149	803	.19
	TOTAL	23	4023	3020	1.3	21	674	3139	.21
59°30'-143°	1	6	4682	2585	1.8	5	142	742	.19
	2	6	3429	1395	2.4	6	197	997	.20
	3	6	3617	2339	1.5	6	391	1634	.24
	4	6	2660	1218	2.2	5	331	1647	.20
	TOTAL	24	14,415	7537	1.9	22	1061	5020	.21
59°30'-144°	1	4	452	284	1.6	4	78	375	.21
	2	6	502	503	1.0	6	311	1316	.24
	3	6	1002	763	1.3	6	392	1753	.22
	4	6	581	416	1.4	5	353	1707	.21
	TOTAL	22	2537	1965	1.3	21	1134	5151	.22
59°30'-145°	1	2	31	26	1.2	2	13	95	.14
	2	3	71	41	1.7	4	39	153	.25
	3	6	218	169	1.3	3	85	400	.21
	4	2	12	9	1.3	6	131	721	.18
	TOTAL	13	329	245	1.3	15	268	1309	.20
59°30'-146°	1	2	23	20	1.2	1	9	30	.30
	2	0	0	0	—	1	51	200	.26
	3	2	82	45	1.8	1	18	81	.22
	4	2	74	36	2.1	1	9	55	.16
	TOTAL	6	[illegible]	101	1.8	4	87	366	.24

BLOCK	QUARTER	STERN TRAWL NUMBER OF YRS.	STERN TRAWL TOTAL CATCH	STERN TRAWL TOTAL EFFORT	STERN TRAWL C.P.U.E.	LONGLINE NUMBER OF YRS.	LONGLINE TOTAL CATCH	LONGLINE TOTAL EFFORT	LONGLINE C.P.U.E.
60°00'-144°	1	0	0	0	—	0	0	0	—
	2	0	0	0	—	0	0	0	—
	3	0	0	0	—	1	27	80	.34
	4	0	0	0	—	0	0	0	—
	TOTAL	0	0	0	—	1	27	80	.34
TOTAL AREA	1		14,622	7,121	2.05		1,741	9,810	.18
	2		11,959	5,610	2.13		2,381	11,440	.21
	3		19,610	12,099	1.62		5,755	23,622	.24
	4		12,291	6,037	2.04		3,165	15,060	.21
	TOTAL		58,482	30,867	1.89		13,042	59,932	.22
	1								
	2								
	3								
	4								
	TOTAL								
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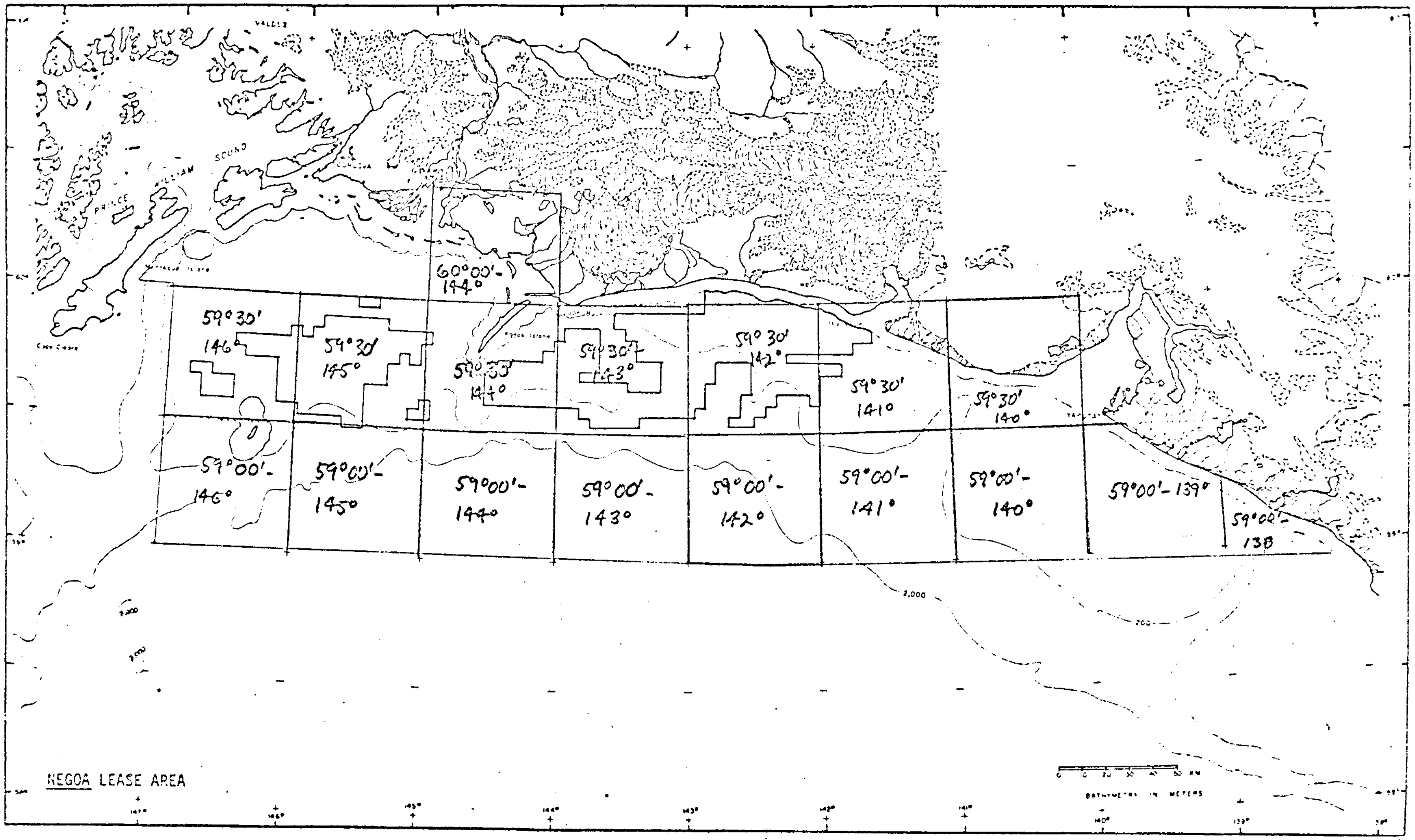
SPECIES COMPOSITION

The species composition of the stern trawl catch is approximately:

61%	Pacific ocean perch
8%	other rockfishes
4%	Turbot
7%	other flatfishes
7%	Blackcod (sablefish)
3%	Pacific cod
2%	Pollock
8%	Other fishes

The species composition of the longline catch is approximately:

95%	Blackcod (sablefish)
5%	Other fishes


PRINCE WILLIAM SOUND
60°00'- 144°
59°30' 146°
59°30' 145°
59°30' 144°
59°30' 143°
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59°30' 141°
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NEGOA LEASE AREA
BATHYMETRY IN METERS

ANNUAL REPORT

Contract No.: R7120802
Research Unit No.: RU 175
Reporting Period: April 1, 1977

BASELINE STUDIES OF FISH AND SHELLFISH RESOURCES OF NORTON SOUND AND THE SOUTHEASTERN CHUKCHI SEA

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Annual Report for the Period April 1, 1976, to March 31, 1977

RU 175--Baseline Studies of Fish and Shellfish Resources of Norton Sound and the Southeastern Chukchi Sea

I. Summary of Objectives and Conclusions

A. Objectives

1. Summarize existing literature and unpublished data on the distribution and abundance and productivity of fish and shellfish resources of Norton Sound and the southeastern Chukchi Sea.

2. Determine the distribution and abundance of fish and shellfish resources of the southeastern Chukchi Sea and Norton Sound, estimate the productivity, length, weight, and age distribution of selected demersal fish and shellfish to develop growth models, and provide a data base against which later changes in these parameters may be compared.

B. Conclusions

Not applicable at present.

II. Introduction

A. General nature and scope of study

1. Historical data.--Along with a review of pertinent biological literature, existing historic data bases will be examined to provide a perspective to the status of demersal populations in the baseline period.

2. 1976 Baseline survey.--A BLM-funded offshore reconnaissance-level survey was conducted in Norton Sound, the northern Bering Sea, and southeastern Chukchi Sea during September-October 1976 based on a stratified systematic sampling design. Demersal fish and shellfish were sampled with otter trawls, and qualitative samples of near-surface fish

species were obtained with gillnets and pelagic trawls. Catch data for this survey will be used to provide estimates of standing stock for all principal fish and shellfish in the survey region for the 1976 baseline year. Biological data obtained will be used to provide estimates of various population parameters outlined above. These data will provide an index to the magnitude and relative importance of fish and shellfish resources vis-a-vis potential offshore oil and gas resources of Norton Sound and the southeastern Chukchi Sea. Furthermore, stock size and population parameter estimates will provide a data base for comparison with future information if major alterations of the marine environment are to occur.

B. Specific Objectives

1. Identify the composition, distribution, and abundance of fish and shellfish resources of Norton Sound and the Chukchi Sea for the summer season by area and depth.

2. Determine population parameter levels for selected fish and invertebrate stocks which could change through environmental stresses; e.g., stock size, size and age composition, growth rate, length-weight relationships, and mortality.

3. Describe the size composition and general distribution of pelagic fish species encountered in the study area.

4. Provide an index for the magnitude and importance of fish and shellfish stocks vis-a-vis potential offshore oil and gas resources within the survey region.

C. Relevance to to problems of petroleum development

Oil and gas development in the arctic and subarctic waters off Alaska can be expected to significantly increase the input of petroleum hydrocarbons to that ocean area. The toxicity and/or chemical interference of continuous low-level oil leakages or unpredictable major oil-spill accidents may adversely affect fish and shellfish resources.

The direct toxicity of certain petroleum hydrocarbons may cause increased mortality and sublethal stress. Although the chemical toxicity of oil would probably affect adult forms only after exposure to a major oil spill and sedimentation of petroleum to the bottom, the egg and larval stages of these organisms are more sensitive. Large inputs of petroleum in spawning and nursery areas might adversely affect year class survival and change population characteristics of some species. Furthermore, the dissolved portion of petroleum could cause sublethal alterations in chemoreception mechanisms used to locate food, and in crustaceans could severely affect growth rates through delayed ecdysis and autotomy.

Indirect effects may also result from ecosystem shifts and changes in sediment quality. If petroleum development causes changes in the qualitative or quantitative composition of plankton or benthic infaunal communities, then shifts in the distributions and abundances of fish and shellfish may also be expected to occur.

In order to be able to understand the magnitude of the impact of oil and gas development on various living marine resources, it is essential to have current baseline information on resource distribution and abundance in time and space and the manner in which these resources are influenced by their environment. These baseline data are necessary for rational decision making with regard to oil and gas development in order to minimize or possibly prevent a deleterious impact on the demersal (and pelagic) community.

III. Current State of Knowledge

Knowledge pertaining to the demersal and pelagic fish and shellfish resources of Norton Sound and the southeastern Chukchi Sea is limited (Abbott, 1966; Alverson and Wilimovsky, 1966; Ellson, et al., 1949; Quast, 1974; and Sparks and Pereyra, 1966). In general, the species present are boreal-arctic forms which are characteristic of the northern Bering Sea community. Biological information has been inadequate to fully describe population parameters for any single species. Additionally, principal studies of the survey region date back to the late 1940's and 1950's which limits their usefulness for contemporary stock analysis. The early studies, however, provide worthwhile background information on the region's fish and shellfish community.

IV. Study Area

The study area comprises about 37,500 square miles and includes waters of Norton Sound, the northern-most portion of the Bering Sea, and the southeastern Chukchi Sea. Depths included in the survey region range from near-shore shallows (9 m) out to 65 m, the maximum depth within the study area.

Four sub-areas were defined within the survey region based upon potential impact from oil development and other factors.

Sub-area A.--An area of proposed oil exploration and occasional site of high-seas salmon fishing by foreign nationals. Includes mostly offshore waters (from 27-64 m) between the Bering Strait and Point Hope. Also contains nearshore areas off the north coast of the Seward Peninsula and coastal waters north of Kotzebue Sound with depths greater than 9 m.

Sub-area B.--Another region of proposed oil exploration and area of salmon fishing by residents of Kotzebue area. Includes all waters of Kotzebue Sound (deeper than 9 meters) and waters outside Kotzebue Sound west to approximately 166 W long.

Sub-area C.--The third area of proposed oil exploration within the survey boundaries. Includes waters (between 9 and 65 m) within a region generally bounded by St. Lawrence Island, the 1867 US-USSR Convention Line, Bering Strait, and outer Norton Sound. Also includes waters (deeper than 9 m) within Port Clarence.

Sub-area D.--The fourth area of proposed oil exploration and a region having large herring concentrations and substantial herring fishery by foreign nationals during summer months. Includes nearshore waters (deeper than 9 m) of Norton Sound utilized for commercial salmon fishing and subsistence fisheries near coastal towns and villages of Nome, Unalakleet, St. Michael, and Stebbins.

V. Sources, Methods, and Rationale of Data Collection

A. Sources.--Existing data sources to be examined include:

1. Bureau of Commercial Fisheries (BCF) demersal survey of the southeastern Chukchi Sea for the Atomic Energy Commission's Project Chariot (1959-1960).

2. Alaska Department of Fish and Game Domestic Catch Statistics.

3. Foreign fisheries statistics from Japanese fisheries (1964-1975).

4. Separate manuscripts on the distribution, abundance, and biology of principal fish and shellfish species.

5. 1976 Baseline Survey of Norton Sound and the southeastern Chukchi Sea.

B. Gear.--Three types of fishing gear were used during the 1976

Baseline survey: an otter trawl, pelagic trawl, and gillnets. A description of each gear is as follows:

1. The otter trawl had a 112' footrope, 83' headrope, and was constructed of 4" mesh (stretched mesh measure) (#48 thread) on the wings and body, and 3-1/2" mesh (#96 thread) in the intermediate section and codend (see Appendix I). There were 31- 8" diameter floats on the headrope. Other accessory gear included four 25-fathom dandylines, two connected to each wing. The codend was lined with 1-1/4" mesh web for the retention of small fish and invertebrates.

2. The pelagic trawl was a Mark 1 Universal type with a 121' headrope and footrope. The net contained 2-1/2" mesh web throughout the wings, body, and codend. The codend was lined with 1-1/4" mesh web for retention of small fish. Accessory gear included six 30-fathom dandylines, three connected to each wing.

3. The gillnet was a series of seven 50-fathom by 3-fathom shackles connected together to form a 350-fathom long net. The mesh size varied by shackle and was .83" (21 mm), 1.38" (35 mm), 1.65" (42 mm), 2.50", 3.25", 4.50", and 5.25". A radio buoy, marker pole, and floats were attached to one end of the set.

All field operations for the 1976 baseline survey were conducted aboard the NOAA FRV Miller Freeman.

C. Methods and rationale of data collection

The 1976 baseline survey was designed to synoptically cover the major part of the ranges of potentially important demersal fish and shellfish in Norton Sound and the southeastern Chukchi Sea. A stratified systematic sampling design was used in determining location of trawling stations with sampling density higher in suspected areas of concentrations for the more important species, the most probable locations of oil lease sites, and areas with a high potential for environmental impact.

Much of the survey region is ice-free for a relatively short period each summer. It was necessary, therefore, to deviate from the usual sampling protocol followed during earlier BLM baseline surveys of demersal fish and shellfish. Trawling was performed on an around-the-clock schedule to optimize vessel operations and complete the survey in the least amount of time necessary for efficient coverage of the area.

Since a considerable portion of the fish stocks within the survey region was thought to occur in midwater or near the sea surface, pelagic trawls and gillnets were used to examine the off-bottom portion of the Norton Sound-Chukchi Sea fish resources. A quantitative evaluation of these off-bottom fish stocks would have required extensive time and effort not available. Sampling with pelagic and surface fishing gear was sufficient only to identify what species occurred off bottom and to obtain biological information on these species.

Pelagic trawl tows occurred whenever off-bottom fish targets were encountered during travel between demersal stations. The location of gillnet sets depended upon daily progress along the demersal station cruise track. The gillnet sets were made in the vicinity of demersal stations scheduled for sampling during the following night. Each set started after sunset and was fished for approximately 8-10 hours.

All demersal and pelagic trawl tows were 1/2 hour in duration.

1. Processing trawl catches

Processing of catches from pelagic and demersal trawl hauls followed the same procedure. After completion of the trawl tow, the net was brought aboard and the codend (with its contents) weighed. If the catch was less than approximately one metric ton, the entire catch was dumped onto a sampling table and processed. For larger catches (those greater than one metric ton), a subsample of about 25-50% of the total catch was obtained using procedures described by Hughes (1974). This subsample was then placed on the sampling table for processing.

After the catch was sorted and weighed by species, random samples of selected fish were taken for biological data collection (length frequencies, length-weights, and age structures). Biological information was obtained for the following fish species:

Saffron cod (*Eleginus gracilis*)
Arctic cod (*Boreogadus saida*)
Pollock (*Theragra chalcogramma*)
Yellowfin sole (*Limanda aspera*)
Alaska plaice (*Pleuronectes quadrituberculatus*)
Starry flounder (*Plattichthys stellatus*)
Bering flounder (*Hippoglossoides robustus*)
Pacific herring (*Clupea harengus pallasi*)
Toothed smelt (*Osmerus mordax dentex*)

While large catches were subsampled before processing fish and miscellaneous invertebrates, the entire catch of commercial species of crab were examined from all trawl hauls. These were sorted by species and sex, and weights and numbers recorded. Carapace measurements were obtained from all crabs in small catches, and from a minimum of 300 individuals when a species catch exceeded that number. In addition to carapace measurements, shell condition, clutch size, and egg color were recorded. Species examined included red king crab (*Paralithodes camtschatica*), blue king crab (*P. platypus*), and Tanner crab (*Chionoecetes opilio*).

2. Processing gillnet catches

As the gillnets were retrieved, the catch from each shackle was removed and kept separate. Weight and number caught by species were then determined for each mesh size in the set. Biological information was obtained for all salmonid species encountered, as well as for herring, toothed smelt, and capelin (Mallotus villosus).

3. Day-night trawl intercalibration

Around-the-clock trawling was performed at five locations within the survey region. This testing was undertaken to establish whether significant catch differences resulted between day and nighttime trawling and if so to provide fishing power factors necessary for pooling all catch information into a uniform data base.

Trawling procedures during the day-night tests were identical to those used during the main survey. Four (4) trawl tows were completed during daylight and four at night at each of the five test areas. Catch information for each principal demersal species caught was then examined by an analysis of variance (ANOVA) with a balanced factorial design (5 areas by 2 time intervals with 4 replicates for each factor).

VI. Results

A. Data collection

Two hundred forty nine (249) trawl hauls were made during the 34 nontransit vessel days of the survey for an average of 7.3 tows per day. This total included 8 pelagic and 44 replicate (day-night) demersal sets. Of the scheduled 240 demersal stations, 25 were found to be untrawlable, and an additional 8, though within the original survey boundaries, were not fished because they were west of the continental shelf median line.[1/]

1/ A boundary established by the 1958 International Convention of the Continental Shelf for dividing shelf areas adjacent to two territories, in this instance, between the US and USSR.

All catches were processed in a manner described in the methods section. Length measurements were taken from over 45,000 fish. Independent age-length-weight information was collected from over 1,800 individuals of selected species from survey stations north and south of Bering Strait. The selected species for which growth data were obtained included: Arctic cod, Pacific herring, toothed smelt, yellowfin sole, starry flounder, and Alaska plaice.

Carapace measurements were taken from about 10,000 crabs. Most of these were from Tanner crab (8,661) and the remainder from red king crab (1,606) and blue king crab (185). Additionally, over 5,000 snails were collected during the survey.

B. Preliminary findings

1. Gillnet and pelagic

Gillnet operations proved to be very unproductive. Catches were small, ranging from approximately 55 fish to no catch. Sets made at inshore areas usually caught more than those made in offshore waters. Most fish were taken in the smaller mesh shackles with Pacific herring and toothed smelt being the most common. Other species taken in gillnets included arctic char (*Salvelinus alpinus*), pink salmon (*Oncorhynchus gorbuscha*), and chum salmon (*Oncorhynchus keta*).

Pelagic trawl hauls were conducted on a random basis during the entire survey because no extensive off-bottom fish concentrations were encountered. Time limitations and equipment malfunctions restricted pelagic trawl operations. Catches were small and provided limited qualitative information. The largest pelagic trawl catch (15 fish) occurred near the entrance of Kotzebue Sound and included toothed smelt, saffron cod, arctic char, and juvenile pink salmon.

2. Demersal

In general, demersal fish catches were small throughout the entire survey area, averaging less than 50 kg per 30-minute trawl haul. The shallower inshore areas were found to be more productive than deeper offshore waters. Average size of several fish and shellfish species taken in the survey region was noticeably smaller than sizes associated with eastern Bering Sea stocks of the same species.

Representatives of the families Gadidae, Pleuronectidae, Osmeridae, Clupeidae, and Cottidae were the most commonly encountered fish fauna. Other less frequently taken families included Agonidae, Cyclopteridae, Zoarcidae, and Stichaeidae. Species composition generally did not vary between areas. Tables 1 and 2 summarize some preliminary catch findings by area and depth.

The Gadids represented a major portion of the catches. Arctic cod was the most common species in the Chukchi Sea and Kotzebue Sound, and their occurrence increased with depth. Saffron cod was the predominant species in the Norton Sound and had the largest average catch per trawl haul. They were, however, less frequently taken in the Chukchi Sea region (sub-areas A and B).

Juvenile saffron cod were generally found to be restricted to the shallows in all areas. They occurred most frequently at depths of 0-25 meters, and their density generally decreased with an increase in depth. The percent occurrence and average weight caught by depth of this species were greater in the Norton Sound region (sub-areas C and D) than in the Chukchi Sea (sub-areas A and B).

The most frequently encountered Pleuronectid was Alaska plaice.

Table 1.--Catch rates (kg per trawl haul) by area and depth interval for principal fish and shellfish species taken during the 1976 baseline survey of Norton Sound and the southeast Chukchi Sea.

	S.E. Chukchi Sea & Kotzebue Sound (Sub-areas A and B) DEPTH (meters)				Norton Sound & Northern Bering Sea (Sub-areas C and D) DEPTH (meters)			
	0-25	26-50	>50	Total[1/]	0-25	26-50	>50	Total[1/]
Saffron cod (juv.)	0.2	0.4	<0.1	0.3	3.5	1.5	<0.1	2.5
Saffron cod (adult)	0.7	1.8	--	1.2	14.1	8.0	--	10.8
Arctic cod	0.1	1.6	0.5	0.9	0.8	0.6	--	0.7
Yellowfin sole	0.5	0.1	--	0.2	1.8	0.3	--	1.1
Alaska plaice	1.0	0.4	--	0.5	2.8	0.5	<0.1	0.8
Starry flounder	1.1	1.2	--	1.0	12.0	2.3	--	3.5
Toothed smelt	0.5	1.1	--	0.8	0.6	0.8	--	0.6
Herring	1.2	4.0	--	2.5	0.4	0.4	--	0.4
Tanner crab	2.6	11.5	5.5	7.4	<0.1	1.6	1.6	0.7
King crab (*camtschatica*)	0.1	< 0.1	--	<0.1	4.2	2.8	--	3.4
King crab (*platypus*)	--	0.1	--	<0.1	--	1.1	2.8	0.6
Snail spp.	5.7	9.8	11.6	8.6	6.0	6.9	1.8	6.1

1/ Replicates and gillnets not included.

Table 2.--Percent occurrence by area and depth interval for principal fish and shellfish species taken during 1976 baseline survey of Norton Sound and the southeastern Chukchi Sea.

Species	SE Chukchi Sea and Kotzebue Sound (Subareas A and B), depth (meters)				Norton Sound and Northern Bering Sea (Subareas C and D), depth (meters)			
	0-25	26-50	50	Total	0-25	26-50	50	Total
Saffron cod (juv.)	69%	29%	10%	40%	78%	42%	0%	58%
Saffron cod (adult)	77	42	--	49	100	73	100	89
Arctic cod	65	87	100	81	86	83	--	79
Yellowfin sole	77	24	--	39	92	42	--	66
Alaska plaice	88	74	--	69	89	50	14	68
Starry flounder	54	21	--	30	78	35	--	55
Toothed smelt	77	58	--	57	86	62	--	71
Herring	65	61	--	54	48	50	--	38
Tanner crab	62	92	100	82	23	85	100	53
King crab (_camtschatica_)	1	5	--	3	66	25	--	45
King crab (_platypus_)	--	5	--	3	--	35	71	19
Snail spp.	69	85	90	78	63	94	100	78

1/ Replicates and gillnets not included.

Starry flounder and yellowfin sole also were frequently encountered, and were more commonly taken south of the Bering Strait than in the Chukchi Sea and Kotzebue Sound. Both starry flounder and yellowfin sole appeared to be restricted to the shallower portion of the survey area. Their incidence of occurrence and average catch dropped sharply with increased depths. Neither species was taken in waters over 50 meters.

Other frequently encountered fish species included rainbow smelt and Pacific herring. Smelt had approximately the same average catch by weight in both areas but was more frequently encountered in the Norton Sound region. Conversely, Pacific herring was more common and had a greater catch rate in the Chukchi Sea.

Cottids were abundant throughout the entire survey area, being represented in nearly all demersal trawl hauls. The plain sculpin (Myoxocephalus joak), shorthorn sculpin (Myoxocephalus groenlandicus), antlered sculpin (Enophrys diceraus), and artic staghorn sculpin (Gymnuscanthus tricuspis) were the cottids most commonly encountered.

Commercially important invertebrate species encountered during the survey included Tanner crab (Chionoecetes opilio), two species of king crab (Paralithodes camtschatica and P. platypus), and several species of snails.

Tanner crab was the most commonly observed crab species throughout the survey area, with their incidence of occurrence increasing with depth. Generally, the catches consisted of juveniles with relatively few mature adults taken. Relative abundance by weight appears much greater in the southeastern Chukchi Sea (sub-area A) than in the other regions surveyed.

Both species of king crab were present throughout much of the survey region but in lesser amounts than Tanner crab. Of the two species, red king crab was highest in Norton Sound (sub-area D), especially in the vicinity of Nome. Other areas contained very few individuals.

Blue king crab was found only at one station north of Bering Strait. Their center of distribution in the survey area was in sub-area C between St. Lawrence Island and Cape Prince of Wales. Relative abundance, however, was very low wherever this species was encountered.

Neptunea heros and N. ventricosa were the principal snail species captured. These species comprised 79 percent of total numbers of snails caught, and 90 percent of the total snail weight taken during the survey. About 8 other species were taken in noticeable amounts (Table 3). Relative abundance for each species has not yet been determined.

3. Day-night comparative fishing and catch intercalibration

Forty (40) comparative demersal trawl tows were performed to examine catch rate and species occurrence differences between day and night-time trawling in the survey area. Analysis of the resulting data indicates that species occurrence did not differ appreciably between night and day fishing at the five test locations. Nearly 30 fish species were encountered during the comparative work, of which about 90 percent were encountered during both time periods (Table 4). A chi-square test for homogeneity on the day and night fish communities detected no significant difference in the incidence of occurrence of species at the .95 level.

Although the fish community did not differ by time of day, catch rates for certain species were statistically different between day and night. Species for which catch rates were tested included saffron cod, arctic cod, yellowfin sole, starry flounder, Alaska plaice, toothed smelt, and Pacific herring. An analysis of variance of $\log_e$ transformed catch rates (by weight) indicated that day catches were significantly larger than

Table 3.--Snail species captured during 1976 baseline survey of Norton Sound and the southeastern Chukchi Sea, listed in order of decreasing abundance by both number and weight.

Species	Number caught	Percent total number	Species	Pounds caught	Percent total weight
Neptunea heros	9,707	64	*Neptunea heros*	2,886	78
N. ventricosa	2,280	15	*N. ventricosa*	439	12
Beringius beringii	859	6	*Beringius beringii*	179	5
Pyrulofusus deformis	392	3	*Pyrulofusus deformis*	94	3
Neptunea borealis	277	2	*Volutopsius fragilis*	26	1
Buccinum scalariforme	271	2	All other species		<1
Natica clausa	250	2			
Buccinum polare	243	2			
Volutopsius fragilis	212	1			
Buccinum angulossum	191	1			
All other species		<1			

Table 4.--Fish species encountered during day-night test fishing, 1976 baseline survey of Norton Sound and the southeastern Chukchi Sea.

Yellowfin sole (Limanda aspera)

Longhead dab (L. proboscidea)

Alaska plaice (Pleuronectes quadrituberculatus)

Arctic flounder (Liopsetta glacialis)

Saffron cod (Eleginnus gracialis)

Arctic cod (Boreogadus saida)

Walleye pollock (Theragra chalcogramma)

Toothed smelt (Osmerus mordax dentex)

Pacific herring (Clupea harengus pallasi)

*Bering cisco (Coregonus laurettae)

*Pond smelt (Hypomesus olidus)

Polar eelpout (Lycodes turneri)

Wattled eelpout (L. palearis)

Slender eelblenny (Lumpenus fabricii)

Prickleback (Lumpenus mackayi)

**Arctic shanny (Stichaeus punctatus)

Arctic staghorn sculpin (Gymnocanthus tricuspis)

**Horned sculpin (G. pistilliger)

Plain sculpin (Myoxocephalus joak)

Shorthorn sculpin (M. groenlandius)

Antlered sculpin (Enophrys diceraus)

Eyeshade sculpin (Nautichthys pribilovius)

Ribbed sculpin (Triglops pingeli)

Belligerent sculpin (Megalocottus platycephalus)

Sturgeon poacher (Agonus acipenserinus)

Tubenose poacher (Pallasina barbata)

Whitespotted greenling (Hexagrammos stelleri)

Ninespine stickleback (Pungitius pungitius)

---

* Caught only during day
**Caught only during night

catches encountered during nighttime for four of the six principal fish of interest which were encountered within the comparative areas (Table 5). Saffron cod catches were analyzed separately for small (less than 13 cm) and large fish. Catch rates for both size groups of saffron cod indicated a significant time effect.

An examination of the area x time interaction for each species catch was important to determine whether differences in day and night catches varied with area. Only catch rates for toothed smelt indicated a significant area x time interaction. The test statistics calculated for the interaction effect, however, only slightly exceeded the critical value for significance, whereas the test statistics for both area and time main effects substantially exceeded their respective critical values, even at levels of a = .001. This suggests that, although differences between day and night catches varied by area, the trend of larger catches during the day than at night was consistent at every location. Since a consistent trend in catch rate occurred, a fishing power factor was estimated for night catches of toothed smelt.

Nighttime fishing power coefficients for all fish species with significant day-night catch rate differences are indicated in Table 6.

Differences between day and night size composition were tested with the Kolomogrov-Smirnov nonparametric two-sample test. Significant size composition differences at a = .001 were detected for two species--yellowfin sole and Pacific herring. Examination of length frequency histograms for these species suggests that differences in day-night size composition may be associated with a differential diurnal migration by size. More small yellowfin sole (less than 16 cm) were encountered at night than during daylight fishing while catches of larger fish (greater than 16 cm) were about the

Table 5.--Analysis of variance from day-night fishing tests on principal fish species encountered during 1976 baseline survey of Norton Sound and the southeastern Chukchi Sea (random variable – $\log_c$ 25/km+1)

Species	Design variable	Degrees of freedom	Mean square	F
Yellowfin sole	Area	4	5.09	56.56*
	Time	1	0.00	0.00
	Area x Time	4	0.38	4.10*
	Error	30	0.09	
Starry flounder	Area	4	6.57	33.43*
	Time	1	1.40	7.10*
	Area x Time	4	0.24	1.22
	Error	30	0.20	
Alaska plaice	Area	4	1.53	11.27*
	Time	1	0.28	2.05
	Area x Time	4	0.02	0.18
	Error	30	0.14	
Saffron cod ≤12 cm	Area	4	5.55	24.77*
	Time	1	1.75	7.79*
	Area x Time	4	0.32	1.44
	Error	30	0.22	
Saffron cod >12 cm	Area	4	16.68	73.68*
	Time	1	1.65	7.30*
	Area x Time	4	0.45	1.98
	Error	30	0.23	
Toothed smelt	Area	4	3.77	54.38*
	Time	1	5.37	77.40*
	Area x Time	4	0.28	4.09*
	Error	30	0.07	
Herring	Area	4	6.57	33.43*
	Time	1	1.40	7.10*
	Area x Time	4	0.24	1.22
	Error	30	0.20	

*Significant at the $\alpha = .05$.

Table 6.--Fishing power coefficients calculated for principal fish species encountered during day-night trawling comparisons in Norton Sound and the southeastern Chukchi Sea, 1976.

	SPECIES				
Time	Starry flounder	Small saffron cod	Large saffron cod	Toothed smelt	Pacific herring
Day	1.00	1.00	1.00	1.00	1.00
Night	1.69	1.52	1.50	2.08	1.45

same for both time periods (Figure 1). Conversely, greater numbers of small Pacific herring (less than 20 cm) were present in daytime catches than at night with day-night catches of larger fish (greater than 20 cm) being nearly equal.

An ANOVA on catch rates by size group for both yellowfin sole and Pacific herring further indicated a differential rate of availability to demersal trawls, but this differential rate was not consistent. In some areas catch rates of a size group were higher during daylight than at night, while at other test locations the opposite was observed.

VII. Discussion

Although analysis of the survey data has not yet been completed, preliminary findings show that (1) there exists a marked change in the composition of demersal fish and shellfish community between Norton Sound and the southeastern Chukchi Sea; (2) relative abundance for most demersal species changes with depth; (3) catch rates for several species are higher during the day and indicate that portions of some fish populations are off bottom at night; and (4), the size composition of most demersal species in trawl catches does not change between day and night although a few species appear to undergo a differential diurnal migration by size.

VIII. Conclusions

Not applicable at the present time.

IX. Needs for Further Study

Not applicable at the present time.

X. Summary of Fourth Quarter Operations

A. Field or laboratory activities

1. Ship or field trip schedule: None.
2. Scientific party (all are Northwest and Alaska Fisheries

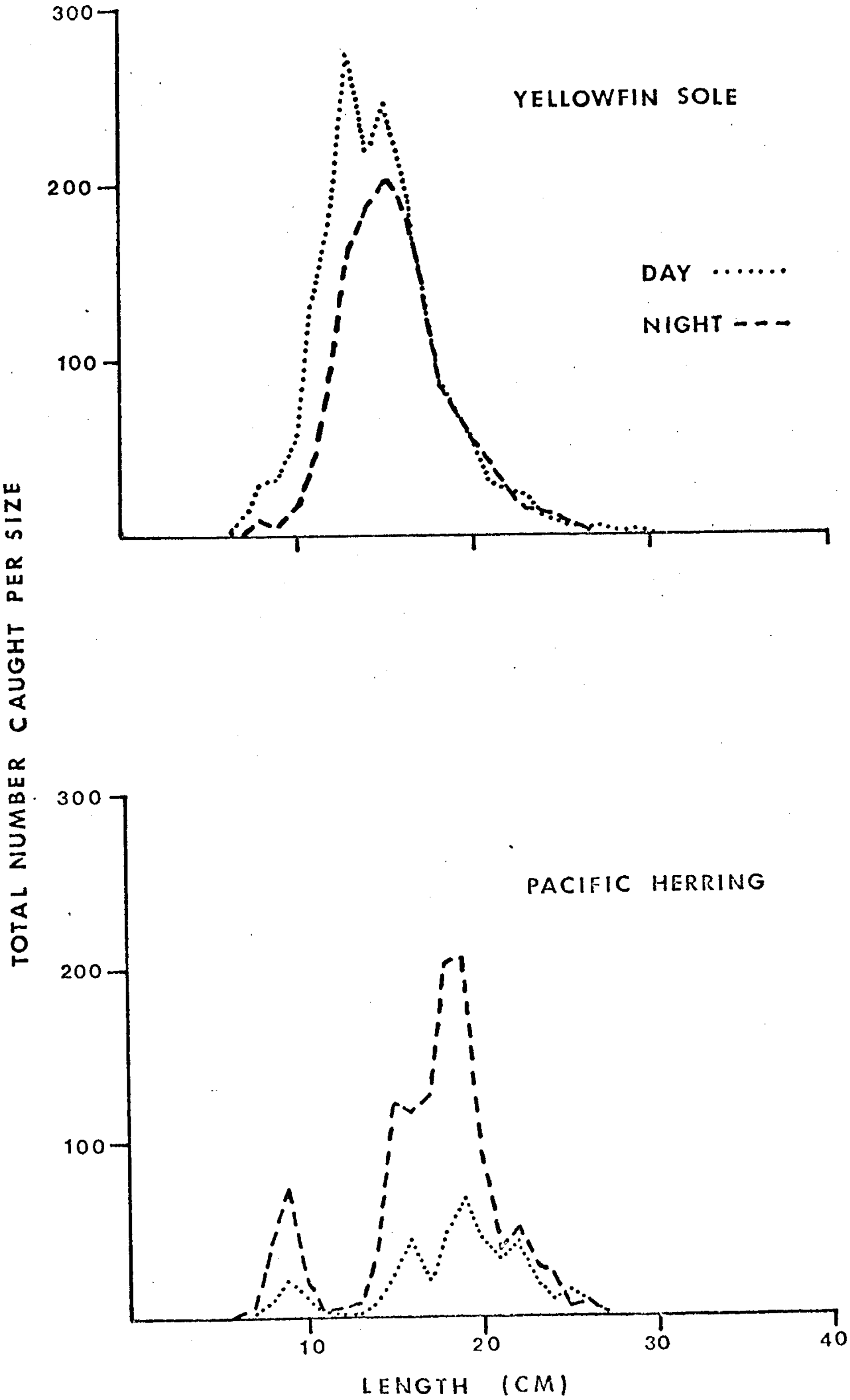

Figure 1.--Size composition for all yellowfin sole and Pacific herring caught during day-night test fishing, 1976 baseline survey of Norton Sound and the southeastern Chukchi Sea.

Center Personnel):

Robert J. Wolotira, Jr. (Principal Investigator)
Terrance M. Sample
Martin M. Morin

3. Methods--laboratory activities

All field data on fish and shellfish from the 1976 baseline survey has been punched, edited, and submitted to OCSEAP on magnetic tape. Additional information, such as calculating individual snail species catches by station, size composition of the principal snail species, and processing age structures for the principal fish species, is essentially complete and ready for integration into our computer files.

Calculating fishing power factors to adjust night catches to standardized daytime catch rates was our first step in determining our biomass estimates. This analysis is completed and standing stock estimates by sub-area and total survey region are underway.

4. Sample localities

The location of all demersal trawl stations, gillnet sets and pelagic trawl stations are indicated in Figures 2, 3 and 4, respectively.

5. Data collected or analyzed

a. From the nearly 250 trawl stations and 33 gillnet sites sampled during the 1976 baseline survey, over 35,000 data records have been obtained under the following record categories:

Demersal and pelagic haul	268
Demersal and pelagic catch	4,700
Gillnet set	33
Gillnet catch	58
Fish length frequency	12,000
Crab length frequency	10,500
Snail size frequency	4,100
Fish length-weight	2,300
Fish age-length	1,200

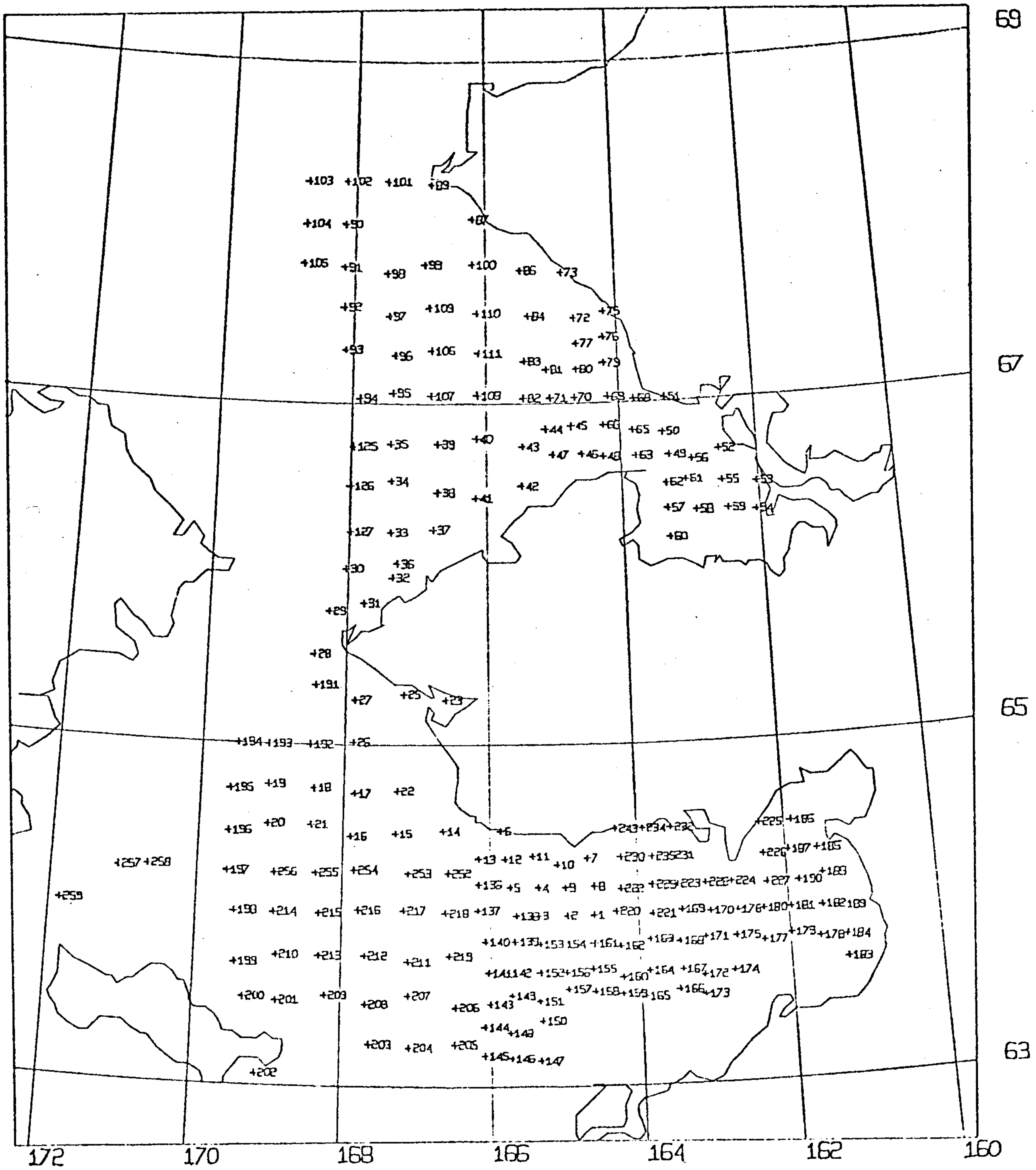

FIGURE 2. DEMERSAL SURVEY TRAWL STATIONS, 1976 BASELINE SURVEY.

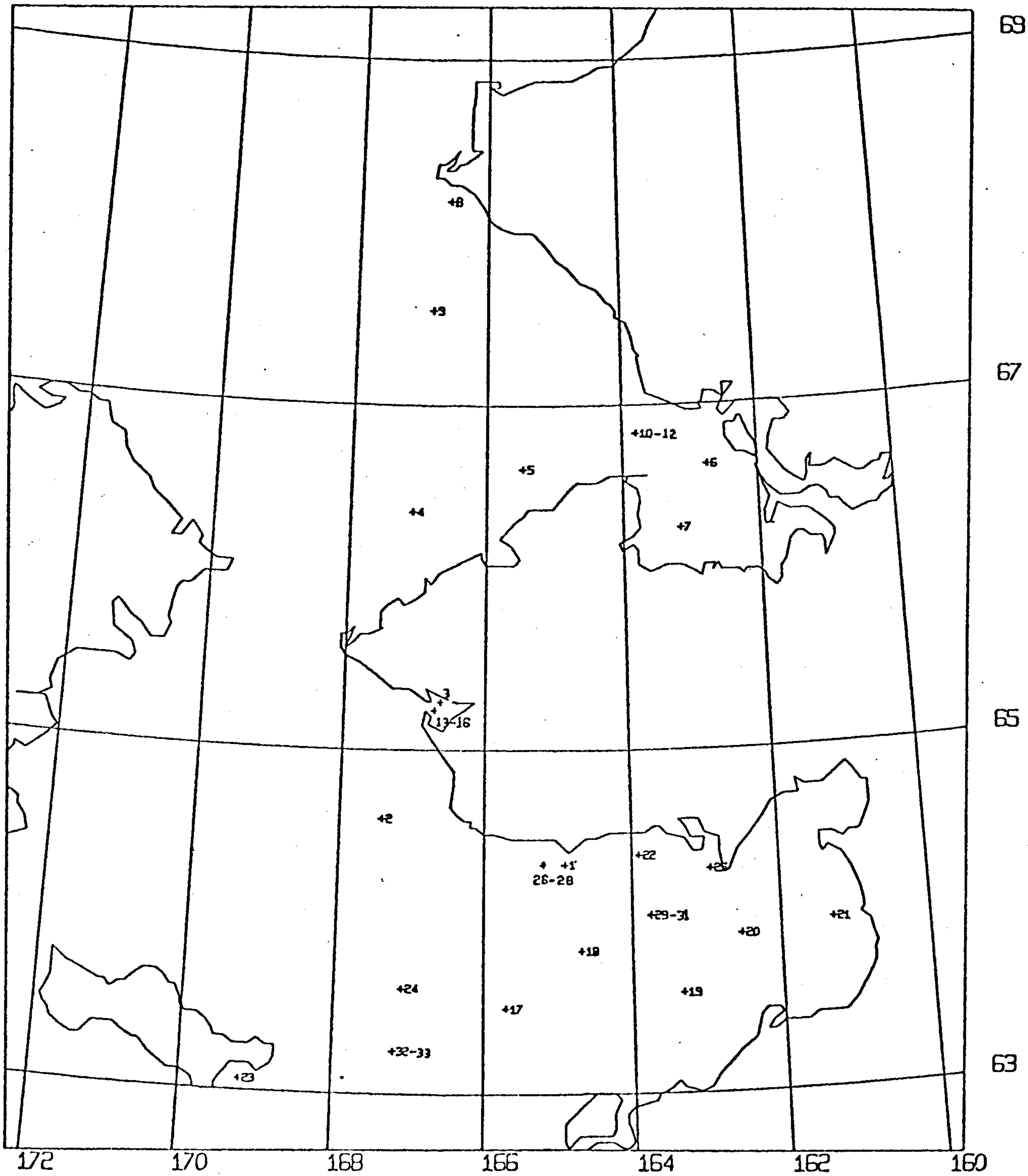

FIGURE 3. GILLNET STATIONS, 1976 BASELINE SURVEY.

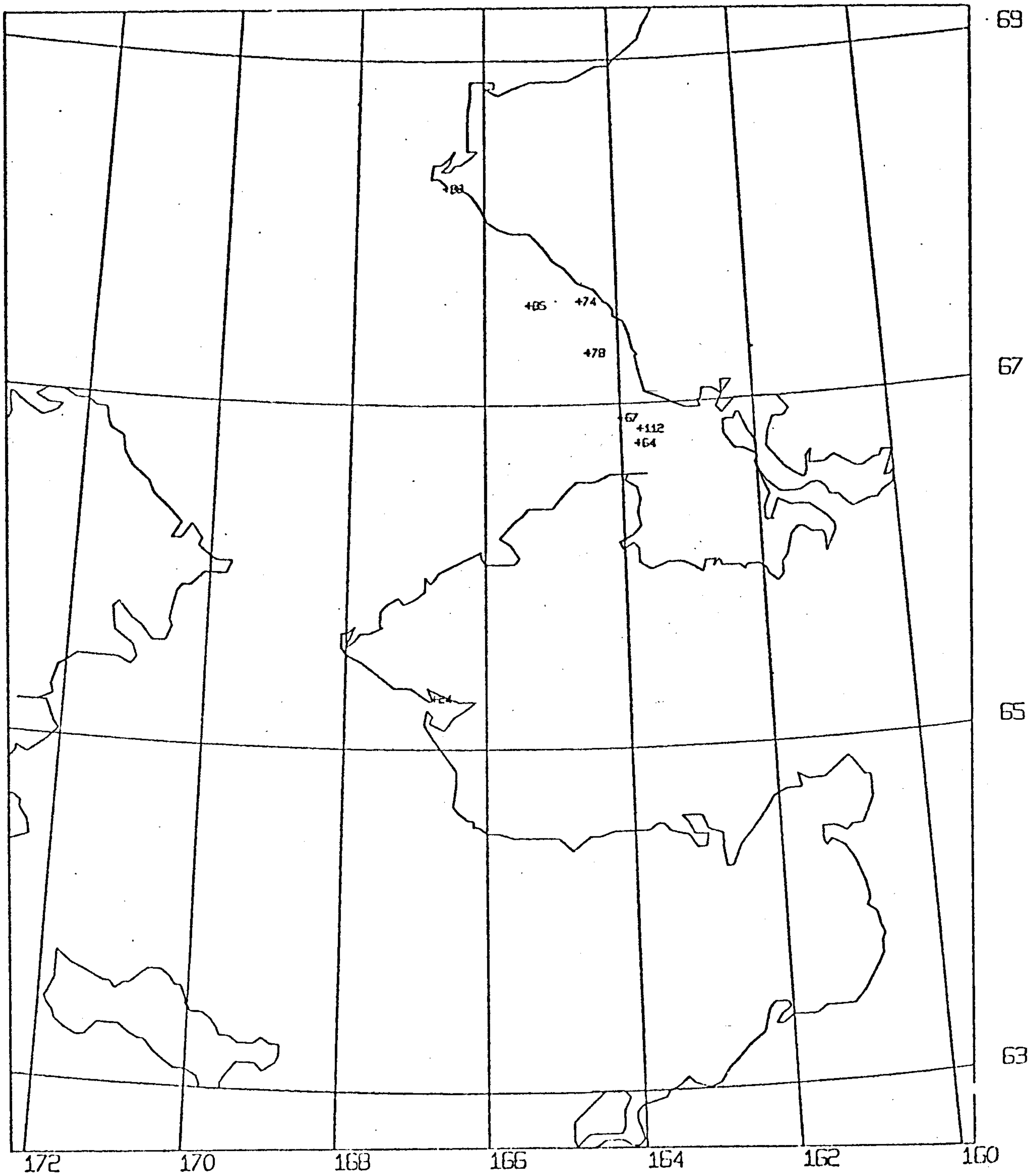

FIGURE 4. PELAGIC SURVEY TRAWL STATIONS, 1976 BASELINE SURVEY.

Ninety-seven (97) stomachs were collected from saffron cod and toothed smelt during the survey. These samples have been preserved in formalin for subsequent analysis.

b. Detailed analysis of the survey information will be completed during next quarter. Types of analyses will include: length composition by species, sex, and strata; age composition of fish species by sex and strata; biomass estimates by species groups and individual species by strata; species assemblages; and species ranking.

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ERRATA

Pereyra, Walter T., Jerry E. Reeves, and Richard G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. U.S. Dep. Commer., NOAA, NMFS, Northwest Fish. Center, Seattle, Wash., Proc. Rep. In two parts: Narrative report, 619 p.; Data appendices, 534 p. C Processed.)

To meet the due date for the Bering Sea report, it was necessary to assemble, type and edit the report within a short time interval. This led to a number of errors. Corrections, other than obvious spelling errors, are listed below.

LIST OF TABLES

Page	
v	Table V-2, line 2 - insert Sea after Bering
vii	Table IX-21, line 1 - insert for after curves

LIST OF FIGURES

xxiii	Figure IX-42 - correct page number to 247
xxix	Figure IX-139 - correct ragilis to fragilis
xxxvii	Figure IX-2 - correct figure number to XI-2

SECTION III

3	Para. 3, line 2 - correct pre to procedural
	Para. 3, line 3 - correct procedural to procedures

SECTION V

12	Para. 7, line 1 - correct Cymatiacea to Tonnacea

SECTION VI

23	Para. 1, line 1 - correct to read: other developments during the period 1964 to present were the shift.....
23	Title, Figure VI-5, line 3 - correct D_w to E
34	Title, Table VI-10, line 2 - correct west to east

SECTION VIII

Page

96 Para. 3, line 6 - correct 20-20 to 20-40

113 para. 6, lines 5-6 - delete the phrase: of sampling effort causing different coverage of species distribution

113 Para. 6, line 6 - delete period and add: ; and (3) between survey differences in trawl efficiencies and sampling methods.

114 Para. 4, line 2 - correct 1961-75 to 1971-75

SECTION IX

161 Para. 3, line 5 - correct nm/hr to nautical mi/hr

170 Para. 1, equation 2 - replace a_i in numerator with A_i
Equation 3 - replace $(n_i - 1)$ with $(\hat{n}_e)$

172 Para. 3, line 11 - correct P_{ijk} to $\hat{P}_{ijk}$
line 13 - correct P_{iklm} to $\hat{P}_{iklm}$
equation 2 - delete $\sum_{k=1}$ in denominator

173 Para. 1, line 4 - correct P_{iklm} to $\hat{P}_{iklm}$

line 4-9 - replace last sentence with: If size composition estimates were not available for all subareas in which the species occurred, total all strata size composition estimates were computed as the sum of the population numbers by size-sex category (P_{iklm}) for those subareas where this information was available.

174 Para. 4, line 3 - correct <u>L</u> to <u>L</u> ∞

323 Legend Figure 1X-95 - contour interval designations for <2 and 2-10 kg/km are reversed.

325 Figure 1X-97 - correct carapace length to carapace width on abscissa

329 Legend Figure IX-101- contour interval designations for <2 and 2-10 kg/km are reversed.

331 Figure IX-103 - correct carapace length to carapace width on abscissa

334 Legend Figure IX-107 - contour interval designations are upside down and the designations for <2 and 2-10 kg/km are reversed.

336 Figure 1X-109 - correct carapace length to carapace width on abscissa

SECTION X

369 Para. 2, line 3 - insert following period: It also occurs in the Okhotsk.

375 Para. 1, line 12 - correct 0.71.0 to 0.7-1.0

400 Para. 4, line 4 - correct equation to $W = .0052 L^{3.222}$

407 Para. 1, line 4 - correct 7 to 8

453 Para. 3, line 3 - correct genus to <u>Callorhinus</u>

SECTION X (Continued)

Page	
479	Table X-35, title, line 2 - correct black to Greenland
483	Para. 5, line 7 - correct to Berzin
487	Figure X-84, title, line 2 - correct to Mikawa
501	Para. 6, lines 3, 4, 5 and 8 - correct % to o/oo
519	Para. 4, line 2 - replace and with comma 3 - insert after Arctic-Boreal: , and Subarctic-Boreal
529	Para. 1, line 3 - replace and with comma insert after Low Arctic Boreal: , and Subarctic-Boreal
534	Para. 7, line 1 - insert after between: 2 mm
552	Para. 1, line 10 - correct 54°30'N to 55°30'N

SECTION XII

585 Insert as 5th reference on page:

Allen, K. R. 1966. Determination of age distribution from age-length keys and length distributions, IBM 7090, 7094, FORTRAN IV. Trans. Amer. Fish. Soc. 95: 230-231.

603 Maeda, T. 1972, line 2 - Correct 34 to 38

ADDITIONAL CORRECTIONS

169 Equation 3 - Change to:

$$\mathrm{VAR}\ (\overline{\mathrm{CPUE}}_{tk}) = \sum_i \left[\left(\frac{A_i}{A_t} \right)^2 \cdot \mathrm{VAR}\ (\overline{\mathrm{CPUE}}_{ik}) \right]$$

ANNUAL REPORT

Contract # 03-5-022-69
Research Unit #233
Reporting Period - July, 1975 -
March 1, 1976

Beaufort Sea Estuarine Fishery Study

Principal Investigator:

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Fisheries Biologist
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Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701

1 April 1977

TABLE OF CONTENTS

SUMMARY

Fisheries surveys were conducted along 102 miles (163 km) of Beaufort Sea coastline between the Colville and Canning rivers over a two year period beginning in 1975. An attempt was made to sample all of the principal habitats within this study area. A total of 28,369 fish representing seven familes and 15 species was captured. During the open water season freshwater and anadromous species dominated the near shore fish fauna and accounted for 52% of the entire catch. Arctic char, Salvelinus alpinus, Arctic cisco, Coregonus autumnalis, and least cisco, C. sardinella, were the most widespread and abundant anadromous fishes. The two most abundant marine species are fourhorn sculpin, Myoxocephalus quadricornis and Arctic cod, Boreogadus saida.

During 1976, 4,962 anadromous fish were tagged with Floy FD-67 anchor tags. Eight percent (384) were recaptured within the study area and in the Colville River. Anadromous fish enter the Beaufort Sea at breakup and forage for variable distances along the coastline. Adults reenter freshwater systems to spawn and overwinter earlier than juveniles and nonspawning members of the same species. The movements of juvenile fish along the coastline are restricted to less saline, protected waters of major river deltas and lagoons. Anadromous whitefish and char spawn during the fall in a variety of river habitats ranging from perennial groundwater springs in headwater tributaries to isolated pockets of under-ice water in river deltas. Overwintering habitat has not been identified in the fast ice zone of the Beaufort Sea. Tag recoveries indicate that the Colville River is the major spawning and overwintering drainage for whitefish captured within the study area. The destruction or disturbance of overwintering and spawning habitat appears to present the greatest threat to survival of near shore anadromous fish populations along the Beaufort Sea.

INTRODUCTION

Petroleum exploration and development is rapidly increasing throughout the near shore areas of the Beaufort Sea. The demands by industry for construction material, gravel sources, fresh water and transportation avenues are substantial. Alterations of the physical environment resulting from water and gravel removal or the construction of roads, pads and causeways are imminent. Information on the biology of fish inhabiting these waters is necessary prior to evaluating the ultimate effects these activities have on the resource.

The objectives of this study are to determine the distribution and relative abundance of the various species of fish inhabiting the near shore environs of the Beaufort Sea. By correlating important life history data with the knowledge of habitat needs, we hope to obtain base line information that can be used to direct the activities of people and industry in the proposed lease area. Specifically, the objectives of the study are:

1. To determine the seasonal distribution, relative abundance, size and species composition, growth rates, feeding habits and reproductive capabilities of Beaufort Sea near shore fishes in the area from the Colville to the Canning rivers and between shore and the barrier islands, including river deltas.

2. To determine migration patterns and timing of these fishes.

3. To identify critical habitats including spawning, overwintering, feeding, rearing and migration areas.

4. To determine the interrelationship of Arctic fishes to lower food-web organisms.

5. To determine the present rate of exploitation of the anadromous fishes of the area and to monitor changes in this usage as development of the areas petroleum resource progresses.

CURRENT STATE OF KNOWLEDGE

Prior to the accelerated interest and development in the Arctic by major oil companies, there have been few investigations of the fishes in the Beaufort Sea. The Alaska Department of Fish and Game (Roguski and Komarek, 1971) initiated a study to assess the environmental characteristics and fish species in coastal waters of the Arctic National Wildlife Range. The following year, a four year investigation of the waters draining into Prudhoe Bay was initiated (Yoshihara 1972, 1973 and Furniss 1974, 1975). These investigations emphasized the life histories and distributions of anadromous species with special emphasis on Arctic char. Other fisheries studies on North Slope drainages were conducted by McCart, Craig and Bain (1972) and Johnson (1973). With the advent of designing and proposing utility corridors to transport natural gas south from the Arctic, several more investigations were initiated, many of which stressed the life history and biology of fish in their freshwater habitats of North Slope drainages. More recently, fisheries investigations have been centered along the northern coastlines of Alaska and Canada. Furniss (1975) investigated the age, growth, fecundity, species composition and distribution of fishes in Prudhoe Bay. Griffiths and Craig et al. (1975) conducted a site specific study of the fishes in the Nunaluk Lagoon, along the Arctic coast of the Yukon Territory. Griffiths et al. (1976) conducted a similar study at Barter Island, and other investigators have conducted studies aimed at evaluating the importance of the Mackenzie (Percy, Eddy and Munro, 1974) and Colville (Kogl and Schell, 1975) river deltas to Arctic Ocean fish. Studies of overwintering fish in the Arctic have been directed towards the larger bodies of fresh water, including river deltas (Mann, 1975; Kogl and Schell, 1975) and spring areas or unfrozen pockets of river water under thick ice (Craig and McCart, 1974; Alt and Furniss, 1976). These studies have led to a much greater understanding of the habitat requirements and life histories of Arctic fishes; however, much remains to be understood of these fishes during their seasonal occupation of the shallow near shore environments along the Beaufort Sea coast.

STUDY AREA

The OCS Beaufort Sea studies encompass an area between the eastern margin of Harrison Bay and Flaxman Island, a linear distance of approximately 102 miles (163 km) (Fig. 1). Centrally located along this stretch of coastline is Prudhoe Bay, the development and staging area for North Slope oil fields and the beginning of the Trans-Alaska oil pipeline. A barrier island system consisting of raised pebble reefs extends intermittently along the entire length of the study area. These islands, lying from 1/2 to 12 miles (1-16 km) offshore, tend to prevent large quantities of fresh water and nutrients entering the Beaufort Sea from readily mixing with the cooler, more saline waters of the Arctic Ocean. They also shelter the mainland coastline from pack ice during the summer months, thus providing a low salinity, relatively ice-free lagoon system inhabited by several species of anadromous, freshwater or marine fish throughout much of the year. Physical features of the mainland coastline include river deltas, spits, shallow bays, and narrow pebble or fine sediment beaches. Direct wave action and thermal erosion of permanently frozen shore banks produce local beaches composed of humus and decayed vegetation. Sharp variations in water temperatures and salinities were noted, both between short distances and with time, during the open water season (Fig. 2). Physiographic and environmental characteristics of the Beaufort Sea and coast are described by Namtvedt, et al. (1974) and State of Alaska, Division of Policy Development and Planning (1975).

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Methods of Capture and Observations

Multifilament graduated mesh sinking gill nets measuring 125' x 6' and consisting of five 25' panels of 1/2' through 2 1/2" mesh were used for capturing and sampling fish. Multifilament gill nets measuring 25' x 3' and consisting of single mesh sized from 1/2" to 1 1/2" were used for capturing fish during under-ice surveys.

Beach seines measuring 100' x 4' were used to sample fish in confined locations within small bays and lagoons, and along exposed beaches where water was sufficiently shallow to allow the seaward end of the seine to be maneuvered on foot.

Fyke traps were operated at several locations within Prudhoe Bay. Traps were 20' in length overall and were supported by five "D" shaped, 3/4" aluminum tube frames. Two throats measuring 10" in diameter were located at the first and third frames. Netting was 1/2" square mesh knotless nylon. The fyke traps were anchored in approximately 4' of water and were attached to shore by 50', 100' or 150' center leads. Two 25' x 4' wings funneled fish into the trap.

A try trawl measuring 12' in width and constructed with 3/4" square measure knotted nylon mesh was used to sample fish offshore.

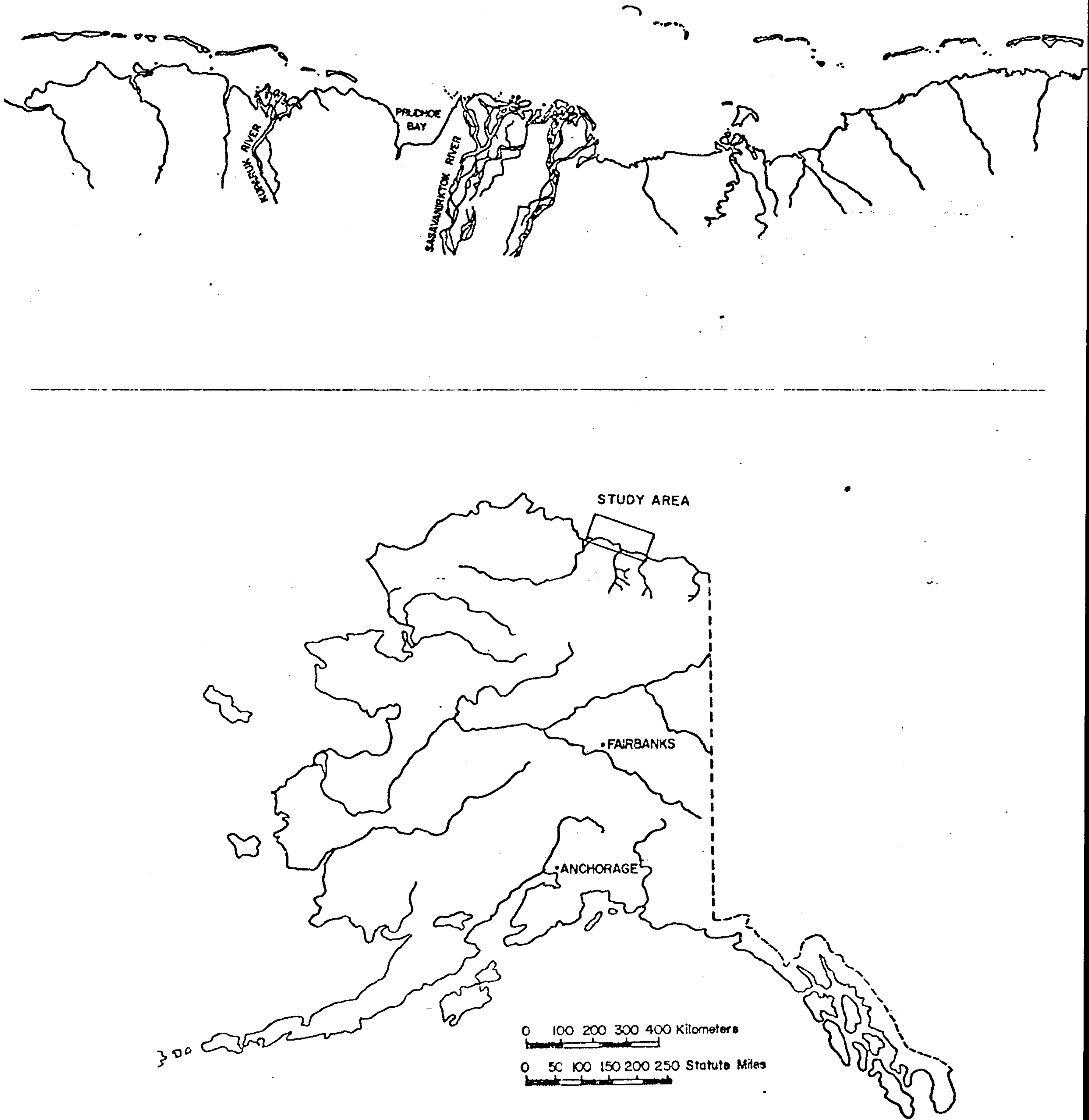

Figure 1. Map of Alaska showing North Slope Study Area.

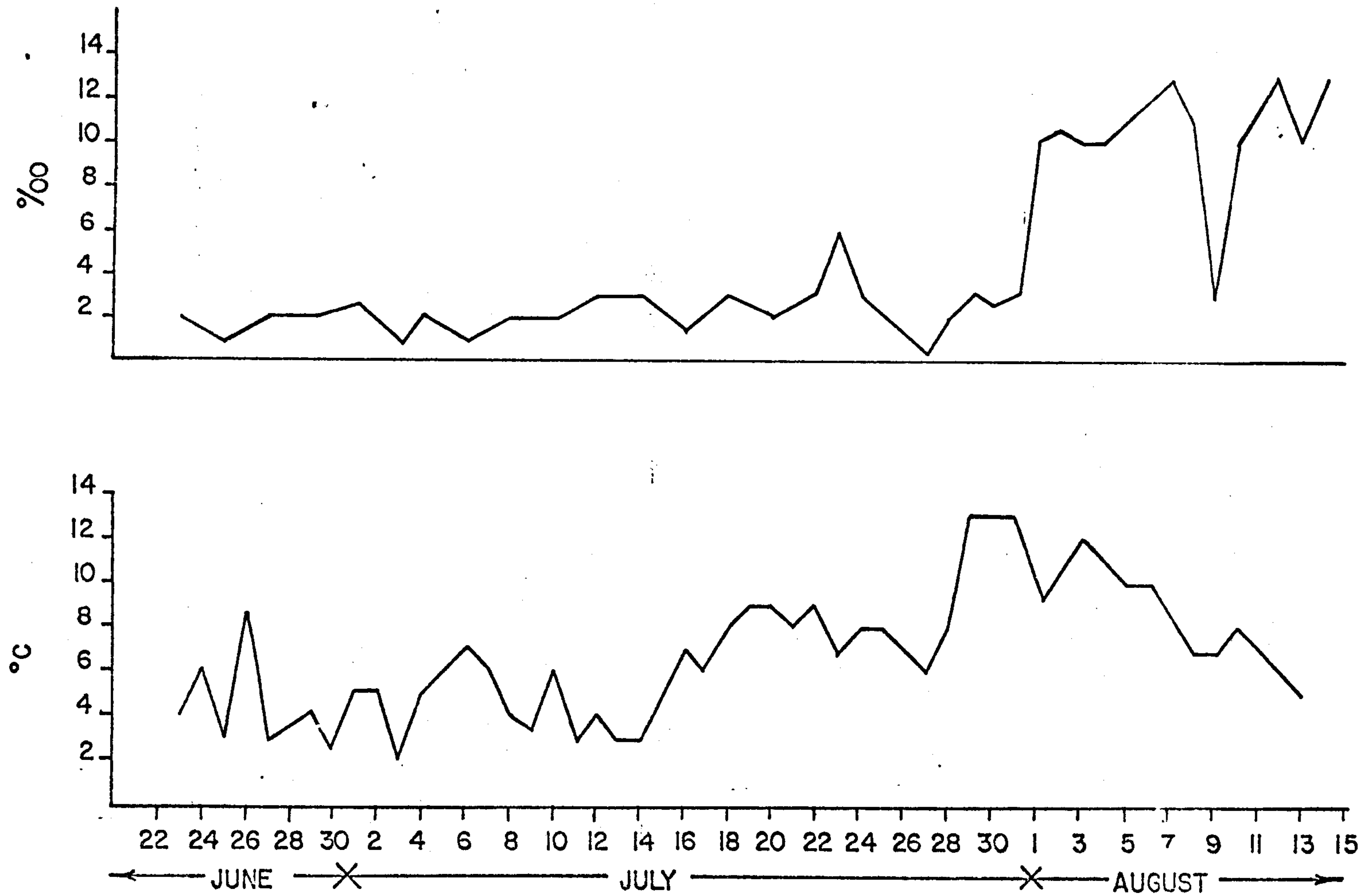

Figure 2. Seasonal variation in salinity and temperature at Prudhoe Bay, 1976.

Hook and line sampling was employed to capture fish in river deltas and under the ice.

An underwater closed circuit television system was used under the ice in the Sagavanirktok and Kuparuk river deltas to detect and observe overwintering fish occupying isolated pockets of unfrozen water. The system is sold by Hydro Products, Box 2528, San Diego, California. Its operation employed the use of the following five components:

Underwater television camera with 12.5 mm optics
High resolution 9" monitor
Gas discharge lamp ballast
250 watt Thallium iodide lamp
Portable 115 V power source

A Yellow Springs Instrument Co. salinity meter was used to determine water temperature, salinity and conductivity. Wind force and direction, current force and direction, sea state, cloud amount, present weather and air temperature were observed and recorded daily throughout most 1976 open water season.

Anadromous fish over 200 mm in fork length that were not sampled were tagged with numbered Floy FD-67 internal anchor tags. All other fish, including those below the "minimum" tagging size that were not sampled, were noted on daily catch forms and released.

A 21' Boston whaler and a 12' Zodiac inflatable boat were used for trawling and setting nets offshore near Prudhoe Bay.

Rotary wing aircraft were used for transporting field personnel and gear for monitoring movements of fish along the coastline and into river deltas.

Processing of Fish

Fish samples were preserved in 10% Formalin or frozen and sent to Fairbanks via commercial airlines for further laboratory analysis. All samples were grouped by date and location. Fish were weighed to the nearest gram on a triple-beam balance. Fork lengths were measured to the nearest millimeter. Sex and stage of maturity were determined by examining gonads.

Fecundity counts were determined by displacing a volume of water with a known quantity of eggs. The total number of eggs was then calculated using the quantity of water displaced by the entire ova mass.

Arctic char, cod, flounder, sculpins and liparids were aged by reading otoliths wetted in zylene under a binocular dissecting scope. Scales were used to age all other species. Scales used for age determination were cleaned and impressed on 20 mil acetate sheets. A Bruning 200 microprojector was used to read the scales. Lengths at the end of each year of life for several species were back calculated using the direct proportion formula.

Selected fish stomachs were slit and preserved in 10% Formalin. The gut contents were later examined, sorted and identified.

Data Management

Raw data collected for this study have been prepared within the design of the OCSEAP data management format and stored on magnetic tape. Voucher specimens of the fish, invertebrates and food items collected during this study are in storage at the Fairbanks office of the Department of Fish and Game.

FINDINGS

Species Composition and Relative Abundance

Seventy-six sampling sites were established between the eastern margins of Harrison Bay (70°33' N, 149°38' W) and Brownlow Point (70°10' N, 145°53' W) (Fig. 3). An attempt was made to sample all of the dominant habitat types within this area. These include outer islands, near shore islands, spits, points, bays, lagoons and river deltas. Salinity, water and air temperature, conductivity and depth of water were recorded at each station. During the summer of 1976 the following additional parameters were recorded at each site: bottom type, present weather, cloud amount, sea state, wind direction, wind force, current direction and current force. These additional parameters were observed rather than measured and were recorded as prescribed by the fish resource assessment format designed and provided by OCS.

A total of 28,369 fish representing seven families and 15 species has been captured. Fish species captured between Harrison Bay and Brownlow Point are listed in Table 1.

During 1975, graduated mesh gill nets were the most extensively used method of capture; however it became obvious late in the season that the use of gill nets was not conducive to the capture of gadids, liparids and the early life stages of salmonids. Fyke traps were subsequently stationed at several locations in Prudhoe Bay and proved more effective at catching the above mentioned fishes. During 1976, an attempt was made to maintain several fyke trap stations throughout the open water season in Prudhoe Bay while graduated mesh gill nets were used for 24 hour sets at more remote stations requiring helicopter transportation. Fyke traps also proved to be the least harmful method of capturing fish for tagging studies.

Beach seines effectively captured fish in shallow waters; however, adverse weather conditions and wave activity frequently prohibited their use. A shrimp try trawl was used in Prudhoe Bay. Transects were run for 20 minutes with the lead line of the trawl riding on the bottom. Larval and early life stages of Arctic cod, capelin and liparids dominated the offshore trawl catches.

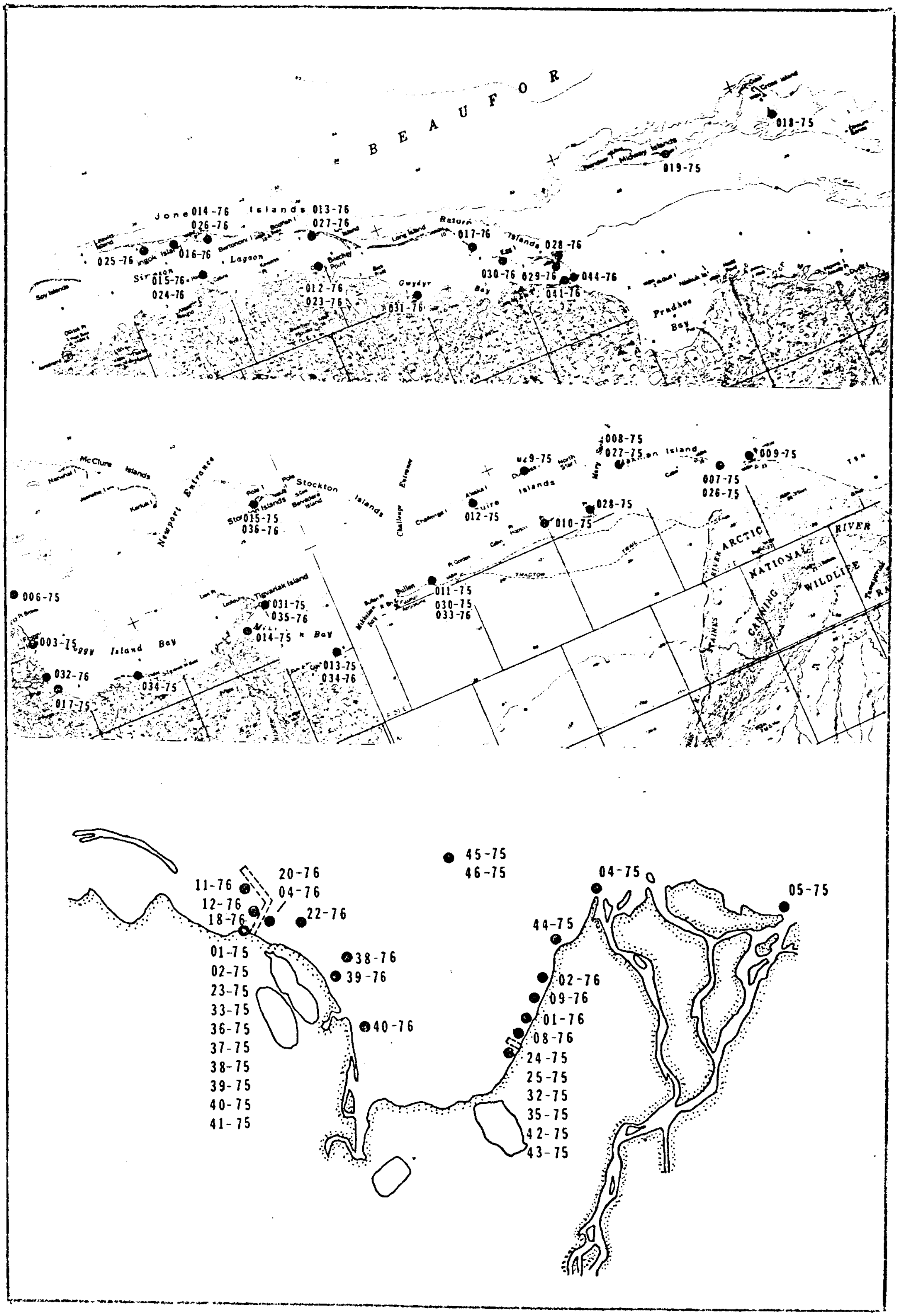

Figure 3. Seventy-six sampling sites established between the eastern margins of Harrison Bay and Brownlow Point.

Table 1. List of near shore species captured between Harrison Bay and Brownlow Point.

Scientific Name	Common Name	Species Abbreviation	OCS Species Code
Salmonidae			
Salvelinus alpinus	Arctic char	AC	7904010402
Coregonus sardinella	Least cisco	LCI	7904010105
C. autumnalis	Arctic cisco	ACI	7904010101
C. nasus	Broad whitefish	BWF	7904010103
C. pidschian	Humpback whitefish	HWF	7904010104
Prosopium cylindraceum	Round whitefish	RWF	7904010601
Thymallus arcticus	Arctic grayling	GR	7904010701
Osmeridae			
Osmerus mordax	Boreal smelt	BSM	7904020302
Mallotus villosus	Capelin	CAP	7904020201
Gadidae			
Boreogadus saida	Arctic cod	ACD	7909020201
Eleginus gracilis	Saffron cod	SCD	7909020301
Cottidae			
Myoxocephalus quadricornis	Fourhorn sculpin	FSC	7915042206
Pleuronectidae			
Liopsetta glacialis	Arctic flounder	AFL	7917021101
Gasterosteidae			
Pungitius pungitius	Ninespine stickleback	NSB	7914010201
Liparidae			
Liparus sp.	Snailfish	Lip	791506

The most widespread group of fishes captured along the coast were salmonids; Arctic char were captured at 75% of the gill net stations. Arctic cisco and least cisco were captured at 59% and 44% of the stations respectively. Least cisco were captured in the greatest abundance however, followed by Arctic char and Arctic cisco. Figure 4 shows the seasonal abundance of Arctic char, least cisco and Arctic cisco captured in Prudhoe Bay.

Catch data show a more widespread distribution for adult Arctic char and Arctic cisco than for other anadromous species. Arctic char and Arctic cisco were captured at nearly all of the barrier island stations as well as along mainland beaches. Least cisco, however, showed a greater affinity for near shore areas throughout the study area. Broad whitefish were rarely captured in waters east of Bullen Point (70°10' N, 146°45' W) and were found in the greatest abundance near the Sagavanirktok and Colville river deltas. Adult humpback whitefish were likewise distributed along mainland beaches between the Sagavanirktok and Colville rivers.

Figure 5 shows the relative abundance of all species captured within the study area. The majority of fish were captured in fyke traps set in locations adjacent to the mainland. The two most abundant marine species (Arctic cod and fourhorn sculpin) accounted for 48% of the entire catch. Figure 6 shows the seasonal distribution of all species captured in Prudhoe Bay.

Migration Patterns and Timing

The presence of bottom-fast ice during winter months over much of the near shore waters between the mainland and the barrier islands precludes the presence of fish near shore until after breakup. During both years of this study, sea ice began lifting during the early weeks of June. During 1976, breakup occurred several weeks earlier in the rivers than in Prudhoe Bay. Fresh turbid water from the Sagavanirktok River flooded bottom-fast sea ice in the vicinity of the delta beginning approximately the first of June. Shortly thereafter, gill nets and fyke traps were set in open water leads as they appeared near shore in Prudhoe Bay. By June 21, the open water along the western margin of Prudhoe Bay (vicinity of ARCO causeway) was 1°C and the salinity was less than 1 ppt, indicating that the sea ice had not yet lifted and that fresh, river water was not mixing with the more saline waters of the ocean. The first fish captured in Prudhoe Bay were Arctic char and broad whitefish on June 22. By June 24, salinity increased to 2.5 ppt along the eastern margin of Prudhoe Bay and the first marine species (fourhorn sculpin) was captured. Throughout the remainder of June, Prudhoe Bay catches consisted of Arctic char, grayling, broad whitefish and fourhorn sculpin. Catches of Arctic cisco, humpback whitefish and saffron cod began in the first week of July. Least cisco, Arctic cod and Arctic flounder appeared in Prudhoe Bay during the second week of July. Both species of smelt found in the study were initially captured near shore in late July and early

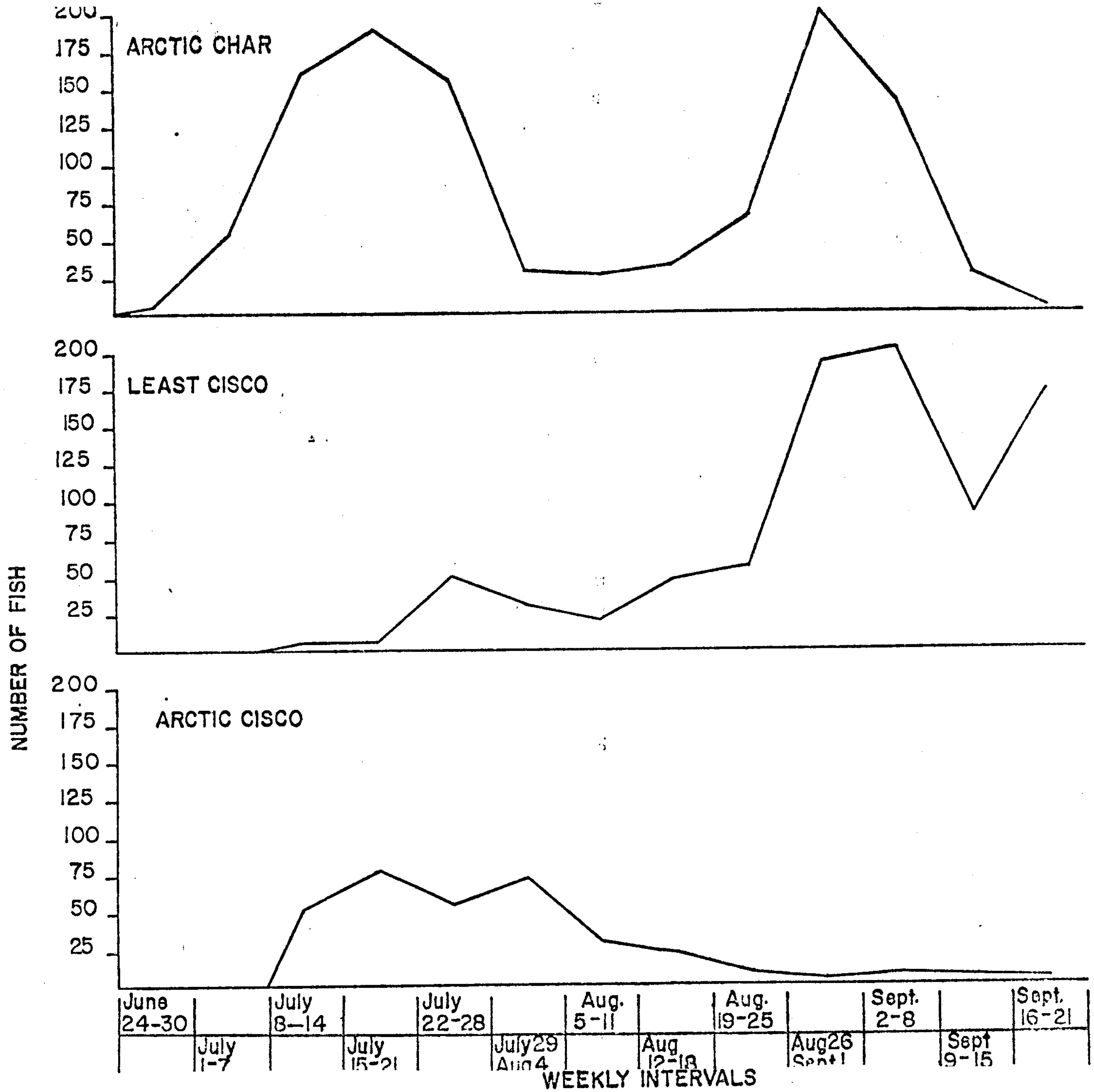

Figure 4. Seasonal abundance of three anadromous fish species in Prudhoe Bay.

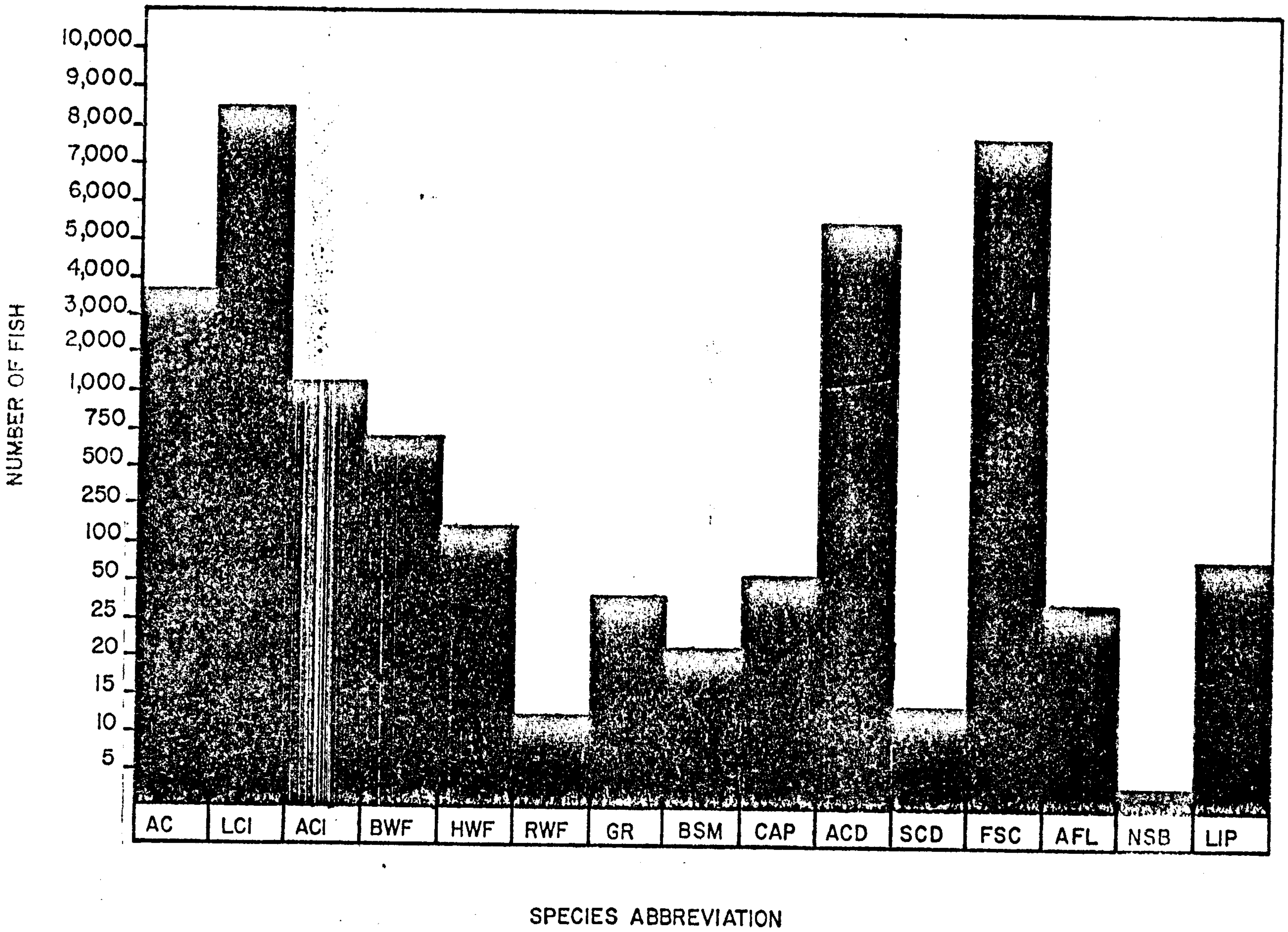

Figure 5. Relative abundance of freshwater, anadromous and marine fish found in Prudhoe Bay.

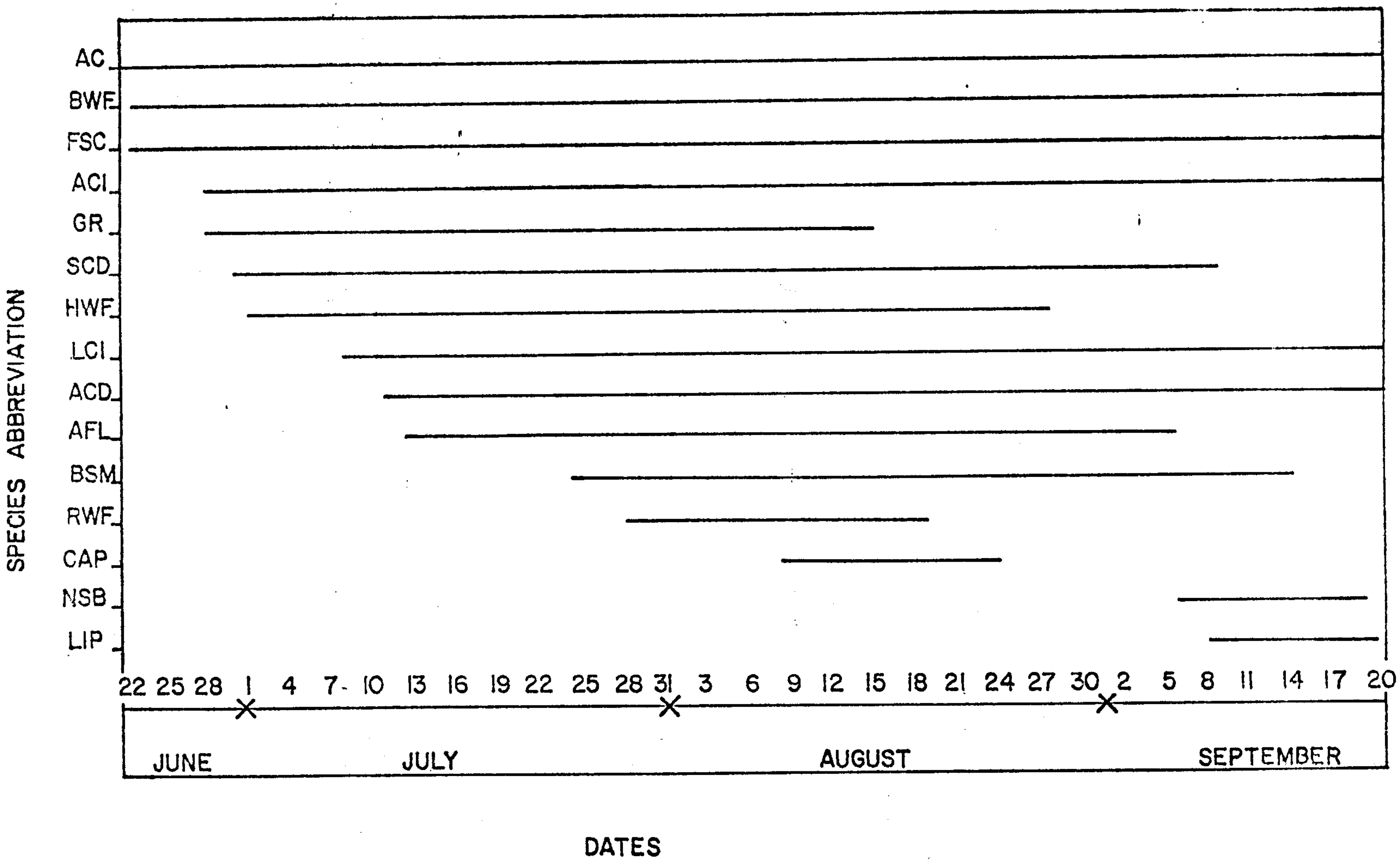

Figure 6. Seasonal distribution of fish species captured in Prudhoe Bay, 1976.

August, and the liparids were captured near shore for the first time on September 8. Throughout the open water season, short term variations in temperature and salinity did not affect the distribution or abundance of fish captured in Prudhoe Bay.

During 1976, 4,962 anadromous fish were tagged in Prudhoe Bay and 384 (8%) were recaptured within the study area and in the Colville River. The total number of fish captured at the permanent stations in Prudhoe Bay increased slowly throughout the 1976 open water season, reaching a peak during the first week of August. The length frequency distribution of the five anadromous species (Arctic char, least cisco, Arctic cisco, broad whitefish and humpback whitefish) found in Prudhoe Bay varied throughout the open water season. All of the above species that were greater than 200 mm in fork length that were captured in fyke traps were tagged with FD-67 Floy tags. Thus, we could segregate the number of each species captured into two rough size groupings; those greater than 200 mm which were subsequently tagged and those less than 200 mm which were accounted for and released. During the month of June, 24% of the above species combined were greater than 200 mm. In July, August and September, 41%, 74%, and .08% of the anadromous fish captured were greater than 200 mm in fork length. Thus the percentage of larger and older fish of each species increased throughout the summer to a peak in early August, then decreased very rapidly and remained low until the time the traps were removed (September 22). The decrease in the percentage of larger fish corresponds with the timing of mature individuals movement back into fresh water spawning and overwintering habitats. In both years of this study, immature Arctic char and least and Arctic cisco remained in the salt water until freezeup. Of the marine species captured, only fourhorn sculpin, Arctic cod and liparids were taken after September 1. More detailed information on distribution and movements follows in the discussion of individual species.

Overwintering Habitats

Very little information is available concerning overwintering fish and their habitat in Arctic and subArctic waters. The two major rivers within the study area (Sagavanirktok and Kuparuk) attain maximum rates of discharge during spring breakup. Thereafter, the flow decreases throughout the remainder of the year. Freezeup usually occurs in September. As the river ice increases in thickness, it freezes into the substrate in shallow areas and riffles. By mid winter, this process has effectively created a series of discontinuous pools of water under the ice which constitute the only overwinter habitat for fish occupying the lower reaches of these rivers. Late winter flows in the Sagavanirktok and Kuparuk deltas are poorly defined, but near zero.

Ten locations were examined for overwintering fish between March 18 and April 10, 1976 (Fig. 7). The following parameters were recorded at each site: ice depth, water depth, bottom type, approximate dimensions of under-ice pool, air temperature, water temperature, salinity and dissolved oxygen. Observations of fish under the ice were made with the underwater closed circuit television system. Fish were captured by hook and

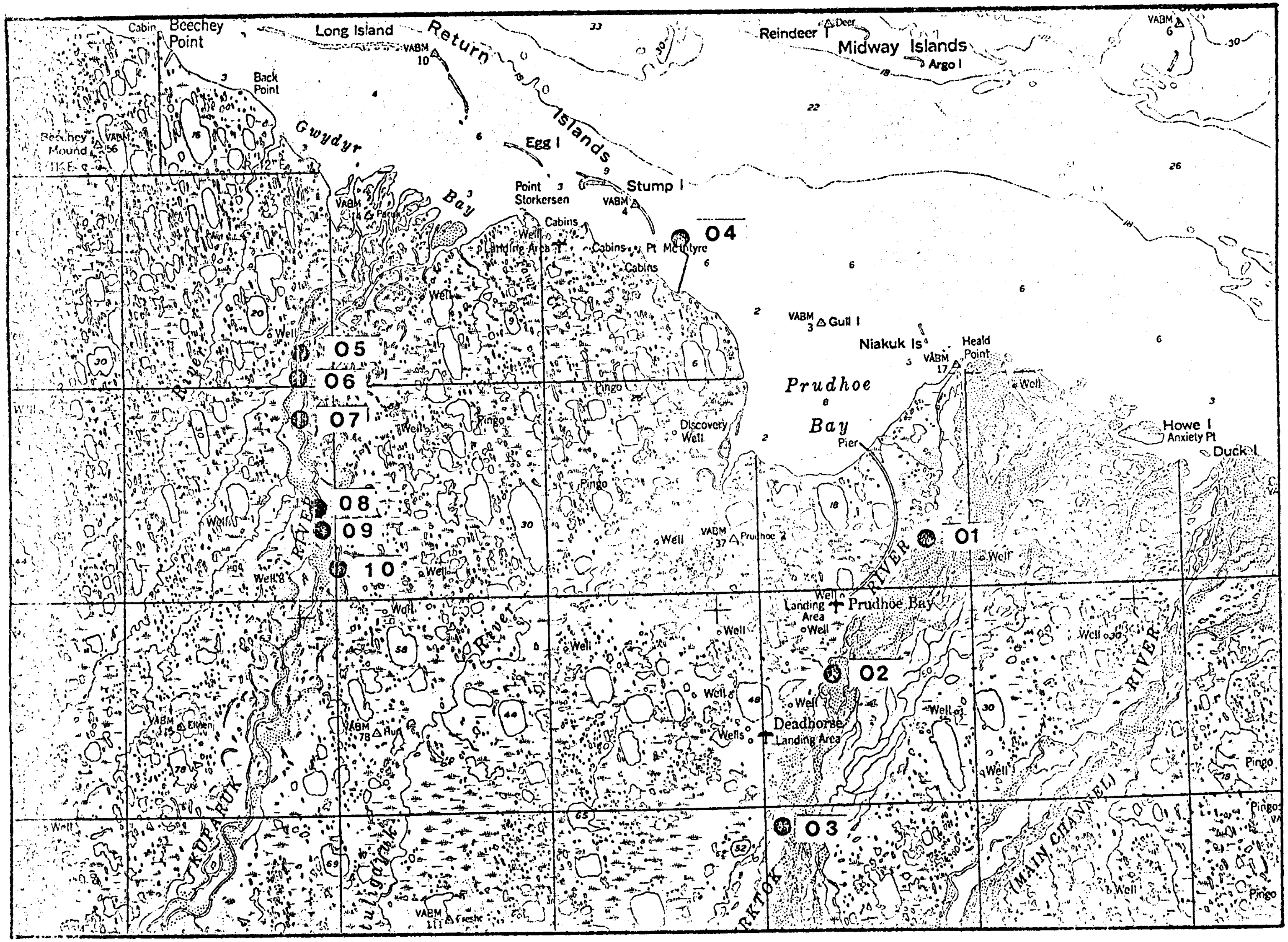

Figure 7. Winter sampling sites, 1976.

line and with gill nets. The use of minnow traps to capture juvenile fish was tried unsuccessfully at several locations. Up to 28 man hours of effort were required to set a single 25' net under the ice.

Our initial investigation indicates that the amount of under-ice habitat is extremely limited during late winter and every location thoroughly examined was found to contain fish. Table 2 summarizes the data collected at each site. Dissolved oxygen readings varied between 7 ppm and saturation (in excess of 15 ppm at 0°C). Station 03 on the Sagavanirktok River was anaerobic in April. This may have resulted from industrial dewatering of this site in earlier winter. Salinity was zero at all river locations. Water depths varied between 7" (dewatered by industry) and 66". The maximum ice thickness was 89". Bottom types varied from sand to coarse gravel up to 3" in diameter.

Following is a list of the fish either observed, or captured during March and April, 1976.

Sagavanirktok River	Kuparuk River
Grayling	Grayling
Round whitefish	Round whitefish
Broad whitefish	...
Humpback whitefish	...
Burbot	Burbot
Slimy sculpin	Slimy sculpin
...	Ninespine stickleback

Grayling captured under the ice averaged 279 mm in fork length and ranged from 35 mm (young-of-year) to 377 mm (X years). Females over 250 mm were gravid. All grayling had empty stomachs at the time of capture.

Round whitefish ranged from 217 mm to 284 mm in fork length with an average of 244 mm. Round whitefish ranged from IV through VI years in age and all had empty stomachs at the time of capture.

Broad whitefish ranged from 239 mm to 445 mm in fork length and averaged 380 mm. Ages ranged from V through XIII years. Broad whitefish from 370 mm to 445 mm had spawned the previous fall probably at or near the same location as captured under the ice. All of the broad whitefish had empty stomachs.

Burbot captured under the ice averaged 493 mm in fork length and ranged from 255 mm to 702 mm. Ages varied from V through XII years and mature individuals, upon examination, showed evidence of having recently spawned. Burbot were feeding on grayling, slimy sculpin, and ninespine stickleback as well as larval insects.

Several age groups of a species, and in some cases all species, were captured at the same site. The only species tentatively identified with an underwater camera but not captured was the humpback whitefish. Arctic char, an important species in the Sagavanirktok River, was neither observed nor captured under the ice in the lower river.

Table 2. Physical parameters recorded at overwintering sites 1976.

Station Number	Date	Location	Under-ice Water Depth (inches)	Ice Thickness (inches)	Water Temp. (°C)	Salinity (ppt)	DO (% saturation)	Species Present
01	3-19	Sagavanirktok R.	20	60	0	0	55	GR, RWF, BB, BWF, *HWF, SC
02	4-10	Sagavanirktok R.	41	89	0	0	100	GR, RWF, SC, BB
03	4-19	Sagavanirktok R.	27	65	0	0	0	GR
04	3-21	Prudhoe Bay	36	72	-1	30	N/A**	...
05	4-3	Kuparuk R.	62	66	0	0	>100	GR, BB, SC, NSB
06	4-3	Kuparuk R.	48	72	1.5	0	90	N/A*
07	4-5	Kuparuk R.	64	69	0	0	49	GR, BB, RWF
08	3-20	Kuparuk R.	20	84	0	0	>100	GR, BB, RWF, SC
09	3-20	Kuparuk R.	16	80	0	0	>100	N/A*
10	4-5	Kuparuk R.	46	66	0	0	>100	N/A*

* No attempt was made to observe with the camera or set a net.
** Dissolved oxygen values were not taken at this site.

These preliminary results stress the importance of the limited overwintering habitat for fish in North Slope rivers. Under-ice pools of water serve as winter refuge for all age classes of the species present and provide spawning and incubation habitat for fall and winter spawners such as whitefish and burbot. Thus, overwintering habitat in North Slope river deltas is clearly susceptible to the deleterious effects of seismic activity, dewatering to meet domestic and industrial water needs, or chemical pollution.

A single under-ice location was examined in Prudhoe Bay on March 21 and 22, 1976. The substrate at this location was composed of mud and fine grained sediments. The underwater television camera showed a slight water current when the bottom sediments were disturbed. No fish were observed at this location. Isopods and several species of amphipods were moving within the water column throughout the duration of our underwater observation. Sufficient effort has not yet been made to determine the significance of near shore waters as overwintering habitat, however enclosed pockets of hyper-saline water within the fast ice zone appear to be the least suitable habitat for overwintering marine species.

INDIVIDUAL SPECIES DISCUSSION

Arctic Char

Arctic char have a circumpolar distribution. Morphological forms are varied and many distinct life history types occur within the range of this species.

Arctic char, found along the entire northern coast of Alaska, are the object of a traditional subsistence and expanding sport fishery. Several recent investigations have been conducted on the life history of the Arctic char in major North Slope drainages (Yosihara, 1973, 1974; Furniss, 1974, 1975; and Griffiths and Craig et al. 1975).

A total of 3,739 Arctic char was captured during 1975 and 1976. Fork lengths ranged from 154 mm through 685 mm with a mean of 427 mm. A length mode occurred between 520 and 529 mm. Length frequency distribution is shown in Fig. 8.

Arctic char ranged from Age III through Age XII, with the majority of fish between VII and IX. Juveniles less than 200 mm were abundant in the near shore waters between the Colville and Sagavanirktok rivers during the open water season.

Sexual maturity is reached from Ages VI to VIII for most anadromous char. Upon reaching maturity, most char spawn in alternate years (Yoshihara, 1973). The sex ratio of Arctic char captured within the study area was biased in favor of females. The female to male ratio of 235 Arctic char was 2:1. Similar disproportions in sex ratios of char were observed by Furniss (1975), Glova and McCart (1974) and others. Of 75 female anadromous char captured in the Beaufort Sea that were judged to be mature, 75% were prespawners (individuals that would spawn in the coming fall).

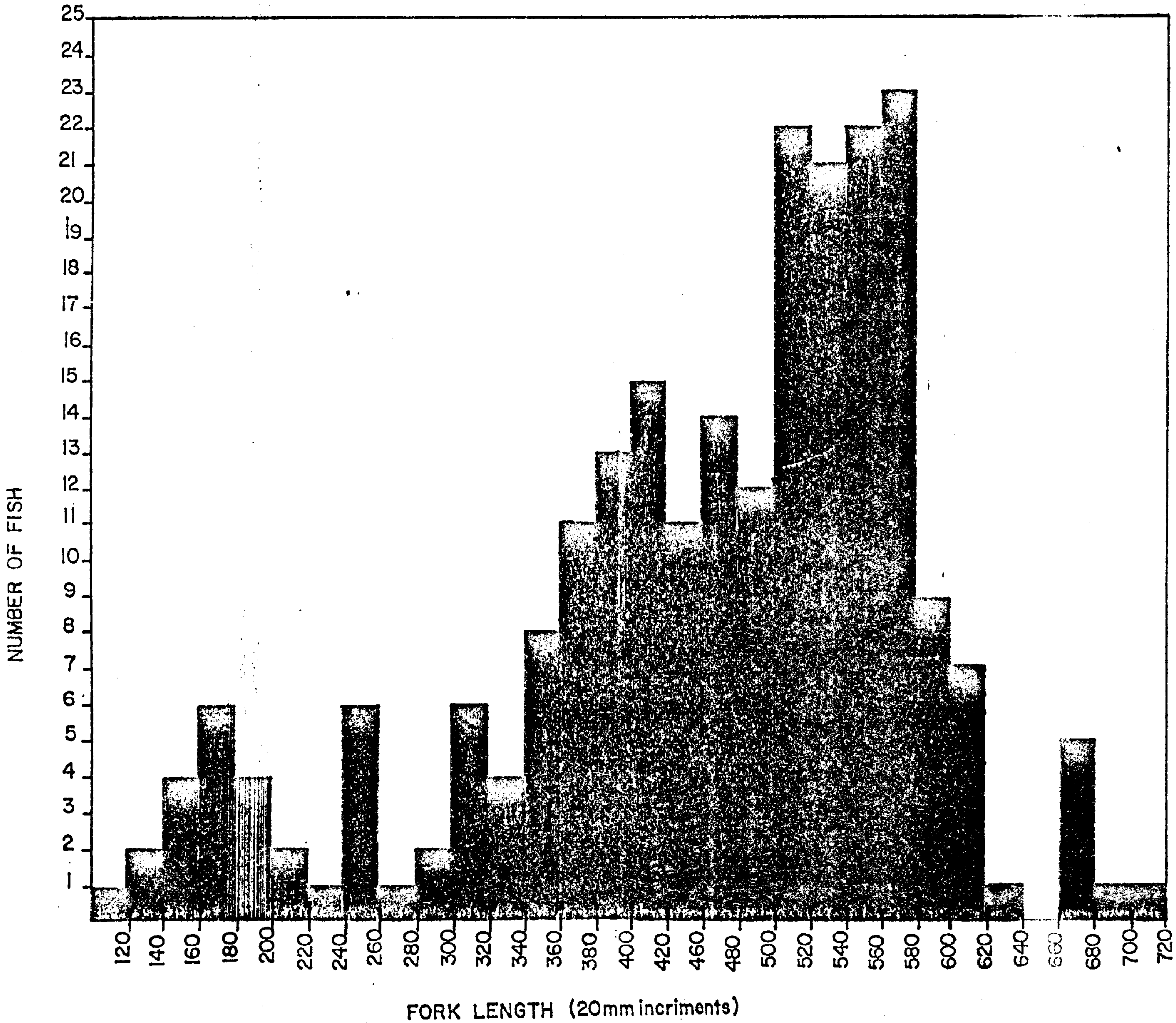

Figure 8. Length frequency of Arctic char captured during 1975 and 1976.

A total of 808 Arctic char was tagged in Prudhoe Bay during 1976 and 30 of these individuals were recaptured. Arctic char enter the Beaufort Sea at breakup and spread out along the coast in plumes of fresh river water that flood the fast ice. Char were first captured in Prudhoe Bay on June 22, 1976. The greatest number of char was captured during the month of July, and adults began entering the Sagavanirktok River to spawn and overwinter during the first week of August. Juvenile char (less than 200 mm) are present in the Beaufort Sea until freezeup and enter the Sagavanirktok River during September. Adult Arctic char forage widely during summer and were captured at the most remote barrier island stations. Previous studies (Furniss, 1975) indicate that char may travel as far as 300 km (from the Sagavanirktok River to Pt. Barrow) during the open water season. A limited amount of sport fishing effort by oil company employees primarily during July and August, was observed in Prudhoe Bay and the Sagavanirktok Delta.

Arctic char are opportunistic feeders and prey on a variety of epibenthic organisms as well as insect larvae and fish. Of 210 guts collected, 44% were empty. Following is a list of food items from Prudhoe Bay char, omitting empty stomachs:

Amphipods	95%
Cod, *B. saida*	42%
Mysids	32%
Isopods	11%

Griffiths et al. (1975) working in Nunaluk Lagoon found char feeding on five species of fish (mostly fourhorn sculpin) as well as chironomid larvae, dipteran pupae and copepods.

Least Cisco

The least cisco is distributed throughout western North America and Siberia. It is a resident of many inland waters of Alaska and is anadromous in streams draining into the Bering, Chukchi and Beaufort seas.

The least cisco was the most frequently captured coregonid within our study area. The absence of least cisco in catches along the outer barrier islands suggests that this species has a strong affinity for brackish waters of the mainland coastline. Life history details of this species residing in northern waters are described by Mann, 1974; Kendel et al., 1974; Percy et al., 1974; and others.

A total of 8,545 least cisco was captured during 1975 and 1976. Fork lengths ranged from 82 mm through 364 mm with a mean of 272 mm (n=271). Figure 9 shows the length frequency of least cisco captured during this investigation. Females (n=216) were larger than males (n=66). The maximum lengths correspond well with least cisco captured in the Colville River (Kogl, 1971) and are lower than those described by McPhail and Lindsey, 1970.

Least cisco ages ranged from I through XII with VII through X individuals most frequently captured (Table 3). The growth rates of least cisco were lower than those reported from the MacKenzie River (Hatfield et al., 1972) and Interior Alaska (Alt, 1971). Figure 10 compares mean back calculated lengths for least cisco taken in Interior Alaska (Chatanika River) and the Beaufort Sea.

Sexual maturity begins at Age VII and 57% of the Age VIII least cisco were mature. Of those that were mature, 20% had redeveloping gonads and would not spawn in the year of capture, indicating that upon reaching maturity, a portion of the population will not spawn every year. The age of maturity of least cisco from the Beaufort Sea is from 1 to 2 years greater than reported from Siberia (Berg, 1948-49). Spawning is reported to take place during fall in the lower reaches of major rivers. There were no spawning or overwintering areas located within the study area. Tag returns and movement patterns obtained during 1976 indicate that the majority of the least cisco captured along the coast move out of, and return to the Colville River.

In 1976, a total of 3,185 least cisco was tagged in Prudhoe Bay and 328 were recaptured within the study area and in the Colville River. Least cisco first appeared in Prudhoe Bay during the first week of July 1976. Their abundance increased to a peak during early September, however the greatest number of large fish (over 200 mm) was captured during the month of August. Although Age I and II least cisco were captured in Prudhoe Bay, it appears that most enter the brackish waters of the Beaufort Sea during their third year. Tagged individuals showed an eastward movement through Prudhoe Bay from breakup through mid-August and then generally westward movement until freeze-up. Several individuals were recaptured at various sites within Prudhoe Bay throughout July and August, indicating random movement within the same general area for an extended period of time. One least cisco was recaptured at Barter Island (250 km east of Prudhoe Bay). The migration of adults to the Colville River was first recorded in mid August when a least cisco tagged in Prudhoe Bay was captured in the Colville River seven days after being tagged. Eighty-two percent of the recaptured least cisco were taken during fall in the lower Colville River. Wohlschlag (1954), in comparing migratory and non-migratory least cisco, suggests that the former migrates over distances of at least 100 miles (161 km) but returns to fresh water during winter.

Seventy-five percent of the least cisco stomachs examined (n=201) contained food. Twelve least cisco stomachs were examined from fish taken during 1975. Of the twelve, one was empty. Following is a list of the gut contents, omitting the empty stomach:

Mysids	91%
Amphipods	45%
Dipterans (adult)	27%
Isopods	9%
Vegetation/detritus	9%

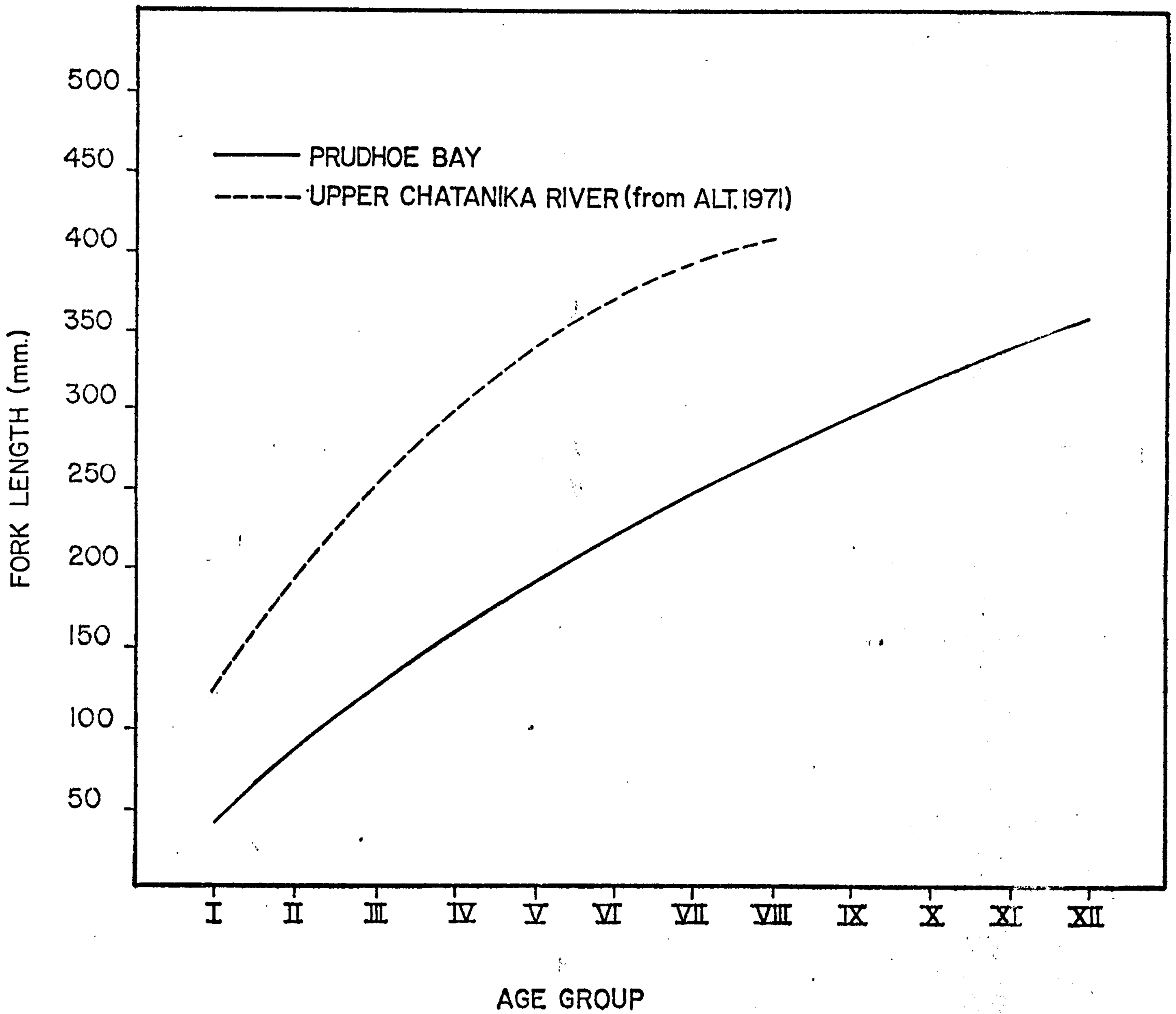

Figure 10. Back calculated fork lengths of least cisco taken in Prudhoe Bay and the Chatanika River (Interior Alaska).

Length Group	Age Classes I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
< 100	1	1											2
100-109	1												1
110-119	4												4
120-129	2	1											3
130-139		1											1
140-149			1										1
150-159		1	1										2
160-169													0
170-179			1										1
180-189			4										4
190-199			9	3									12
200-209			11	7	1								19
210-219			3	10			1						14
220-229				6	1	1	4						12
230-239				1	4		1						6
240-249				1	1	1							3
250-259					1	3	3						7
260-269						4	4	2	3				13
270-279						3	10	2	1				16
280-289						2	17	4	5	1			29
290-299						1	4	7	5	6	2		25
300-309							1	7	15	5	3		31
310-319								3	5	11	2		21
320-329									7	4	4		15
330-339								1	4	3	1	1	10
340-349									1	7	2	2	12
350-359										2		1	3
360-369										1	1	2	4
n	8	4	30	28	8	15	45	26	46	40	15	6	271
$\bar{x}$	110	127	197	212	231	264	272	296	309	319	320	350	272
Range	82-125	92-150	139-210	190-240	202-250	225-290	219-285	260-345	278-340	290-353	297-360	331-364	84-364

Table 3. Age length frequency of least cisco captured during 1975 and 1976.

Arctic Cisco

The Arctic cisco is distributed throughout northern Europe, Siberia and western Arctic North America. From the Gulf of Alaska north to the western Beaufort Sea, the Arctic cisco is replaced by the Bering cisco, *C. laurettae*, as described by McPhail (1966). In Alaskan waters, the Arctic cisco ranges from Point Barrow east to Demarcation Point. They are one of the most common and widely distributed fish found with our study area and are used by local residents in coastal subsistence fisheries as well as in small commercial fisheries at the mouth of the Colville River and near Point Barrow. Arctic cisco life history data are discussed by Craig and McCart (1976) and Hatfield, Stein et al. (1972).

A total of 1,361 Arctic cisco was captured during 1975 and 1976. Fork lengths ranged from 62 mm to 390 mm with a mean of 285 mm (n=253). Figure 11 shows the length frequency of Arctic cisco captured during this study. Few individuals in the sample were greater than 350 mm. Maximum lengths are less than those reported by Berg (1948-49) for Siberian forms, McPhail (1966) for Point Barrow and Hatfield, Stein et al. (1972) for MacKenzie River forms.

Although Arctic cisco reach a maximum age of at least XI (Hatfield, Stein et al., 1972), cisco within the study area ranged from Age I through Age IX. Immature fish of Age VI comprised 46% of the sample. An age-length frequency is presented in Table 4. As with least cisco the growth rate of Arctic cisco captured in the Beaufort Sea is lower than reported for the MacKenzie River (Hatfield, 1972) and Siberia (Berg, 1948-1949). Figure 12 shows the mean back calculated lengths of Arctic cisco from the Beaufort Sea. Arctic cisco enter the Beaufort Sea at Age I.

The female to male sex ratio of 198 Arctic cisco was 9:1. There were no sexually mature individuals in our sample. Berg (1948, 1949) states that Siberian Arctic cisco mature at Age V, however the age at maturity varied between river systems. Craig and McCart (1976) suggest that Arctic cisco from the Beaufort Sea reach maturity between ages of VII and IX. Craig and McCart (1976) further postulate that Arctic cisco only use the two largest drainages in the region, the Colville and MacKenzie rivers, as spawning areas. Arctic cisco spawn in the fall. The spawning periods and locations for the Colville River have not been identified. Either mature Arctic cisco do not range in the area of our study or they do not range as far from natal streams as do the younger age classes.

Six hundred twenty-eight Arctic cisco were tagged in Prudhoe Bay during 1976 and 21 of those were recaptured throughout the season. The first Arctic cisco was captured on June 28, and their seasonal abundance was similar to that of least cisco; the greatest number being captured during the month of August. A single individual tagged in Prudhoe Bay was recaptured at Griffin Point near Barter Island, 19 days after being tagged. Movement trends of Arctic cisco in Prudhoe Bay require further investigation. Nineteen of the 21 recaptured Arctic cisco were taken during the fall run in the Colville River.

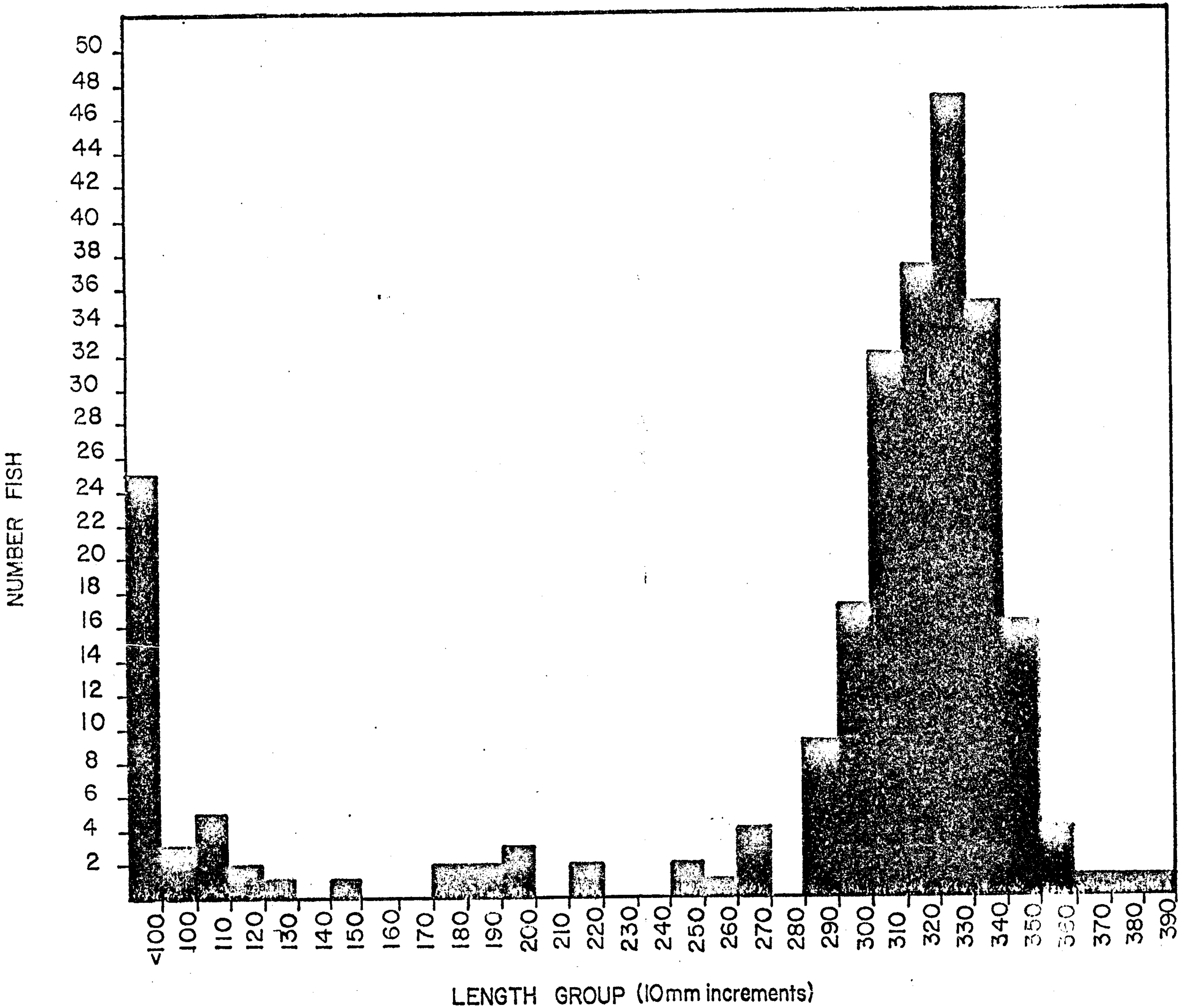

Figure 11. Length frequency of Arctic cisco captured during 1975 and 1976.

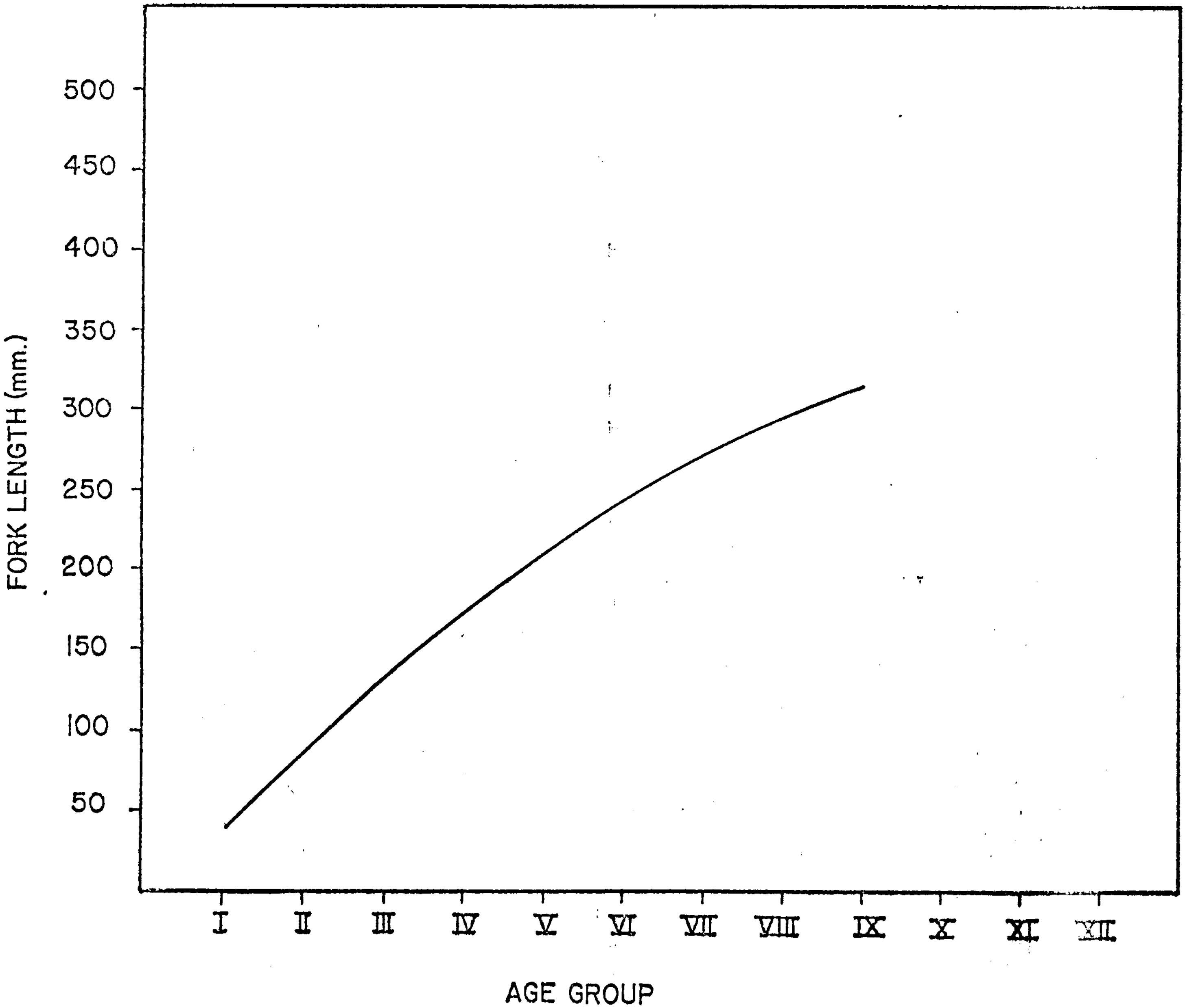

Figure 12. Back calculated fork lengths of Arctic cisco captured in Prudhoe Bay.

Table 4. Age length frequency of Arctic cisco captured during 1975 and 1976.

Length Group	Age Classes									
	I	II	III	IV	V	VI	VII	VIII	IX	total
< 100	25									25
100-109		3								3
110-119	3	2								5
120-129		2								2
130-139		1								1
140-149										
150-159			1							1
160-169										
170-179										
180-189			2							2
190-199			2							2
200-209			3							3
210-219										
220-229			1	1						2
230-239										
240-249										
250-259				2						2
260-269				1						1
270-279				1	3					4
280-289										
290-299				1		6	2			9
300-309					1	10	3	2	1	17
310-319					5	16	4	7		32
320-329					1	28	3	3	2	37
330-339					1	30	9	5	2	47
340-349						16	8	11		35

Table 4. (Cont.) Age length frequency of Arctic cisco captured during 1975 and 1976.

Length Group	Age Classes									
	I	II	III	IV	V	VI	VII	VIII	IX	total
350-359						7	5	4		16
360-369						3		1		4
370-379								1		1
380-389								1		1
390-399								1		1
n	28	8	9	6	11	116	34	36	5	253
$\bar{x}$	82	116	199	259	303	327	331	339	323	283
Range	62-115	104-131	156-220	222-290	270-335	290-365	298-355	305-390	306-331	62-390

Sixty-five percent of the Arctic cisco stomachs examined (n=153) contained food. Following is a list of the gut contents of stomachs:

Mysids	60%
Amphipods	53%
Vegetation/detritus	40%

Broad Whitefish

Broad whitefish are distributed throughout Eurasia and drainages of the Arctic Ocean. In North America, broad whitefish inhabit drainages of the Bering, Chukchi and Beaufort seas ranging as far east as Perry River. Berg (1948-49), Nikolsky (1961), Alt (1972) and Hatfield, Stein et al. (1972) have investigated the life histories of northern populations of broad whitefish. Broad whitefish in Alaskan waters support valuable commercial and subsistence fisheries.

A total of 741 broad whitefish was captured between the Colville River and the eastern margin of Foggy Bay during 1975 and 1976. Fork lengths ranged from 58 mm to 555 mm with a mean of 287 mm (n=113). Maximum lengths are considerably smaller than those reported for the MacKenzie River (Hatfield, Stein et al., 1972) and Siberia (Berg, 1948). Figure 13 compares back calculated fork lengths of broad whitefish in Prudhoe Bay and Minto Flats (Interior Alaska). The length frequency for broad whitefish is presented in Fig. 14.

Ages ranged from young-of-the-year through Age XV, however Ages IV-VII were not represented in the sample. The ratio of females to males was 0.52:1. Fifty percent of the Age IX broad whitefish were mature. Twenty-three of those fish between Ages XI and XIII had redeveloping gonads and would not spawn in the year of capture.

One hundred ninety-seven broad whitefish were tagged in Prudhoe Bay during 1976. Only one of these individuals was recaptured. Broad whitefish enter the Beaufort Sea when the larger rivers break up in early June. Broad whitefish were captured off the Sagavanirktok River delta on June 11 and were found in Prudhoe Bay on June 23. Upon entering the Beaufort Sea, broad whitefish forage along the mainland coastline, inhabiting shallow bays and lagoons. Young-of-the-year and Age I broad whitefish seldom traveled beyond the waters adjacent to the Sagavanirktok and Colville river deltas. Tagging conducted by Furniss (1975) suggests that both Colville and Sagavanirktok river stocks of broad whitefish inhabit Prudhoe Bay and other near shore waters between these two rivers during the summer months. Broad whitefish were absent from all but the western barrier islands within the study area. Adult broad whitefish re-enter the Sagavanirktok River in late August and spawn in deep pools throughout the lower reaches of the delta. In 1976, ripe broad whitefish were captured in the Sagavanirktok River during the last week of September. Large numbers of broad whitefish overwinter in deep pools within the river delta.

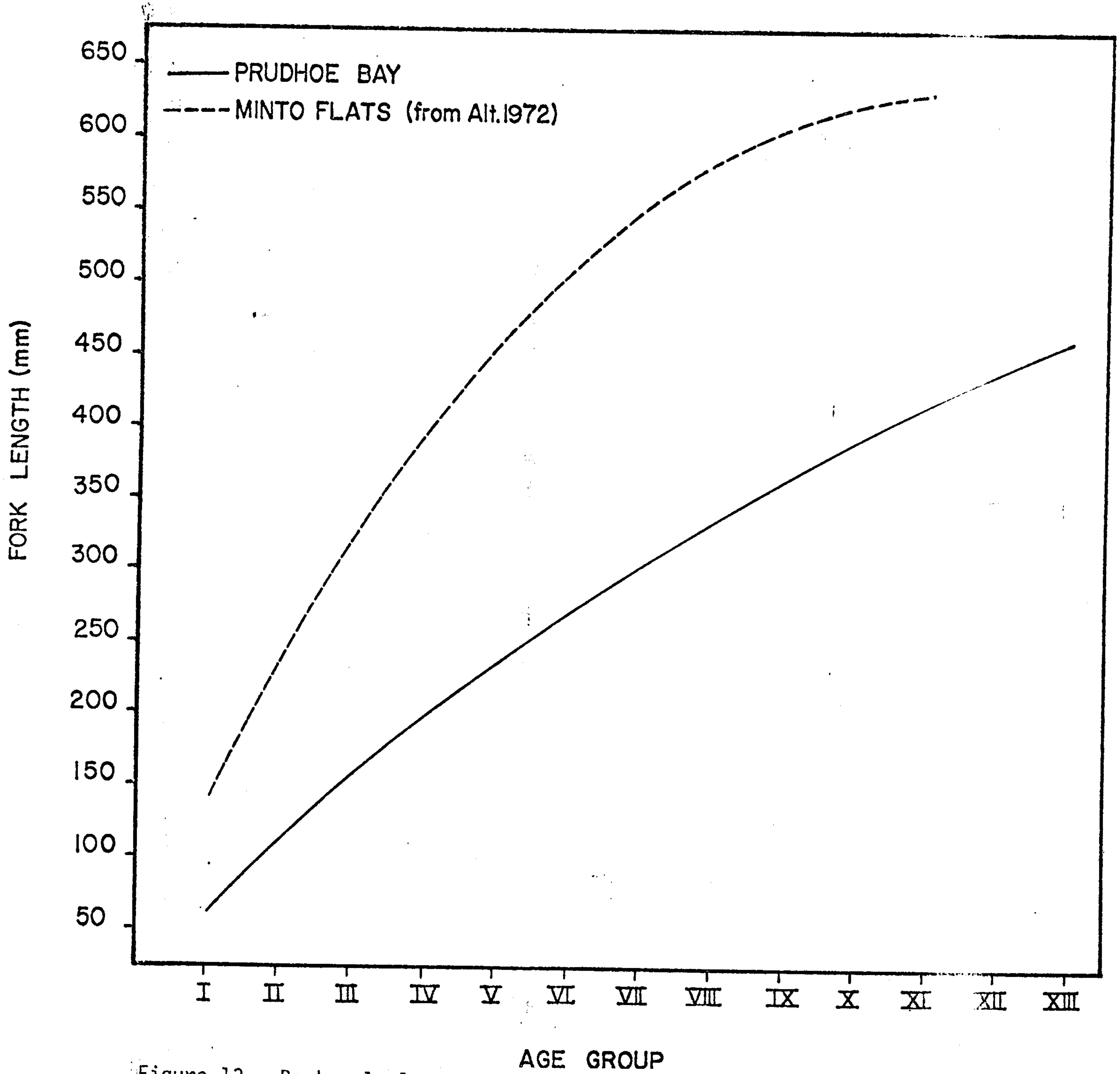

Figure 13. Back calculated fork lengths of broad whitefish taken in Prudhoe Bay and Minto Flats (Interior Alaska).

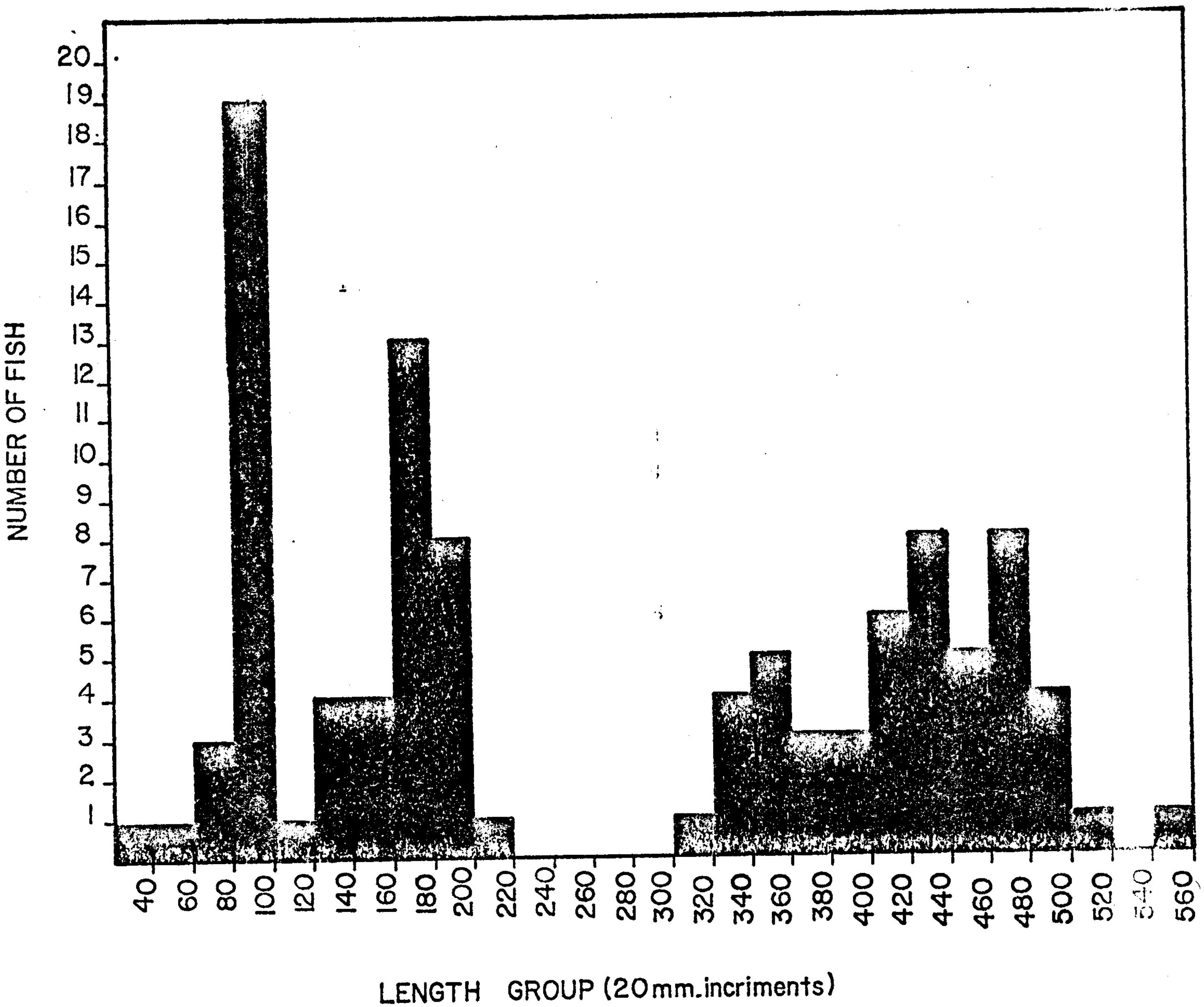

Figure 14. Length frequency of broad whitefish taken in Prudhoe Bay during 1975 and 1976.

Forty percent of the broad whitefish stomachs contained food. The predominant food organisms were chironomid larva and amphipods. All of the spawning broad whitefish captured in the Sagavanirktok River had empty stomachs.

Humpback Whitefish

Humpback whitefish are distributed across northern North America and Arctic Siberia. It is the most widely distributed of any whitefish in Alaska. They generally range throughout mainland drainages and are less frequently found at sea. McPhail and Lindsey (1970), Hatfield, Stein et al. (1972); and Alt (1973, 1974) present life history data on northern populations of humpback whitefish. Alt (1974) considers all Alaskan humpback whitefish to be the species *C. pidschian* and that the allied species *C. clupeaformis* of the Great Lakes extends west only to British Columbia and the Yukon Territory.

A total of 170 humpback whitefish was captured during 1975 and 1976. Fork lengths range from 61 mm to 475 mm and averaged 410 mm. The length frequency of 170 humpback whitefish is presented in Fig. 15.

Ages ranged from I to XIII. Figure 16 presents mean back calculated fork lengths for humpback whitefish and compares growth between Prudhoe Bay and the Chatanika River (Interior Alaska).

The greatest abundance of humpback whitefish was near the western border of the study area in the vicinity of the Colville River delta. One hundred forty-six humpback whitefish were tagged in Prudhoe Bay during 1976. Only two individuals were recaptured, moving westward approximately 6 miles in early August. Humpback whitefish were only sparsely distributed between the Colville and Sagavanirktok deltas.

The Colville River is undoubtedly the major contributor of humpback whitefish to the Beaufort Sea on the Alaskan Arctic Slope. Humpback whitefish spawn during the fall in the lower reaches of the Colville River and probably overwinter near the river delta.

Arctic Cod

Arctic cod are circumpolar in distribution. They are widespread throughout the Arctic Ocean and are usually associated with sea ice. Quast (1974) reported that densities of juvenile Arctic cod in the Chukchi Sea increased with depth but they are also known to inhabit freshened surface sea waters (salinity 10-15 ppt) and brackish coastal waters of the Beaufort Sea. Arctic cod occupy an important trophic position in the Arctic food web. They are considered the main consumer of plankton in Arctic seas (excluding coastal regions) and serve as a major food item in the diets of many species of marine mammals, birds and fish. They are sought for both human consumption and for animal food by coastal residents in northern Alaska. Various life history aspects of Arctic cod are discussed by Andriyashev (1964).

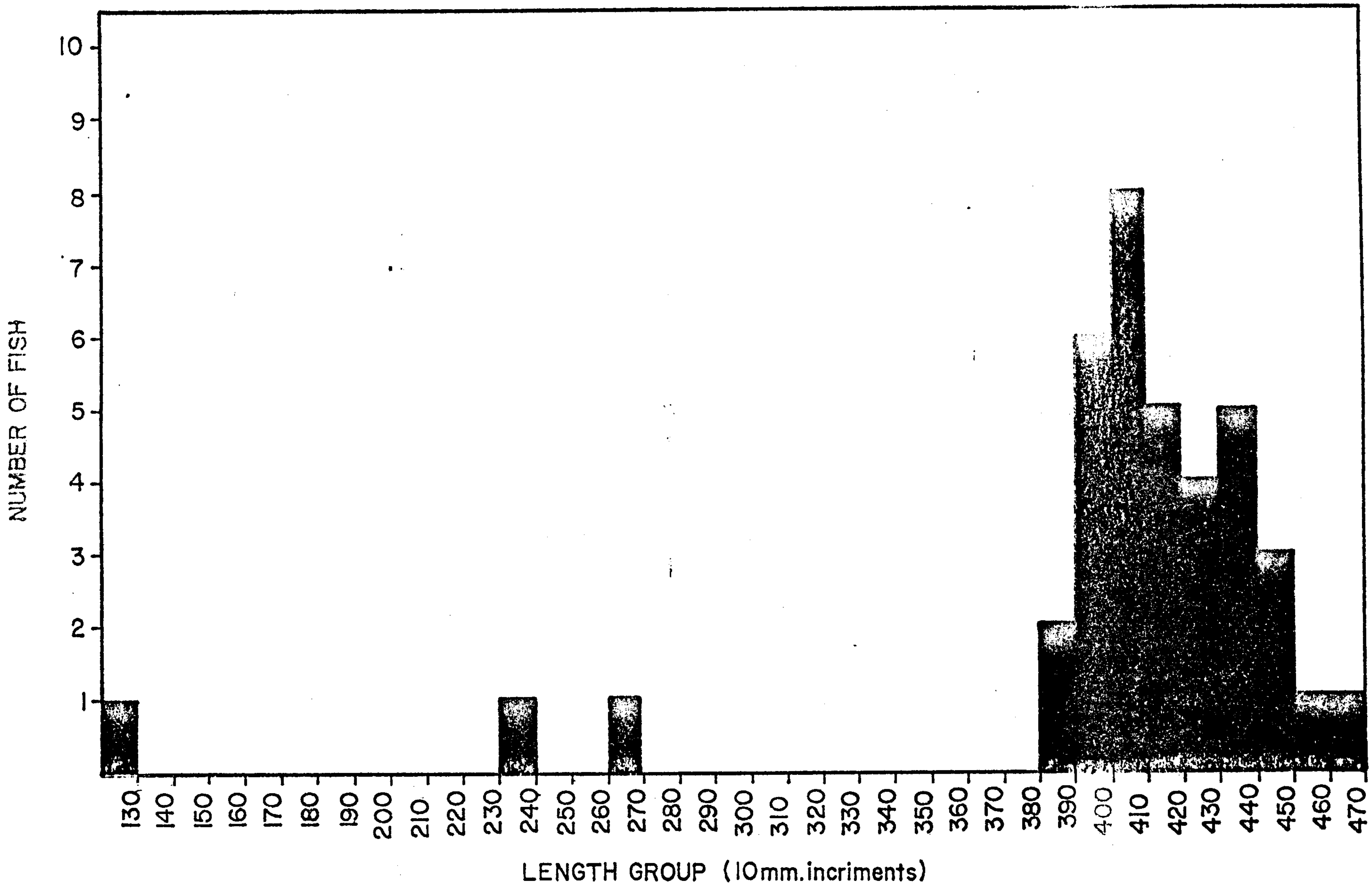

Figure 15. Length frequency of humpback whitefish taken in Prudhoe Bay during 1975 and 1976.

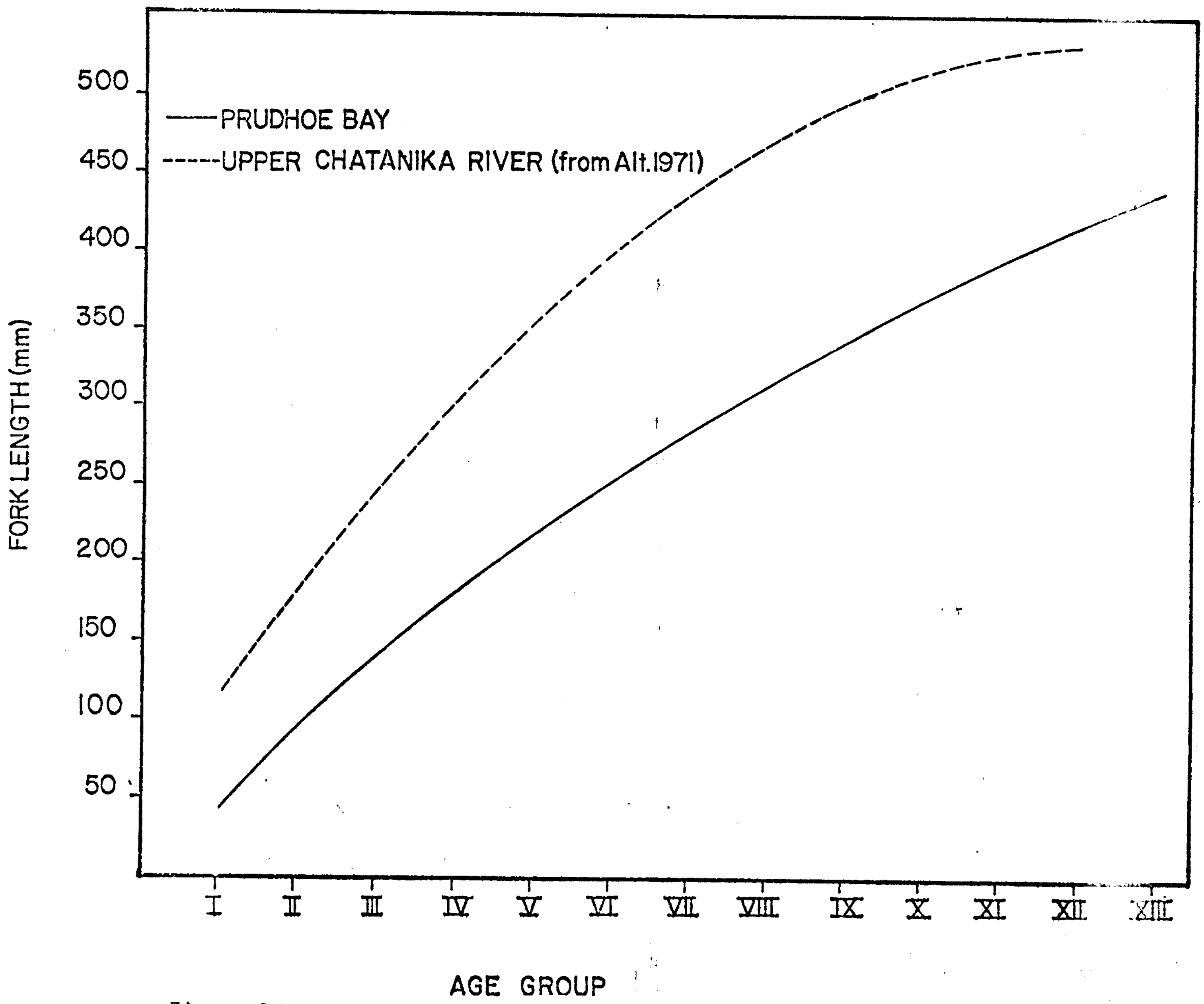

Figure 16. Back calculated fork lengths of humpback whitefish taken in Prudhoe Bay and the Chatanika River (Interior Alaska).

Arctic cod were the second most abundant marine species found in near shore waters of our study area. A total of 5,659 Arctic cod was captured during 1975 and 1976. Total lengths of Arctic cod ranged from 20 mm through 193 mm and averaged 120 mm. A length mode was observed between 110 and 129 mm corresponding to Age II individuals. The length frequency of Arctic cod captured in Prudhoe Bay is shown in Fig. 17.

Ages of Arctic cod ranged from young-of-the-year through Age III. Age II individuals comprised 52% of the sample. According to Andriyashev (1964) Arctic cod mature at Age IV (greater than 200 mm total length) however no mature specimens were taken in our sample. The female to male sex ratio of 89 Arctic cod was 1.7:1.

Growth of Arctic cod captured near shore in the Beaufort Sea was slower than reported in Andriyashev (1964) for the Bering Sea and Cheshskaya Bay. The average total length at age for Arctic cod captured near shore during August is as follows: Age 0, 24 mm; Age I, 99 mm; Age II, 131 mm; Age III, 161 mm.

Arctic cod were first captured in Prudhoe Bay during the second week of July. Daily catches were low for the remainder of July and first half of August then increased greatly through the second week of September. Large numbers of cod fry (corresponding to Age 0 fish above), were trawled offshore in Prudhoe Bay (2-4 m of water) during the second week of August 1975.

Arctic cod spawn near shore under the ice during January and February, however locations and timing of spawning have not been documented for the Beaufort Sea. Arctic cod eggs are the largest and fewest per female of all Gadidae and fecundity varies from 9,000 to 21,000 eggs (Andriyashev).

Arctic cod reportedly feed on phytoplankton and zooplankton including copepod eggs, nauplii, and copepods.

The examination of 12 stomachs indicated that cod feed primarily on mysids in Prudhoe Bay.

Fourhorn Sculpin

The distribution of the fourhorn sculpin is circumpolar. They are found in marine, brackish, and occasionally fresh water. The fourhorn sculpin is the most abundant marine species in our study area.

It occupies nearly all available habitats and was captured off several of the outer barrier islands, as well as in the low salinity waters of the major river deltas. Some life history aspects of fourhorn sculpin in the Beaufort Sea are discussed by Griffiths et al., (1975).

A total of 7,890 fourhorn sculpin was captured during this investigation. Total lengths ranged from 50 mm to 263 mm with a mean of 125 mm. Figure 18 shows the length frequency of fourhorn sculpin captured during 1975 and 1976.

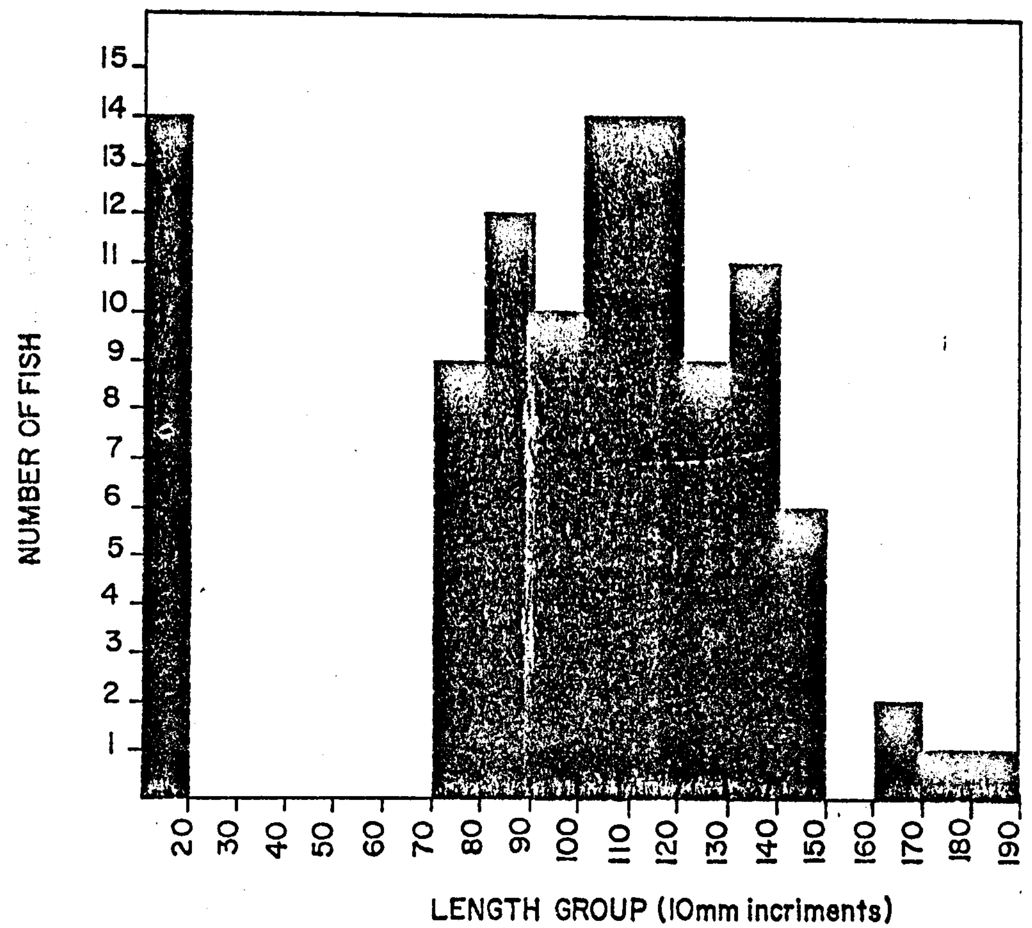

Figure 17. Length frequency of Arctic cod captured in Prudhoe Bay during 1975 and 1976.

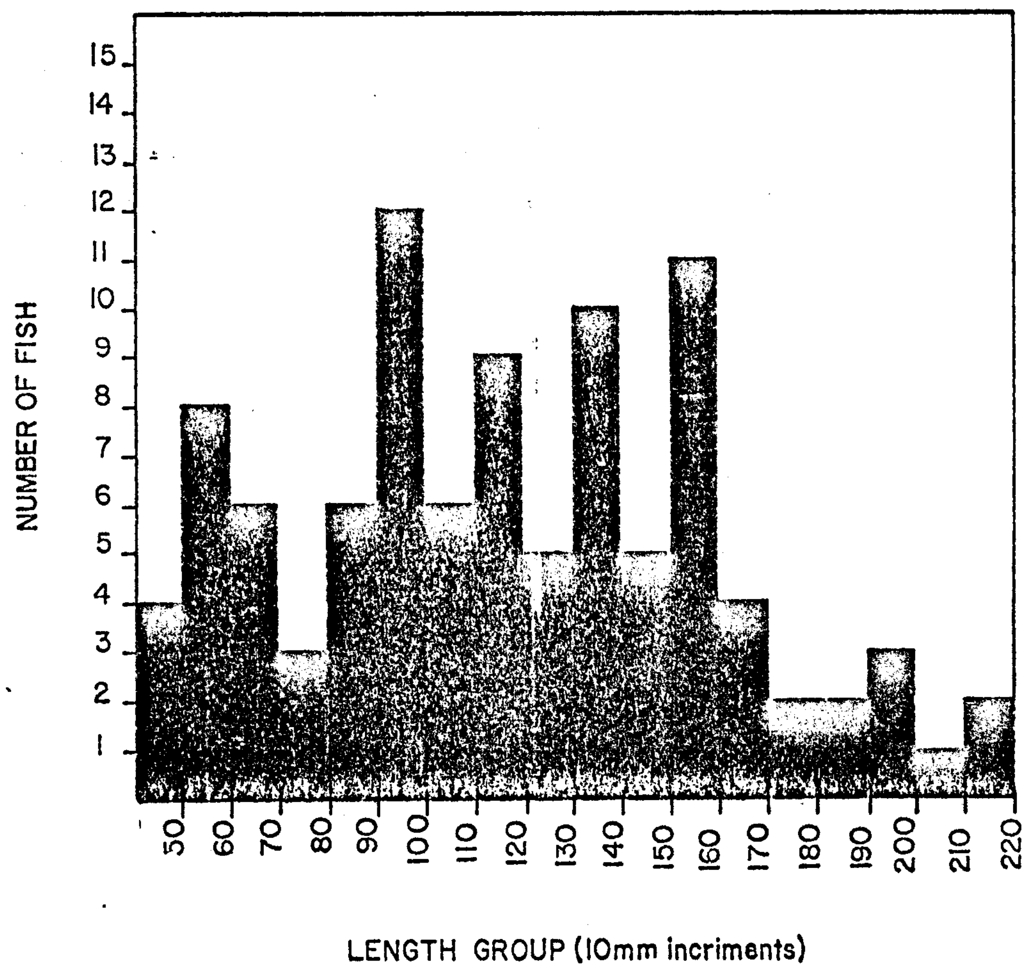

Figure 18. Length frequency of fourhorn sculpin captured during 1975 and 1976.

Ages of fourhorn sculpin varied from I through VII years with the majority of fish captured in Age Classes II and III.

Fourhorn sculpin were the earliest marine species captured in Prudhoe Bay (June 23) and they were captured in abundance throughout the open water season.

Within the study area, fourhorn sculpin fed primarily on immature isopods, amphipods and juvenile Arctic cod.

Arctic Flounder

The Arctic flounder was the only marine flatfish taken near shore during the two years of this study. Little information is available on the life history of Arctic flounder taken in North American Arctic waters. McPhail and Lindsey (1970) delineatethe worldwide distribution of Arctic flounder and Griffiths et al. (1975) examined a small sample of Arctic flounder captured in Nunaluk Lagoon, east of Barter Island. Andriyashev (1964) provides other life history information for this species.

Arctic flounder were not common within the study area, however small numbers were captured throughout the open water season. Their near shore abundance was greatest near the mouth of the Colville River. Arctic flounder were captured near shore in Prudhoe Bay from the second week of July through the first week of September.

A total of 37 Arctic flounder was captured during the present study. Fork lengths ranged from 60 mm through 254 mm and averaged 191 mm (n=31). Figure 19 shows the length frequency of Arctic flounder captured during this study. The length distribution of Arctic flounder taken in Prudhoe Bay corresponds well with catches reported by Griffiths et al. (1975) and Andriyashev (1964).

Ages of Arctic flounder ranged from I to XII with the greatest number of fish captured at Age X. The growth rate of Arctic flounder is apparently very slow.

Sexual maturity is attained at the fourth or fifth year of life. Fecundity is 50,000-200,000 eggs and spawning takes place under the ice during January and February (Andriyashev). Mature individuals in Prudhoe Bay ranged from Age IV through Age XII. There were no Arctic flounder spawning or overwintering areas located in this study.

Arctic flounder reportedly feed on small fish, bivalve mollusks and small bottom invertebrates. In Prudhoe Bay, Arctic flounder feed primarily on amphipods and to a lesser extent on mysids and juvenile isopods.

Other Species

Two species of smelt (capelin and boreal smelt) were captured in low numbers throughout the study area. Of the two, capelin were the most

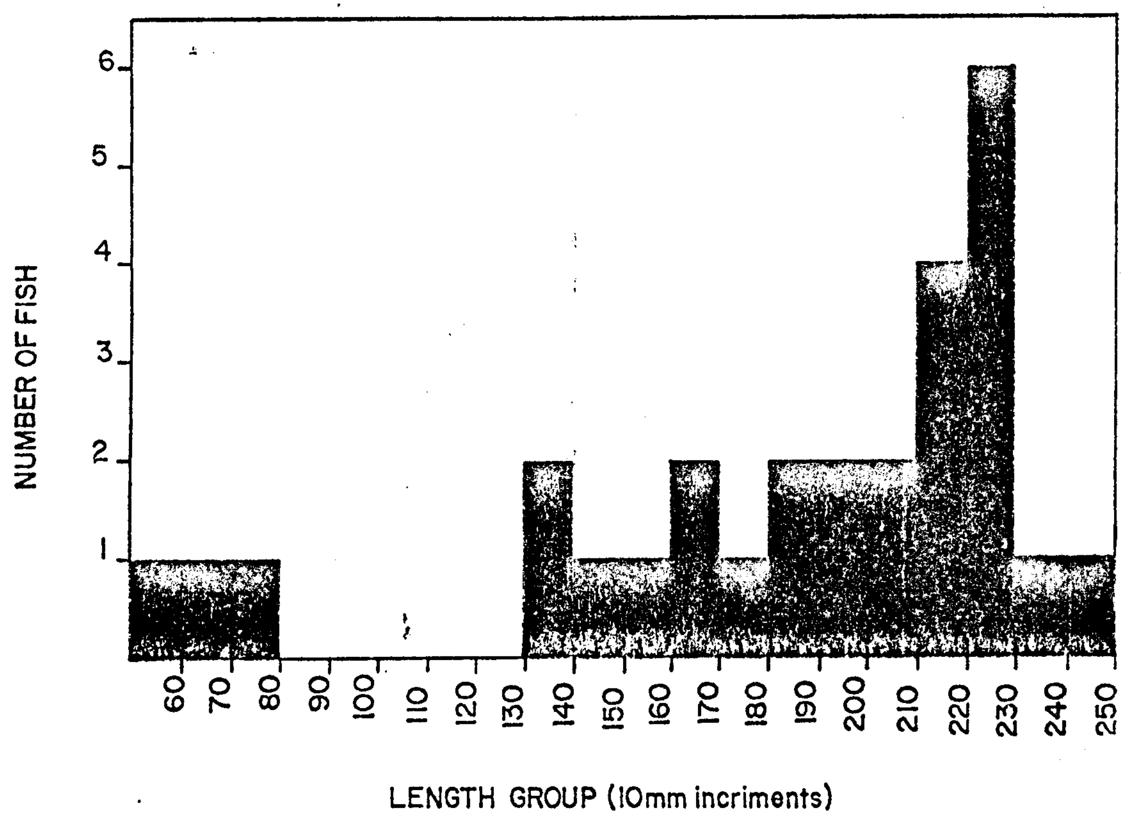

Figure 19. Length frequency of Arctic flounder captured during 1975 and 1976.

abundant, but they were only captured during a two week period in mid-August when spawning took place within the surf along exposed gravel beaches. Young-of-the-year capelin were trawled in Prudhoe Bay during the same time period. A total of 60 capelin was captured during 1975 and 1976. Little information is available on the life history, spawning and overwintering habits of capelin. Andriyashev (1964) describes three spawning runs of capelin in the Barents Sea taking place from March through September. Near Pt. Barrow, capelin spawn in late July and August and are captured with hand nets by local residents for food. The importance of capelin in the marine trophic system is not clearly understood.

Fifty-five boreal smelt were captured during this study. They are distributed across the northern coast of Alaska and Canada and ascend the Mackenzie River as far as the Arctic Red River. During January and February, large numbers of boreal smelt are caught under the ice of the Kuk River Delta (near Wainwright, Alaska) by local residents. Boreal smelt captured within the study area ranged from 92 mm to 251 mm with a mean of 146 mm. Ages varied from II through IX. Age III individuals comprised 64% of the catch and those individuals Aged IV and older were mature.

Saffron cod and an unidentified species of the genus Liparus were also captured in low numbers incidental to the other marine species. Fourteen saffron cod were captured between June and September, and 71 liparids were netted during the second and third weeks of September. Young-of-the-year liparids were trawled in Prudhoe Bay during late August.

Grayling, round whitefish and ninespine stickleback were captured sporadically and in low numbers throughout Prudhoe Bay during 1976. Only two ninespine stickleback were captured in September. Fourteen immature round whitefish were captured in July and August. Forty-seven grayling were captured in Prudhoe Bay between the last of June and the middle of August 1976. Grayling in Prudhoe Bay were captured in salinities that ranged from 1 ppt to 13 ppt.

CONCLUSIONS

Species diversity of fish inhabiting the near shore waters of the Beaufort Sea between Harrison Bay and Brownlow Point is low.

Freshwater and anadromous species are more abundant than marine species within the study area during the open water season.

The density of both anadromous and marine species is greatest shoreward of the 2 meter depth during the open water season.

Arctic fish are slow growing and late maturing and several species may only spawn in alternate years.

Stomach analysis indicates that fish utilizing the nearshore waters of the study area are opportunistic feeders, preying on a variety of marine epibenthic organisms, as well as fresh water invertebrates, aerial insects and other fish. Thus, a large scale reduction in invertebrate fauna may have a profound effect on the fishery.

The larger rivers draining into the study area serve as overwintering and spawning habitat as well as important migration corridors for anadromous fish utilizing the Beaufort Sea for the brief open water season.

Overwintering and fall spawning areas within river deltas are extremely sensitive to disruption due to the concentrated number of fish that are restricted to small pockets of under-ice water.

Large-scale gravel mining in river deltas can disrupt their hydrologic regime, thus affecting the availability of fall spawning and overwintering habitat.

The summer distribution of anadromous fish did not appear to be influenced by short term changes in water temperature and salinity.

Human use of fish resources within the study area is low, however sport fishing has been steadily increasing since the advent of North Slope oil development.

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THE DISTRIBUTION, ABUNDANCE, DIVERSITY, AND BIOLOGY OF BENTHIC ORGANISMS IN THE GULF OF ALASKA AND THE BERING SEA

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The skills and patience of Ana Lea Vincent (Publications, Institute of Marine Science, University of Alaska), are responsible for the excellently rendered food webs in 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 benthic species within identified oil-lease sites in the northeast Gulf of Alaska (NEGOA), lower Cook Inlet and the Bering Sea, 2) a description of spatial distribution patterns of selected species in the designated study areas, 3) a preliminary comparison of dominant species with physical, chemical, and geological features with emphasis on the latter parameter, and 4) preliminary observations of biological interrelationships between selected segments of the benthic biota in the 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. Twenty-one widely dispersed stations were occupied with a van Veen grab in the northwestern Gulf of Alaska as an addendum to the NEGOA program. Substrate characteristics in this region made it difficult to sample with a grab. Forty-five widely dispersed stations were occupied in Cook Inlet; thirteen of these stations were ultimately selected for detailed analysis of van Veen grab samples. A total of 77 widely dispersed permanent stations for quantitative grab sampling have been established in the Bering Sea.

The general patchiness of fauna observed at most stations in the first year of study 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 have been taken at all stations during the current project period. Analysis of grab data by the end of the project period should enable us to suggest the optimum number of grabs per station needed for monitoring programs in these two areas.

One-hundred forty stations were occupied with an otter trawl in the northeastern Gulf of Alaska. Forty-seven stations were occupied with three types of trawls in Cook Inlet. Two-hundred eight (208) stations were occupied by otter trawl in the Bering Sea in 1975 and 104 stations were occupied by otter trawl in 1976.

Four-hundred fifty seven (457) species have been determined from the grab sampling program, and 168 species from the trawl program in the northeast Gulf of Alaska. Two-hundred eleven (211) species have been determined from the grab sampling program, and 189 species from the trawl and dredge programs in Cook Inlet. Six-hundred forty three (643) species have been isolated from the grab-sampling program and 225 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 currently available for the Bering Sea benthos from the current sampling program, but a continuing series of cruises during the first year of the investigation made available data (now being processed or temporarily archived) from the spring, summer and early fall. Limited seasonal data are available in the literature.

Basic information on Diversity, Dominance and Evenness for grab stations is now available for all permanent stations on the northeastern grid and for 27 stations on the Bering Sea grid. Caution is indicated in the interpretation of these values until further data is available over a longer time base.

Criteria established for Biologically Important Taxa (BIT) have delineated 95 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 construction of 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 here.

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. Two trawl surveys in lower Cook Inlet on the R/V *Moana Wave* and R/V *Miller Freeman* achieved extensive coverage, although only limited seasonal data was obtained. The joint National Marine Fisheries Service trawl survey on the R/V *Miller Freeman* for investigation of epifaunal invertebrates and demersal fishes 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.

Preliminary information on feeding biology of species collected by grab and trawl is available from literature analysis and information collected on OCS/NOAA cruises of the past two years. Feeding habits of selected infaunal invertebrate species have been tabulated from literature sources and unpublished data. A food web, inclusive of major epifaunal species, for Cook Inlet is available. The snow crab, *Chionoecetes bairdi*, in the latter area feeds, in order of decreasing importance, on clams, hermit crabs, barnacles and crangonid shrimps. King crab, *Paralithodes camtschatica*, in Cook Inlet feeds on *Nuculana* and *Macoma*, two deposit feeders. The principal food groups used by the Pacific cod, *Gadus macrocephalus*, at all sizes 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 coelenterates, annelids, euphausids, isopods and echinoderms taken by cod. The frequency of occurrence of snow crab, *Chionoecetes bairdi*, as food for cod for 1972-1975 in the northeast Gulf of Alaska study area, was 33, 40, 36, and 36 percent respectively.

Initiation of clam age-growth studies in Cook Inlet has resulted in preliminary age-growth data on 673 specimens of *Tellina nuculoides* and 555 specimens of *Glycymeris subobsoleta*. Further age-growth data on other clam species from Cook Inlet and the Bering Sea will be available for the Final Report. Such age-growth analyses will make available important biological parameters useful for long-range monitoring programs in these areas.

Food items of Bering Sea crabs differed from crabs in Cook Inlet. King crab (*Paralithodes camtschatica*) in the former area were primarily taking *Clinocardium*, small snails and ophiuroids; snow crab (*Chionoecetes bairdi*) were taking mainly polychaetes and ophiuroids.

The pollock, target of one of the world's largest fisheries in the Bering Sea, is a very important link in the food web for that area. Small pollock are the major food item of large pollock as well as several other large predatory fishes and marine mammals.

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 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; 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 the present Annual Report). 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 exploratory study, selected stations should be examined regularly on a long-term basis to determine any 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 also essential to an understanding of the trophic interactions involved in these areas and the potential changes that could take place once oil-related activities are initiated.

The ongoing benthic biological program in the Gulf of Alaska has emphasized development of a qualitative and quantitative inventory of prominent species as part of the overall 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 shelf of the northeast Gulf of Alaska will expand the understanding of distribution patterns of species here. A developing investigation concerned with the biology of selected species and feeding interactions 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.*, 1976b; Feder and Mueller, 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 is essential to the development of environmental predictive capabilities required for the Bering Sea.

The benthic biological program in the Bering Sea during its first year emphasized development of a qualitative and quantitative inventory of species as part of the overall examination of the biological, physical and chemical components of those portions of the shelf slated for oil exploration and drilling activity. In addition, development of computer programs for use with data collected in the northeast Gulf of Alaska, 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 distribution patterns of species in the latter area. Studies in the second year encompassed limited investigations of trophic interactions between selected epifaunal species.

The study program as designed will survey and define variability of the benthic fauna on the eastern Bering Sea shelf in regions of offshore oil and gas concentrations. During the first phases of research, emphasis was placed on studies of the southeastern Bering Sea shelf. Data was obtained on faunal composition and abundance to form baselines to which potential future changes can be compared. Long-term studies on life histories and trophic interactions should define aspects of the functioning of communities and ecosystems potentially vulnerable to environmental damage, and should help to determine the rates at which damaged environments can recover.

Specific Objectives

1. A qualitative and quantitative inventory of dominant benthic species within identified oil-lease sites.
2. A description of spatial and seasonal distribution patterns of selected species in the designated study areas, with emphasis on assessing patchiness and correlation with microhabitat.

3. A preliminary comparison of the distribution of dominant species with physical, chemical, and geological features with emphasis on the latter parameter.
4. Preliminary observations of biological interrelationships between selected segments of the benthic biota in the designated study areas.

Relevance to Problems of Petroleum Development

The effects of oil pollution on subtidal benthic organisms have been seriously neglected, although a few studies, conducted after serious oil spills, have been published (see Boesch *et al.*, 1974 for review of these papers). Thus, lack of a broad 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 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 total 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 and Mueller, 1975, and 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, stations with substantial numbers of epifaunal species should be assessed on a continuing basis (see Feder and Mueller, 1975 for references to relevant stations). The potential effects of loss of specific species to the overall trophic structure in the Gulf of Alaska and the Bering Sea cannot be assessed at this time, but the problem can probably be better addressed once benthic food studies resulting from the current projects are available (Feder, unpublished data from Cook Inlet and the Bering Sea, and the present Annual Report; Smith *et al.*, 1976, 1977).

Data indicating the effects of oils on most subtidal benthic invertebrates are fragmentary, 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 and Mueller, 1975 for references to relevant stations in the northeast Gulf of Alaska; also, Feder, Bering Sea NODC submitted data), and could be affected by oil activities there. Asteroids (sea stars) and ophiuroids (brittle stars) are often important components of the diet of large crabs (for example King crab feed on sea stars and brittle stars: unpub. data, Guy Powell, Alaska Dept. of Fish and Game; present report) and demersal fishes. The tanner or snow crabs (*Chionoecetes bairdi* and *C. opilio*) 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 is 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 oil 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. The most common members of the infauna of the Gulf of Alaska and many Bering Sea infauna 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 excellent techniques for the selection of stations for continuous monitoring of 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 OCS 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 OCS investigation. Some scattered data based on trawl surveys by the Bureau of Commercial Fisheries 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 crab (*Chionoecetes bairdi*), starfish (Asteroidea), Dungeness crab (*Cancer magister*), scallop (*Pecten caurinus*), shrimps (*Pandalus borealis, P. platyceros*, and *Pandalopsis dispar*), King crab (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.) (Hitz and Rathjen, 1965). Heart urchins accounted for about 50 percent of the invertebrate catch and snow crab ranked second, representing about 22 percent. Approximately 20 percent of the total invertebrate catch was composed of starfish.

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.* (1976a), and this report represent the first intensive qualitative and quantitative examinations of the benthic infauna and epifauna of the Gulf of Alaska.

Data collected in the first year (1974-1975) of the OCS study in the northeast Gulf of Alaska served as a springboard and an intensive data base for the studies in 1975-1977. Additional data are available from the cruises of 1975-1976, and are the bases for the analyses needed to meet the project objectives. Information in the literature has uncovered data that will aid in the interpretation of the biology of some dominant organisms in the Gulf of Alaska (present report). The use of cluster and multivariate techniques for the analysis of benthic biological data (now being applied to our data from the Gulf of Alaska) has been widely used by numerous investigators examining shallow-water marine environments. Techniques are well reviewed in Clifford and Stephenson (1975).

Examination of trophic relationships for some infaunal and epifaunal species was initiated in 1976 as a part of the lower Cook Inlet investigation. Much of this data is included in this Annual Report. Food studies by Smith *et al.* (1977) and Feder *et al.* (present report) in the northeast Gulf of Alaska will contribute to an understanding of trophic relationship in this region.

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.*, 1976b; 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.

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 mass (see Fenchel, 1969 for review). Of unique interest is the potential relationship of the ice edge and under-ice primary productivity blooms to the underlying benthic-biotic-chemical system.

Crabs and bottom-feeding fishes of the Bering Sea exploit a variety of food types, benthic invertebrate species being most important (see Results and Discussion of this report). Most of these predators feed on the nutrient-enriched upper slope during the winter, but they 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.*, 1977). 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 AREA

Gulf of Alaska

In the grab-sample program a series of stations were occupied with a van Veen grab on a grid established in conjunction with the physical, chemical, hydrocarbon, and trace metal programs in the northeastern (Fig. 1; Table I) and northwestern Gulf of Alaska (Fig. 2; Table II). In the northeastern Gulf of Alaska (NEGOA), thirty-three stations on this grid were occupied as frequently as possible and nine other stations were occupied at least once in order to increase the coverage of the area. Twenty-five

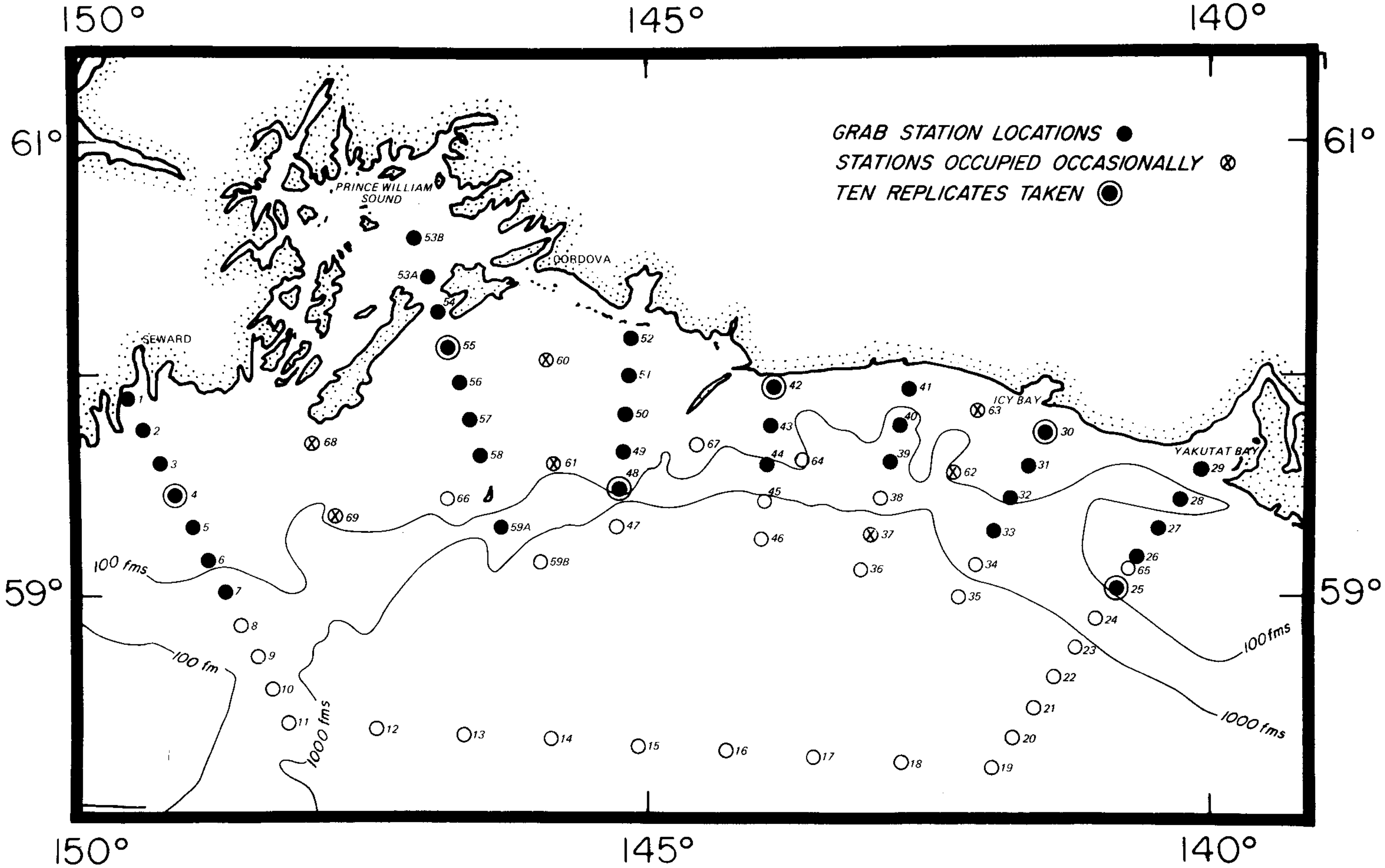

Figure 1. Station grid established for oceanographic investigations in the northeastern Gulf of Alaska. Shaded circles = major stations sampled with van Veen grab. Crossed circle = station occasionally occupied. Open circles = physical, chemical and zooplankton stations. See Table I for additional station data.

TABLE I

STATIONS SAMPLED BY VAN VEEN GRAB IN THE NORTHEASTERN GULF OF ALASKA, JULY 1974 TO FEBRUARY 1975. NUMBER AT EACH ENTRY UNDER CRUISE NUMBER REFERS TO NUMBER OF REPLICATE SAMPLES.

GASS Station	Latitude (N)	Longitude (W)	Approx. Depth (m)	Jul.	Oct.	Nov.	Feb.	May	Sept.	Nov.-Dec.
				Cruise Number						
				193	200	202	805	807	811	816
1	59°50.2'	149°30.5'	263	–	–	3	–	–	5	–
2	59°41.5'	149°22.0'	219	–	–	–	–	5	5	–
3	59°33.0'	149°13.2'	220	3	–	–	–	–	5	–
4	59°24.5'	149°04.9'	200	–	–	–	–	4	10	–
5	59°16.0'	148°56.0'	174	–	–	–	–	4	5	–
6	59°07.2'	148°47.5'	151	3	–	–	–	–	5	–
7	58°58.7'	148°38.7'	220	–	–	–	–	1	5	5
25	59°02.5'	140°49.8'	179	–	–	–	–	3	5	10
26	59°10.8'	140°38.9'	148	3	–	–	–	4	5	5
27	59°18.6'	140°27.9'	129	–	–	–	–	3	5	–
28	59°26.5'	140°16.9'	239	–	–	–	–	4	5	–
29	59°34.6'	140°06.0'	68	3	–	–	–	–	0	–
30	59°44.1'	141°27.9'	43	1[1]	–	–	6[1]	–	10[1]	–
31	59°35.2'	141°36.8'	117	–	–	–	4	–	5	–
32	59°26.3'	141°45.0'	179	3	–	–	4	–	5	–
33	59°17.5'	141°54.8'	219	–	–	–	1[1]	–	5	–
37	59°16.2'	142°59.2'	2,620	–	–	–	1[1]	–	–	–
39	59°35.7'	142°49.5'	549	1[1]	–	–	1[1]	–	3	5
40	59°45.5'	142°44.5'	195	–	–	–	4	–	5	–
41	59°55.1'	142°39.5'	119	3	–	–	4	–	5	–
42	59°55.1'	143°51.2'	93	3	–	–	23	–	10	–
43	59°45.0'	143°52.8'	117	–	–	–	23	–	5	–
44	59°35.0'	143°54.2'	181	3	–	–	1	–	3	5
48	59°27.5'	145°11.5'	117	3	–	–	–	–	5	10
49	59°37.5'	145°10.0'	186	–	–	–	4	4	5	–
50	59°47.7'	145°09.0'	164	2	3	–	–	–	5	–
51	59°57.6'	145°07.8'	135	–	–	–	4	–	5	–
52	60°07.6'	145°06.5'	53	3	3	–	–	41	5	–
53a	60°23.0'	146°54.0'	279	–	3	–	2	1	5	–
53b	–	–	384	–	–	–	–	–	–	–
54	60°13.9'	146°48.6'	204	–	–	–	3	–	2	5
55	60°04.5'	146°42.6'	117	3	–	–	4	–	5	10
56	59°55.2'	146°36.8'	64	–	–	–	4	–	5	–
57	59°45.6'	146°31.0'	69	–	3	–	3	–	5	–
58	59°36.2'	146°25.5'	97	–	–	–	4	–	5	–
59	59°17.1'	146°14.0'	334	1	–	–	–	–	5	5
60	60°01.5'	145°51.2'	90	–	–	–	–	–	–	5
61	59°34.2'	145°46.9'	170	–	–	–	–	–	–	5
62	59°33.2'	142°16.0'	240	–	–	–	–	–	–	5
63	59°49.5'	142°03.8'	80	–	–	–	–	–	–	5
68	59°38.2'	147°36.5'	120	–	–	–	–	–	–	5
69	59°20.0'	147°32.0'	120	–	–	–	–	–	–	5

[1]Grab volumes less than 5 ℓ.

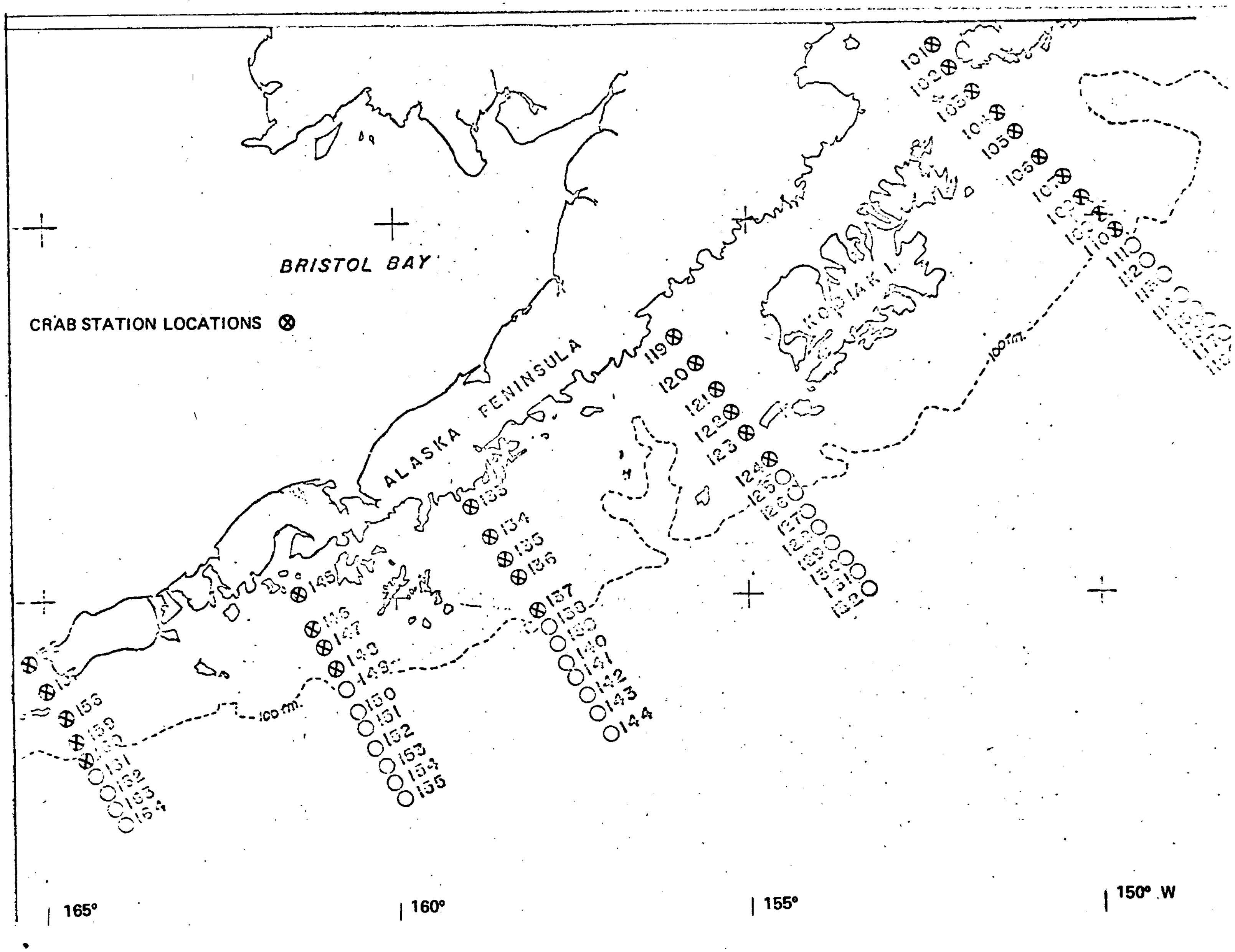

Figure 2. Station grid established for oceanographic investigations in the northwestern Gulf of Alaska. Shaded circles - stations occupied with van Veen grab. See Table II for additional station data.

TABLE II

STATIONS SAMPLED BY VAN VEEN GRAB IN THE NORTHWESTERN GULF OF ALASKA (NEGOA), OCTOBER THROUGH DECEMBER 1975. NUMBER AT EACH ENTRY UNDER CRUISE NUMBER REFERS TO NUMBER OF REPLICATE SAMPLES.

GASS Station	Latitude (N)	Longitude (W)	Approx. Depth (m)	Oct. Cruise Number 812	Nov.-Dec. Cruise Number 816
101	59°19.8'	152°24.1'	90	5	–
102	59° 9.9'	152° 4.1'	112	5	–
103	59° 0.0'	151°45.1'	135	5	–
104	58°50.0'	151°26.4'	104	5	–
105	58°39.9'	151° 7.1'	185	3	–
106	58°28.1'	150°47.7'	86	–	0
107	58°18.6'	150°28.0'	53	–	0
108	58° 9.1'	150° 9.1'	57	–	0
109	58° 2.5'	148°56.3'	176	–	1[1]
110	57°55.5'	149°43.4'	180	–	4[1]
119	57° 6.9'	156° 0.0'	207	5	–
120	56°55.0'	155°44.1'	290	1[1]	–
121	56°43.2'	155°27.9'	230	5	–
123	56°31.3'	155°12.0'	43	5	–
124	56°19.1'	154°55.1'	110	6	–
133	55°46.3'	158°51.0'	73	6	–
134	55°33.4'	158°38.3'	154	6	–
135	55°20.3'	158°25.1'	150	5	–
136	55° 7.5'	158°12.4'	140	0	–
137	54°54.3'	157°59.0'	109	1	–
145	53°03.1'	161°24.4'	75	0	–
146	54°49.4'	161°12.5'	73	3	–
147	54°36.2'	161° 0.7'	106	0	–
148	54°23.5'	160°49.1'	109	0	–
156	54°29.2'	165°11.3'	160	0	–
157	54°17.0'	164°58.8'	70	1[1]	–
158	54°04.5'	164°46.2'	104	1[1]	–
159	53°51.9'	163°34.0'	96	1	–
160	53°43.3'	164°25.4'	140	1	–

[1]Grab volume less than 5 ℓ.

stations were occupied in the northwestern Gulf of Alaska, but many of these stations did not yield satisfactory samples due to the nature of the substratum. All stations typically extended from inshore (depth of 43 m) to a maximum depth of approximately 200 m.

One-hundred fourty (140) stations were occupied in conjunction with the National Marine Fisheries Service Resource Assessment trawl survey which sampled a grid extending from the western tip of Montague Island (148° longitude) to Yakutat Bay (140° longitude) (Fig. 3). This survey sampled to a maximum depth of approximately 500 m (274 fathoms).

Fifty-nine stations on a newly-developed grid and eight stations of opportunity were occupied with van Veen grab and/or pipe dredge in lower Cook Inlet. Nine stations, either on the grid or stations of opportunity, were occupied in the same area with an Agassiz trawl. Sixteen stations, on the grid or stations of opportunity, were occupied in the same area with a demersal trawl (Fig. 4; Table III).

Bering Sea

A series of van Veen grab and pipe-dredge stations were occupied on a grid established in conjunction with the chemical, hydrocarbon, geological and trace metal program (Fig. 5). Seventy-seven (77) stations were sampled; these stations extended from inshore to a maximum depth of approximately 1000 m. Only a few deep stations along the slope were occupied.

Additional stations were occupied in conjunction with the National Marine Fisheries Service Resource Assessment trawl survey 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 (see Pereyra *et al.*, 1976 for map of study area and specific location of stations).

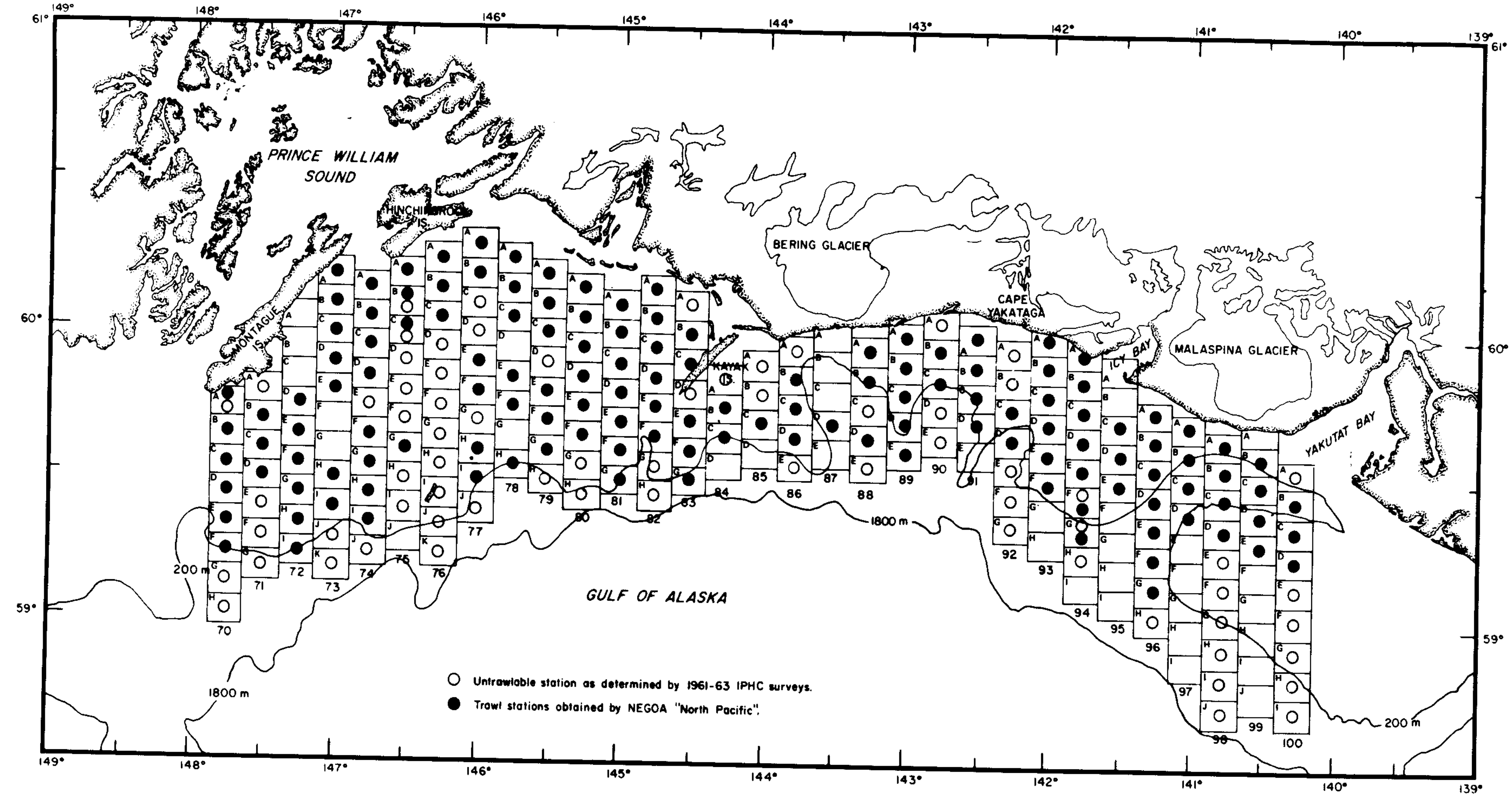

Figure 3. Station grid established for the trawl survey on the continental shelf of the northeastern Gulf of Alaska (NEGOA), summer 1975.

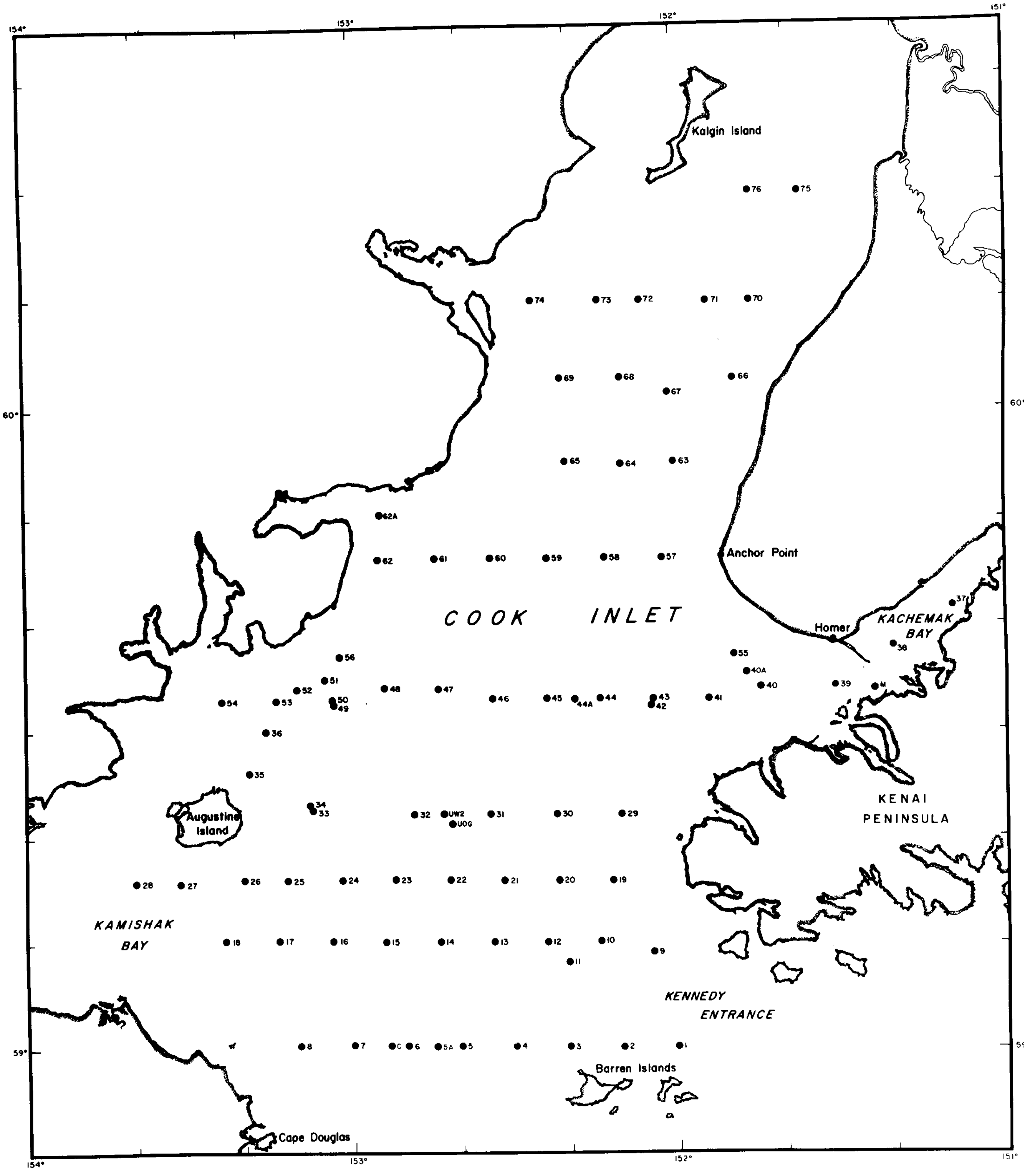

Figure 4. Lower Cook Inlet benthic stations occupied by R/V *Moana Wave* April, 1976 and NOAA ship *Miller Freeman* October, 1976.

TABLE III

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)
1[1]	-	-	-
2[1]	-	-	-
3[1]	-	-	-
4	59° 00'	152° 30'	152
5	59° 00'	152° 40'	151
6	59° 00'	152° 50'	167
7	59° 00'	153° 00'	155
8	59° 00'	153° 09.4'	137
9	59° 09'	152° 04'	117
10	59° 10'	152° 14'	133
11	59° 08'	152° 20'	116
12	59° 10'	152° 24'	100
13	59° 10'	152° 34'	113
14	59° 10.3'	152° 45'	139
15	59° 10'	152° 54'	139
16	59° 10'	153° 04'	102
17	59° 10'	153° 13.5'	67
18	59° 10'	153° 23.7'	35
19[1]	-	-	-
20[1]	-	-	-
21[1]	-	-	-
22[1]	-	-	-
23[1]	-	-	-
24[1]	-	-	-
25[1]	-	-	-
26	59° 15.8'	153° 20'	42
27	59° 15.5'	153° 33'	35
28A	59° 15.4'	153° 40'	31
29	59° 22'	152° 10'	90
30	59° 22.1'	152° 22.2'	82

TABLE III

CONTINUED

Station Name	Latitude	Longitude	Depth (m)
31	59° 21.9'	152° 34.5'	71
32	59° 22.2'	152° 22.2'	78
33	59° 22.7'	153° 07.3'	53
34	59° 23'	153° 07.6'	51
35	59° 26.2'	153° 19'	33
36	59° 30'	153° 15.7'	33
37	59° 41.6'	151° 08.9'	59
38[1]	-	-	-
39[1]	-	-	-
40	59° 34'	151° 44'	72
40A	59° 37.6'	151° 50'	32
41	59° 33'	151° 54'	53
42	59° 33'	152° 04'	40
43[1]	-	-	-
44	59° 33'	152° 14'	61
45	59° 33'	152° 24'	59
46	59° 33'	152° 34'	68
47	59° 34'	152° 44'	59
48	59° 34'	152° 54'	42
49	59° 33'	153° 04'	37
50[1]	-	-	-
51	59° 35'	153° 05'	36
52	59° 34'	153° 10'	35
53	59° 33'	153° 14'	29
54	59° 33'	153° 24'	25
55	59° 40'	152° 00'	34
56	59° 37'	153° 02'	35
57	59° 46'	152° 02'	34
58	59° 46.1'	152° 13.0'	58
59	59° 46.0'	152° 23.0'	90

TABLE III

CONTINUED

Station Name	Latitude	Longitude	Depth (m)
60	59° 46.3'	152° 34.2'	35
61	59° 46.5'	152° 44.5'	36
62	59° 46.2'	152° 55'	26
63	59° 54.6'	152° 00'	40
64	59° 55'	152° 10'	72
65[1]	-	-	-
66	50° 03.0'	151° 49'	34
67	60° 01.5'	152° 01'	51
68	60° 03.0'	152° 10'	49
69	60° 03'	152° 21'	52
70[1]	-	-	-
71[1]	-	-	-
72[1]	-	-	-
73[1]	-	-	-
74[1]	-	-	-
75	60° 20'	151° 36.9'	31
76	60° 20'	151° 46'	27

[1]Stations without latitude, longitude and depth data have not been occupied, but are plotted on a working chart (see Fig. 4).

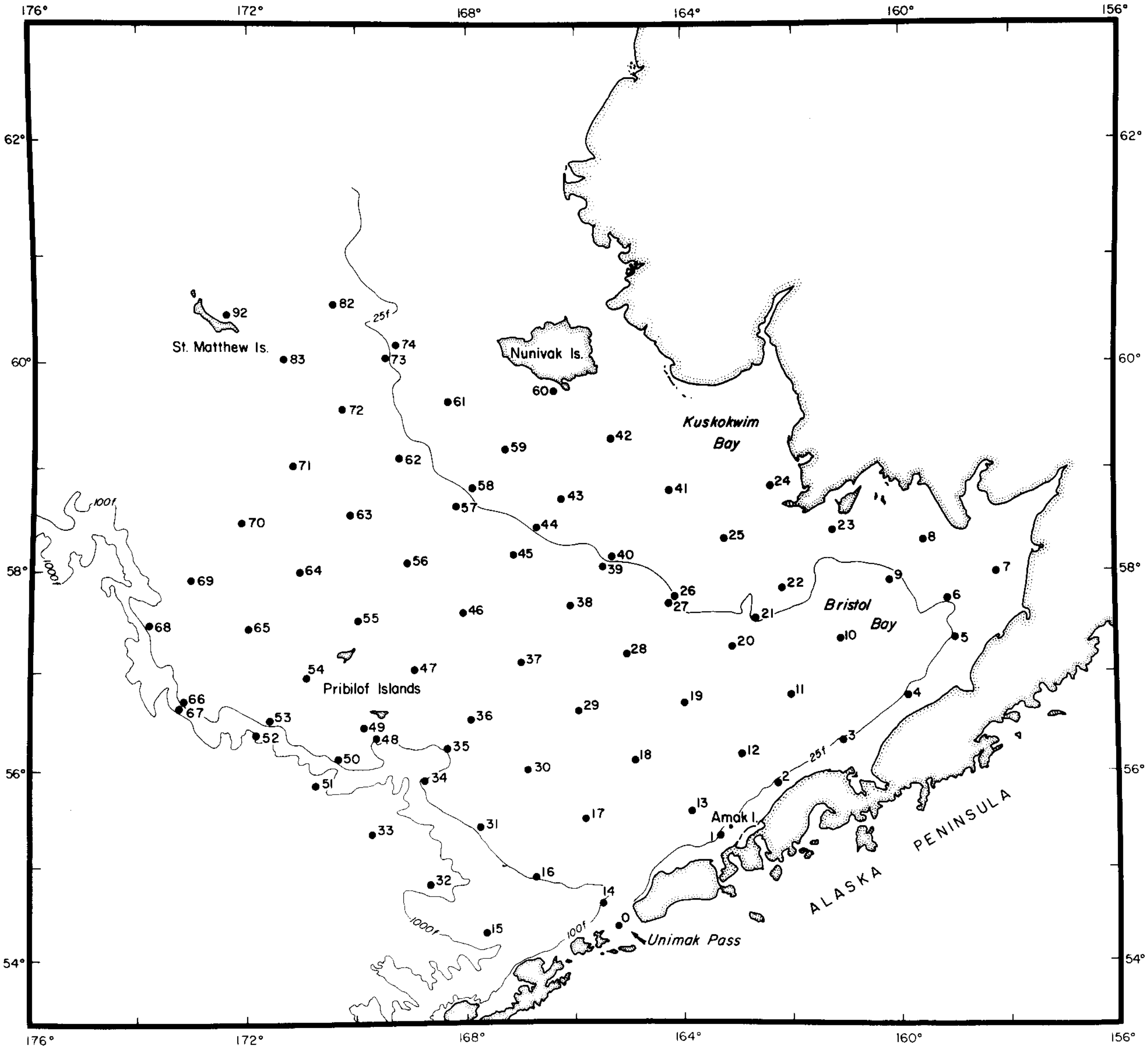

Figure 5. The station grid occupied for the grab - station program in the Bering Sea from May - September 1975.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Gulf of Alaska

Benthic infauna was collected in the northeast Gulf of Alaska on cruises of the R/V *Acona* (July, October and November, 1974), the R/V *Oceanographer* (February, 1975), the R/V *Townsend Cromwell* (May, 1975), the USNS *Silas Bent* (September, 1975), and the R/V *Discoverer* (March through April, 1975). Additional cruises on the R/V *Discoverer* (October and November, 1975) occupied grab stations in the northwestern Gulf of Alaska. During these cruises samples were collected at 42 stations in the northeastern Gulf of Alaska and 21 stations in the northwestern Gulf of Alaska. Benthic infauna was collected at 67 stations in lower Cook Inlet on cruises of the R/V *Moana Wave* (30 March-15 April 1976) and the NOAA ship *Miller Freeman* (October 1976).

To satisfy the objectives of the project, widely dispersed stations were selected. These stations were occupied whenever a vessel was available. Stations on the northeastern grid were deliberately chosen to coincide with those sampled by the OCS physical oceanography program. Quantitative samples were taken with a 0.1 m^2 van Veen grab with bottom penetration facilitated by addition of 70 pounds of lead weight to the grab. Two 1.0 mm mesh screen doors on top of the grab permitted removal of undisturbed sediment samples by members of the hydrocarbon and heavy metals study groups whenever cruises were shared with these programs. In addition, the screen doors served to decrease shock waves produced by bottom grabs (see Feder *et al.*, 1973 for discussion of grab operation and effectiveness of the van Veen grab in sediments of the type found in the Gulf of Alaska). A minimum number of samples, three replicates, were taken in the July (1974), October (1974), and February (1975) cruises, thereby increasing the possibility of complete station coverage in the time available on shipboard: four (4) or five (5) replicate grabs were taken on the May (1975) cruise of the R/V *Townsend Cromwell*. All subsequent cruises sampled five replicates per station. Material from each grab was washed on a 1.0 mm stainless steel screen and preserved in 10 percent formalin buffered with hexamine. Samples were stored in plastic bags.

A pipe dredge (14 x 36 inches/36 x 91 cm) was used at most of the Cook Inlet stations as sea conditions and weather permitted. This sampling gear was added to the program in the second year for three reasons: 1) to determine if the van Veen grab was adequately sampling species living deep in the sediment, 2) to provide specimens for comparison with items found in stomachs of crabs and fishes examined in feeding studies, and 3) to collect large numbers of clams for age-growth investigations. All clams were removed from the samples and stored separately in preparation for age-growth work at the Seward Marine Station. The rest of the material was then archived at the Institute of Marine Science, and will be examined prior to project completion. A large clam dredge was used on five occasions at sand bottom stations in Cook Inlet. All material was separated onboard ship, and preserved in 10 percent formalin for further examination in the laboratory at the University of Alaska.

In the laboratory (Marine Sorting Center, University of Alaska, Fairbanks), all van Veen samples were rinsed to remove the last traces of sediment, spread on a gridded tray, covered with water and rough-sorted by hand. The material was then transferred to fresh preservative (buffered 10 percent formalin), and identifications were made. All organisms were counted and wet-weighed after excess moisture was removed.

Benthic epifauna were collected onboard the M/V *North Pacific* in the northeast Gulf of Alaska. One hour tows were made at predetermined stations (Fig. 3) using a commercial size 400-mesh Eastern otter trawl. All invertebrates of non-commercial importance 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. All weights of the family Paguridae (hermit crabs) from the Gulf of Alaska (but not the Bering Sea) were inclusive of their shells. Counts and weights of commercially important invertebrate species were recorded by National Marine Fisheries Service biologists, and the 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 of Alaska. Closer laboratory examination often revealed more than one species of what was designated in the field as one species (e.g., field identifications of *Pandalus borealis* was later found to also contain *P. montagui tridens*). In such cases the counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to the entire catch of the trawl.

Selected fish species from the northeast Gulf of Alaska were collected or their stomachs removed and preserved; this material was given to Dr. Ron Smith for stomach content analysis (Smith *et al.*, 1976).

The stomachs of King crab (*Paralithodes camtschatica*), snow crab (*Chionoecetes bairdi*), and selected species of fishes were collected in Cook Inlet. All stomach contents were determined on shipboard.

After final identification, all invertebrate species were assigned code numbers to facilitate computer analysis of the data (Mueller, 1975).

Pacific cod (*Gadus macrocephalus*) stomachs were obtained in 1973, 1974, and 1975 by two fishing methods, pots and trawls. During 1973, 1974, and 1975 stomachs were obtained as a by-product of the Alaska Department of Fish and Game King Crab-Snow Crab Indexing Study. In 1973, samples were also obtained on the NOAA National Marine Fishery Service Bottomfish Survey. All fishes came from the vicinity of Kodiak Island, Alaska.

The fishing gear was Seattle-type wrap-around pots, each measuring 80" by 80" by 30" inside and weighing approximately 750 pounds. The webbing was #72 tarred nylon thread stretched to three inches.

During the charters, two fishery biologists and three technicians were employed on each vessel (2 vessels each year) with one vessel fishing mostly the ocean stations and the other fishing mostly bay stations.

All fishes caught during the 1973-1975 ADF&G King Crab-Snow Crab Indexing Studies were obtained using the same sampling procedure at predetermined stations.

To determine the distribution of these stations on the ocean floor, a scattered sampling plan was devised. Because the elaborate sampling design was directed toward "crab" assessment and not "cod" assessment, it is not necessary to describe this procedure.

As pots were pulled, various species of fishes were caught in addition to crabs. Although all fishes were measured, not all were examined for stomach contents. Fishes, primarily cod, were often caught as they were attracted by the bait (chopped frozen herring and occasionally cod or bullhead).

All stomachs were examined and data recorded in the field. The contents were identified to the lowest possible taxon. Date, station, and pot number, depth of catch and frequency of occurrence as well as relative abundance of contents were also recorded. Contents unidentifiable in the field were preserved for later identification in the laboratory. As fishes were caught in pots, they were measured (standard length). If time did not permit immediate examination of the stomach contents, the fishes were thrown into a basket for later examination. This method did not allow separation of fishes by specific pots but instead grouped all fishes from the station area.

Stomachs of the bullheads, great sculpin *Myoxocephalus polyacanthocephalus*, the yellow Irish lord *Hemilepidotus jordani*, and the red Irish lord *Hemilepidotus hemilepidotus* were examined along with various miscellaneous species.

Selection of species from pots posed little difficulty as cod and sculpin were the most numerous species. Cottids, the great sculpin (*Myoxocephalus polyacanthocephalus*) and the yellow Irish lord (*Hemilepidotus jordani*) were commonly found. Other fishes such as rockfishes (*Sebastes* spp.), searchers (*Bathymaster* sp.), lumpsuckers (*Cyclopteridae*), and pollock (*Theragra chalcogramma*) were also found but to a lesser extent. They were typically examined. All halibut (*Hippoglossus stenolepis*) examined were dead when taken from the pots.

As fishes were caught, they were placed in a large wooden tagging bin with a fiberglassed meter stick used for measuring. All were chosen at random for examination. Bias was minimized as most cod in a specific pot were similar in length. The cottids, yellow Irish lord (*H. jordani*) and red Irish lord (*Hemilepidotus hemilepidotus*) were also of similar size.

The selection of number of fishes taken from each pot was flexible, and no strict sampling guidelines were followed. When time only permitted the examination of two or three fishes from a pot before the next pot was lifted, the remainder were returned to the sea or saved for later examination.

During September 1973, the NOAA R/V *John N. Cobb* conducted a ground-fish survey southwest of Kodiak Island. Trawling was performed with a standard 400-mesh Eastern otter trawl. The trawl was constructed of 4" mesh throughout the wings, square and belly, and 3-1/2" mesh throughout the intermediate and cod end. Headrope and footrope lengths were 71 and 94 feet, respectively. Three-eighths inch (3/8") single braid polypropylene chafing gear was attached along the cod end. Cod were taken during this 30-minute tow in 98 fathoms at 57°46.6'N and 154°18.1'W. This was the only trawl sample that was obtained. All cod stomachs from trawls were subsequently removed, separately placed in muslin bags, preserved in 10 percent formaldehyde with the pertinent data for each fish recorded, and held for later examination. Each fish was sexed. Stomach contents were later enumerated and identified in the laboratory.

Often stomach contents could not be identified in the field, and were returned to the laboratory for examination. In order to determine frequency of occurrence of food items, the number of individual samples was recorded in which each kind of food item is found. The results are ly expressed as percentage of the total number of specimens analyzed containing various food items.

Several types of dragging gear were employed in Cook Inlet on the R/V *Moana Wave*; the gear chosen at each station was contingent on the type of bottom and/or weather conditions. The gear used consisted of: 1) a beam trawl (10 feet/3 m beam), 2) an Agassiz or Sixby trawl (6.5 x 1.8 foot/2.0 x 0.6 m opening at mouth), and 3) a small otter trawl or try net (12 foot/3.7 m opening at the mouth). Two types of dragging gear were used on the NOAA ship *Miller Freeman* depending on bottom type and/or weather -- the Agassiz or Sixby trawl and a 400-mesh commercial otter trawl (ship equipment).

Criteria developed by Feder *et al.* (1973) to recognize Biologically Important Taxa (BIT) were applied to the grab data collected in the Gulf of Alaska. By use of these criteria, each species was considered independently (items 1, 2, and 3 below) as well as in combination with other benthic species (items 4 and 5, adopted from Ellis, 1969). Each taxon classified as BIT in this study met at least one of the four conditions.

1. It was distributed in 50 percent or more of the total stations sampled.

2&3. It comprised over 10 percent of either the composite population density or biomass collected at any one station.

4. Its population density was significant at any given station. The significance was determined by the following test:

   a. A percentage was calculated for each taxon with the sum of the population density of all taxa equalling 100 percent.

   b. These percentages were then ranked in descending order.

   c. The percentages of the taxa were summed in descending order until a cut-off point of 50 percent was reached. The BIT were those taxa whose percentages were used to reach the 50 percent cut-off point. When the cut-off point of 50 percent was exceeded by the percentage of the last taxon added, this taxon was also included.

5. Its biomass was significant at any given station. This significance was determined by the following test:

   a. A percentage was calculated for each taxon with the sum of all taxa equalling 100 percent.

   b. These percentages were then ranked in descending order.

   c. The percentages of the taxa were summed in descending order until a cut-off point of 50 percent was reached. The BIT were those taxa whose percentages were used to reach the 50 percent cut-off point. When the cut-off point of 50 percent was exceeded by the percentage of the last taxon added, this taxon was also included.

Species diversity was examined by way of three indices of diversity:

1. Shannon-Wiener Index of Diversity:

$$H' = -\Sigma\ p_i \log_e p_i \quad \text{where } p_i = \frac{n_i}{N}$$

n_i = number of individuals of species $i_1, i_2, i_3 \ldots i_x$

N = total number of individuals

s = total number of species

2. Simpson Index of Diversity:

$$s = \Sigma \frac{n_i\ (n_i-1)}{n\ \ (N-1)}$$

3. Brillouin Index of Diversity:

$$H = \frac{1}{N}\ (\log_{10} N! - \Sigma \log_{10} N_i!) \text{ where}$$

N = total number individuals in all species

N_i = number of individual in the i^{th} species.

These indices were calculated for all stations sampled.

The Simpson Index is an indicator of dominance since the maximum value, 1, is obtained when there is a single species (complete dominance), and values approaching zero are obtained when there are numerous species, each a very small fraction of the total (no dominance). The Shannon-Wiener and Brillouin indices are indicators of diversity in that the higher the value, the greater the diversity and the less the community is dominated by one or a few kinds of species (see Odum, 1975 for further discussion and additional references).

All species taken by grab were coded according to the 10 digit VIMS system used for fauna collected in a benthic study in Chesapeake Bay (Swartz *et al.*, 1972); coding was suitably modified to conform to species collected in the Gulf of Alaska (Mueller, 1975). Data was recorded on computer cards, and converted to magnetic tape. Data printout was accomplished by means of special programs written by Mr. James Dryden (Data Processing Services, Institute of Marine Science, University of Alaska). Data output consisted of a listing of stations occupied and replicates (samples) taken, a species-coding number list associated with a printout of Biologically Important Taxa (BIT) for all grab stations, and a series of station printouts (species collected, number of individuals, percentage of each species (number), biomass of individuals, percentage of each species (biomass), Simpson Index, Shannon-Wiener Diversity Index and Brillouin Index).

Ten van Veen grabs were taken at six stations with varying sediment types and species assemblages throughout the northeastern Gulf of Alaska study area (Fig. 1). When available, this data is being analyzed by the grab sampling simulation program developed by Feder *et al.* (1973) in order to determine the optimum number of grabs required to adequately sample a station. In addition, these samples will be analyzed for dispersal patterns using the "k" parameter of the negative binomial distribution

$[k = \bar{X}^2/(S^2-\bar{X})]$ as a measure of patchiness, as well as the coefficient of dispersion. The "k" parameter is independent of sample size (Taylor, 1953) and thus is preferable to the coefficient of dispersion for measuring patchiness (Lie, 1968). The data can then be transformed to approximate a normal distribution, statistical limits set about the mean, and the number of samples required to give a satisfactory population estimate determined (McIntyre, 1971).

In order to improve our understanding of the diversity of stations an additional program was written to determine the Shannon-Wiener evenness component, the Brillouin Index of Diversity, and its evenness component (see Table 3 of Feder *et al.*, 1976a).

Shannon-Wiener Evenness:

$$J' = \frac{H'}{H'_{max}} \qquad H' = \text{Shannon-Wiener diversity measure}$$

where $H'max = \log S$

S = total number of species

Brillouin Evenness:

$$J = H/Hmax$$

$$Hmax = \frac{1}{N} \log \frac{N!}{\{[N/S]!\}^{S-r}\{([N/S]+1)!\}^{r}}$$

where N = total number of individuals of all species

S = number of species

$[N/S]$ = the integer part of N/S

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

Both the Brillouin H, and the Shannon-Wiener H', diversity indices are based on the information theory. The difference between the two measures is that the Shannon-Wiener Index assumes that a random sample has been taken from an infinitely large population and that "all species in the community population are represented in the sample" (Poole, 1974) while the Brillouin Index is simply a measure of the diversity of the species sampled (see Poole, 1974; Pielou, 1966a, 1966b, 1975 for a discussion of the use of these measures). Feder *et al.* (1973) and Lie (1968) using cumulative plots of species recruited with increasing sampling found that 5 grabs contained 75 to 85 percent of the total species found in 8 and 10 grabs respectively. As the number of grabs sampled declines these percentages decline logarithmically. Thus, if the number of samples is low or if the grab inadequately samples the community due to poor penetration or patchiness in distribution of organisms a considerable error is introduced in the Shannon-Wiener estimate of diversity. This error makes itself apparent when the Shannon-Wiener Evenness is calculated.

Diversity as measured by the Shannon-Wiener and the Brillouin information theory indices can be divided into two components, one component is simply the number of species represented in the sample and the other is the relative numbers of individuals in the community or sample. Thus, if two communities (or samples) contained the same number of species but in one community one of two species dominated the community while in the other the number of individuals (or biomass) per species was relatively even, the latter would have a higher diversity. The relative number of individuals/species is called the evenness component of the diversity index. It is calculated as shown in the equations above by dividing the calculated diversity by the maximum diversity (the diversity of a community in which all species occurred in the same proportion). It was observed (in Table 3, Feder *et al.*, 1976a) that the Shannon-Wiener Evenness component is >1. This results because we have not sampled all the species in the "community" and the value for H'max = logS we calculated is lower than the actual value for all species in the community.

Classification

Station groups and species assemblages have been identified using several classificatory techniques. These techniques can be broken down into 3 basic steps (Field, 1971).

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

Data reduction prior to calculation of similarity coefficients consisted of eliminating species which have only a single occurrence and occur in such low abundance or biomass that they contribute very little to the recognition of station groups. In addition, all taxa which could not be identified at least to genus were eliminated.

Two similarity coefficients have been used in the initial classification of the benthic infauna, the Søensen coefficient which is based on the presence or absence of attributes and the Motyka (synonymous with the Czekanowski (Field, 1969) and Bray-Curtis (Clifford and Stephenson, 1975) coefficients) quantitative modification of the Søensen coefficient.

Søensen:

$C_{s_{1,2}} = \frac{2c}{A+B}$ where A = total number of attributes of entity one

B = total number of attributes of entity 2

c = total number of attributes shared by entities 1 and 2

Motyka:

$C_s = \frac{2W}{A+B}$ where W = is the sum of the lesser measure of attributes shared by entities 1 and 2

A = is the sum of the measures of attributes in entity 1

B = is the sum of the measures of attributes in entity 2

The Motyka coefficient has been used effectively in marine benthic studies by Field and MacFarlane (1968), Field (1969, 1970 and 1971), Day *et al.* (1971), Stephenson and Williams (1971), and Stephenson *et al.* (1974). Compared with the similar "Canberra metric" (Lance and Williams, 1966) coefficient the Motyka coefficient tends to emphasize the effects of dominant species (for a discussion see Clifford and Stephenson, 1975) and it is often used with some form of transformation. However, Raphael and Stephenson (1972) found that the Motyka coefficient produces site groups that are more closely related to changes in abiotic attributes (i.e., sediment type). Clifford and Stephenson state that "the implications of this appear to be that a reasonable stress on dominant species is preferable to stress on the infrequently occurring ones if indications of the importance of abiotic factors are required. Contrary to expectation the best 'indicator' species, at least in the above studies of marine benthos were not the uncommon ones". A similar comment has also been made independently by Dr. B. Dicks for the shallow benthos of the North Sea (B. Dicks, Orielton Oil Pollution Research Unit, personal communication).

The Motyka, quantitative, coefficient will be used to classify all stations except those in which quantitative grabs (sediment volume $\geq 5\ell$) could not be obtained due to lack of penetration of the grab. The

Sørensen coefficient will be used on the entire data set including qualitative data in an attempt to determine the relationship of these stations to the previously clustered stations. Stations (and species) will be clustered on the basis of numbers per square meter and wet biomass per square meter for untransformed and log transformed data. The log transformation $Y = \ln(x+1)$ reduces the influence that dominant species have on the similarity determination.

Sorting strategies have been classified into three groups by Lance and Williams (1967) depending on the intensity of clustering. Space contracting strategies tend to form clusters which upon formation have closer to all other clusters or individuals. These strategies tend to form chains. The nearest neighbor (single linkage) technique is an example of space contracting strategy. Space dilating strategies tend to form discrete clusters which, upon formation, move further from other clusters or individuals. Thus, once a cluster has formed, there is a smaller chance that it will join another cluster or individual. Space conserving strategies form clusters which move neither closer nor further away from other clusters or individuals. We plan to use three sorting strategies: 1) single linkage (nearest neighbor), a space contracting strategy, 2) average linkage (group average; Lance and Williams, 1967), a space conserving strategy, and 3) Lance and Williams' (1967) flexible sorting strategy which is a space contracting strategy when B is set to equal -0.25. Results from these methods will be compared to determine which one forms clusters which make the most ecological sense. Initial analyses have been completed using the single linkage and average linkage techniques. The flexible sorting strategy will also be utilized as soon as the algorithms arrive from CSIRO Division of Computing Research, Canberra, Australia.

Both a normal and inverse analysis have been used to delineate station groups and species groups. In a normal analysis, stations are classified and species are the attributes. For example, using the Motyka coefficient of similarity for a normal analysis the similarity between two stations would be:

$C_{s_{Sta.\ 1,2}} = \frac{2W}{A+B}$ where W = is the sum of the smaller measure (numbers and biomass) of each species for the two stations being compared.

An inverse analysis yields a classification of species where their presence or numbers at a station are the attributes. Station groups and species groups are then compared using a two way coincidence table.

We are currently developing programs to analyze both the species distributions and such environmental parameters as sediment type, organic carbon content, salinity, temperature, and oxygen concentrations of the bottom water by principal component or principal co-ordinate analysis (Gower, 1967, 1969; Field, 1971, personal communication; Cassie and Michael, 1968; Moore, 1974; Hughes and Thomas, 1971a, 1971b). Canonical correlation analysis (Cassie and Michael, 1968; Williams and Lance, 1968) and/or multiple regression analysis will also be used to investigate the relationship between physical parameters and species distributions.

Bering Sea

Benthic infauna were collected on two legs of a cruise on the R/V *Discoverer* (May-June 1975), three legs of a cruise on the R/V *Miller Freeman* in 1975 (Leg I-16 August - 3 September, Leg II - 12 September - 26 September; Leg III - 3 October - 24 October), and three legs of a cruise of the *Miller Freeman* in 1976 (March-June). To satisfy the objectives of the project, stations were selected over the entire study area, and these stations were occupied whenever a vessel was available.

Quantitative samples were taken with a 0.1 m^2 van Veen grab with bottom penetration facilitated by addition of 31.7 kg (70 pounds) of lead weight to each grab. Two 1.0 mm mesh screen doors on top of the grab permitted removal of undisturbed sediment samples by members of the hydrocarbon and heavy metals study groups. In addition, the screen doors served to decrease shock waves produced by bottom grabs (see Feder *et al.*, 1973 discussion of grab operation and effectiveness of the van Veen grab in sediment of the type found in the Gulf of Alaska). Five to six replicate grabs were taken at all stations on all cruises. Ten (10) replicates (for analysis of the optimum number of replicates needed per station in the Bering Sea) were taken at selected stations. Sediment samples were removed from extra replicate samples taken for this purpose. Sediment for trace metal analysis was taken at selected stations; generally an extra replicate was taken for the latter samples. Material (used for biological sampling) from each grab was washed on a 1.0 mm stainless steel screen and preserved in 10 percent formalin buffered with hexamine. Samples were stored in plastic bags.

In the laboratory (Marine Sorting Center, University of Alaska, Fairbanks) all grab samples were rinsed to remove the last traces of sediment, spread on a gridded tray, covered with water and rough-sorted by hand. The material was then transferred to fresh preservative (buffered 10 percent formalin), and identifications made. All organisms were counted and wet-weighed after excess moisture was removed with absorbent towel.

A pipe dredge (14 x 36 inches/36 x 91 cm) was added to the Bering Sea program on Leg III of the NOAA ship *Miller Freeman* in June 1976.

The reasons were the same as those cited for the Cook Inlet sampling program. Most of the stations on the Bering Sea grid (Fig. 5) were sampled with this piece of gear.

Criteria developed by Feder *et al.* (1973) to recognize Biologically Important Taxa (BIT) were applied to the data collected. By use of these criteria, each species was considered independently (items 1, 2 and 3 below) as well as in combination with other benthic species (items 4 and 5; adopted from Ellis, 1969). Each taxon classified as BIT in this study met at least one of the four conditions below.

1. It was distributed in 50 percent or more of the total stations sampled.

2&3. It comprised over 10 percent of either the composite population density or biomass collected at any one station.

4. Its population density was significant at any given station. The significance was determined by the following test:
    a. A percentage was calculated for each taxon with the sum of the population density of all taxa equalling 100 percent.
    b. These percentages were then ranked in descending order.
    c. The percentages of the taxa were summed in descending order until a cut-off point of 50 percent was reached. The BIT were those taxa whose percentages were used to reach the 50 percent cut-off point. When the cut-off point of 50 percent was exceeded by the percentage of the last taxon added, this taxon was also included.

Species diversity were examined by way of two Indices of Diversity:

1. Shannon-Wiener Index of Diversity:

$$H = -\Sigma\, p_i \log_e p_i \quad \text{where } p_i = \frac{n_i}{N}$$

n_i = number of individuals of species i_1, i_2, $i_3 \ldots i_x$

N = total number of individuals

s = total number of species

2. Simpson Index of Diversity:

$$s = \Sigma \frac{n_i}{n} \quad \frac{n_{j-1}}{N-1}$$

3. Brillouin Index of Diversity:

$$H = \frac{1}{N} (\log_{10} N! - \Sigma \log_{10} N_2 !) \text{ where}$$

N = total number individuals in all species

N_i = number of individual in the i^{th} species.

These indices were calculated for all stations sampled.

The Simpson Index is an indicator of dominance since the maximum value, 1, is obtained when there is a single species (complete dominance), and values approaching zero are obtained when there are numerous species, each a very small fraction of the total (no dominance). The Shannon-Wiener and Brillouin indices are indicators of diversity in that the higher the value, the greater the diversity and the less the community is dominated by one or a few kinds of species (see Odum, 1975 for further discussion and additional references).

All species taken by grab were coded according to the 10 digit VIMS system used for fauna collected in a benthic study in Cheaspeake Bay (Swartz *et al.*, 1972); coding was suitably modified to conform to species collected in the Gulf of Alaska (Mueller, 1975). Data was recorded on computer cards, and will be converted to magnetic tape. Data printout was accomplished by means of special program written by Mr. James Dryden

(Data Processing Services, Institute of Marine Science, University of Alaska). Data output consisted of a listing of stations occupied and replicates (samples) taken, a species-coding number list associated with a printout of Biologically Important Taxa (BIT) for all grab stations, and a series of station printouts [species collected, number of individuals, percentage of each species (number), biomass of individuals (per m^2 for all replicates per station), percentage of each species (biomass), Simpson Index, Shannon-Wiener Diversity Index]. All data was submitted in NODC format.

Station groups and species assemblages have been identified using classificatory techniques applied to the NEGOA data (see Section V on Classification of Infauna for the Gulf of Alaska).

Benthic epifauna were collected onboard the NOAA vessel *Miller Freeman*. One-half hour and one hour tows were made at predetermined stations using a commercial size 400-mesh Eastern otter trawl. All invertebrates of non-commercial importance were sorted out on shipboard, given tentative identifications, counted, weighed when time permitted, and aliquot samples of individual species were 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, and the data was 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.

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

The stomachs of variable numbers of King crab (*Paralithodes camtschatica*), snow crab (*Chionoecetes opilio*), and selected species of fishes were examined to determine stomach contents. Food items were identified in the laboratory on shipboard. All stomach contents were then placed in "Whirlpak" bags and fixed in 10 percent neutralized formalin for final identification at the University of Alaska.

All species were assigned code numbers after final identifications in the laboratory in Fairbanks.

Hermit crab weights as recorded on the data sheets do not include shell weights.

VI. RESULTS

Northeast Gulf of Alaska

Benthic Infaunal Program[1]

The basic plan of operation suggested in the proposal (and presented in Methods) was completed for the northeastern portion of the study area; substratum differences encountered in the northwestern Gulf study area during the October 1975 cruise resulted in only partial quantitative coverage of the sampling grid (see Feder *et al.*, 1976a for further details). Although vessel time and weather constraints did not permit complete sampling of all stations in the northwestern grid on a seasonal basis, it was

[1]Grab data was still in process of analysis at the time of the preparation of this Annual Report. Preliminary results of this analysis are included in Appendix VI of this report.

possible to accumulate samples in three time blocks -- July through November (1974); February through May (1975); and September through October (1975). No vessel time was available for the summer of 1975. All samples for the northwest Gulf of Alaska have been archived pending funds for processing.

The van Veen grab functioned effectively in the fine sediments of the Gulf of Alaska, and typically delivered sample volumes of 13 to 19 ℓ with the exception of Stations 26 (6 to 9 ℓ), 29 (1 to 3 ℓ) and 30 (2 ℓ). These stations tend to be sand or sand-gravel dominated, and penetration of the grab was reduced. The surface of all samples, examined through the top door of the grab, was undisturbed as evidence by the smooth detrital cover. (See Feder *et al.*, 1973 for a review on use of the van Veen grab in soft sediments of the type found in the Gulf of Alaska.) The three (3) replicates typically taken at each station in the first year of the study appeared to be a minimal number as evidenced by qualitative examination of the station data (see Appendix Tables II and III in Feder and Mueller, 1975); fauna was obviously very patchy. The five (5) replicates taken at all stations in the next sampling year should be sufficient, but this value is being tested by way of 10 replicate samples taken at selected stations (see Feder *et al.*, 1973 for discussion on the optimum number of replicate samples needed in a grab-sampling program).

The size of screen chosen for the onboard washing process, 1.0 mm, was appropriate for the sediments sampled, and was the minimal size that could be used efficiently at most stations. A smaller size mesh would greatly increase the overall shipboard washing time which in turn would reduce the overall station coverage possible on each cruise.

All of the station data for the northeast Gulf of Alaska for the July, October, November, February, and May cruises have been processed and tabulated (Feder and Mueller, 1975; data submitted to NODC). The samples from September and October 1975 have been processed and are being currently analyzed.

Isolation of 457 species was made from the grab samples analyzed to date (Feder and Mueller, 1975; Feder *et al.*, 1976a). Members of fourteen marine phyla were collected with polychaetous annelids comprising the most important group with 132 species. Molluscs were next in importance with 69 species, and Arthropod crustaceans next with 66 species. Echinoderms were fourth in significance with 24 species. Other groups were less important. One hundred two (102) new species were added in the second year of the investigation.

The indices (Simpson, Shannon-Wiener, Shannon Evenness, Brillouin, and Brillouin Evenness) calculated for all species in the quantitative grab stations are included in Table 3 of Feder *et al.* (1976a). Examination of the data indicates that the indices are reflecting dominance (Simpson) and diversity (Shannon-Wiener and Brillouin). In the Simpson Index, the higher values are a reflection of the dominance in numbers of individuals of a few species. Lower Shannon-Wiener and Brillouin diversity indices also tend to reflect species dominance or lower diversity at some of the stations. Higher diversity indices are found at stations with many species but no particular dominance by any one species. The calculated evenness indices further clarify dominance relationships at any particular station.

Utilization of the criteria for Biologically Important Taxa delineated 95 species (see Appendix Table I in Feder *et al.*, 1976a). The data used to determine the BIT were pooled from the cruises in July, October, November, and May. Thirty-two (32) of the BIT were identifiable as important by way of biomass at one or more stations. Some of the latter species were well distributed throughout the study area, for example - the clams *Axinopsida serricata, Nucula tenuis, Nuculana pernula*; the polychaete *Sternaspis scutata*; the echinoderms *Ctenodiscus crispatus, Ophiura sarsi* and *Molpadia* sp. These species may be ones with great influence on the trophic interactions in their particular localities, and should be followed in succeeding years (see Feder and Mueller, 1975; Feder *et al.*, 1976a; data submitted to NODC for a listing of the species dominating at stations by biomass).

The distribution of selected BIT species are plotted in Figures 4 through 41 in Feder *et al.* (1976a). An update of these distribution maps will be available in the Final Report.

The feeding methods for the majority of the species collected are included in Appendix Table VI of Feder and Mueller (1975). The data are compiled from the literature and from personal observations (see Feder *et al.*, 1973; Feder and Mueller, unpublished data and interpretations). Some of the species probably utilize two feeding methods, and such dual feeding methods where suspected, were included in the table. Deposit feeding is the most common method used (90 examples: 39%) with suspension feeding next in importance (58 examples: 25%). The predominant feeding methods utilized by species at each station have not been determined as yet. It is presumed that the methods used will tend to vary with local currents and be reflected to a certain extent by the substrate type at each station. Feeding methods for the additional species taken during the current year have not yet been examined; comments should be available for the Final Report.

Initial cluster analyses performed on an incomplete data set which included all of the stations occupied on cruises 193, 200, 202 and part of the stations occupied during cruise 805 (see Feder *et al.*, 1976a). A discussion of the results of cluster analysis of all data available to date is included in Appendix VI of this report.

Trawl Program

The basic intent of the joint benthic invertebrate-demersal fish program has been fullfilled by collection of invertebrate samples and fish stomachs on three legs (25 days per leg) of the Northwest Fishery Center trawl charter, from May through August, 1975. In addition, hydrocarbon and trace metal samples were taken from invertebrates and fishes on these cruises (see Smith, 1976; Shaw, 1976; Burrell, 1976). Many of the stations were located in the general areas of the grab stations. All epifaunal invertebrates were typically counted, although in some cases, for very abundant species, only weights were taken. At some stations it was possible to count and weigh most invertebrate species; conversion factors have been developed to approximate wet weights for all invertebrate species at all stations.

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 (Tables IV, V, VI, and VII). 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%).

Crustacean families Majidae, Pandalidae, Lithodidae, Paguridae, and Crangonidae were most abundant. The snow crab *Chionoecetes bairdi* (family

TABLE IV

SPECIES TAKEN BY TRAWL FROM THE NORTHEAST GULF OF ALASKA (NEGOA) ONBOARD THE M/V *NORTH PACIFIC*, 25 APRIL - 7 AUGUST 1975

Phylum Porifera
- unidentified species

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

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

TABLE IV

CONTINUED

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

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

TABLE IV

CONTINUED

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

TABLE IV

CONTINUED

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

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

TABLE IV

CONTINUED

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

Phylum Ectoprocta
unidentified species

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

Phylum Echinodermata
Class Asteroidea
Family Asteropidae
Dermasterias imbricata (Grube)
Family Astropectinidae
Dipsacaster borealis Fisher
Family Benthopectinidae
Luidiaster dawsoni (Verrill)
Nearchaster pedicellaris (Fisher)
Family Goniasteridae
Ceramaster patagonicus (Sladen)
Hippasterias spinosa Verrill
Mediaster aequalis Stimpson
Pseudarchaster parelii (Düben and Koren)
Family Luiidae
Luidia foliolata Grube
Family Porcellanasteridae
Ctenodiscus crispatus (Retzius)
Family Echinasteridae
Henricia aspera Fisher
Henricia sp.
Poraniopsis inflata Fisher

TABLE IV

CONTINUED

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

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

TABLE V

THE INVERTEBRATE PHYLA AND THE NUMBER AND PERCENTAGE OF SPECIES OF EACH PHYLUM COLLECTED BY COMMERCIAL TRAWL IN THE NORTHEAST GULF OF ALASKA (NEGOA) ON THE M/V *NORTH PACIFIC*, COLLECTION MADE MAY - AUGUST 1975

Phylum	Number of Species	% of Species
Mollusca	47	28.0
Arthropoda (Crustacea)	42	25.0
Echinodermata	36	21.4
Annelida	30	17.8
Cnidaria	6	3.6
Brachiopoda	3	1.8
Chordata (Tunicata)	2	1.2
Ectoprocta	1	0.6
Porifera	1	0.6
TOTAL	168	100.0%

TABLE VI

THE NUMBER AND PERCENTAGE OF SPECIES OF SUBGROUPS OF MOLLUSCA, ARTHROPODA AND ECHINODERMATA COLLECTED BY COMMERCIAL TRAWL IN THE NORTHEAST GULF OF ALASKA (NEGOA) ON THE M/V *NORTH PACIFIC*, COLLECTIONS MADE MAY - AUGUST 1975

Phylum	Subgroup	No. of Species	% of Species
Mollusca	Gastropoda (snails, nudibranchs)	24	51.1
	Pelecypoda (clams, scallops)	18	38.3
	Cephalopoda (octopus, squid)	4	8.5
	Polyplacophora (chitons)	1	2.1
	TOTAL	47	100.0%
Arthropoda	Decapoda (crabs, shrimp)	36	85.7
	Thoracica (barnacles)	4	9.5
	Isopoda	2	4.8
	TOTAL	42	100.0%
Echinodermata	Asteroidea (sea stars)	24	66.7
	Ophiuroidea (brittle stars)	5	13.9
	Echinoidea (sea urchins)	3	8.3
	Holothuroidea (sea cucumbers)	3	8.3
	Crinoidea (feather star)	1	2.8
	TOTAL	36	100.0%

TABLE VII

PERCENTAGE COMPOSITION BY WEIGHT OF LEADING INVERTEBRATE SPECIES COLLECTED DURING NORTHEAST GULF OF ALASKA (NEGOA) TRAWLING INVESTIGATIONS, SUMMER 1975

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

Majidae) contributed 66.2% of the invertebrate biomass (Table VII), and was collected at most of the stations. The density of this crab was highest at Station 82-A[2] where 1984 crabs taken in one hour weighed 892 kg (1967 pounds) equivalent to 19.8 g/m^2 (Fig. 6). The average catch per unit of effort (CPUE) at all stations was 112 kg/hr (247 pounds/hr). Sex composition of the snow crab was 53% males and 47% females. Pink shrimp, *Pandalus borealis*, consistently made up an important segment of the invertebrate biomass (Table VII). The biomass of this shrimp was highest at Station 83-C with 2.4 g/m^2 or 167.7 kg (370 pounds) taken per hour (Fig. 7). The average CPUE of this species was 5 kg/hr (11 pounds/hr). *Lopholithodes foraminatus*, the box crab, was the third most important crustacean in weight composition (Table VII). The highest density was found in a one-hour tow at Station 86-D, where 55 of these crabs weighed 25.4 kg (56 pounds) equivalent to 0.3 g/m^2 (Fig. 8). The average CPUE of the box crab was 0.8 kg/hr (8 pounds/hr).

The echinoderm fauna was generally diverse at most stations, but typically only a few individuals of each species were present per station. Sea stars represented the most diverse group with 20 genera and 21 species collected. The percent-weight composition of sea stars as a percentage of all echinoderms and all invertebrate species was 35.3% and 6.7% respectively. Ophiuroids were the second largest group of echinoderms, making up 33.5% of the echinoderm biomass and 6.4% of the total invertebrate biomass. Holothuroidea and Echinoidea made up 15.9 and 14.4% respectively of the echinoderm biomass.

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[2]Data from fourteen stations (74-C, 74-D, 80-B, 81-D, 82-A, 83-C, 83-E, 86-D, 89-A, 94-A, 94-B, 97-C, 99-D), referred to in the text, are compiled separately as an Appendix Table in Jewett and Feder (in press).

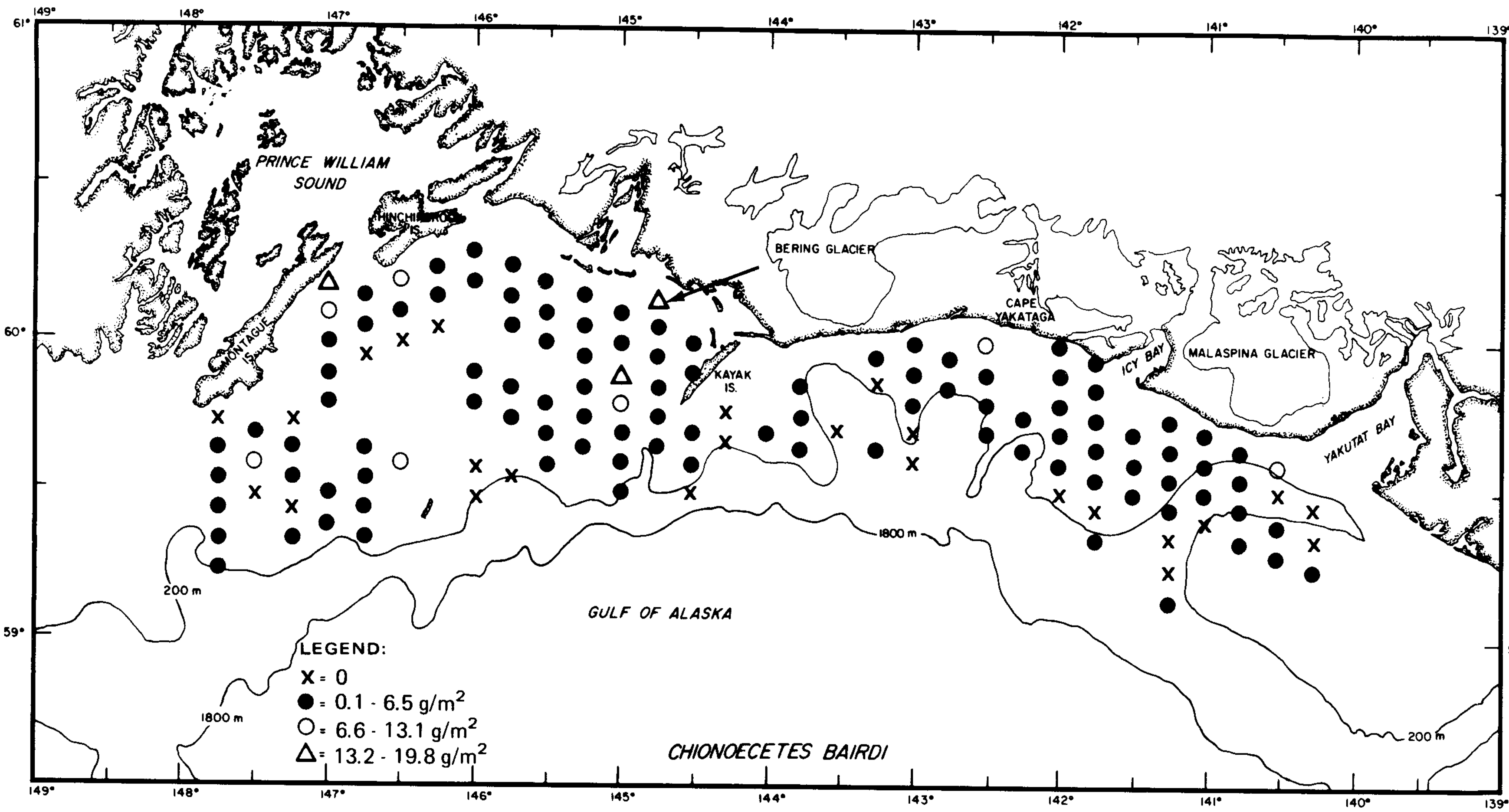

Figure 6. Distribution and abundance of the snow crab, *Chionoecetes bairdi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. bairdi*.

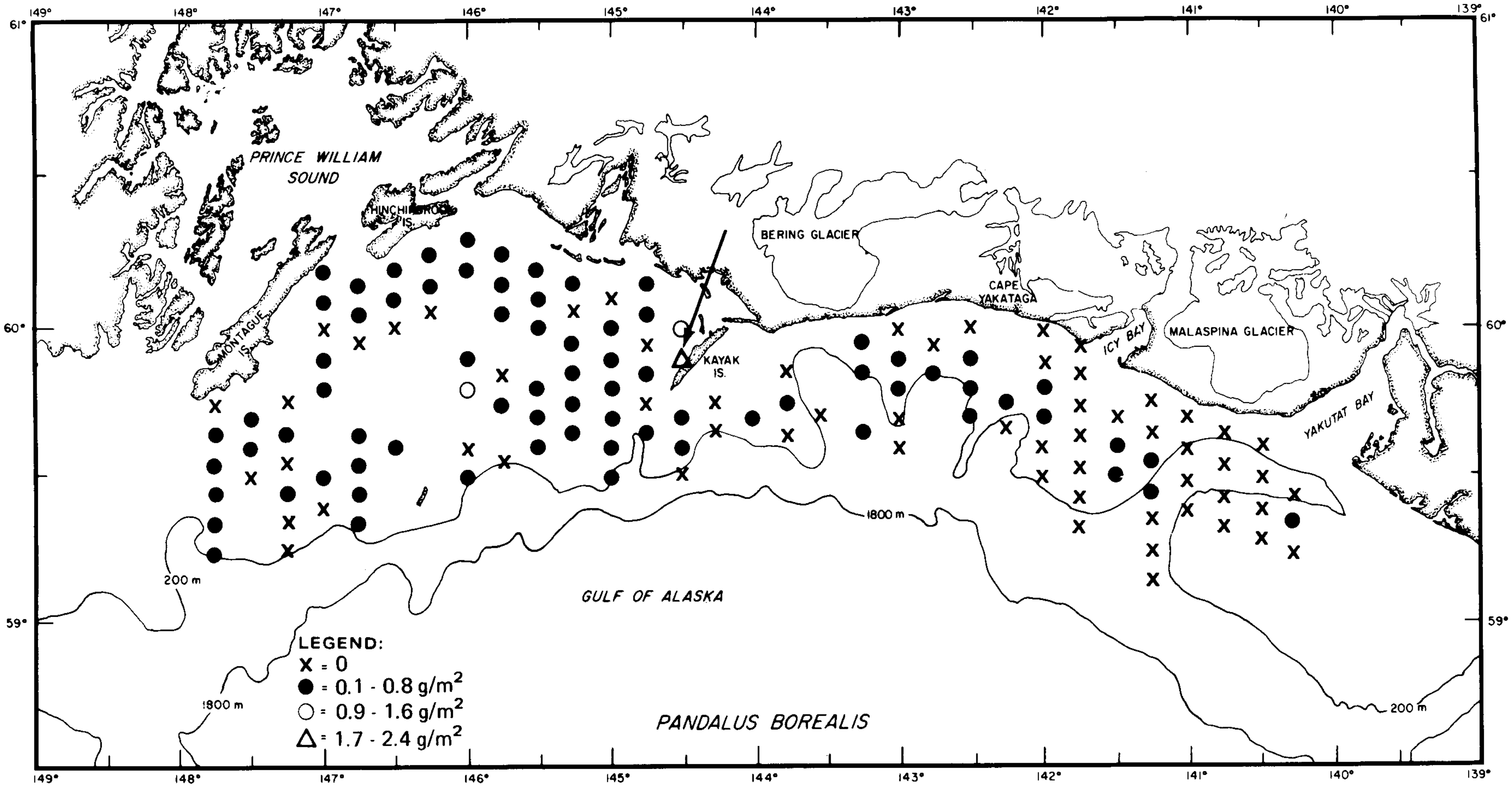

Figure 7. Distribution and abundance of the pink shrimp, *Pandalus borealis*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. borealis*.

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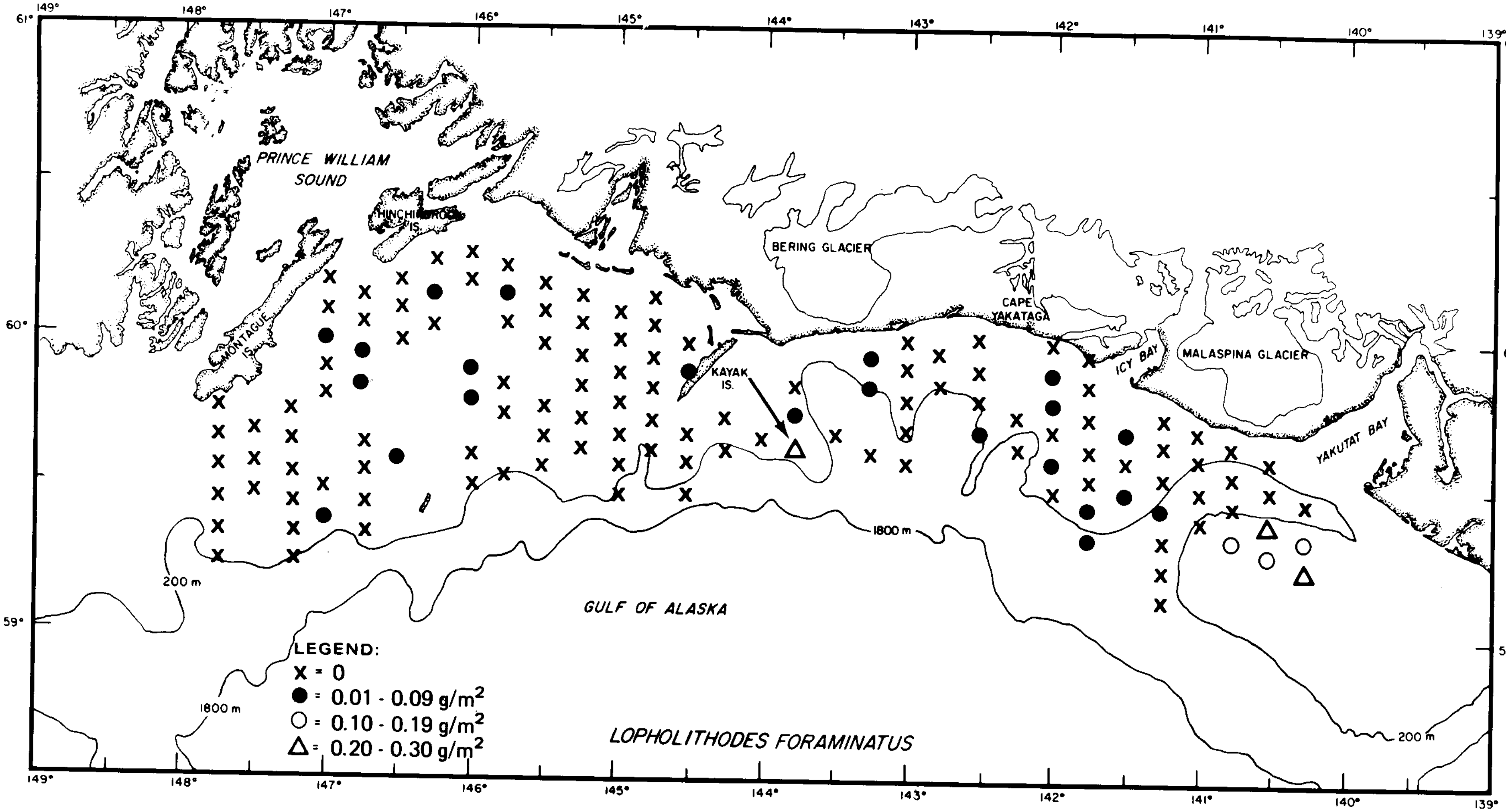

Figure 8. Distribution and abundance of the box crab, *Lopholithodes foraminatus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *L. foraminatus*.

Four echinoderm species (a brittle star (*Ophiura sarsi*), two sea stars (*Ctenodiscus crispatus* and *Pycnopodia helianthoides*), and the heart urchin (*Brisaster townsendi*)) were found in large quantities (Table VII; Appendix Table I in Jewett and Feder, in press). *Ophiura sarsi* was the most abundant echinoderm. The largest catch of this brittle star, at Station 81-D, was 750 kg (1653 pounds) in the hour tow equivalent to 11.4 g/m^2 (Fig. 9). Average CPUE at all stations was 7.4 kg/hr (16 pounds/hr). Greatest biomass for the small sea star *Ctenodiscus crispatus* was found at Station 80-B with 0.8 g/m^2 or 55.8 kg (123 pounds) taken per hour (Fig. 10). The average CPUE of this species was 5 kg/hr (11 pounds/hr). *Pycnopodia helianthoides* was another widely distributed sea star. One hundred and seventy of these large sea stars (average weight 0.453 kg) were taken at Station 93-C (Fig. 11). At this station the biomass of *Pycnopodia* was 1.3 g/m^2 or 85.5 kg (188 pounds) taken per hour. The average CPUE was 3.3 kg/hr (7 pounds/hr). The heart urchin *Brisaster townsendi* accounted for approximately 11% of the echinoderm biomass taken in the trawl survey. Station 97-C yielded the largest catch of this urchin with 2.9 g/m^2 or 213 kg (469 pounds) per hour; this represented 21,272 urchins collected during the tow (Fig. 12). The average CPUE was 3.6 kg/hr (8 pounds/hr).

Although sea cucumbers (family Cucumariidae) were found at only seven stations, they ranked high in echinoderm weight composition. For example, the tow at Station 99-D contained approximately 2600 of these holothuroids weighing 650 kg (1433 pounds), equivalent to 9.6 g/m^2 (Fig. 13). The average CPUE was 4.8 kg/hr (11 pounds/hr).

Molluscs were represented by 28 families with Pectinidae, Neptuneidae and Cymatiidae leading respectively in weight composition. Important

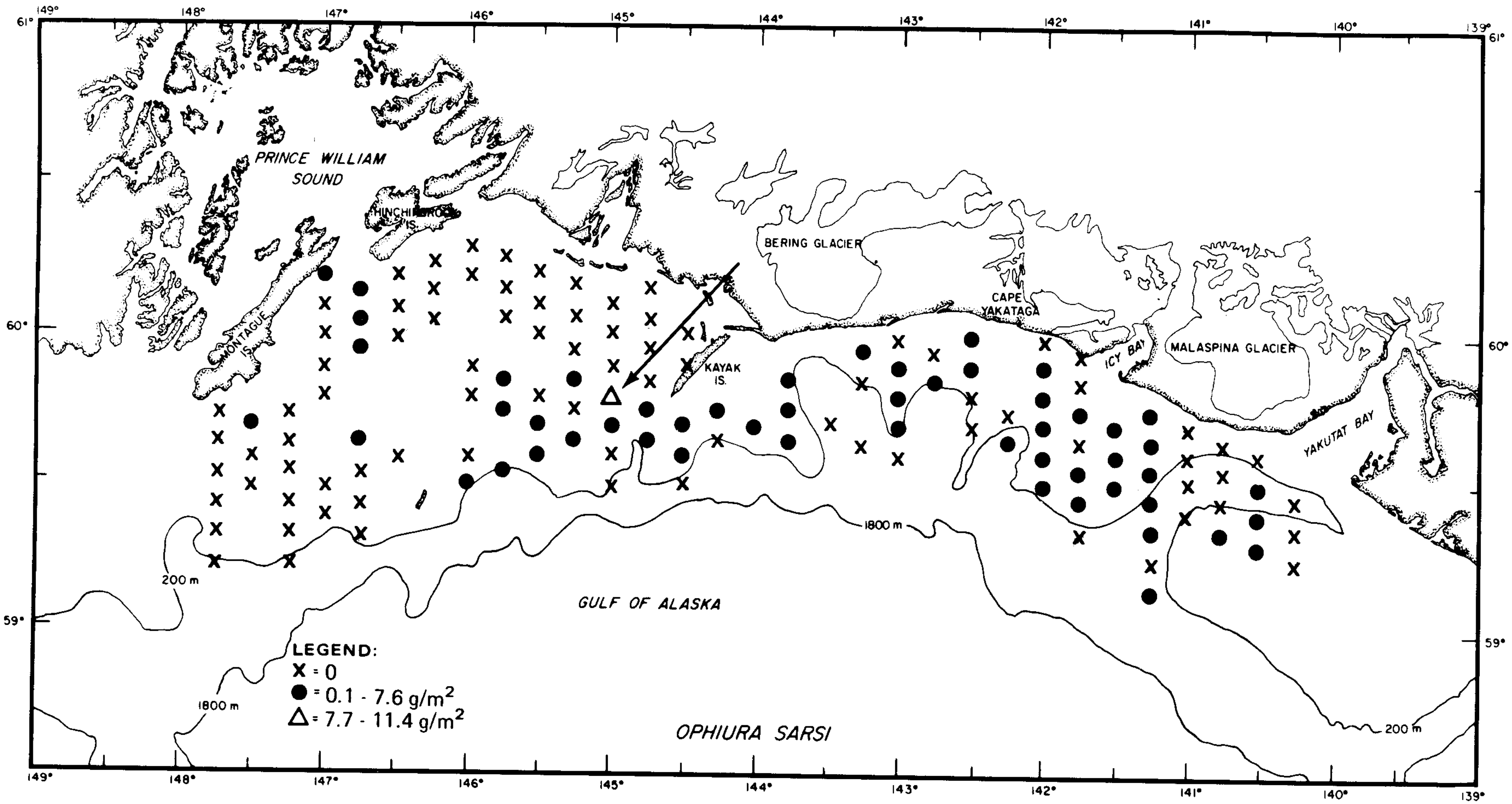

Figure 9. Distribution and abundance of the brittle star, *Ophiura sarsi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *O. sarsi*.

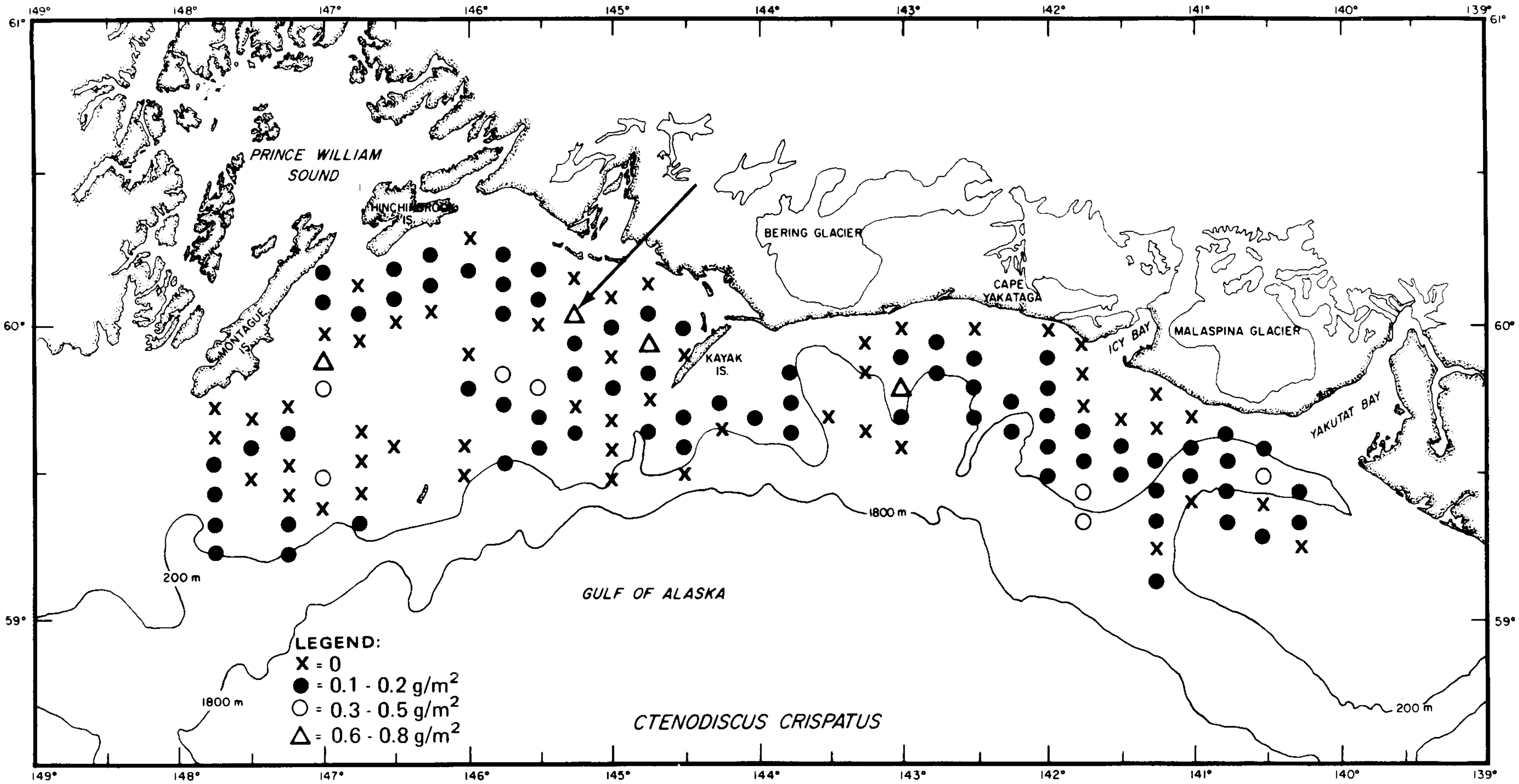

Figure 10. Distribution and abundance of the sea star, *Ctenodiscus crispatus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. crispatus*.

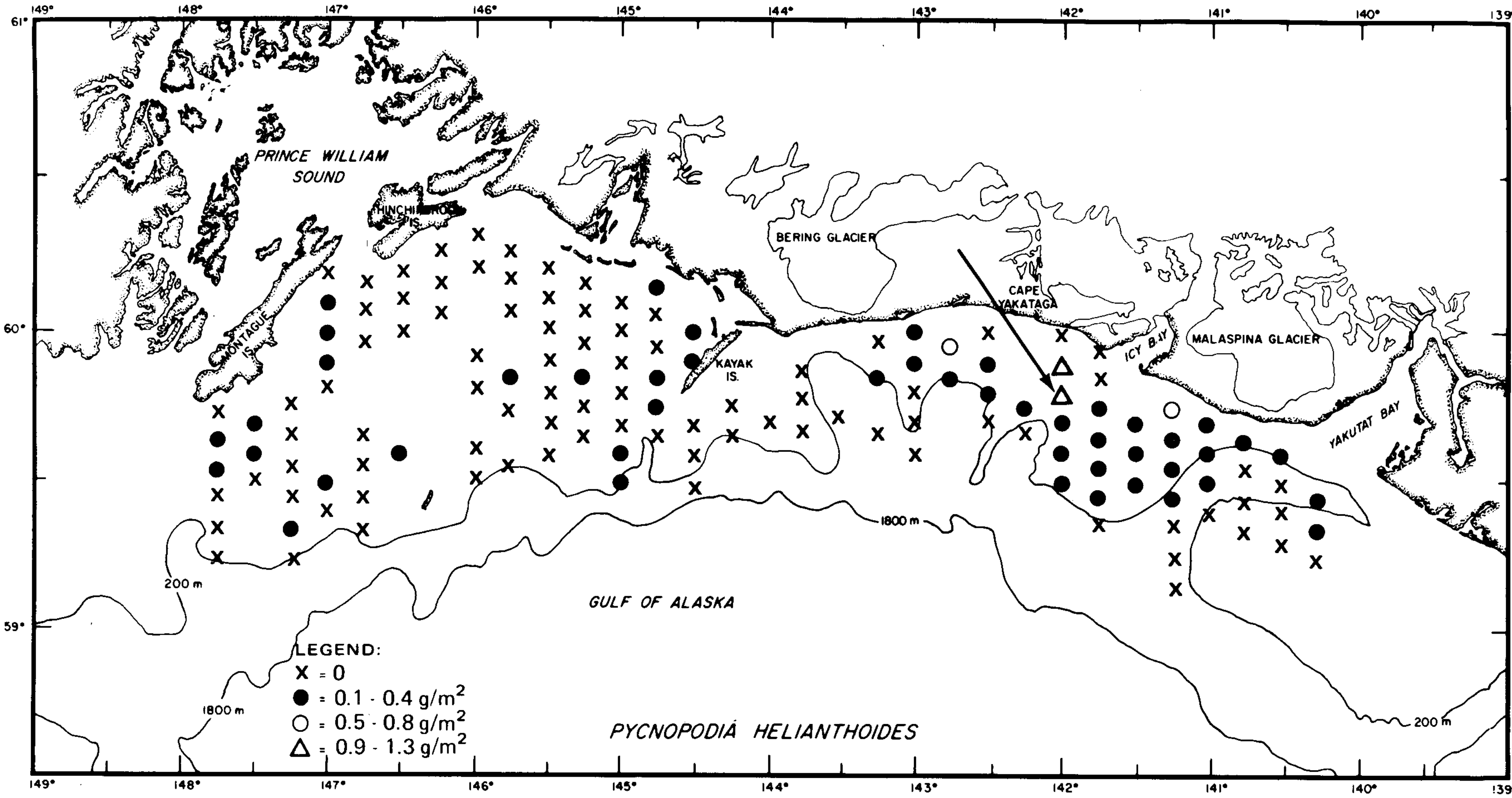

Figure 11. Distribution and abundance of the sea star, *Pycnopodia helianthoides*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. helianthoides*.

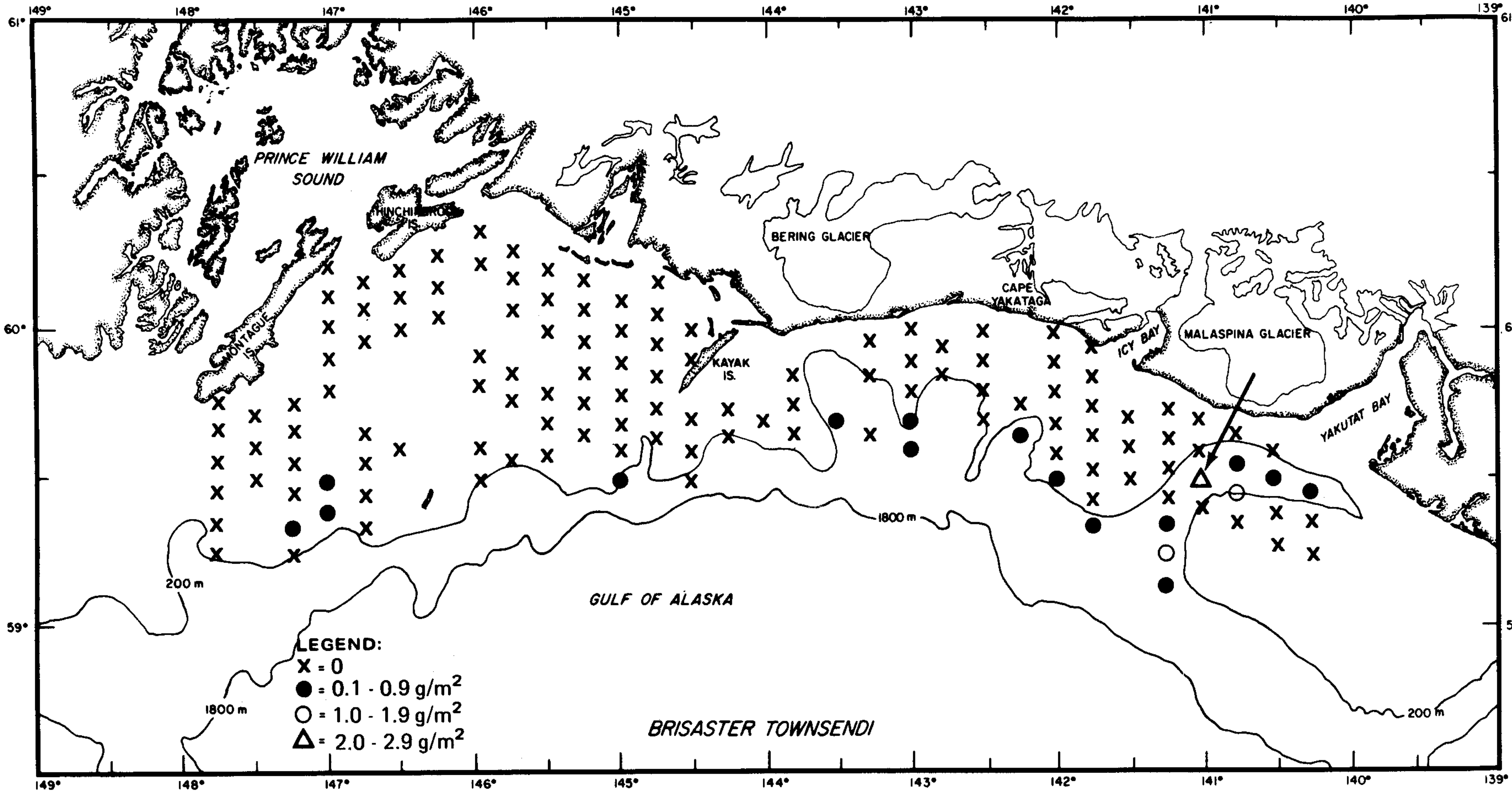

Figure 12. Distribution and abundance of the heart urchin, *Brisaster townsendi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *B. townsendi*.

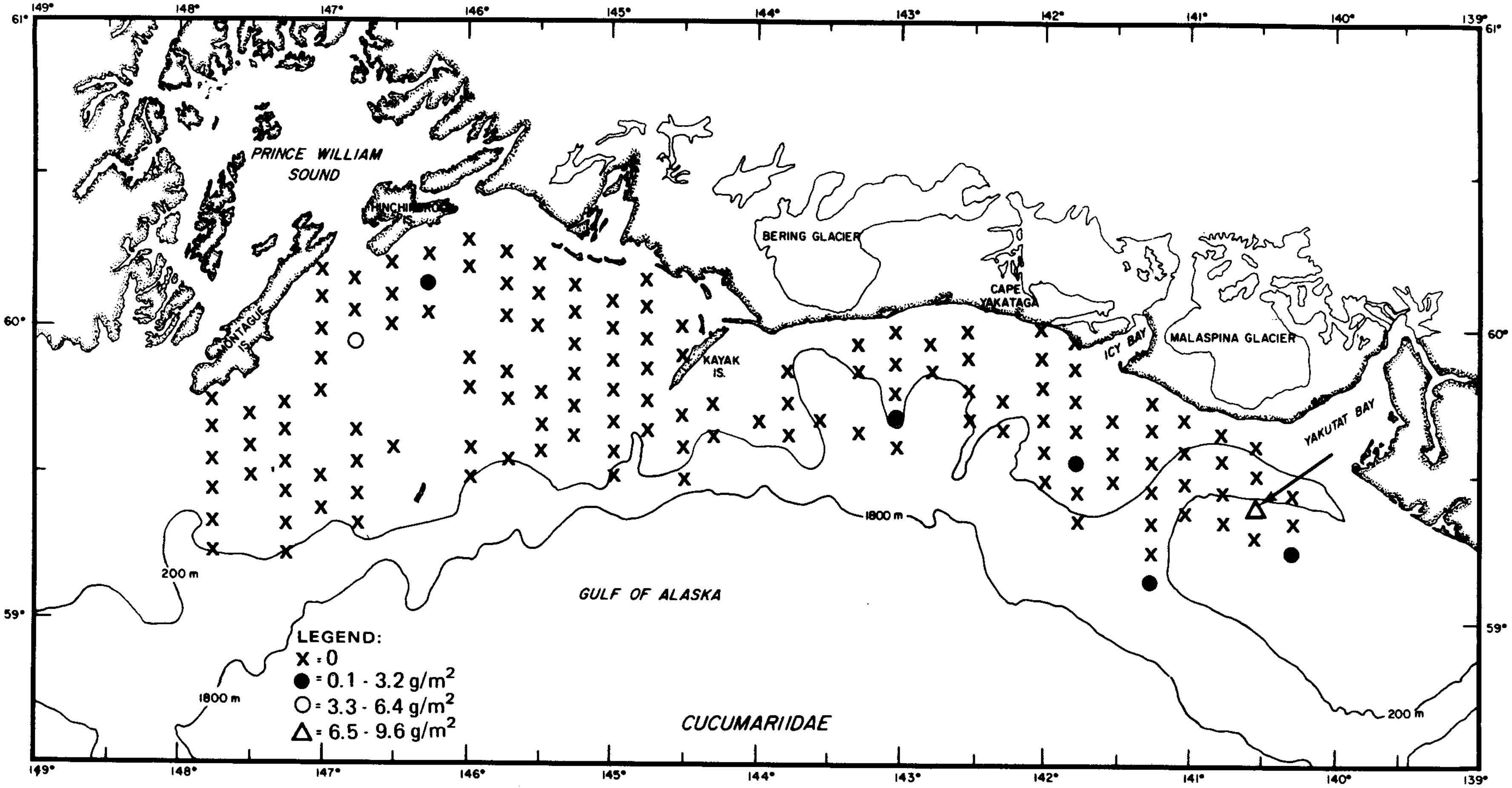

Figure 13. Distribution and abundance of the sea cucumber, family Cucumariidae, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of Cucumariidae.

members of these families were the weathervane scallop *Pecten (= Patinopecten) caurinus* (family Pectinidae), the whelk *Neptunea lyrata* (family Neptuneidae), and the Oregon triton *Fusitriton oregonensis* (family Cymatiidae) (Table VII). *Pecten caurinus* made up 2% of the total invertebrate biomass and 43% of the molluscan biomass, and was generally taken at nearshore stations from Kayak Island to Icy Bay. Station 83-E provided the largest catch of scallops with 1.7 g/m^2 or 116 kg (370 pounds) per hour (Fig. 14). The average CPUE was 3.4 kg/hr (7 pounds/hr). *Neptunea lyrata* was the most common gastropod, and was most abundant at Station 89-A with 0.4 g/m^2 or 32.4 kg (71 pounds) taken per hour (Fig. 15). The average CPUE was 1.0 kg/hr (2.2 pounds/hr). The snails *Pyrulofusus harpa* and *Colus halli* were also dominant representatives of the family Neptuneidae. *Fusitriton oregonensis*, the only member of the family Cymatiidae, was widely distributed (Fig. 16). It was most common from stations at the west end of the grid, specifically Station 74-C where the density was 0.37 g/m^2 or 4.5 kg (10 pounds) taken in a 35 minute tow. The average CPUE was 0.9 kg/hr (2 pounds/hr). The snail, *Arctomelon stearnsii*, was relatively common at stations occupied in the present survey.

Two areas of biological interest, in terms of species composition and diversity, encompass Stations 74-C and D and Stations 94-A and B (Fig. 3). Stations 74-C and D contained seven species of fishes (*Hippoglossus stenolepis, Bathymaster signatus, Lepidopsetta bilineata, Gadus macrocephalus, Hemilepidotus jordani, Atheresthes stomias*, and *Glyptocephalus zachirus*), and had the highest diversity of invertebrates of all of the stations sampled. Crustaceans (14 species), echinoderms (13 species) and molluscs (13 species) made up 85% of the 47 species found there. The biomass of the ascidian, *Halocynthia helgendorfi igaboja*, at Station

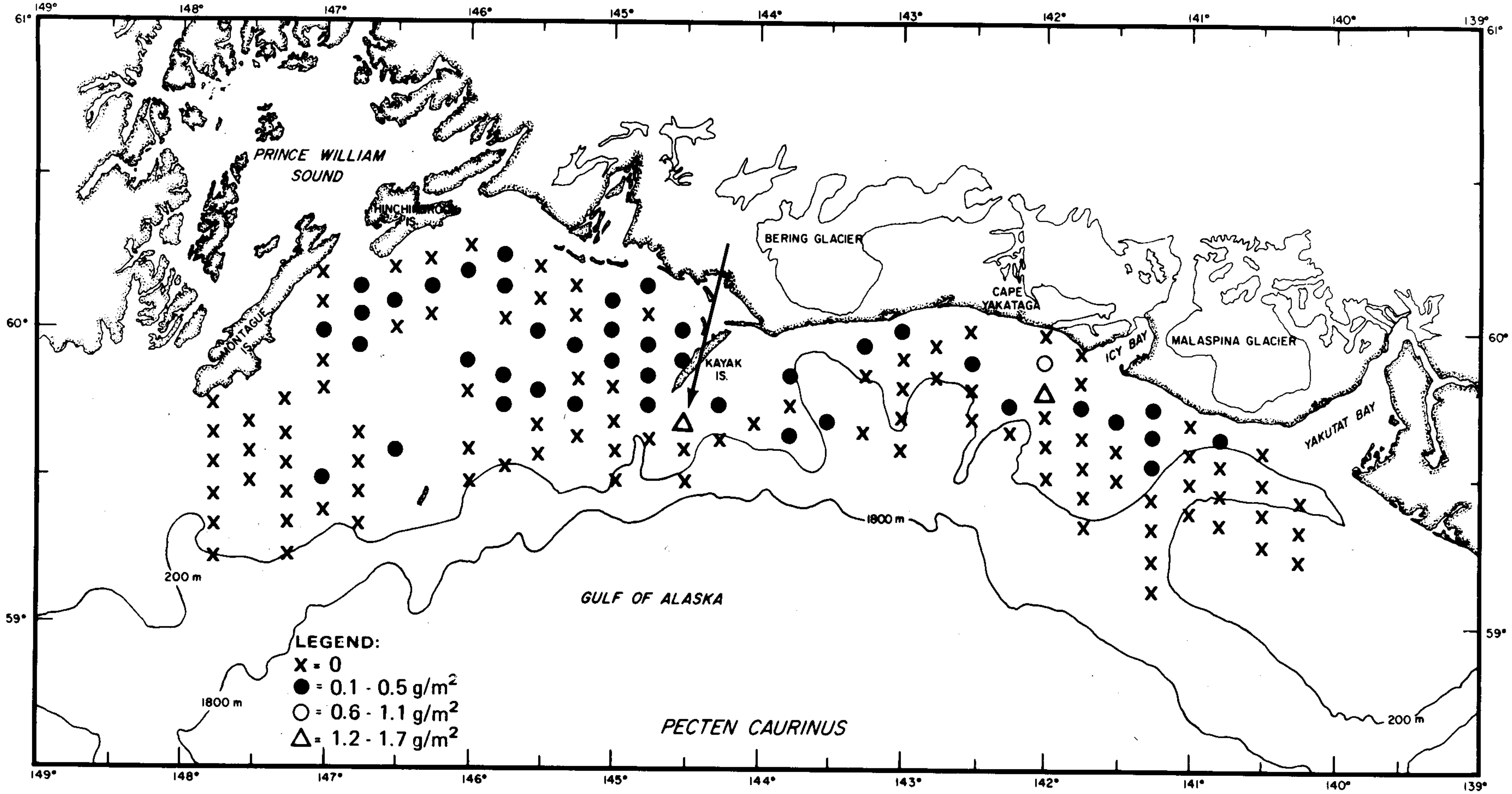

Figure 14. Distribution and abundance of the scallop, *Pecten caurinus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. caurinus*.

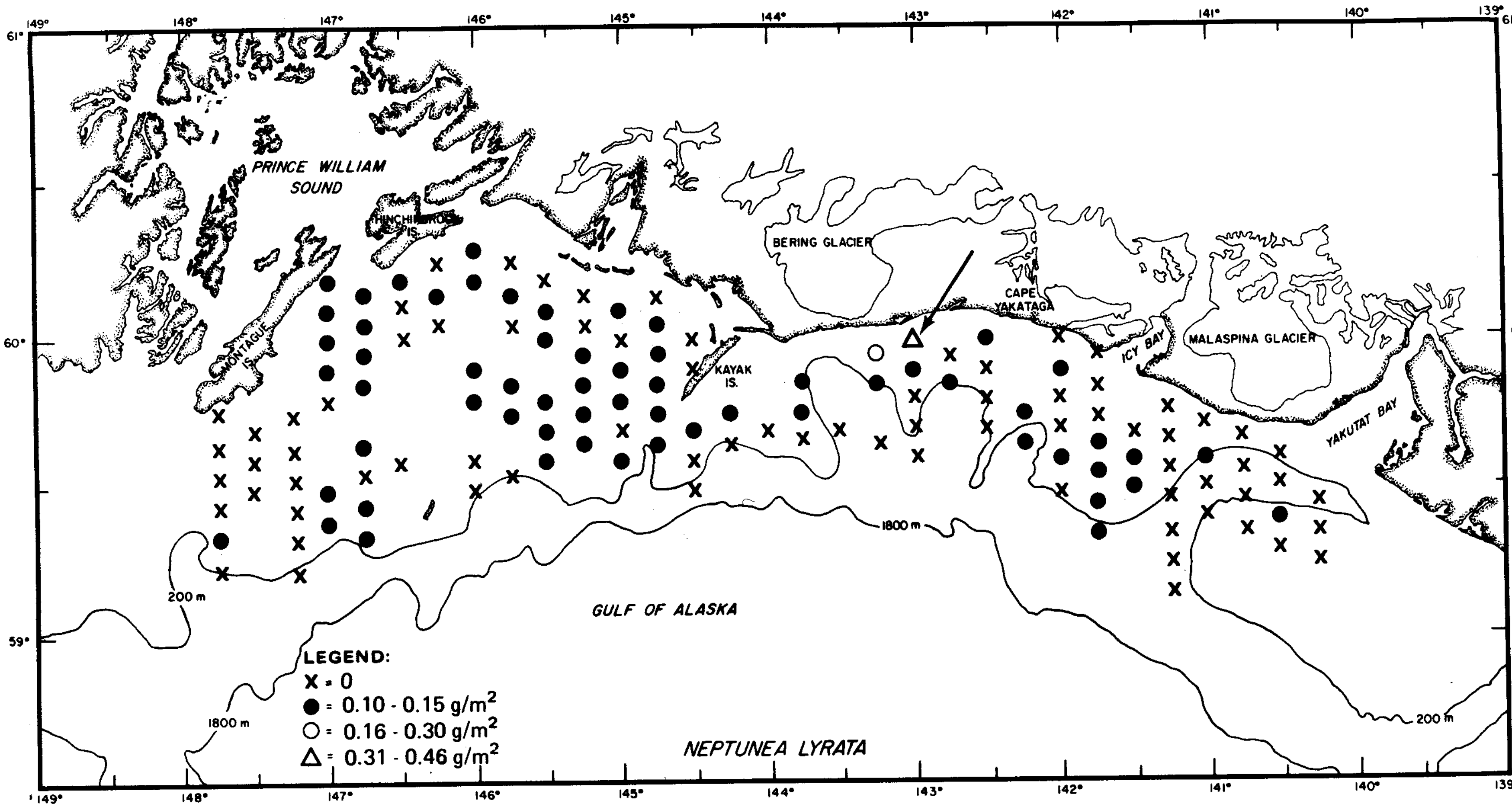

Figure 15. Distribution and abundance of the snail, *Neptunea lyrata*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *N. lyrata*.

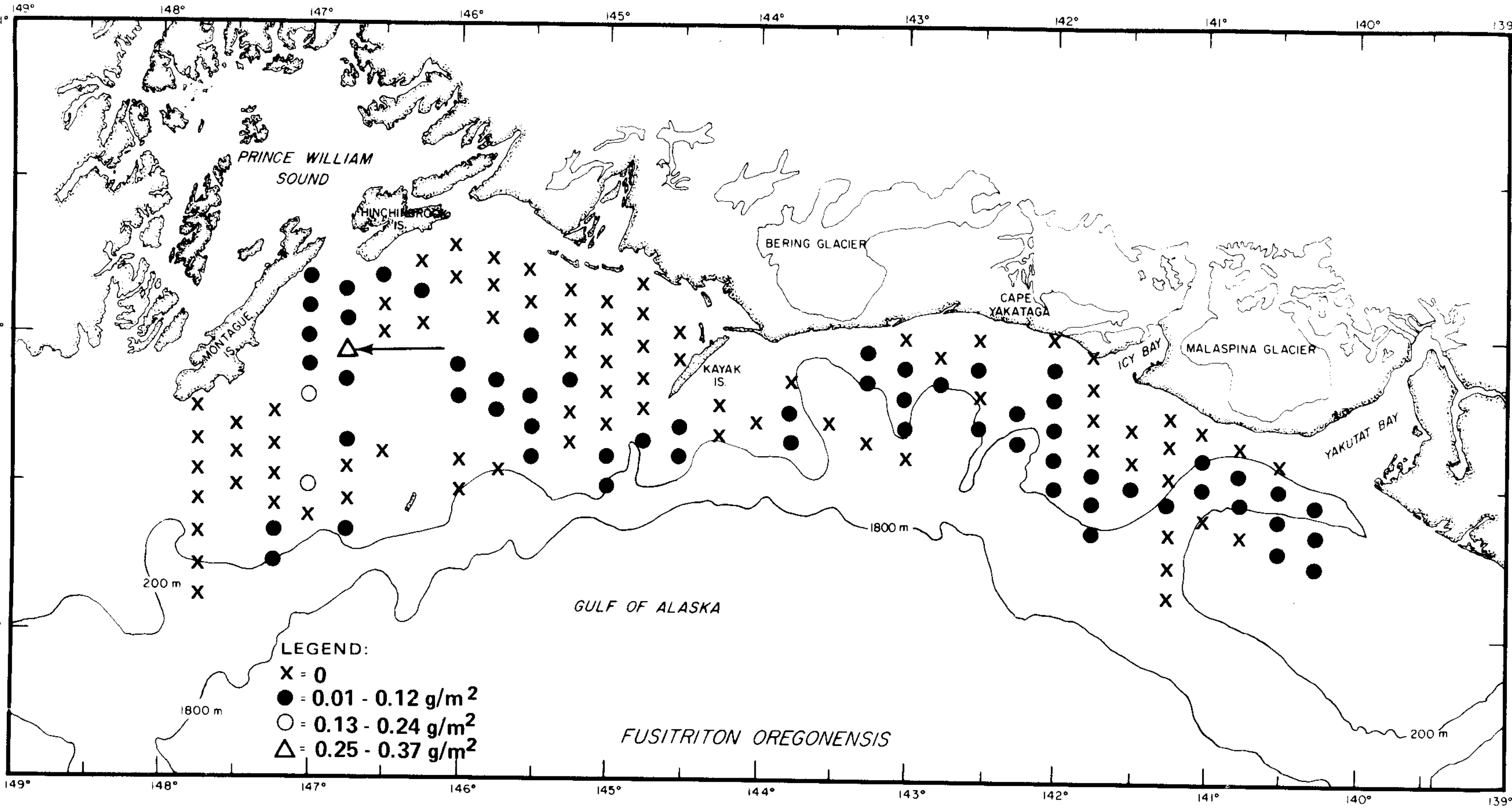

Figure 16. Distribution and abundance of the Oregon triton, *Fusitriton oregonensis*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *F. oregonensis*.

74-C was 4.5 g/m^2 or 419.8 kg (925 pounds) taken per hour. The Pacific halibut *Hippoglossus stenolepis*, dominated the fish catch at Station 74-C with 1399 kg (3084 pounds) per hour; each fish averaged 18.5 kg (41 pounds). Stations 94-A and B, off Icy Bay were characterized by an abundance of three species of fishes (*Platichthys stellatus, Theragra chalcogramma,* and *Isopsetta isolepis*), and the near-absence of invertebrates. Although the diversity of fishes was low, biomass was high. At Station 94-B, 4309 kg (9499 pounds) of fishes were taken in the one-hour tow.

The starry flounder *Platichthys stellatus* dominated the above two stations with 726 kg (1600 pounds) taken in a 30 minute tow at Station 94-A, and 3549 kg (7824 pounds) taken in a one-hour tow at Station 94-B. Average weight of *P. stellatus* at these stations was 2 kg. Starry flounders fed exclusively on the clams, *Yoldia seminuda, Siliqua sloati,* and *Macoma dexiosttera.* All stomachs were full. There appears to be a definite seasonal trend in feeding intensity for *P. stellatus* (Feder and Jewett, unpublished OCSEAP data; Miller, 1965). Around January (month of the lowest bottom temperature), feeding stops and does not begin again until about June. The fullness of the stomachs of the starry flounder on 3 June 1975 in the Gulf of Alaska may be evidence of a recently terminated fasting period. Clam populations in the Icy Bay area obviously play a vital role in the trophic dynamics of *P. stellatus*.

An unusually large catch of juvenile walleye pollock, *Theragra chalcogramma* (approximately 10 cm long) at Station 94-B yielded approximately 544 kg (1200 pounds) of the fish per hour. Abundance of young pollock there suggests the area may be an important nursery ground for a species known to be an important trophic link in the North Pacific (Chang, 1974; Kamba, 1974; Takahashi and Yamaguchi, 1972).

The snow crab *Chionoecetes bairdi*, he most abundant invertebrate in the Gulf of Alaska and the basis of an extensive commercial fishery there, is the main invertebrate food of the Pacific cod *Gadus macrocephalus* (Jewett, unpublished data). The snow crab feeds predominantly on bivalve molluscs, crangonid shrimps, pagurid crabs, and barnacles in lower Cook Inlet, an embayment of the Gulf of Alaska (Feder, Paul and Jewett, unpublished OCSEAP data; also, see Food Studies Section of this report). No feeding data are available for other regions of the Gulf of Alaska. Yasuda (1967) examined the stomach contents of a related species, *C. opilio elongatus* in Japanese waters, and found the bulk of the stomach contents to be echinoderms (especially ophiuroids), protobranch clams, and decapod crustaceans (especially *C. opilio elongatus*). *Chionoecetes opilio* in the southeastern Bering Sea also feeds primarily on brittle stars (*Ophiura* sp.); they also utilize polychaetous annelids, clams, and hermit crabs (Feder, unpublished data; also, see Bering Sea Food Studies in this report).

The large sea star, *Pycnopodia helianthoides*, preyed almost entirely on gastropod molluscs and echinoderms. The abundant echinoderms, *Ctenodiscus crispatus* and *Ophiura sarsi*, were the dominant organisms preyed upon. Seventy-eight percent (78%) of the stations with *Pycnopodia* also contained *C. crispatus* and/or *O. sarsi*. Other food of lesser importance consumed by *Pycnopodia*, in order of diminishing frequency of occurrence, were the gastropods *Colus halli*, *Mitrella gouldi*, *Solariella obscura*, *Oenopota* sp., and *Natica clausa*, and the pelecypods *Serripes groenlandicus* and *Clinocardium ciliatum*. Intertidal and shallow subtidal *Pycnopodia* from Prince William Sound feed primarily on small bivalve molluscs (Paul and Feder, 1975). This sea star is also capable of excavating for large clams (Mauzey *et al.*, 1968).

The sea star, *Ctenodiscus crispatus*, a non-selective deposit feeder, was typically found with its stomach full of mud. As a deposit feeder, *Ctenodiscus* is continuously reworking and ingesting sediments, and probably has an important role in recycling nutrients. Although the feeding habits of the common brittle star *Ophiura sarsi* were not examined in this study, it probably uses a combination of browsing, detritus feeding, and prey-capture techniques (Gentleman, 1964; Kyte, 1969).

Cod Feeding Studies

The dominant means of sampling fish stomachs was from King crab pots during the 1972, 1973, 1974, and 1975 ADF&G King Crab-Snow Crab Indexing Studies. During this time, 3933 Pacific cod were examined. Cottids and miscellaneous fish stomachs were also examined. For comparison of diets between trawl-caught and pot-caught cod, a sample of 59 Pacific cod was obtained from the bottomfish trawl.

The diversity of the diet of the various fishes examined were identified as belonging to nine phyla, 14 classes, four orders, 19 families, and 49 genera. Molluscs, crustaceans, and fishes were the dominant food of all fishes.

To determine the frequency of occurrence of food items, the number of individual samples were recorded in which each kind of food item was found. The results have been expressed as the number and percent of stomachs containing various food items from the total number of stomachs analyzed.

While fishing at 236 stations in 1973, 1833 cod were caught of which 689 were examined. In 1974, 172 stations yielded 5143 cod of which 1183 were examined. The largest sample of stomachs were examined in 1975. While fishing 1751 pots, 3874 cod were caught and 2061 were examined.

In order of decreasing importance, snow crab, fishes, amphipods, and shrimps were the organisms most frequently occurring in cod stomachs (Table VIII). Molluscs were commonly found in stomachs. The number of genera that were identified as pelecypods and gastropods in 1973, 1974, and 1975 was 20, 19, and 29, respectively.

Crustaceans were unquestionably a major food of codfish. Euphausids and amphipods increased in frequency of occurrence in 1973. During this year more shrimp were identified to the families Pandalidae and Crangonidae yielding a decline in the percentage of unidentified shrimp.

Crabs such as the King crab, *Paralithodes camtschatica*, and crabs belonging to the families Cancridae and Pinnotheridae were an uncommon article of food of the Pacific cod. Of the crabs belonging to the family Majidae, only the snow crab *Chionoecetes bairdi* was frequently consumed.

Eleven families of fishes were represented in cod stomach contents. Among the fishes, eelpouts (Zoarcidae) and flatfishes (Pleuronectidae) were the most abundant. Fishes which remained unidentified in 1973, 1974, and 1975 ranked highest at 37.1, 40.2, and 31.8%, respectively.

All cod were caught between 11 and 230 m with the highest catch per unit of effort occurring between 191 to 210 m. The general trend was for cod to increase in size with increasing depth. The depths between 65 to 82 m was most heavily fished with the deeper water, 191 to 210 m receiving the least effort.

Codfish were divided into three size groups (30 to 49 cm, 50 to 69 cm, and 70 to 89 cm) and the percentage of occurrence of food items were enumerated within each group. Feeding trends which are characteristic of most gadiformes were found here. Fishes, echinoderms, crabs, shrimps, molluscs, cephalopods, and empty stomachs increased in frequency per

TABLE VIII

FREQUENCY AND PERCENT FREQUENCY OCCURRENCE OF FOOD ITEMS IN STOMACHS OF *GADUS MACROCEPHALUS* COLLECTED 1973, 1974, AND 1975 BY POTS NEAR KODIAK ISLAND, ALASKA. N = number of stomachs examined.

FOOD ITEMS	1973 N=689 No.	%	1974 N=1183 No.	%	1975 N=2061 No.	%	TOTAL 1973-75 N=3933 No.	%
Coelenterata								
Hydrozoa (hydroids)	2	0.2	-	-	1	0.1	3	0.08
Scyphozoa (jellyfishes)	-	-	-	-	1	0.1	1	0.03
Anthozoa (anemones)	5	0.7	3	0.3	1	0.1	9	0.2
Annelida								
Polychaeta (segmented worms)	-	-	53	4.5	74	3.6	127	3.2
Aphrodita sp.	15	2.1	10	0.9	24	1.2	49	1.2
Mollusca								
Polyplacophora (chitons)	-	-	1	0.1	-	-	1	0.03
Pelecypoda (clams, mussels, cockles)								
Nuculidae								
Nucula tenuis	1	0.1	-	-	4	0.2	5	0.1
Nuculanidae								
Nuculana fossa	30	4.3	43	3.6	36	1.8	109	2.7
Yoldia beringiana	2	0.2	-	-	5	0.2	7	0.2
Yoldia myalis	-	-	2	0.2	-	-	2	0.05
Yoldia thraciaeformis	-	-	1	0.1	-	-	1	0.03
Yoldia spp.	7	1.0	4	0.3	-	-	11	0.3
Glycymerididae								
Glycymeris subobsoleta	1	0.1	-	-	-	-	1	0.03
Limopsidae								
Limopsis okutanica	-	-	1	0.1	-	-	1	0.03
Limopsis vaginatus	-	-	2	0.2	-	-	2	0.05
Mytilidae								
Musculus discors	-	-	-	-	1	0.1	1	0.03
Musculus olivaceus	1	0.1	1	0.1	1	0.1	3	0.08
Modiolus sp.	-	-	-	-	2	0.1	2	0.05
Pectinidae								
Chlamys sp.	-	-	-	-	1	0.1	1	0.03
Patinopecten caurinus	-	-	7	0.6	5	0.2	12	0.3
Anomiidae								
Pododesmus macrochisma	-	-	1	0.1	1	0.1	2	0.05
Astartidae								
Astarte polaris	-	-	1	0.1	1	0.1	2	0.05
Carditidae								
Cyclocardia crebricostata	1	0.1	1	0.1	-	-	1	0.03
Cyclocardia crassidens	1	0.1	1	0.1	1	0.1	3	0.08
Cyclocardia sp.	-	-	-	-	2	0.1	2	0.05
Cardiidae								
Clinocardium sp.	1	0.1	-	-	4	0.2	5	0.1
Serripes groenlandicus	-	-	3	0.3	3	0.1	6	0.1
Veneridae								
Psephidia lordi	1	0.1	-	-	-	-	1	0.03
Tellinidae								
Macoma calcarea	-	-	-	-	1	0.1	1	0.03
Macoma brota	-	-	-	-	1	0.1	1	0.03
Macoma moesta	-	-	1	0.1	1	0.1	2	0.05
Macoma expansa	1	0.1	-	-	-	-	1	0.03
Macoma sp.	1	0.1	1	0.1	1	0.1	3	0.08
Tellina nuculoides	-	-	-	-	1	0.1	1	0.03
Solenidae								
Siliqua sloati	-	-	-	-	1	0.1	1	0.03
Hiatellidae								
Hiatella arctica	1	0.1	-	-	-	-	1	0.03
Panomya ampla	1	0.1	-	-	-	-	1	0.03
Unidentified pelecypods	26	3.8	27	2.3	53	2.6	106	2.7
Gastropods (snails)								
Fissurellidae								
Puncturella galeata	-	-	1	0.1	-	-	1	0.03
Trochidae								
Margarites pupillus	-	-	-	-	1	0.1	1	0.03
Margarites baxter	-	-	1	0.1	-	-	1	0.03
Solariella obscura	-	-	1	0.1	2	0.1	3	0.08
Solariella varicosa	-	-	1	0.1	-	-	1	0.03

TABLE VIII

CONTINUED

FOOD ITEMS	1973 N=689 No.	%	1974 N=1183 No.	%	1975 N=2061 No.	%	TOTAL 1973-75 N=3933 No.	%
Turritellidae								
Tachyrhynchus sp.	-	-	1	0.1	-	-	1	0.03
Trichotropididae								
Trichotropis cancellata	1	0.1	1	0.1	3	0.2	5	0.01
Naticidae								
Natica clausa	-	-	1	0.1	-	-	1	0.03
Natica aleutica	1	0.1	2	0.2	-	-	3	0.08
Natica sp.	-	-	-	-	5	0.2	5	0.1
Polinices nanus	-	-	-	-	1	0.1	1	0.03
Polinices pallida	2	0.2	2	0.2	3	0.2	7	0.2
Velutinidae								
Velutina velutina	1	0.1	-	-	-	-	1	0.03
Cymatiidae								
Fusitriton oregonensis	1	0.1	-	-	2	0.1	3	0.08
Muricidae								
Boreotrophon pacifica	-	-	1	0.1	1	0.1	2	0.05
Buccinidae								
Buccinum sp.	1	0.1	-	-	-	-	1	0.01
Beringius kennicotti	-	-	-	-	1	0.1	1	0.03
Colus halli	-	-	-	-	2	0.1	2	0.05
Neptunea sp.	1	0.1	-	-	1	0.1	2	0.05
Columbellidae								
Amphissa columbiana	1	0.1	-	-	1	0.1	2	0.05
Mitrella gouldi	-	-	-	-	1	0.1	1	0.03
Cancellariidae								
Admete couthouyi	-	-	-	-	1	0.1	1	0.03
Turridae								
Cytharella sp.								
Aforia circinata	-	-	-	-	1	0.1	1	0.03
Scaphandridae								
Cylichna alba	1	0.1	1	0.1	-	-	2	0.05
Unidentified gastropods	1	0.1	26	2.2	34	1.7	61	1.5
Cephalopoda								
Octopi	53	7.6	108	9.1	164	8.0	326	8.3
Squid	-	-	1	1.0	-	-	-	-
Arthropoda								
Crustacea								
Malacostraca								
Euphausiacea (krill) and Mysidacea (mysids)	20	2.9	34	2.9	181	8.8	235	6.0
Isopoda	3	0.4	4	0.3	10	0.5	17	0.4
Amphipoda (sand fleas)	192	27.8	195	16.5	407	19.8	794	20.2
Ampelisca macrocephala	-	-	-	-	52	2.5	52	1.3
Decapoda								
Pandalidae (shrimps)	67	9.7	118	10.0	-	-	185	4.7
Pandalus borealis	-	-	-	-	166	8.1	166	4.2
Pandalopsis dispar	-	-	4	0.3	19	0.9	23	0.6
Pandalus goniurus	-	-	-	-	4	0.2	4	0.1
Pandalus hypsinotus	-	-	-	-	7	0.3	7	0.2
Pandalus montagui tridens	-	-	-	-	8	0.4	8	0.2
Pandalus platyceros	-	-	1	0.1	3	0.2	4	0.1
Crangonidae (shrimps)	77	11.1	95	8.0	286	13.9	458	11.6
Argis crassa	-	-	-	-	3	0.2	3	0.08
Sclerocrangon boreas	-	-	-	-	5	0.2	5	0.1
Hippolytidae								
Spirontocaris sp.	-	-	-	-	5	0.2	5	0.1
Unidentified shrimps	131	19.0	82	6.9	171	8.3	384	9.8
Paguridae (hermit crabs)	24	3.4	21	1.8	55	2.7	100	2.5
Elassochirus cavimanus	-	-	-	-	2	0.1	2	0.05
Elassochirus tenuimanus	-	-	1	0.1	3	0.2	4	0.1
Lithodidae (crabs)								
Paralithodes camtschatica	2	0.2	9	0.8	31	1.5	42	1.1
Placetron wosnessenskii	-	-	1	0.1	2	0.1	3	0.08
Rhinolithodes wosnessenskii	-	-	-	-	1	0.1	1	0.03

TABLE VIII

CONTINUED

FOOD ITEMS	1973 N=689 No.	%	1974 N=1183 No.	%	1975 N=2061 No.	%	TOTAL 1973-75 N=3933 No.	%
Galatheidae (crabs)								
Munida quadrispina	-	-	-	-	1	0.1	1	0.03
Cancridae (crabs)	-	-	1	0.1	13	0.6	14	0.4
Cancer sp.	4	0.5	-	-	-	-	4	0.1
Atelecyclidae (crabs)								
Telmessus cheiragonus	1	0.1	-	-	2	0.1	3	0.08
Pinnotheridae (pea crabs)								
Pinnixa sp.	5	0.7	36	3.0	23	1.1	64	1.6
Majidae (spider crabs)								
Chionoecetes bairdi	281	40.7	428	36.2	735	35.6	1444	36.7
Hyas lyratus	13	1.8	44	3.7	42	2.0	99	2.5
Oregonia gracilis	-	-	3	0.3	6	0.3	9	0.2
Unidentified crabs	12	1.7	3	0.3	4	0.2	19	0.5
Echinodermata								
Asteroidea (sea stars)	1	0.1	2	0.2	1	0.1	4	0.1
Ctenodiscus crispatus	-	-	-	-	1	0.1	1	0.03
Echinoidea (sea urchins)	1	0.1	-	-	1	0.1	2	0.05
Holothuroidea (sea cucumbers)	2	0.2	5	0.4	10	0.5	17	0.4
Ophiuroidea (brittle stars)	-	-	3	0.3	3	0.2	6	0.1
Ophiura sarsi	-	-	-	-	2	0.1	2	0.05
Vertebrata								
Osteichthyes								
Clupeidae (herrings)								
Clupea harengus pallasi	6	0.8	1	0.1	2	0.1	9	0.2
Osmeridae (smelts)	3	0.4	2	0.2	4	0.2	9	0.2
Mallotus villosus	-	-	-	-	1	0.1	1	0.03
Gadidae (codfishes)								
Theragra chalcogramma	12	1.7	32	2.7	109	5.3	153	3.9
Gadus macrocephalus	7	1.0	13	0.9	3	0.2	23	0.6
Zoarcidae (eelpouts)	29	4.2	9	0.8	7	0.3	45	1.1
Lycodes brevipes	-	-	-	-	3	0.2	3	0.08
Scorpaenidae (rockfishes)	1	0.1	1	0.1	-	-	2	0.05
Hexagrammidae (greenlings)								
Pleurogrammus monopterigius	-	-	-	-	2	0.1	2	0.05
Cottidae (bullheads)	8	1.1	27	2.3	6	0.3	41	1.0
Dasycottus setiger	-	-	-	-	2	0.1	2	0.05
Hemilepidotus jordani	-	-	-	-	1	0.1	1	0.03
Gymnocanthus sp.	-	-	-	-	6	0.3	6	0.1
Agonidae (poachers)	-	-	3	0.3	17	0.8	20	0.5
Bathymasteridae (ronquils)								
Bathymaster signatus	-	-	1	0.1	2	0.1	3	0.05
Trichodontidae (sandfishes)								
Trichodon trichodon	-	-	4	0.3	2	0.1	6	0.1
Cyclopteridae (lumpsuckers)	1	0.1	1	0.1	5	0.2	7	0.2
Pleuronectidae (flatfishes)	22	3.1	21	1.8	40	1.9	83	2.1
Atheresthes stomias	-	-	-	-	2	0.1	2	0.05
Hippoglossoides elassodon	-	-	-	-	12	0.6	12	0.3
Hippoglossus stenolepis	-	-	-	-	2	0.1	2	0.05
Ammodytidae (sand lances)								
Ammodytes hexapterus	20	2.9	20	1.7	9	0.4	49	1.2
Stichaeidae (pricklebacks)	14	2.0	-	-	10	0.5	24	0.6
Crypacanthodidae (wrymouths)								
Lyconectes aleutensis	9	1.3	4	0.3	4	0.2	17	0.4
Unidentified fishes	256	37.1	476	40.2	655	31.8	1387	35.3
Stomachs empty	8	1.6	59	5.0	184	8.9	251	6.4

stomach with increasing cod size. Euphausids and amphipods decreased in percentage of occurrence with increasing fish size. Isopods and annelids showed little change with cod size.

The trawl-caught cod yielded some interesting results. Nematodes were often found in the lower region of the stomach, yet not always recorded in pot-caught cod. The fact that nematodes were often located at the junction of the stomach and intestine made recognition difficult upon evisceration.

The fifty-nine cod stomachs which were obtained by the R/V *John N. Cobb* south of Kodiak Island were closely examined for the presence of nematodes. All fifty-nine stomachs contained from three to twelve nematodes per stomach. This small sample with 100% infestation may indicate some degree of parasitism in *Gadus macrocephalus*.

While the degree of infestation of nematodes was high in the R/V *John N. Cobb* sample, amphipods were only present in 5% of the cod examined. Paulsen (1918) reports that amphipods are often the primary host of nematodes. It is assumed that infestation of cod occurs when cod are smaller and feeding more intensively on amphipods.

Among the organisms which increased in percentage of occurrence in trawl-caught cod were octopus and shrimp. Amphipods were the outstanding food item which declined in trawl-caught cod. The item in which the percentage of occurrence remained similar to pot-caught cod was the snow crab *Chionoecetes bairdi*.

Cook Inlet

Benthic Infaunal Program

Grab Data

Forty-eight stations were occupied with a van Veen grab on the cruise of the R/V *Moana Wave* from 30 March to 15 April 1976. Thirteen of these stations were reoccupied on the NOAA vessel *Miller Freeman* from 17 October to 29 October 1976.

The van Veen grab functioned less effectively in Cook Inlet than it did at the northeast Gulf of Alaska stations. A greater proportion of sand in bottom sediments in Cook Inlet generally impeded grab penetration, although volumes of 8 to 9 ℓ were collected at some stations. Thirteen stations were selected for laboratory analysis from the material collected in the spring cruise: 6, 18, 27, 28A, 31, 33, 37, 40, 42, 45, 46, 54. These stations were either: (1) ones with relatively good replicability from one grab to the next, and/or (2) ones with sediments that were readily penetrated by the grab. Some of these stations will be chosen as likely ones for continued monitoring after industrial activities are initiated in the Inlet. The balance of the grab stations were described qualitatively in the eighty-seven page Special Data Submission - Lower Cook Inlet OCS No. 76-1 as forwarded to NOAA on 13 August 1976.

The five replicate samples typically taken at each station appeared to be a minimal number as evidenced by the qualitative examination of the station data; the fauna was obviously very patchy.

Isolation of 211 invertebrate species was made from the thirteen grab stations examined (Table IX). Members of ten phyla were collected; polychaetous annelids comprised the most important group with 93 species. Mollusca were next in importance with 64 species, and Arthropoda

TABLE IX

SPECIES LIST FOR COOK INLET GRAB SAMPLES TAKEN IN MARCH-APRIL 1976;
13 STATIONS ARE INCLUDED

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.
    - *Typosyllus* sp.
    - *Typosyllus 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*
    - *Nephtys longasetosa*

TABLE IX

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
- *Lumbrinereis* sp.
- *Lumbrinereis similabris*
- *Lumbrinereis zonata*
- *Lumbrinereis luti*
- *Lumbrinereis 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 IX

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 IX

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 pernula*
    - *Yoldia* sp.
    - *Yoldia hyperborea*
    - *Yoldia scissurata*
    - *Yoldia secunda*
  - Family Glycymerididae
    - *Glycymeris subobsoleta*
  - Family Phylobryidae
    - *Solariella obscura*
  - 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 IX

CONTINUED

Family Veneridae
- *Liocyma fluctuosa*
- *Psephidia lordi*
- *Protothaca staminea*

Family Mactridae
- *Spisula polynyma*

Family Tellinidae
- *Macoma* sp.
- *Macoma calcarea*
- *Macoma moesta alaskana*
- *Tellina nuculoides*

Family Solenidae
- *Siliqua alta*

Family Myidae
- *Mya elegans*

Family Cuspidariidae
- *Cardiomya* sp.
- *Cardiomya pectenata*

Class Gastropoda

Family Trochidae
- *Margarites* sp.
- *Solariella obscura*
- *Solariella varicosa*

Family Naticidae
- *Polinices* sp.
- *Polinices nanus*
- *Polinices 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 IX

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 IX

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 caleigera*

(Crustacea) next with 33 species. Echinoderms were fourth in importance with 8 species (Table X).

Pipe Dredge Data

Verified data from the cruise in lower Cook Inlet from 30 March through 15 April 1976 is included in Special Data Submission No. 76-1 to NOAA. This information and additional data from a second cruise from 17 October through 29 October 1976 are being analyzed. A summarization and discussion of data from these cruises will be included in the Final Report to be submitted to NOAA.

Clam Studies

The samples were collected with a van Veen grab and a pipe dredge. Bivalves were separated from other benthic organisms and the sediment. A total of 18 bivalve species were collected of which nine species were predominant. Aging was accomplished by counting winter annuli with a 2x lens and a dissection microscope (see Paul and Feder, 1973; Feder and Paul, 1973 for methodology). Measurements were taken of shell length at each annulus and total shell height. Six-hundred seventy-three specimens of *Tellina nuculoides* and 878 *Glycymeris subobsoleta* have been measured and aged. Additional species will be examined in a similar manner.

The age structure for *T. nuculoides* and *G. subobsoleta* is provided in Table XI and Table XII, respectively. Age and growth data are now being computed for specific stations. The majority of the specimens of *T. nuculoides* examined were between five and eight years of age and ranged in size from 7.5 to 15.6 mm in length. The oldest and largest

TABLE X

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 XI

AGE STRUCTURE OF *TELLINA NUCULOIDES* FROM COOK INLET, SPECIMENS COLLECTED IN OCTOBER 1976

Year Class	Number of Clams	Range Length in mm
0	14	2.1 - 2.7
1	70	2.8 - 4.5
2	20	4.8 - 7.3
3	43	6.0 - 10.6
4	49	6.7 - 12.3
5	95	7.5 - 14.3
6	119	8.1 - 14.1
7	112	9.1 - 14.6
8	79	9.6 - 15.6
9	38	10.4 - 15.7
10	20	11.6 - 16.2
11	11	12.2 - 16.3
12	2	14.6 - 15.4
13	1	16.4
TOTAL	673	

TABLE XII

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM COOK INLET

Year Class		Number of Clams	Range Length in mm
0		126	1.3 - 2.7
1		476	2.6 - 4.8
2		93	4.0 - 6.5
3		45	6.3 - 9.7
4		65	9.5 - 12.3
5		26	12.0 - 15.6
6		15	13.8 - 17.7
7		8	17.1 - 21.2
8		15	17.9 - 22.3
9		6	20.2 - 23.7
10		2	25.6 - 26.5
11		1	27.0
	TOTAL	878	

T. nuculoides collected was 13 years of age and 16.4 mm in length. Recruitment success appears to vary from year to year.

The majority of the specimens of *G. subobsoleta* examined were between zero and five years of age and ranged in size from 1.3 to 15.6 mm in length. The oldest and largest *G. subobsoleta* collected was 11 years of age and 27.0 mm in length. Recruitment seems to vary from year to year.

Trawl Program

Distribution and Abundance

Verified data from the cruise in lower Cook Inlet from 30 March through 15 April 1976 is included in Special Data Submission No. 76-1 to NOAA. This information and additional data from a second cruise from 17 October through 29 October 1976 are being analyzed. A summarization and discussion of data from these cruises will be included in the Final Report to be submitted to NOAA.

Food data included below were taken from trawl-caught fishes taken on the cruise of 7 October through 29 October 1976.

Food Studies

Stomach contents were determined for snow crab (*Chionoecetes bairdi*) (Tables XIII and XIV), King crab, and selected fishes (Tables XV and XVI).

Major food items of snow crabs include *Macoma*, *Pagurus ochotensis*, other pagurids, and *Balanus*. Sediment was found in 9.1% of snow crab stomachs.

King crabs were feeding primarily on *Nuculana* and *Macoma*. Pacific cod were eating primarily crangonid shrimps and snow crab. The tom cod,

TABLE XIII

FREQUENCY OF OCCURRENCE OF PREY OF COOK INLET *CHIONOECETES BAIRDI* OF DIFFERENT SIZE AND SEX (Carapace width - mm)

	MALES				FEMALES		
	Immature		Mature		Immature		Mature
Prey	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
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	-	-
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

TABLE XIV

STATION CHECKLIST OF POTENTIAL PREY ORGANISMS OF *CHIONOECETES BAIRDI* 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
Nemertea	-	-	R	-	-	-	-	-	-	-	-
Annelids	-	-	C	C	A	A	-	C	C	C	-
Sipunculida	-	-	-	-	-	C	-	-	-	-	-
Mollusca											
Pelecypoda	-	-	C	C	C	C	R	C	C	C	R
Nucula tenuis	-	-	C	-	-	C	-	-	C	-	-
Nuculana fossa	C	-	C	-	C	C	-	-	A	R	-
Yoldia hyperboria	-	-	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 clam	-	-	-	-	-	-	-	C	-	-	-
Gastropoda											
Natica clausa	-	-	-	-	-	C	-	C	-	R	-
Polinices sp.	-	-	C	-	-	C	-	-	-	-	-
Colus halli	-	R	-	-	-	-	-	-	-	-	-
Buccinum plectrum	-	R	-	-	-	-	-	-	-	-	-
Neptunea lyrata	-	C	A	R	C	A	A	-	A	A	-
Beringius kennicotti	-	R	-	-	R	-	-	-	-	-	-
Nucella lamellosa	-	-	-	-	-	-	A	R	R	-	-
Trichotropis cancellata	-	-	-	-	R	C	-	-	-	-	-
Fusitriton oregonensis	F	C	-	-	R	-	-	-	R	-	-
unidentified gastropod	-	C	C	C	C	-	C	-	-	-	-
limpets	-	-	-	-	C	-	-	-	-	-	C
Amphineura											
unidentified species	-	-	-	-	-	C	-	-	-	-	-
Arthropoda (crustacea)											
Cumacea	-	-	C	-	-	-	-	-	C	C	C
Amphipoda	F	R	C	-	A	C	-	R	C	-	-
Shrimps											
Pandalidae	-	C	-	-	-	-	-	-	-	-	-
Pandalis borealis	R	C	R	-	-	C	-	-	-	-	R
P. hypsinotus	-	-	-	-	-	-	-	-	R	C	-
P. goniurus	-	C	R	-	-	A	-	-	A	-	-
Crangonidae	C	C	C	-	C	C	R	-	C	R	C
Crangon dalli	-	-	C	-	C	C	R	-	A	A	C
Argis ovifer	-	R	-	-	-	-	-	-	-	-	-
A. dentata	-	-	R	-	-	-	-	-	-	-	-
A. crassa	-	-	-	-	R	-	-	-	-	-	-
Sclerocrangon sp.	-	-	-	-	-	-	-	-	-	-	R
Hippolytidae	-	-	-	-	-	-	-	-	R	-	-
Spirontocaris sp.	-	R	-	-	-	-	-	-	-	-	-
Lebbeus sp.	-	-	-	-	-	-	R	-	-	-	-
Crabs											
Paguridae	F	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. kennerlyi	-	-	-	-	-	-	R	-	-	-	-
P. aleuticus	-	A	-	-	-	-	-	-	-	-	-
Elassochirus tenuimanus	-	-	-	-	-	-	R	-	-	-	-
Pinnixa occidentalis	-	-	R	R	-	-	-	-	R	-	-
Cancer magister	-	-	-	-	-	-	R	R	-	-	R
C. oregonensis	-	R	-	-	-	-	R	R	R	-	-
Hyas lyratus	-	C	-	-	-	-	A	C	-	-	R
Oregonia gracilis	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	-	-	-	-	-	-	-	-
Asteroidea											
Ctenodiscus crispatus	-	R	-	-	-	-	-	-	-	-	-
Echinoidea											
Strongylocentrotus drobachiensis	-	-	-	-	-	C	R	C	-	-	-

TABLE XV

PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS (LISTED ACCORDING TO LOWEST LEVEL OF TAXONOMIC IDENTIFICATION) FOUND IN STOMACHS OF INVERTEBRATES AND FISHES FROM COOK INLET, ALASKA, OCTOBER 1976
(N=Number of stomachs examined)

	Percent frequency of occurrence of food item in stomachs of:						
Food Item	*Paralithodes camtschatica* N=15	*Gadus macrocephalus* N=43	*Theragra chalcogramma* N=17	*Microgadus proximus* N=12	*Myoxocephalus* N=26	*Hippoglossus stenolepis* N=52	*Platichthys stellatus* N=49
Polychaeta	6.7	11.7	-	-	-	-	-
Natica (egg collar)	-	2.3	-	-	-	-	-
Pelecypoda	-	4.6	-	-	-	-	2.0
Nuculana	66.7	2.3	-	-	-	-	-
Macoma	26.7	-	-	-	-	-	-
Serripes	-	-	-	-	-	1.9	-
Spisula polynyma	-	-	-	-	-	-	38.8
Octopus	-	-	-	-	-	1.9	-
Crustacea	-	2.3	23.5	-	-	-	-
Isopoda	-	4.7	-	-	-	-	-
Amphipoda	-	4.7	-	-	-	1.9	-
Anonyx	-	2.3	-	-	-	1.9	-
Caridea	-	-	-	-	3.8	-	-
Crangonidae	-	51.1	5.9	-	-	9.6	-
Crangon sp.	-	9.3	-	-	-	-	4.1
C. dalli	-	4.7	-	16.7	23.1	13.5	14.3
Pandalus sp.	-	2.3	-	-	-	-	-
P. borealis	-	9.3	23.5	75.0	-	-	2.0

TABLE XV

CONTINUED

Food Item	Percent frequency of occurrence of food item in stomachs of:						
	Paralithodes camtschatica N=15	*Gadus macrocephalus* N=43	*Theragra chalcogramma* N=17	*Microgadus proximus* N=12	*Myoxocephalus* N=26	*Hippoglossus stenolepis* N=52	*Platichthys stellatus* N=49
P. goniurus	-	-	-	-	-	7.7	-
P. hypsinotus	-	-	-	-	-	3.8	-
Pandalopsis dispar	-	-	-	-	-	1.9	-
Paguridae	-	2.3	-	-	-	-	-
Pagurus ochotensis	-	-	-	8.3	3.8	5.8	-
Cancer magister	-	-	-	-	3.8	7.7	-
C. oregonensis	-	-	-	-	3.8	-	-
Pinnixa	-	2.3	-	-	-	1.9	-
Chionoecetes bairdi	-	62.8	-	-	30.8	32.7	2.0
Hyas	-	2.3	-	-	15.4	-	-
Oregonia gracilis	-	-	-	-	3.8	-	-
Echiurus	-	2.3	-	-	-	-	-
Teleostei	-	23.2	-	-	7.6	32.7	-
Microgadus boreas	-	-	-	-	-	1.9	-
Zoarcidae	-	-	-	-	-	1.9	-
Trichodon trichodon	-	2.3	-	-	-	13.5	-
Stichaeidae	-	-	-	-	-	1.9	-
Lumpenus sagitta	-	-	-	-	3.8	13.5	-
Cottidae	-	-	-	-	3.8	3.8	-

TABLE XV

CONTINUED

Food Item	Percent frequency of occurrence of food item in stomachs of:						
	Paralithodes camtschatica N=15	*Gadus macrocephalus* N=43	*Theragra chalcogramma* N=17	*Microgadus proximus* N=12	*Myoxocephalus* N=26	*Hippoglossus stenolepis* N=52	*Platichthys stellatus* N=49
Liparidae	-	-	-	-	3.8	-	-
Liparis sp.	-	-	-	-	3.8	-	-
Atheresthes stomias	-	2.3	-	-	-	-	-
Hippoglossoides elassodon	-	2.3	-	-	-	-	-

TABLE XVI

PERCENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF SELECTED EPIFAUNAL INVERTEBRATES AND FISHES FROM COOK INLET, OCTOBER 1976

		% Freq. of Occurrence
Lepidopsetta bilineata		
53 stomachs examined		
Stomach fullness:	empty (35) = 66%	
	with contents = 34%	
Stomach contents:	unidentified Crustacea (2)	3.8
	Amphipoda (12)	22.6
	Nudibranch (1)	1.9
	Spisula (1)	1.9
	Crangon dalli (1)	1.9
	unidentified Pelecypoda (1)	1.9
	unidentified remains (1)	1.9
Major component:	Amphipoda	
Hippoglossus stenolepis		
52 stomachs examined		
Stomach fullness:	empty (4) = 7.7%	
	with contents = 92.3%	
Stomach contents:	octopus (1)	1.9
	unidentified fish (17)	32.7
	Crangonidae (5)	9.6
	Chionoecetes bairdi (17)	32.7
	Pandalus hypsinotus (2)	3.8
	Stichaeidae (1)	1.9
	Serripes (1)	1.9
	Pandalopsis dispar (1)	1.9
	Lumpenus sagitta (7)	13.5
	Pagurus ochotensis (3)	5.8
	Cottidae (2)	3.8
	Cancer magister (4)	7.7
	Trichodon (7)	13.5
	Amphipoda (1)	1.9
	Crangon dalli (7)	13.5
	Zoarcidae (1)	1.9
	Pandalus goniurus (4)	7.7
	Pinnixia (1)	1.9
	Microgadus (1)	1.9
	Anonyx (1)	1.9
Major components:	fishes	
	crabs	

TABLE XVI

CONTINUED

		% Freq. of Occurrence
Platichthys stellatus		
49 stomachs examined		
Stomach fullness:	empty (24) = 49.0%	
	with contents = 51.0%	
Stomach contents:	*Crangon dalli* (7)	14.3
	Crangon (2)	4.1
	Pandalus borealis (1)	2.0
	Spisula polynyma (19)	38.8
	Chionoecetes bairdi (1)	2.0
	unidentified Pelecypoda (1)	2.0
Major components:	*Spisula polynyma*	
	Crangon dalli	
Gadus macrocephalus		
43 stomachs examined		
Stomach fullness:	empty (2) = 4.7%	
	with contents = 95.3%	
Stomach contents:	*Chionoecetes bairdi* (27)	62.8
	Crangonidae (22)	51.1
	Crangon (4)	9.3
	Crangon dalli (2)	4.7
	Pandalus (1)	2.3
	Pandalus borealis (4)	9.3
	Isopoda (2)	4.7
	Amphipoda (2)	4.7
	unidentified Crustacea (1)	2.3
	Hyas (1)	2.3
	Pinnixia (1)	2.3
	Paguridae (1)	2.3
	Anonyx (1)	2.3
	Polychaeta (2)	4.7
	unidentified Pelecypoda (1)	2.3
	Nuculana (1)	2.3
	Scallop (1)	2.3
	Natica egg collar (1)	2.3
	bristleworm (3)	7.0
	Echiurus (1)	2.3
	Trichodon (1)	2.3
	Hippoglossoides elassodon (1)	2.3
	Atheresthes stomias (1)	2.3
	unidentified fishes (10)	23.2
Major components:	*Chionoecetes bairdi*	
	Crangonidae	

TABLE XVI

CONTINUED

	% Freq. of Occurrence
Myoxocephalus	
26 stomachs examined	
Stomach fullness: empty (4) = 15.4%	
with contents (22) = 84.6%	
Stomach contents: *Chionoecetes bairdi* (8)	30.8
Hyas (4)	15.4
Oregonia gracilis (1)	3.8
Crangon dalli (6)	23.1
Cyclopteridae (1)	3.8
snake prickleback (1)	3.8
Liparis sp. (1)	3.8
unidentified Caridean shrimp (1)	3.8
Cancer oregonensis (1)	3.8
Cottidae (1)	3.8
unidentified fish (2)	7.6
Cancer magister (1)	3.8
Pagurus ochotensis (1)	3.8
Major components: *Chionoecetes bairdi*	
Crangon dalli	
Hyas	
Bathymaster	
21 stomachs examined	
Stomach fullness: empty (17) = 80.9%	
with contents (4) = 19.1%	
Stomach contents: unidentified Anthozoa (1)	4.8
Chionoecetes bairdi (1)	4.8
Crangonidae (1)	4.8
unidentified Crustacea (1)	4.8
Theragra chalcogramma	
17 stomachs examined	
Stomach fullness: empty (9) = 52.9%	
with contents (8) = 47.1%	
Stomach contents: Crangonidae (1)	5.9
Pandalus borealis (4)	23.5
unidentified Crustacea (4)	23.5
Major components: Crustacea	

TABLE XVI

CONTINUED

		% Freq. of Occurrence
Microgadus proximus		
12 stomachs examined		
Stomach fullness:	empty (1) = 8.3%	
	with contents (11) = 91.7%	
Stomach contents:	*Crangon dalli* (2)	16.7
	Pandalus borealis (9)	75.0
	Pagurus ochotensis (1)	8.3
Major components:	*Pandalus borealis*	
Paralithodes camtschatica		
15 stomachs examined		
Stomach fullness:	empty (3) = 20%	
	with contents = 80%	
Stomach contents:	*Macoma* (4)	26.7
	Nuculana (10)	66.7
	Polychaeta (1)	6.7
Major components:	*Nuculana*	
Trichodon trichodon		
5 stomachs examined		
Stomach fullness:	empty (3) = 60%	
	with contents (2) = 40%	
Stomach contents:	capelin (2)	100.0
Major components:	capelin	
Hippoglossoides elassodon		
6 stomachs examined		
Stomach fullness:	empty = 0%	
	with contents (6) = 100%	
Stomach contents:	Ophiuroidea (3)	50.0
	Macoma (1)	16.7
	Polynoidae (1)	16.7
	Crangonidae (3)	50.0
	Nuculana (2)	33.4
Major components:	Ophiuroidea	
	Crangonidae	
	Nuculana	

TABLE XVI

CONTINUED

	% Freq. of Occurrence
Atheresthes stomias	
10 stomachs examined	
Stomach fullness: empty (10) = 100%	
rex sole	
6 stomachs examined	
Stomach fullness: empty (6) = 100%	
Agonus sp.	
6 stomachs examined	
Stomach fullness: empty (6) = 100%	
Cottidae	
3 stomachs examined	
Stomach fullness: empty (0) = 0%; with contents (3) = 100%	
Stomach contents: *Chionoecetes bairdi*	100.0
Major components: *Chionoecetes bairdi*	
Squalus sp.	
1 stomach examined	
Stomach fullness: empty (0) = 0%; with contents (1) = 100%	
Stomach contents: unidentified fish and leech	100.0
Major components: unidentified fish and leech	
Cyclopteridae	
4 stomachs examined	
Stomach fullness: empty (0) = 0%; with contents (4) = 100%	
Stomach contents: *Crangon dalli* (4)	100.0
Major components: *Crangon dalli*	
Lycodes palearis	
2 stomachs examined	
Stomach fullness: empty (0) = 0%; with contents (2) = 100%	
Stomach contents: *Crangon dalli* (2)	100.0
Major components: *Crangon dalli*	

TABLE XVI

CONTINUED

		% Freq. of Occurrence
Lycodes sp.		
1 stomach examined		
Stomach fullness:	empty (0) = 0% with contents (1) = 100%	
Stomach contents:	*Macoma* and Crangonidae	100.0
Major components:	Crangonidae	
Limanda aspera		
1 stomach examined		
Stomach fullness:	empty (0) = 0% with contents (1) = 100%	
Stomach contents:	unidentified Pelecypoda	100.0
Major components:	unidentified Pelecypoda	

Microgadus proximus feeds extensively on *Crangon dalli* and *Pandalus borealis*.

Crangonid shrimps, *Crangon dalli* in particular, appear to be the most widely utilized food source for fishes in Cook Inlet. All fishes in Table XV plus liparids and *Lycodes* (Table XVI) were found to be feeding on members of this family. *Pandalus borealis* and *Chionoecetes bairdi* also showed up in the stomachs of a wide variety of fishes. *Chionoecetes bairdi* is a major food source for Pacific cod, *Myoxocephalus*, and halibut.

The Cook Inlet food web (Fig. 17) is based on data contained in Tables XIII, XV, and XVI. Energy flows through the web 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*, pandalid and crangonid shrimps, *Chionoecetes bairdi*, Paguridae, and ophiuroids. Feeding relationships between fishes in Cook Inlet are not well known.

The portions of the web dealing with King crab (Fig. 18), snow crab (Fig. 19), Pacific cod (Fig. 20), halibut (Fig. 21), and *Myoxocephalus* (Fig. 22) have been separated from the overall web to show greater detail. Of these animals, *Myoxocephalus* appears to rely on the least variety of foods. Most of its food items are predatory or scavenging crustaceans with no evidence of feeding on suspension or deposit feeders (Table XVII).

Food occurred in 428 (60%) of the 715 *Chionoecetes bairdi* examined, and included representatives of four phyla and 17 genera. Clams, hermit crabs, and barnacles were the dominant food organisms. The most frequently occurring items were small clams, especially *Macoma* spp. The remains of this clam were found in 149 stomachs from six of the 11 stations.

LOWER COOK INLET - Food Web

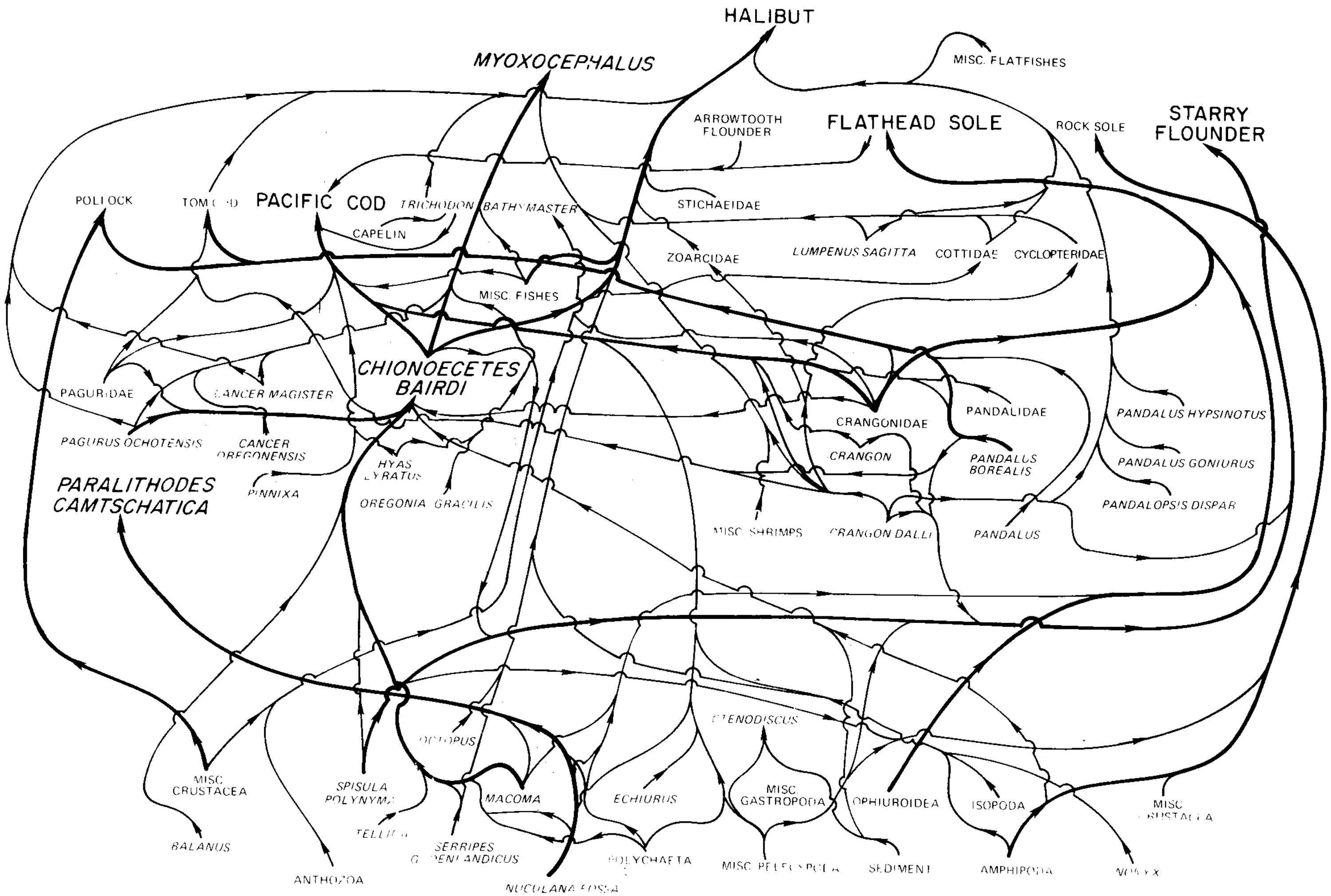

Figure 17. A food web based on the benthic invertebrates of lower Cook Inlet. Carbon flow is in the direction of the arrows. Bold lines indicate major food sources based on frequency of occurrence.

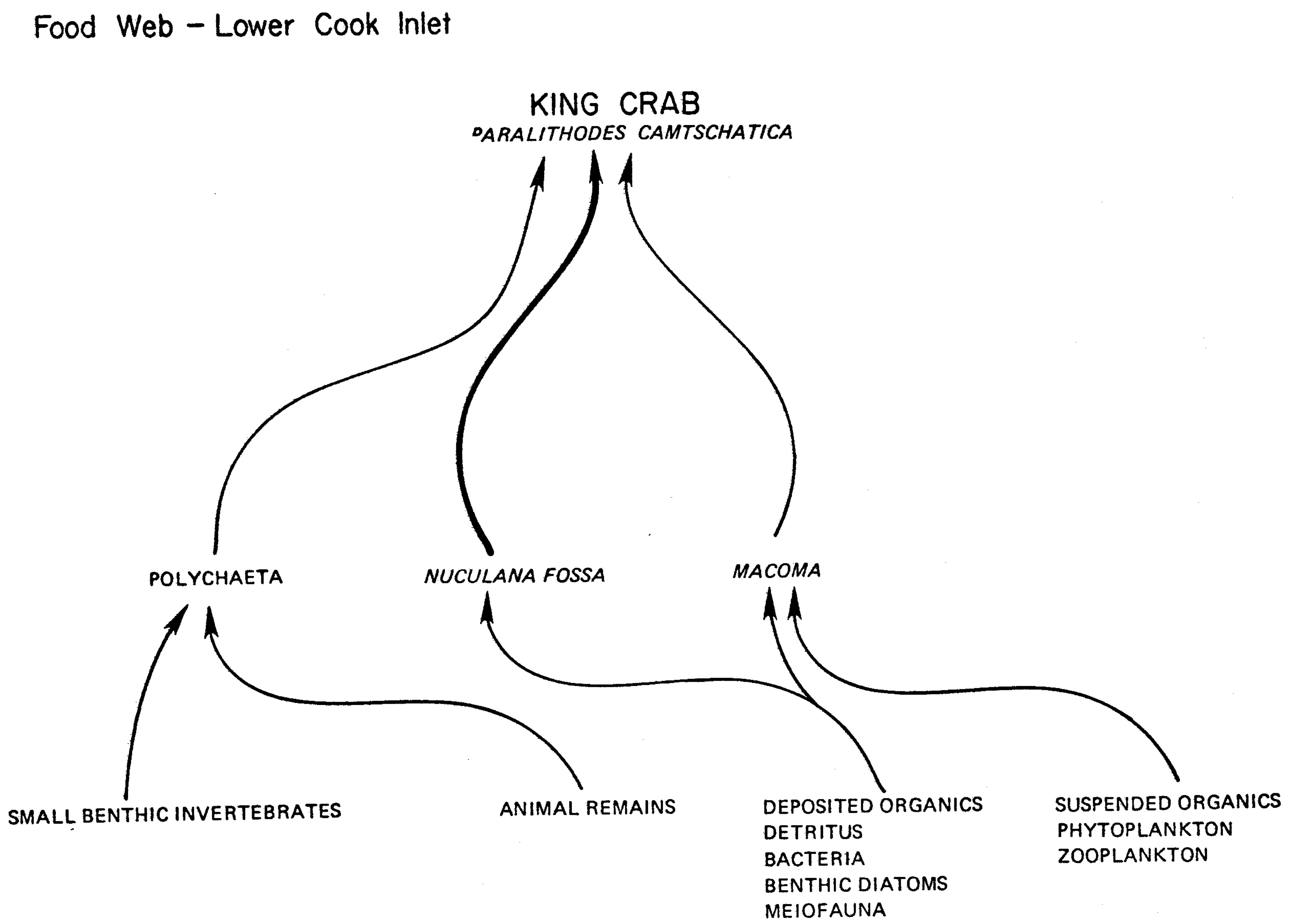

Figure 18. A food web showing carbon flow to King crab (*Paralithodes camtschatica*) in lower Cook Inlet. Bold line indicates major food sources based on frequency of occurrence.

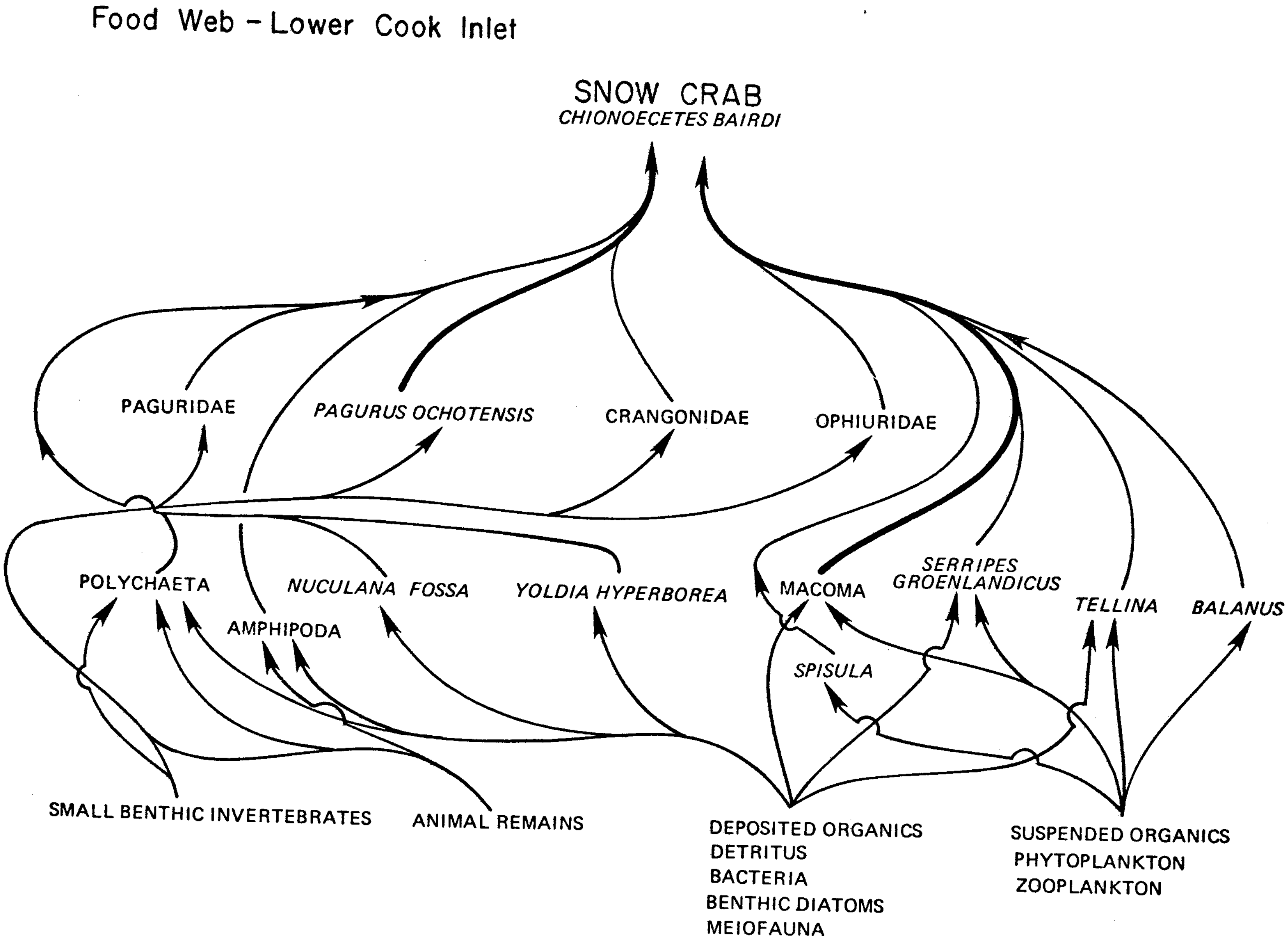

Figure 19. A food web showing carbon flow to snow crab (*Chionoecetes bairdi*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

Food Web - Lower Cook Inlet

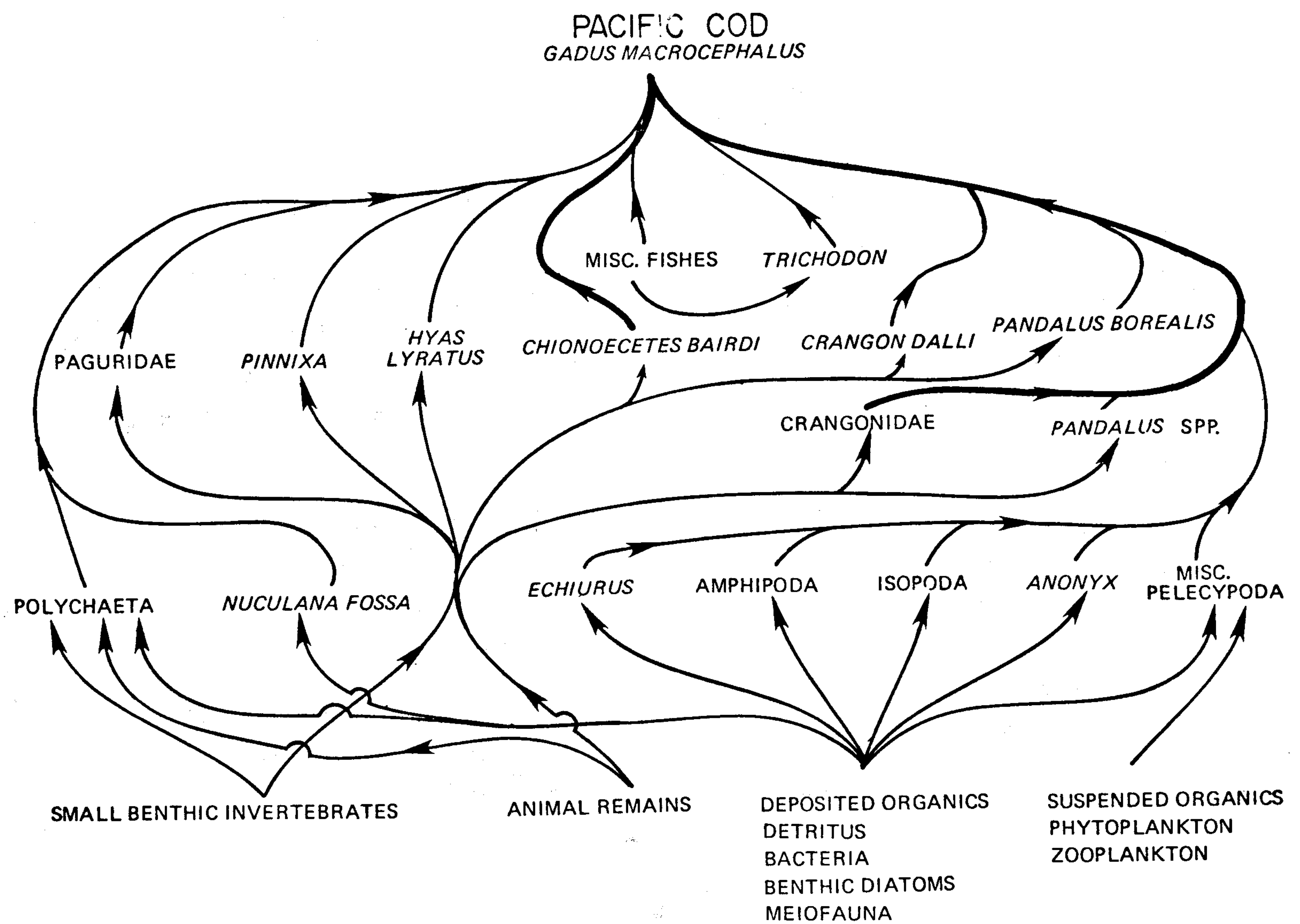

Figure 20. A food web showing carbon flow to Pacific cod (*Gadus macrocephalus*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

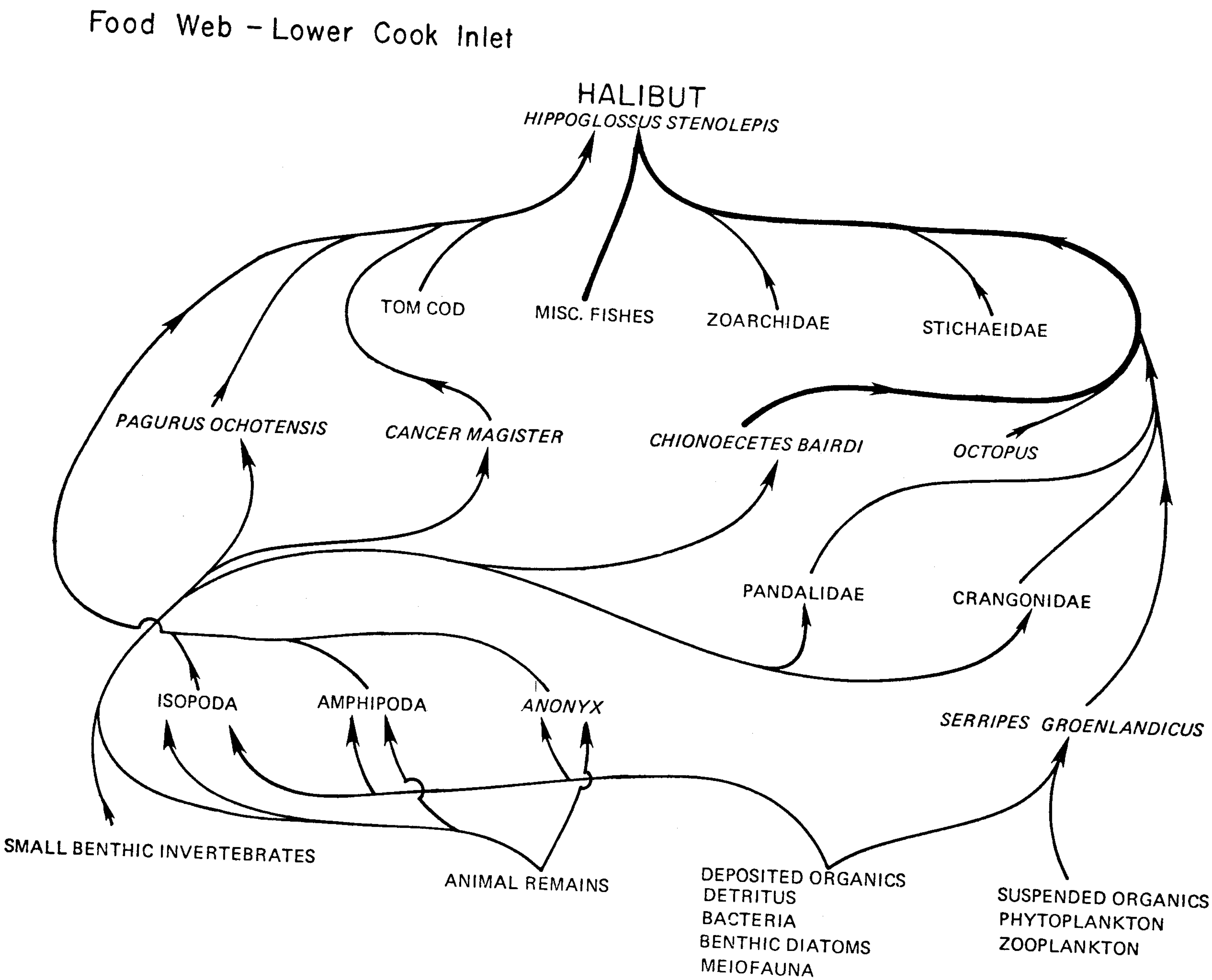

Figure 21. A food web showing carbon flow to Pacific halibut (*Hippoglossus stenolepis*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Lower Cook Inlet

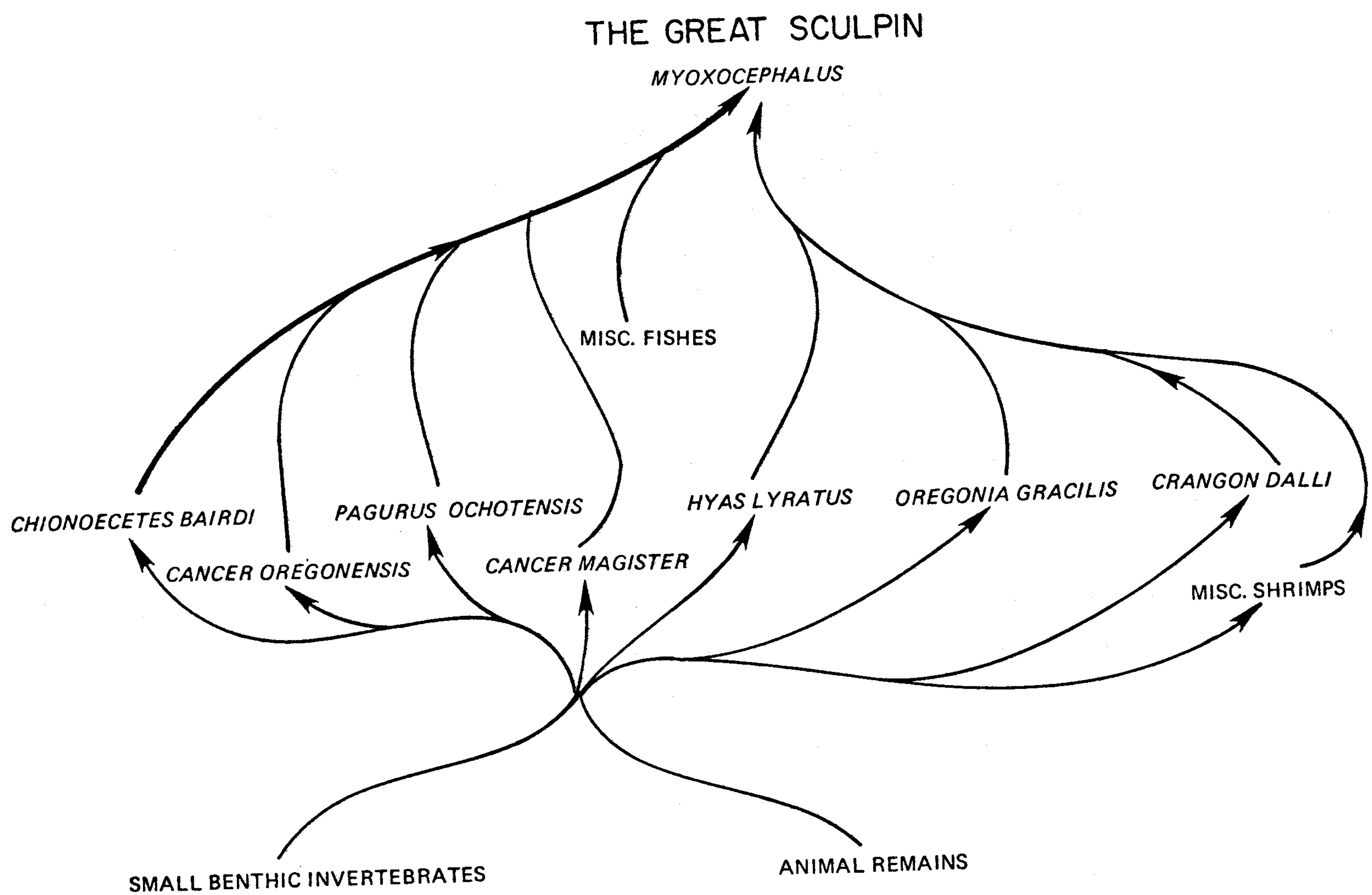

Figure 22. A food web showing carbon flow to the great sculpin (*Myoxocephalus*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

TABLE XVII

FEEDING METHODS OF INVERTEBRATES AND FISHES INCLUDED IN THE COOK INLET FOOD WEB[1]. PHYLUM ABBREVIATIONS: C=CNIDARIA; A=ANNELIDA; M=MOLLUSCA; ART=ARTHROPODA; 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	O	X	–	–	–
Tellina sp.	M	X	O	–	–	–
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 XVII

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 (tom cod)	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 prickle-back)	Cho	-	-	-	X	-
Cottidae (sculpins)	Cho	-	-	-	X	-
Myoxocephalus sp. (great sculpin)	Cho	-	-	-	X	-
Liparidae (snail fish)	Cho	-	-	-	X	-
Atheresthes stomias (arrowtooth flounder)	Cho	-	-	-	X	-
Hippoglossoides elassoden (flat-head 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, 1969; Pearce and Thorson, 1967; Rasmussen, 1973; Hart, 1973; Skalkin, 1963; and Feder, unpublished data.

Hermit crabs (family Paguridae), particularly *Pagurus ochotensis* (Benedict), were next in importance, and occurred in 147 stomachs from nine of the 11 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 commonly contained the remains of several barnacles or clams. In one stomach 16 recently settled *Macoma* spp. were found. Few stomachs contained more than one crab or shrimp. No difference was detected in the prey of *C. bairdi* of different size or sex (Table XIII). Potential prey species in Cook Inlet are included in Table XIV for comparative purposes.

Unanalyzed data on feeding of invertebrates and fishes of Cook Inlet is included as Appendices IV and V.

Bering Sea

Benthic Infaunal Program

Grab Data

The grab data from 59 stations were being analyzed at the time of the preparation of this Annual Report. Preliminary results of this analysis are included as an Appendix to this report. Final assessment of this data will be included with the Final Report.

The basic plan of operation for grab sampling suggested in the initial proposal was completed with little alteration. A systematic station grid was established in cooperation with other programs (physical and chemical oceanography, trace metal chemistry, hydrocarbon analysis, zooplankton), and a total of 77 stations were located on the established grid. Twenty-six (26) additional stations of opportunity were occupied in conjunction with the ice-edge studies on Leg I of the cruise of the R/V *Discoverer*. Although vessel time constraints did not permit sampling of the basic stations on a quarterly (seasonal) basis, it was possible to accumulate some seasonal information from two time blocks - May through June; August through September.

The van Veen grab functioned effectively in the fine sediments of the Bering Sea, and typically delivered sample volumes of 10 to 14 ℓ. In stations that were sand or sand-gravel dominated, penetration was reduced. The surface of all samples, examined through the top door of the grab, was undisturbed as evidenced by the smooth detrital cover (see Feder *et al.*, 1973 for a review on use of the van Veen grab in soft sediments of the type found in the Gulf of Alaska). The five to six replicates typically taken at each station appeared to be a minimal number as evidenced by qualitative examination of the station data (see Appendix Table 1 of Feder *et al.*, 1976b); fauna was obviously very patchy. The optimum number of replicates needed to properly sample the infauna of the Bering Sea has been tested by way of 10 replicate samples taken at selected stations (see Feder *et al.*, 1973 for discussion on the optimum number of replicate samples needed in a grab-sampling program). The results of the latter analysis will be included in the Final Report.

The size of screen chosen for the onboard washing process, 1.0 mm, was appropriate for the sediments sampled, and was the minimal size that could efficiently be used at most stations. A smaller size mesh would greatly increase the overall shipboard washing time which in turn would have reduced the overall station coverage possible on each cruise.

Data from 59 stations taken on the May through October cruises of the R/V *Discoverer* and the NOAA vessel *Miller Freeman* have been processed and tabulated for this report (see Appendix Table 1 in Feder *et al.*, 1976b for examples of selected stations). Additional samples archived at the Marine Sorting Center from the R/V *Discoverer* and R/V *Miller Freeman* will be processed by the end of the project year.

A total of 643 species have been isolated from the 59 stations processed to date. Members of 13 phyla were collected with the Annelida comprising the most important group with 180 species. Arthropoda were next in importance with 120 species, and Mollusca next with 109 species. Other groups were less important (Tables 2 and 3, and Appendix Table 3 in Feder *et al.*, 1976b).

The two diversity indices, Simpson and Shannon-Wiener calculated for the 27 stations occupied in 1975 are summarized in Table 4 of Feder *et al.* (1976b). No statements can be made at this time concerning the importance of these indices; when data for all stations are available some overall generalizations may be possible.

Utilization of the criteria for Biologically Important Taxa delineated 121 species for the 1975 data (see Appendix Table 3 in Feder *et al.*, 1976b). Thirty-eight (38) of the BIT were identified as important by way of biomass at one or more stations. Some of the species that were well distributed throughout the study area were *Macoma moesta alaskana* (clam), *Diamphiodia craterdometa* (brittle star), *Yoldia hyperborea* (clam), *Echinarachnius parma* (sand dollar), and *Clinocardium ciliatum* (cockle). These species may be ones with great influence on the trophic interactions in their particular localities.

The feeding methods for many of the species collected are included in Appendix Table VI in Feder and Mueller (1975). The data are compiled from the literature and from personal observations (Feder *et al.*, 1973; Feder and Mueller, unpublished data and interpretations). Some of the species probably utilize two feeding methods, and such dual feeding methods where known, are included in the table. The predominant feeding methods utilized by species at each station have not been determined as yet. It is presumed that the methods used will tend to vary with local conditions, and be reflected to a certain extent by the substrate type at each station.

Pipe Dredge Data

Pipe dredges were taken at most of the stations on the Bering Sea grid. This material is being processed, and the data will be available for the Final Report. This data will be used, (1) for comparison with species taken by grab to determine if deeper sampling by dredge collects additional species, (2) as a taxonomic base for material found in crab and fish stomachs, (3) as an assessment of the relative abundance of infauna used as food by crabs and fishes, and (4) to obtain large numbers of clams that will lend themselves to age-growth studies.

Clam Studies

It is assumed that all of the bivalve molluscs collected in large numbers (e.g., *Tellina lutea, Spisula polynyma, Nuculana* spp., *Yoldia* spp., *Clinocardium* spp.) will be examined for age-growth characteristics. These data will be presented in the Final Report as growth-history tables and growth curves.

Trawl Program

Distribution and Abundance

Trawling operations during 1975 and 1976 resulted in the collection of animals from 11 phyla, 99 families, and 225 species (Table XVIII and XIX) of epifaunal invertebrates.

During 1975, four phyla dominated the epifaunal invertebrate biomass (Table XX). Ninety-five (95) percent of the biomass was made up of these groups: Arthropoda (58.0%), Echinodermata (22.0%), Chordata (Ascidiacea) (8.5%), and Mollusca (6.5%). Annelida, Echiurida, Ectoprocta, and Brachiopoda combined contributed less than 0.03% to the epifaunal invertebrate biomass.

A pattern of biomass dominance by a few families was found. Five families made up 87.5% of the total epifaunal invertebrate biomass (Table XXI). Similarly, only 11 species were present in sufficient abundance to account for over 1% each of the total epifaunal invertebrate biomass (Table XXII).

Paralithodes camtschatica, Chionoecetes opilio, C. bairdi, and *Asterias amurensis* contributed over 69.2% of the total epifaunal biomass. *Paralithodes camtschatica*, the King crab (of major commercial importance), was the dominant invertebrate in the area. King crab averaged slightly over 1 kg in weight and made up 21.1% of the total epifaunal biomass. *Chionoecetes opilio*, a commercially important brachyuran averaged less than 0.1 kg per animal but its numerical abundance was nearly 12 times that of King crab. *Chionoecetes opilio* was a near second to King crab in terms of biomass with 19.9% of the total. Only two non-arthropods were found in large quantities: *A. amurensis*, a sea star and *Styela rustica macrenteron*, a tunicate, made up 17.9% and 7.4% respectively of the epifaunal invertebrate biomass.

TABLE XVIII

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

Phylum Porifera
- Unidentified species

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

Phylum Annelida
- Class Polychaeta
  - 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
  - Family Nuculanidae
    - *Nuculana fossa* Baird
    - *Yoldia myalis*
    - *Yoldia scissurata*
    - *Yoldia hyperborea* Torrell
    - *Yoldia seminuda* Dall
  - Family Mytilidae
    - *Mytilus edulis*
    - *Musculus niger* (Gray)
    - *Musculus discors* (Linnaeus)
    - *Modiolus modiolus*

TABLE XVIII

CONTINUED

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 fucanum* (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 oldroyi*

Class Gastropoda

Family Trochidae
- *Margarites giganteus* (Leche)
- *Margarites costalis* (Gould)
- *Solariella obscura*
- *Solariella varicosa* (Mig. & C. B. Adams)
- *Solariella macuralix*

Family Turritellidae
- *Tachyrynchus erosus* (Couthouyi)

Family Calyptraeidae
- *Crepidula grandis* Middendorff

Family Trichotropididae
- *Trichotropis insignis*

TABLE XVIII

CONTINUED

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

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

Family Cymatiidae
- *Fusitriton oregonensis* Redfield

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

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

Family Neptuneidae
- *Ancistrolepis eucosmia*
- *Ancistrolepis magna* Dall
- *Ancistrolepis okhotensis*
- *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*
- *Pyrulofusus deformis*
- *Volutopsius* sp.

TABLE XVIII

CONTINUED

		Family Neptuneidae (con't)		
			Volutopsius fragilis (Dall)	
			Volutopsius middendorfi	
			Volutopsius melonis (Dall)	
			Volutopsius trophonius	
			Volutopsius castanees (Dall)	
		Family Volutidae		
			Arctomelon stearnsii	
		Family Cancellariidae		
			Admete couthouyi (Jay)	
			Leucosyrinx circinata (Dall)	
		Family Turridae		
			Aforia circinata	
		Family Dorididae		
			Unidentified species	
		Family Dendronotidae		
			Unidentified species	
		Family Tritoniidae		
			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 sp.	
			Balanus evermani	
			Balanus rostratus	
			Balanus hesperius	
		Sub-class Malacostraca		
		Order Cumacea		
		Family Diastylidae		
			Diastylis bidentata (Dall)	

TABLE XVIII

CONTINUED

Order Mysidacea
- Family Mysidae
  - *Neomysis integer*

Order Isopoda
- Family Idoteidae
  - *Synidotea bicuspida* (Owen)
- Family Sphaeromatidae
  - *Tecticeps alascensis* (Richardson)
- Family Aegidae
  - *Rocinela augustata* Richardson
- Family Bopyridae
  - *Argeia pugettensis* Dana

Order Amphipoda
- 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 XVIII

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 XVIII

CONTINUED

Family Dallinidae
- *Laqueus californicus*
- *Terebratalia transversa*

Phylum Echinodermata
- Class Asteroidea
  - Family Astropectinidae
    - *Dipsacaster borealis* Fisher
  - Family Goniasteridae
    - *Geophyreaster swifti*
    - *Ceramaster patagonicus* Sladen
    - *Pseudoarchaster parelii*
  - Family Porcellanasteridae
    - *Ctenodiscus crispatus*
  - Family Echinasteridae
    - *Henricia aspera* Fisher
    - *Henricia beringiana*
    - *Henricia* sp.
  - Family Pterasteridae
    - *Diploteraster 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
  - Family Asteronychidae
    - *Asteronyx loveni*
  - Family Gorgonocephalidae
    - *Gorgonocephalus caryi* (Lyman)

TABLE XVIII

CONTINUED

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

TABLE XIX

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	0.9
Cnidaria	Hydrozoa	1	0.4
	Scyphozoa	1	0.4
	Anthozoa	4	1.8
Annelida	Polychaeta	6	2.7
	Hirudinea	2	0.9
Mollusca	Pelecypoda	30	13.3
	Gastropoda	63	.3
	Cephalopoda	3	1.3
Arthropoda	Pycnogonida	2	.9
	Crustacea	66	29.3
Sipunculida	-	1	.4
Echiurida	Echiurida	1	.4
Ectoprocta	-	1	.4
Brachiopoda	Articulata	3	1.3
Echinodermata	Asteroidea	22	9.8
	Echinoidea	3	1.3
	Ophiuroidea	6	2.7
	Holothuroidea	4	1.8
	Crinoidea	1	.4
Chordata	Urochordata	4	1.8
	Total	225	

TABLE XX

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE PHYLA OF THE BERING SEA, 1975. TRAWL SURVEY.

Phylum	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Porifera	159	303.65	1.1	0.195
Cnidaria	5006	1118.95	3.9	0.718
Annelida	1514	4.13	<.1	0.003
Mollusca	21760	1890.76	6.5	1.214
Arthropoda (Crustacea only)	124636	16729.99	58.0	10.739
Echinodermata	54629	6337.70	22.0	4.07
Chordata (Ascidiacea only)	24700	2448.10	8.5	1.57
Total	232404	28833.28	100.0	18.509

Errata

A trawl width of 2.2 m was erroneously keypunched in place of the correct width of 12.2 m for the calculations of mean grams per square meter. Thus, incorrect values occur in the column "Mean Grams per Square Meter" in the following tables:

Table XX	p. 130
Table XXI	p. 131
Table XXII	p. 132
Table XXIII	p. 134
Table XXV	p. 136
Table XXVI	p. 137
Table XXVII	p. 138
Table XXVIII	p. 140

Also, on page 133, paragraph 3, line 1 - 18.5 should read 3.34.

TABLE XXI

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF THE BERING SEA, 1975. TRAWL SURVEY.

Family	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Neptuneidae	9671	1612.71	5.6	1.04
Lithodidae	6192	6209.24	21.5	3.99
Majidae	87589	9633.86	33.4	6.18
Asteridae	46059	5640.33	19.6	3.62
Styelidae	22595	2144.28	7.4	1.37
Total	172056	25240.42	87.5	16.20

TABLE XXII

NUMBERS, WEIGHT, AND DENSITY OF 11 SPECIES CONTRIBUTING MORE THAN ONE PERCENT EACH TO THE TOTAL EPIFAUNAL INVERTEBRATE BIOMASS, BERING SEA, 1975. TRAWL SURVEY.

Species	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Neptunea ventricosa	2101	350.82	1.2	0.23
Neptunea heros	4250	692.18	2.4	0.44
Pagurus trigonocheirus	12302	370.29	1.3	0.24
Paralithodes camtschatica	6056	6097.13	21.1	3.91
Chionoecetes (hybrid)	3591	585.87	2.0	0.38
Chionoecetes opilio	72586	5740.87	19.9	3.69
Chionoecetes bairdi	9351	3120.29	10.8	2.00
Asterias amurensis	44421	5167.50	17.9	3.32
Leptasterias polaris ascervata	1231	335.46	1.2	0.22
Gorgonocephalus caryi	1831	446.77	1.6	0.29
Styela rustica macrenteron	22595	2144.19	7.4	1.38
Total	180315	25051.37	86.8	16.1

Within the major phyla, a few species usually dominated the biomass (Table XXIII). For example, out of 49 arthropod species, *P. camtschatica, C. opilio*, and *C. bairdi* made up 89.4% of the arthropod biomass. The echinoderms, *A. amurensis, Leptasterias polaris ascervata*, and *Gorgonocephalus caryi* (3 species out of 29 total) made up 94% of the echinoderm biomass. Similarly, the genus *Neptunea* made up over 82% of the molluscan biomass and *S. r. macrenteron* made up 87.6% of the ascidian biomass.

Frequency of occurrence of species varied from occurrence at only one station to a high of 140 stations for *A. amurensis* (Table XXIV). Twenty-seven organisms occurred at greater than 20% of the stations. High frequency of occurrence did not correlate well with greatest biomass. *Paralithodes camtschatica* occurred at only 37.2% of the stations while the polychaete family Polynoidae (less than .01% of total biomass) occurred at 57.5% of the stations.

Total epifaunal invertebrate biomass averaged 18.5 grams per square meter for the stations trawled in 1975 (Table XX). During the 1976 trawl operations, the epifaunal invertebrate biomass was dominated by Arthropoda (67%) and Echinodermata (11.1%) with Porifera (8.8%) and Cnidaria (5.2%) of lesser importance (Table XXV). Annelida, Sipunculida (the single additional phylum occurring in 1976), Echiurida, Ectoprocta, and Brachiopoda contributed less than 0.02% to the total biomass.

In 1976, seven of the 81 families made up 82% of the biomass (Table XXVI) with Majidae contributing 48.4% (over three times the biomass of the second family, Lithodidae). Ten species contributed more than 1% each to the total biomass (Table XXVII). *Chionoecetes opilio* (28.8%), *C. bairdi* (16.7%), and *P. camtschatica* (10.8%) were the dominant individual species. The order of importance shifted in 1976 with *P. camtschatica*

TABLE XXIII

NUMBERS, WEIGHT, AND DENSITY OF THE MAJOR EPIFAUNAL SPECIES OF MOLLUSCA, ARTHROPODA, ECHINODERMATA, AND CHORDATA (ASCIDIACEA) FROM THE BERING SEA, 1975. TRAWL SURVEY.

Phylum	Species	Number of Organisms	Weight (kg)	Percent of Total Weight	Percent of Phylum Weight	Mean Grams Per Square Meter
Mollusca	*Neptunea lyrata*	730	173.23	0.6	9.2	0.11
	N. ventricosa	2101	350.82	1.2	18.6	0.23
	N. pribiloffensis	730	143.40	0.5	7.6	0.09
	N. communis borealis	1380	191.15	0.7	10.11	0.12
	N. heros	4250	692.18	2.4	36.61	0.44
	Total	9191	1550.78	5.4	82.01	0.99
Arthropoda	*Paralithodes camtschatica*	6057	6097.13	21.1	36.44	3.91
	Chionoecetes opilio	72585	5740.88	19.9	34.31	3.69
	Chionoecetes bairdi	9352	3120.29	10.8	18.65	2.00
	Total	87994	14958.30	51.8	89.40	9.60
Echinodermata	*Asterias amurensis*	44421	5167.50	17.9	81.54	3.32
	Leptasterias polaris ascervata	1231	335.46	1.2	5.29	0.22
	Gorgonocephalus caryi	1832	446.77	1.6	7.05	0.29
	Total	47484	5949.73	20.7	93.88	3.83
Chordata (Ascidiacea)	*Styela rustica macrenteron*	22595	2144.19	7.4	87.59	1.38
	Boltenia ovifera	1777	204.41	0.7	8.35	0.13
	Halocynthia aurantium	328	99.40	0.3	4.06	0.63
	Total	24700	2448.00	8.4	100.00	2.14

TABLE XXIV

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES FOUND AT GREATER THAN 20 PERCENT OF BERING SEA TRAWL STATIONS, 1975

Taxonomic Name	Number of Stations at which Organism Occurred	Percent of Stations at which Organism Occurred
Scyphozoa	54	26.1
Eunephthya rubiformis	48	23.2
Actiniidae	107	51.7
Polynoidae	119	57.5
Serripes groenlandicus	43	20.8
Neptunea ventricosa	74	35.7
N. heros	91	44.0
Tritoniidae	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 ascervata	52	25.1
Gorgonocephalus caryi	89	43.0
Styela rustica macrenteron	95	45.9

TABLE XXV

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE PHYLA OF THE BERING SEA, 1976. TRAWL SURVEY.

Phylum	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Porifera	110	1754.02	8.8	2.45
Cnidaria	3709	1029.00	5.2	1.45
Annelida	1217	3.41	<.1	<.01
Mollusca	5506	911.43	4.6	1.28
Arthropoda (Crustacea only)	97360	13298.73	67.0	18.72
Echinodermata	9756	2195.38	11.1	3.09
Chordata (Ascidiacea only)	110	659.65	3.3	.93
Total	117769	19851.62	100.0	27.92

TABLE XXVI

NUMBERS, WEIGHT, AND DENSITY OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF THE BERING SEA, 1976. TRAWL SURVEY.

Family	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Actiniidae	3385	772.90	3.9	1.09
Neptuneidae	2175	412.78	2.1	0.58
Lithodidae	2227	2932.37	14.8	4.13
Majidae	56914	9614.59	48.4	13.54
Asteridae	1047	1015.86	5.1	1.43
Gorgonocephalidae	3960	877.45	4.4	1.24
Pyuridae	not enumerated	631.65	3.2	0.89
Total		16257.60	81.9	22.90

TABLE XXVII

NUMBERS, WEIGHT, AND DENSITY OF 10 SPECIES CONTRIBUTING MORE THAN ONE PERCENT EACH TO THE TOTAL EPIFAUNAL INVERTEBRATE BIOMASS, BERING SEA, 1976. TRAWL SURVEY.

Species	Number of Organisms	Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter
Octopus	51	298.60	1.5	0.42
Paralithodes camtschatica	1734	2152.60	10.8	3.03
P. platypus	452	744.63	3.8	1.05
Chionoecetes (hybrid)	1395	520.83	2.6	0.73
C. opilio	45592	5724.94	28.8	8.06
C. bairdi	9275	3322.42	16.7	4.68
Erimacrus isenbeckii	313	412.62	2.1	.58
Asterias amurensis	842	936.67	4.7	1.32
Gorgonocephalus caryi	3960	877.45	4.4	1.24
Halocynthia aurantium	not enumerated	568.77	2.9	.80
Total		15559.53	78.3	21.91

moving from first to third. *Asterias amurensis* (third in 1975) was fourth in biomass (4.7%). The 1976 list of species contributing over 1% to the biomass differs from 1975 by the addition of *Octopus*, *P. platypus*, *Erimacrus isenbeckii*, and *Halocynthia aurantium*. Deletions from 1975 included *Neptunea* (2 species), *Pagurus trigonocheirus*, *L. p. ascervata*, and *S. r. macrenteron*.

Major phyla again contained several dominant members by weight: *Neptunea* (40.6%) and *Octopus* (32.8%) for Mollusca; King crabs (*P. camtschatica* and *P. platypus*, 21.8%) and snow crabs (*C. bairdi* and *C. opilio*, 68.1%) for Arthropoda; *A. amurensis* (42.7%), *G. caryi* (40.0%) and *Parastichopus* (8.0%) for Echinodermata (Table XXVIII).

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

Total biomass for all epifaunal invertebrates in 1976 averaged 27.9 grams per square meter, a 50.8% increase over the biomass at 1975 stations.

A summarization of general biological information collected by trawling in 1975 and 1976 is included in Appendices I and II.

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 *Paralithodes camtschatica*, *Chionoecetes opilio*, *Asterias amurensis*, *Leptasterias polaris ascervata*, *Gadus macrocephalus*, *Hemilepidotus papilio*, and *Myoxocephalus* spp. (Table XXX). In addition, incomplete or limited data were recorded for several other species (Table XXXI). *Paralithodes camtschatica*

TABLE XXVIII

NUMBERS, WEIGHT, AND DENSITY OF THE MAJOR EPIFAUNAL SPECIES OF MOLLUSCA, ARTHROPODA, AND ECHINODERMATA FROM THE BERING SEA, 1976. TRAWL SURVEY.

Phylum	Species	Number of Organisms	Weight (kg)	Percent of Total Weight	Percent of Phylum Weight	Mean Grams Per Square Meter
Mollusca	*Fusitriton oregonensis*	778	84.20	0.4	9.2	0.12
	Neptunea lyrata	586	144.51	0.7	15.9	0.20
	N. ventricosa	448	98.82	0.5	10.8	0.14
	N. pribiloffensis	503	80.74	0.4	8.9	0.11
	N. heros	262	45.76	0.2	5.0	0.06
	Octopus sp.	51	298.60	1.5	32.8	0.42
	Total	2628	752.61	3.7	82.6	1.05
Arthropoda	*Paralithodes camtschatica*	1739	2152.60	10.8	16.2	3.03
	P. platypus	452	744.63	3.8	5.6	1.04
	Chionoecetes opilio	45592	5724.94	28.8	43.1	8.06
	C. bairdi	9275	3322.42	16.7	25.0	4.68
	Total	57058	11944.59	60.1	89.9	16.81
Echinodermata	*Asterias amurensis*	842	936.67	4.7	42.7	1.32
	Gorgonocephalus caryi	3960	877.45	4.4	40.0	1.24
	Parastichopus sp.	510	176.74	0.9	8.0	0.25
	Total	5312	1990.86	10.0	90.7	2.81

TABLE XXIX

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES FOUND AT GREATER THAN 20 PERCENT OF BERING SEA TRAWL STATIONS, 1976

Taxonomic Name	Number of Stations at which Organism Occurred	Percent of Stations at which Organism Occurred
Porifera	35	33.7
Scyphozoa	22	21.2
Stylatula gracile	71	68.2
Polynoidae	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	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 sp.	26	25.0
Asterias amurensis	39	37.5

TABLE XXIX

CONTINUED

Taxonomic Name	Number of Stations at which Organism Occurred	Percent of Stations at which Organism Occurred
Lethasterias nanimensis	28	26.9
Strongylocentrotus droebachiensis	23	22.1
Gorgonocephalus caryi	37	35.6
Ophiopholis aculeata	21	20.1

TABLE XXX

PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS (LISTED ACCORDING TO LOWEST LEVEL OF TAXONOMIC IDENTIFICATION) IN THE STOMACHS OF *PARALITHODES CAMTSCHATICA*, *CHIONOECETES OPILIO*, *LEPTASTERIAS POLARIS ASCERVATA*, *GADUS MACROCEPHALUS*, *HEMILEPIDOTUS PAPILIO*, AND *MYOXOCEPHALUS* SP. FROM THE S.E. BERING SEA, 1976. N=Number of stomachs examined.

	Frequency of Occurrence of Food Item in Stomachs of:						
Food Item	*Paralithodes camtschatica* N = 56	*Chionoecetes opilio* N = 23	*Asterias amurensis* N = 41	*Leptasterias p. ascervata* N = 12	*Gadus macrocephalus* N = 29	*Hemilepidotus papilio* N = 9	*Myoxocephalus* spp. N = 7
Porifera	–[1]	–	9.8	–	–	–	–
Coelenterata	–	–	4.9	–	–	–	–
Polychaeta	3.6	52.2	4.9	–	3.4	22.2	–
Gastropoda	7.1	4.3	–	–	3.4	–	–
Solariella	19.6	–	–	–	–	–	–
Neptunea	1.8	–	–	–	–	–	–
Pelecypoda	17.9	13.0	2.4	–	–	–	–
Cyclocardia	8.9	4.3	–	–	–	–	–
Clinocardium	32.1	–	14.6	100	–	–	–
Spisula	–	–	4.9	–	–	–	–
Macoma	7.1	–	–	–	–	–	–
Cephalopoda	–	–	–	–	3.4	11.1	–

TABLE XXX

CONTINUED

Food Item	Frequency of Occurrence of Food Item in Stomachs of: *Paralithodes camtschatica* N = 56	*Chionoecetes opilio* N = 23	*Asterias amurensis* N = 41	*Leptasterias p. ascervata* N = 12	*Gadus macrocephalus* N = 29	*Hemilepidotus papilio* N = 9	*Myoxocephalus* spp. N = 7
Arthropoda	-	-	-	-	3.4	-	-
Crustacea	5.3	-	-	-	-	-	-
Copepoda	-	-	4.9	-	-	-	-
Cirripedia	-	-	7.3	-	-	-	-
Mysidacea	-	-	2.4	-	-	-	-
Isopoda	-	-	-	-	-	11.1	-
Amphipoda	-	13.0	-	-	17.2	-	-
Gammaridea	-	-	-	-	-	22.2	14.3
Caprellidea	-	-	-	-	-	22.2	-
Euphausiacea	-	-	-	-	3.4	-	-
Decapoda	-	4.3	-	-	-	11.1	-
Pandalus borealis	-	-	-	-	51.7	-	-
P. goniurus	-	-	17.1	-	-	-	-
Crangonidae	-	-	-	-	-	-	-

TABLE XXX

CONTINUED

Food Item	Frequency of Occurrence of Food Item in Stomachs of: *Paralithodes camtschatica* N = 56	*Chionoecetes opilio* N = 23	*Asterias amurensis* N = 41	*Leptasterias p. ascervata* N = 12	*Gadus macrocephalus* N = 29	*Hemilepidotus papilio* N = 9	*Myoxocephalus* spp. N = 7
Crangon dalli	-	-	4.9	-	-	11.1	-
Paguridae	-	4.3	-	-	-	-	-
Pagurus ochotensis	-	-	2.4	-	-	-	-
P. trigonocheirus	-	-	-	-	3.4	-	-
Labidochirus splendescens	1.8	-	-	-	-	-	-
Brachyura	3.6	-	-	-	6.9	11.1	28.6
Oregonia	-	-	2.4	-	-	-	-
Chionoecetes	-	-	2.4	-	10.3	-	28.6
Pinnotheridae	-	-	-	-	3.4	-	-
Ectoprocta	-	-	17.1	-	-	-	-
Brachiopoda	-	-	-	-	-	-	-
Echinarachnius parma	-	-	12.2	-	-	-	-
Ophiuroidea	33.9	17.4	-	-	-	11.1	-
Ophiura	-	26.1	-	-	-	-	-

TABLE XXX

CONTINUED

Food Item	Frequency of Occurrence of Food Item in Stomachs of: *Paralithodes camtschatica* N = 56	*Chionoecetes opilio* N = 23	*Asterias amurensis* N = 41	*Leptasterias p. ascervata* N = 12	*Gadus macrocephalus* N = 29	*Hemilepidotus papilio* N = 9	*Myoxocephalus* spp. N = 7
Teleostei	-	13.0	7.3	-	-	22.2	14.3
Mallotus villosus	-	-	-	-	-	-	14.3
Theragra chalcogramma	-	-	-	-	17.2	22.2	-
Cottidae	-	-	-	-	3.4	-	14.3
Sand	3.6	-	-	-	-	-	-
Eggs	5.3	-	-	-	-	-	-
Empty stomachs	16.1	30.4	-	-	0	11.1	16.7

[1]Dash indicates item not found in stomach.

TABLE XXXI

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

		Percent Frequency of Occurrence
Paralithodes camtschatica: 56 stomachs		
1) Stomach fullness:	full: (17)	30.4%
	1/2 full: (17)	30.4%
	<1/2 full: (13)	23.2%
	empty: (9)	16.1%
2) Stomach contents:	unidentified debris (15)	26.8%
	unidentified soft parts (13)	23.2%
	sand (2)	3.6%
	eggs (3)	5.3%
	unidentified crustaceans (3) (other than clams)	5.3%
	unidentified crabs (2)	3.6%
	unidentified snails (4)	7.1%
	unidentified clam (10)	17.9%
	unidentified brittle star (19) (inclusive of *Nuculana* sp.)	33.9%
	unidentified polychaete (2)	3.6%
	Macoma (4)	7.1%
	Cardita (5)	8.9%
	cockle (18)	32.1%
	Solariella (11)	19.6%
	Lebidochirus splendescens (1)	1.8%
	Neptunea (1)	1.8%
3) Major components:	brittle stars	
	cockles	
	clams	
	snails	
	Solariella	
	Macoma	
	Cardita cyclocardia	
Chionoecetes opilio: 23 stomachs		
1) Stomach fullness:	empty: (7)	30.4%
	not empty: (16)	69.6%
2) Stomach contents:	*Ophiura* (6)	26.1%
	unidentified polychaetes (12)	52.2%
	unidentified hermit crabs (1)	4.3%
	unidentified soft parts (3)	13.0%
	unidentified clam (3)	13.0%

TABLE XXXI

CONTINUED

		Percent Frequency of Occurrence
2) Stomach contents:	(continued)	
	unidentified decapod (1)	4.3%
	unidentified brittle star (4)	17.4%
	[1]unidentified shell fragments (2)	8.6%
	Cyclocardia (1)	4.3%
	[1]unidentified debris (3)	13.0%
	fish (unidentified) (3)	13.0%
	unidentified amphipods (3)	13.0%
	[1]unidentified skeletal fragments (1)	4.3%
	unidentified snail (1)	4.3%
3) Major components:	brittle stars	
	polychaetes	
	clams	
Asterias amurensis: 41 stomachs		
1) Stomach fullness:	Only animals with food in oral area recorded.	
2) Stomach contents:	sand dollar (5)	12.2%
	unidentified sponge (4)	9.8%
	unidentified jelly fish (2)	4.9%
	Spisula polynyma (2)	4.9%
	Pandalus goniurus (7)	17.1%
	Crangon dalli (2)	4.9%
	unidentified clam (1)	2.4%
	unidentified barnacle (3)	7.3%
	unidentified polychaete (2)	4.9%
	Pagurus ochotensis (1)	2.4%
	Oregonia gracilis (1)	2.4%
	unidentified mysid (1)	2.4%
	unidentified fish (3)	7.3%
	snow crab (1)	2.4%
	unidentified Bryozoa (7)	17.1%
	parasitic copepods (2)	4.9%
	unidentified soft parts (2)	4.9%
	cockle (6)	14.6%
3) Major components:	sand dollars	
	unidentified bryozoa	
	cockles	
	Pandalus goniurus	

TABLE XXXI

CONTINUED

	Percent Frequency of Occurrence
Gadus macrocephalus: 29 stomachs	
1) Stomach fullness: empty (0) = 0.0%	
with food 29 = 100%	
full - data insufficient	
part full - data insufficient	
2) Stomach contents: *Chionoecetes* (3)	10.3%
unidentified crab (2)	6.9%
pinnotherid crab (1)	3.4%
Theragra chalcogramma (5)	17.2%
unidentified euphausids (1)	3.4%
Pandalus borealis (15)	51.7%
unidentified amphipods (5)	17.2%
unidentified snails (1)	3.4%
unidentified sculpin (1)	3.4%
Pagurus trigonocheirus (1)	3.4%
unidentified soft parts (1)	3.4%
unidentified arthropod (1)	3.4%
unidentified polychaete (1)	3.4%
unidentified cephalopod (1)	3.4%
3) Major components: *Pandalus borealis*	
crabs	
Theragra chalcogramma	
amphipods	
Myoxocephalus spp.: 7 stomachs	
1) Stomach fullness: empty (1) = 16.7%	
with food = 83.3%	
2) Stomach contents: unidentified gammarid amphipod (1)	14.3%
unidentified fish (1)	14.3%
capelin (1)	14.3%
unidentified sculpin (1)	14.3%
Chionoecetes (2)	28.6%
unidentified crab (2)	28.6%
3) Major components: crabs	

TABLE XXXI

CONTINUED

	Percent Frequency of Occurrence
Leptasterias polaris: 12 stomachs	
1) Stomach fullness: Only animals with food in oral area were recorded.	
2) Stomach contents: cockles (12)	100%
3) Major components: cockles (12)	100%
Pteraster sp.: 1 stomach	
1) Stomach contents: worm tube	
Lipard fish: 1 stomach	
1) Stomach contents: *Dasycottus* (1)	
Ophiura	
Pandalus	
Chionoecetes opilio	
Hemilepidotus papilio: 9 stomachs	
1) Stomach fullness: empty (1)	11.1%
food containing	88.9%
2) Stomach contents: *Theragra chalcogramma* (2)	22.2%
Crangon (1)	11.1%
unidentified fish (2)	22.2%
unidentified caprellid amphipods (2)	22.2%
unidentified gammarid amphipods (2)	22.2%
unidentified isopod (1)	11.1%
unidentified debris (2)	22.2%
unidentified crab (1)	11.1%
squid (1)	11.1%
unidentified brittle star (1)	11.1%
unidentified polychaetes (2)	22.2%
unidentified decapods (1)	11.1%
3) Major components: amphipods	
fish	
Starry flounder: 1 stomach	
1) Stomach fullness: empty	
Yellowfin sole: 4 stomachs	
1) Stomach fullness: all empty	

TABLE XXXI

CONTINUED

	Percent Frequency of Occurrence
Alaska plaice: 6 stomachs	
1) Stomach fullness: empty (4) = 66.6%	
polychaetes (1)	
clam (1)	
amphipods (1)	
nemertean (1)	
unidentified annelid (1)	
Pacific halibut: 3 stomachs	
1) Stomach fullness: empty (1)	
unidentified fish (1)	
Theragra chalcogramma (1)	
Reinhardtius hippoglossoides: 5 stomachs	
1) Stomach fullness: all empty	
Glyptocephalus zachirus: 3 stomachs	
1) Stomach fullness: amphipods (3)	100%
leech (1)	33%
nemertean (1)	33%
polychaetes (2)	66%
Raja stellulata: 1 stomach	
1) Stomach fullness: amphipods	
crangonids	
Hippoglossoides: 4 stomachs	
1) Stomach fullness: empty	
Lepidopsetta lineata: 1 stomach	
1) Stomach fullness: empty	

[1]Lumped as debris for king crab.

(King crab) was found to be feeding primarily on the small snail *Solariella*, *Clinocardium ciliatum*, other pelecypods (notably *Nuculana*, which occurs in all Bering Sea King crab stomachs currently being examined), and ophiuroids which had the highest percent frequency of occurrence in King crab stomachs (33.9%). Polychaetes and ophiuroids were the dominant food items in *C. opilio* (snow crab) stomachs. Pelecypods and ophiuroids were the only two food items found to be very important to both crabs. Among the sea stars, *A. amurensis* concentrated on *Clinocardium*, *Pandalus goniurus*, and Ectoprocta (bryozoans) while *L. p. ascervata* fed exclusively on *Clinocardium*. The fishes showed a variety of food preferences. *Gadus macrocephalus* (Pacific cod) fed mainly on *Pandalus borealis* while *H. papilio* consumed polychaetes, gammarid and caprellid amphipods, pollock, and miscellaneous fishes with about equal frequency. *Myoxocephalus* spp. showed a preference for *Chionoecetes* and other crabs.

Data from Table XXX, various literature sources for fish feeding (Salveson and Alton, 1976a, b; Salveson and Dunn, 1976; Morin and Dunn, 1976; Alton and Weber, 1976; Alton and Sample, 1976; Dunn and Sample, 1976; Salveson 1976a, b; Webber and Alton, 1976; Webber and Sample, 1976; Bartlett, 1976a, b, c; McIntosh, 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; Shubnikov and Lisovenko, 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; Kleinenberg *et al.*, 1964; Townsend, 1942; Novikov, 1964; Lowry and Burns, 1976; Fay *et al.*, 1975, 1977) were used to complete the Bering Sea food web (Fig. 23).

SOUTHEAST BERING SEA - Food Web

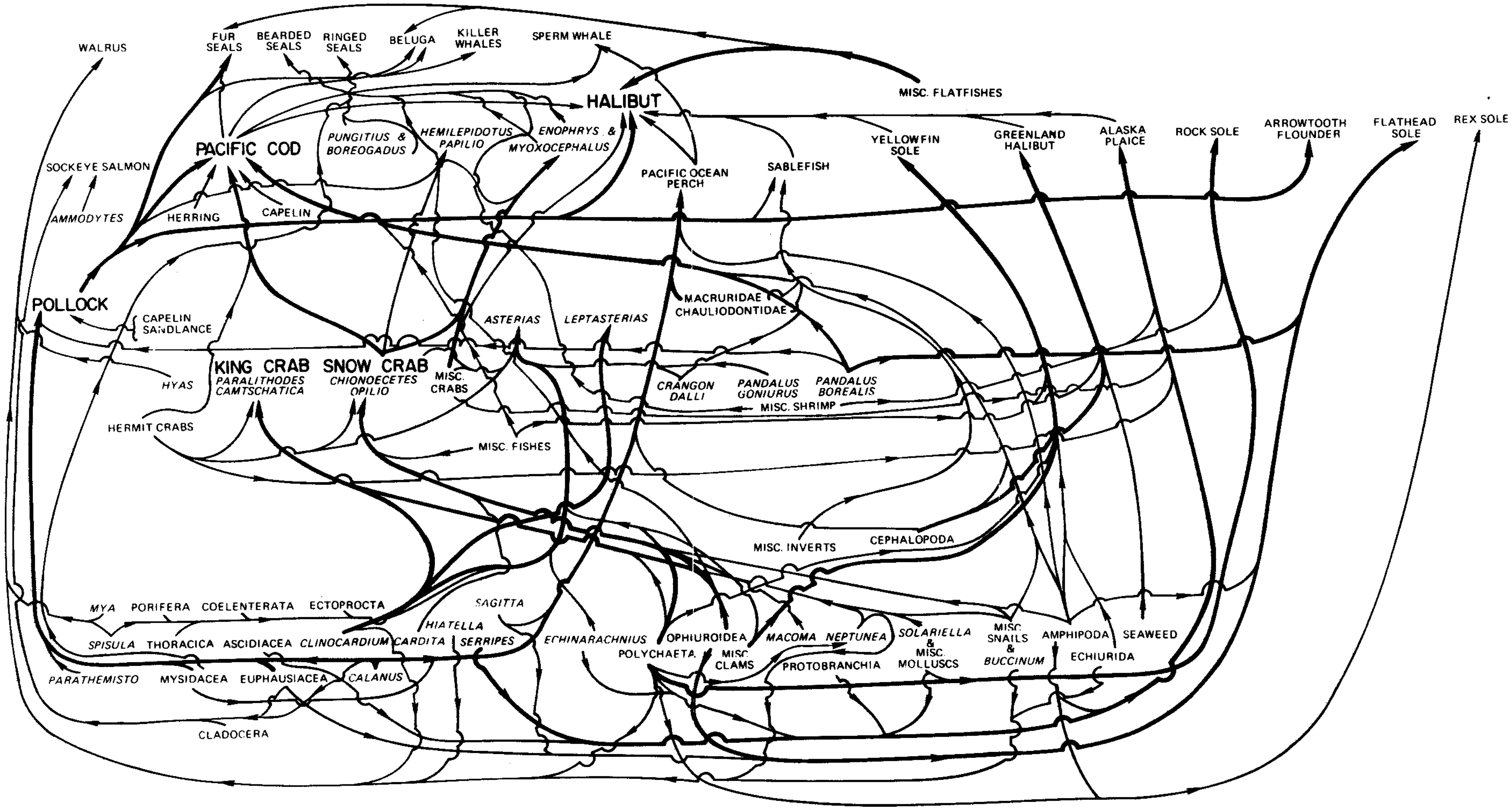

Figure 23. A food web based on the benthic invertebrates of the southeastern Bering Sea. Carbon flows generally in the direction of the arrows. Bold lines indicate major food sources based on frequency of occurrence.

The Bering Sea food web is set up so that the flow of energy is generally from bottom to top, but always in the direction of the arrows. Bold lines are used to indicate the most important food sources for a given animal. For example *Clinocardium* and *Ophiuroidea* are connected to King crab by bold lines since they are the major components of its diet based on frequency of occurrence. Feeding relationships of five important species: King crab (Fig. 24), snow crab (Fig. 25), pollock (Fig. 26), Pacific cod (Fig. 27), and halibut (Fig. 28), are shown individually.

Polychaetes, gastropods, pelecypods, isopods, amphipods, mysids, euphausids, caridean shrimp, brachyurans, bryozoans, sand dollars (Echinoidea), and ophiuroids are the main invertebrate components of the Bering Sea food web. Deposit feeding bivalves (Table XXXII) are a very important food source 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 the major component in the food web. Feeding on plankton, shrimp, and small fishes (Fig. 26), the pollock is the major food item of its own kind (small pollock are found in up to 99.7% of larger pollock stomachs (Mito, 1974)), as well as being a major food source for fur seals, Pacific cod, halibut, and arrowtooth flounders.

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

Among the marine mammals, fishes are the major food of the seals and whales while walruses feed primarily on clams, polychaetes, and gastropods.

Unanalyzed data on feeding of invertebrates and fishes at the Bering Sea in 1976 is included as Appendix III.

Food Web – Bering Sea

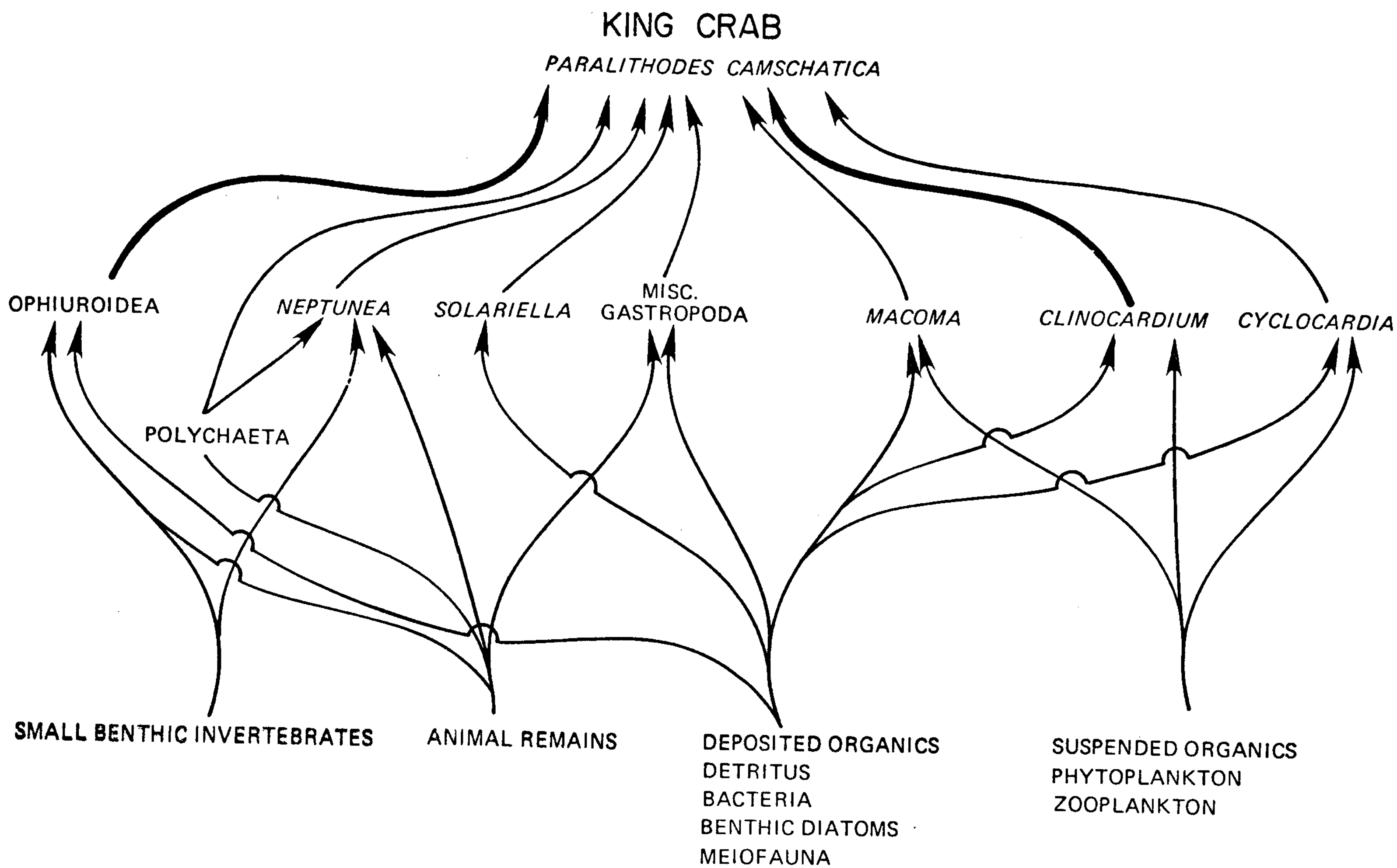

Figure 24. A food web showing carbon flow to king crab (*Paralithodes camtschatica*) in the S.E. Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Bering Sea

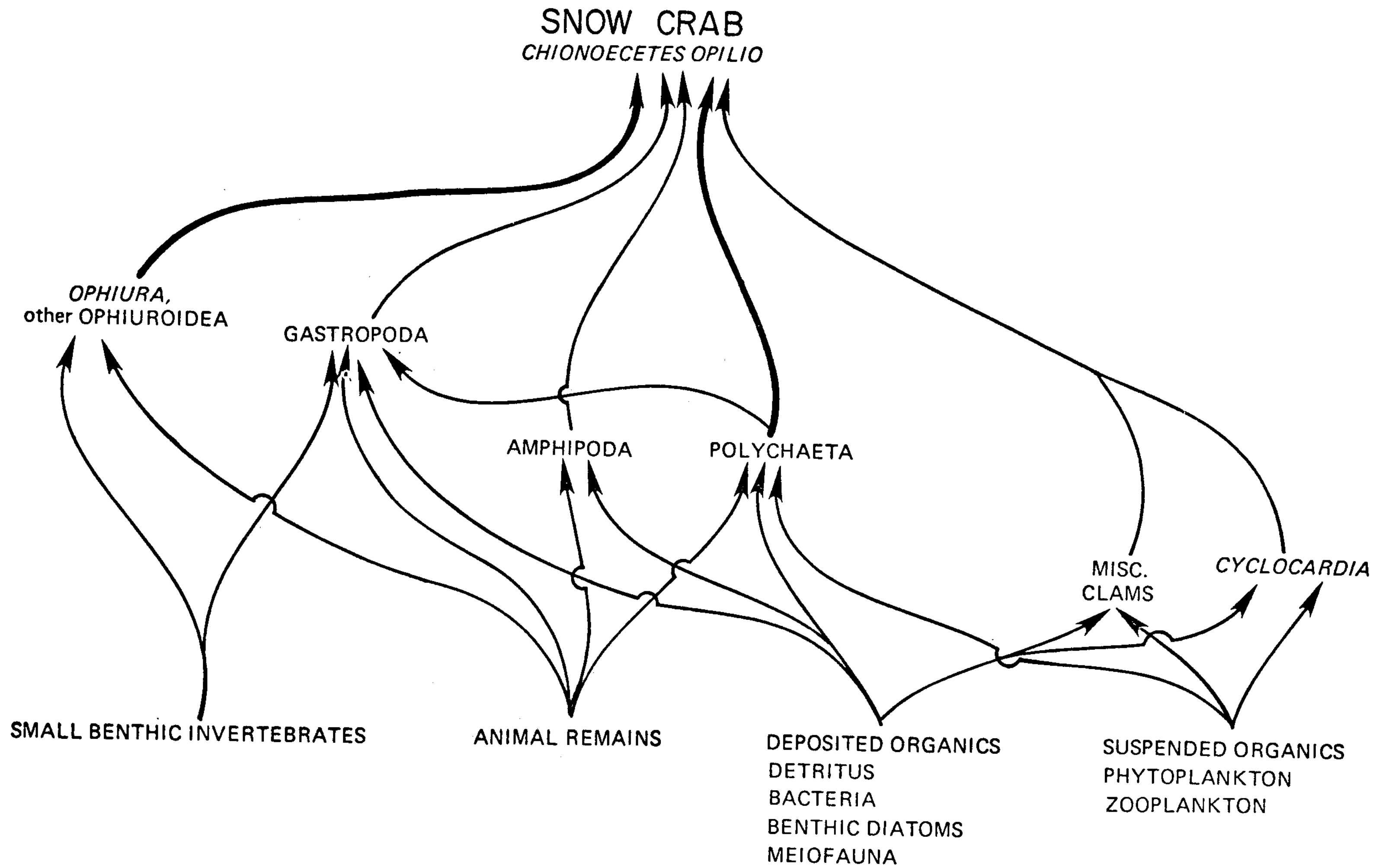

Figure 25. A food web showing carbon flow to snow crab (*Chionoecetes bairdi*) in the S.E. Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

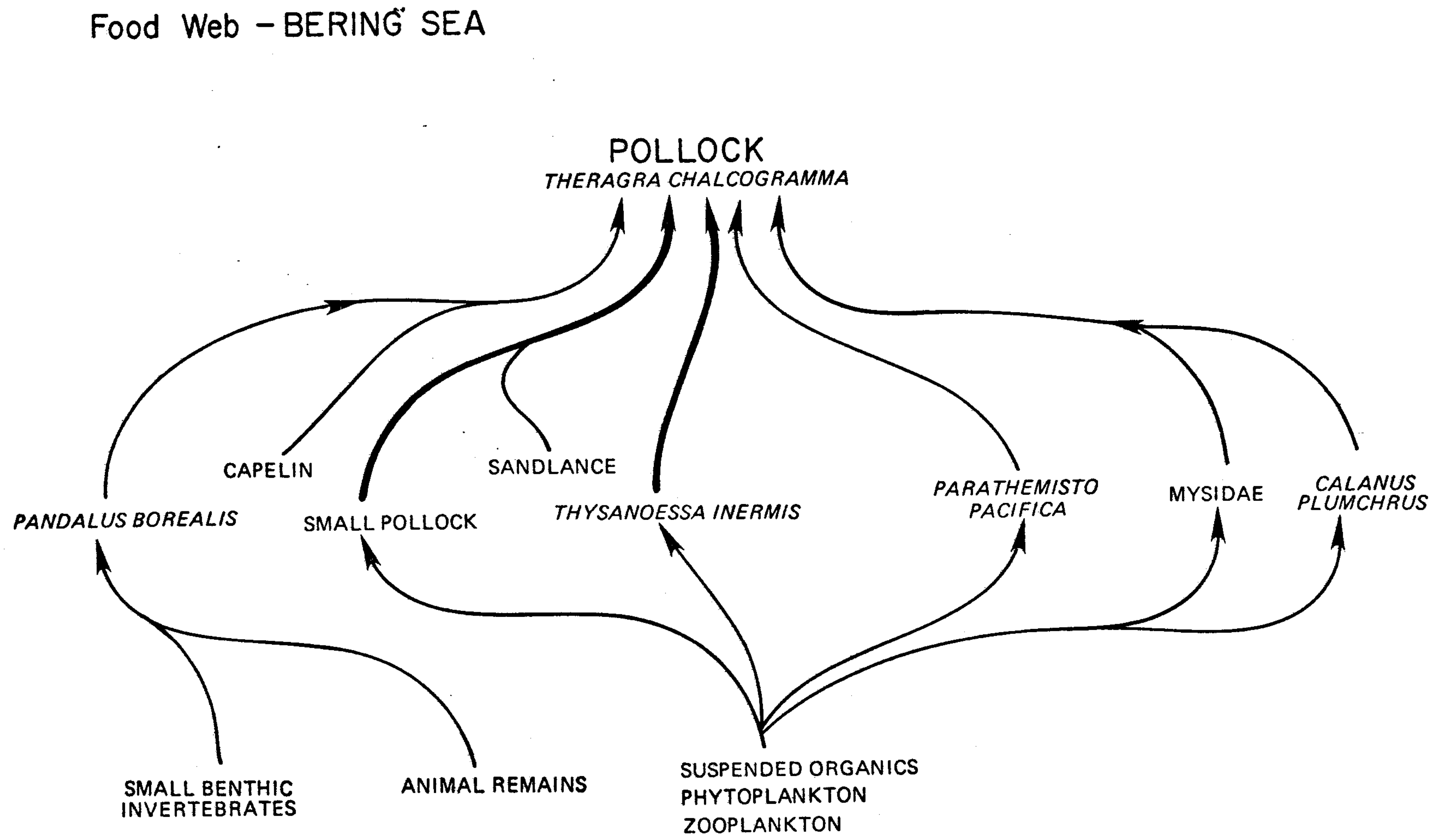

Figure 26. A food web showing carbon flow to pollock (*Theragra chalcogramma*) in the S.E. Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Bering Sea

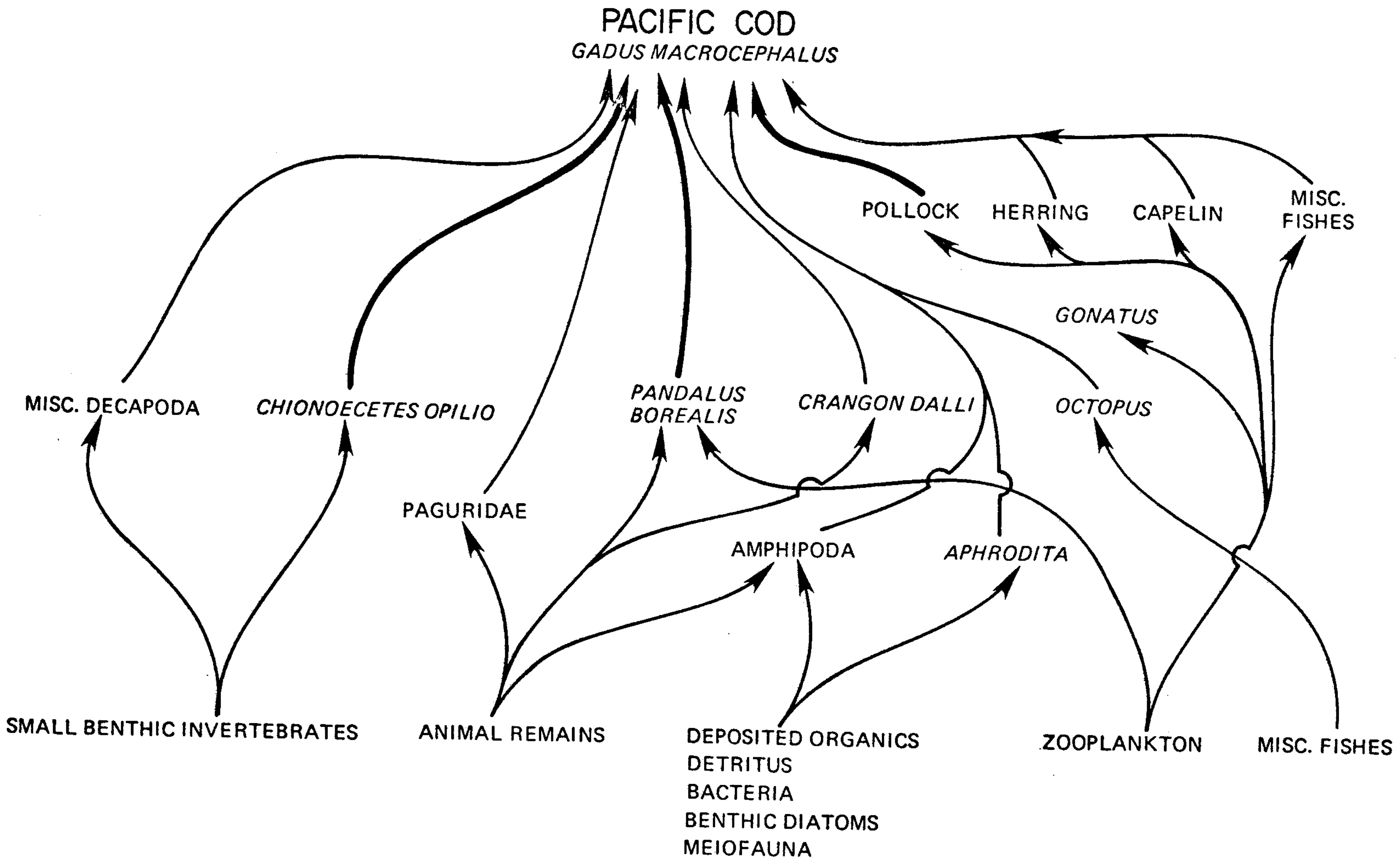

Figure 27. A food web showing carbon flow to Pacific cod (*Gadus macrocephalus*) in the S.E. Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

Food Web - Bering Sea

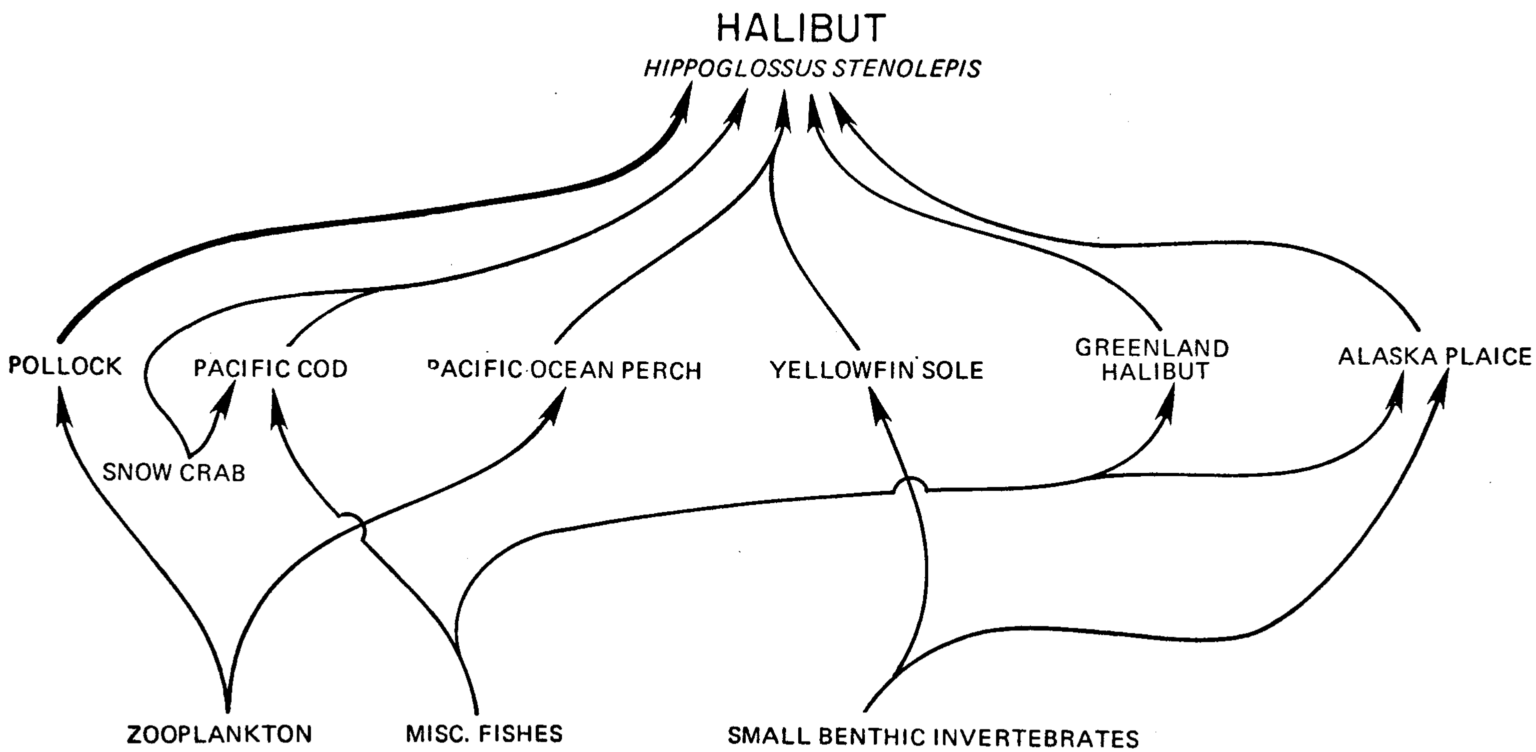

Figure 28. A food web showing carbon flow to Pacific halibut (*Hippoglossus stenolepis*) in the S.E. Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

TABLE XXXII

FEEDING METHODS OF INVERTEBRATES AND FISHES INCLUDED IN THE BERING SEA FOOD WEB (SEE FIG. 23)[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	A	X	–	–	–	–
Solariella	M	–	–	–	–	X
Neptunea	M	–	–	X	X	–
Buccinum	M	–	–	X	X	–
Protobranchia	M	X	O	–	–	–
Cyclocardia	M	O	X	–	–	–
Clinocardium	M	O	X	–	–	–
Spisula polynyma	M	–	X	–	–	–
Serripes groenlandicus	M	O	X	–	–	–
Mya	M	O	X	–	–	–
Hiatella arctica	M	X	–	–	–	–

TABLE XXXII

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Macoma	M	X	O	-	-	-
Cephalopoda	M	-	-	-	X	-
Gonatus	M	-	-	-	X	-
Calanus	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 XXXII

CONTINUED

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

TABLE XXXII

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 (Arctic cod)	Cho	-	-	-	X	-
Pungitius (nine-spine stickleback)	Cho	-	-	-	X	-
Hemilepidotus papilio (sculpin)	Cho	-	-	-	X	-
Myoxocephalus (sculpin)	Cho	-	-	-	X	-
Enophrys (sculpin)	Cho	-	-	-	X	-
Sebastes alutus (Pacific Ocean perch)	Cho	-	-	-	X	-
Anaplopoma fimbria (sablefish)	Cho	-	-	-	X	-

TABLE XXXII

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 hippglossoides (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.

Pollutants on the Bottom

Proposed oil development in the Bering Sea has led to intensive biological assessment surveys there. A benthic trawl, used to collect bottom invertebrates and fishes in these surveys, also brings up any man-made debris in its path. A description of this debris, its distribution, and frequency of occurrence are given for the southeastern Bering Sea as collected in 1975 and 1976.

Benthic trawls were made from the NOAA vessel *Miller Freeman* at stations on a grid extending from 160°W longitude to 173°W longitude and 54°30'N latitude to 60°30'N latitude (Fig. 29). Each trawl covered a 12.2 m wide path averaging 3.25 km in length, and was pulled for 0.5 hour. 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 106 trawls (41%) 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 XXXIII). Of the 55 trawls containing debris, 49 (90%) were made in the shaded area on Figure 29. 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 in Figure 29.

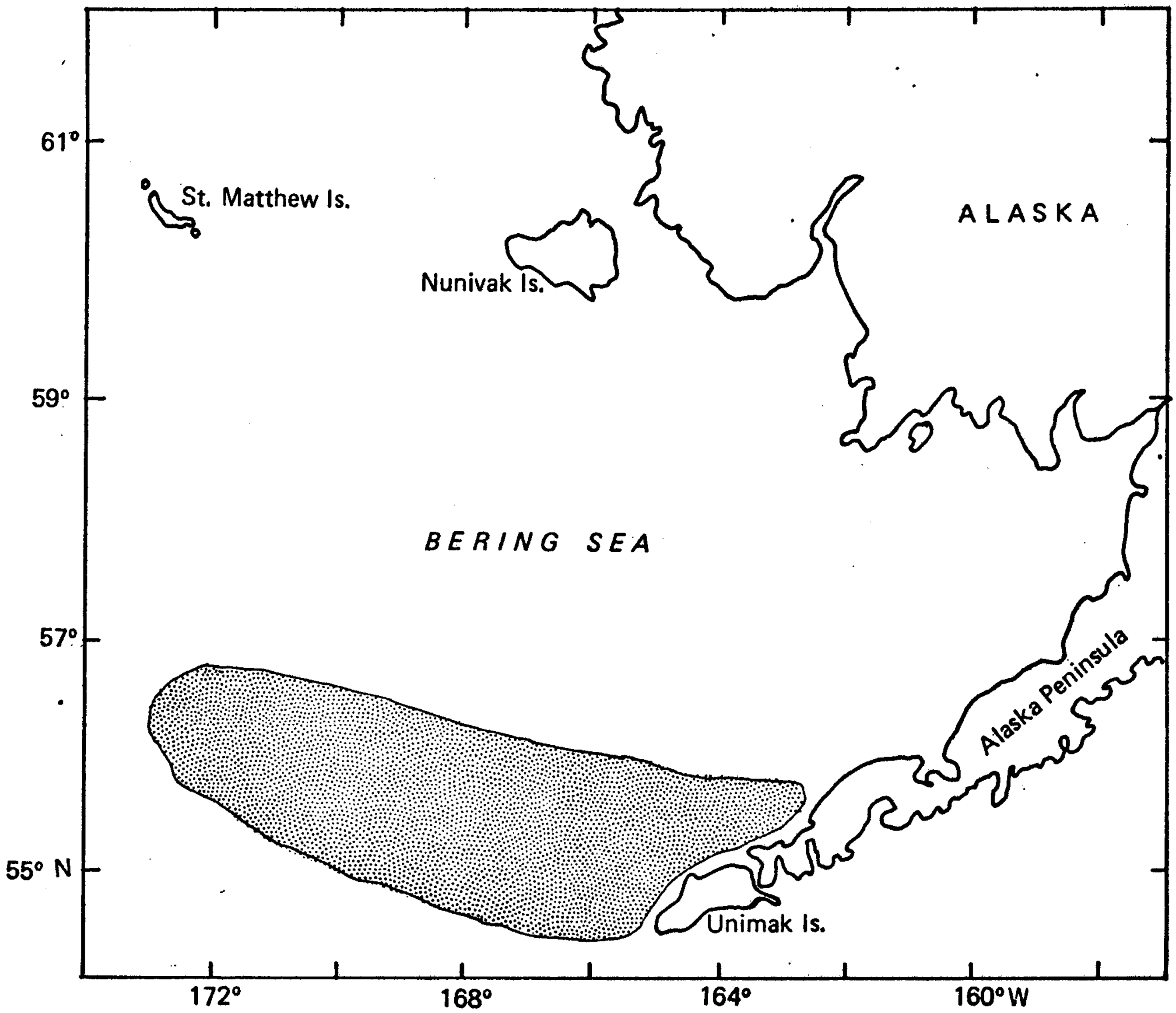

Figure 29. Southeastern Bering Sea study area. Shaded area shows the location of 90% of the debris containing trawls.

TABLE XXXIII

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

Most of the debris collected was either metal, rope (usually synthetic), plastic, or glass. In part, this must be due to the longevity of these materials in seawater. We suspect that much of the debris comes from fishing activities in the southern Bering Sea. The debris-containing area corresponds closely to the southern Bering Sea fishing areas. The Bering Sea is still relatively less cluttered than the northeastern Gulf of Alaska where Jewett (1976) found 57% of benthic trawls contained man-made debris, primarily plastics.

VII. DISCUSSION

Gulf of Alaska

Performance of the 0.1 m^2 Van Veen Grab

The van Veen grab was a suitable instrument for quantitatively sampling the soft sediments characteristic of the shallow shelf of the Gulf of Alaska; the grab typically collected large volumes of sediment. Lie (1968) indicates that 1 cm penetration of the 0.1 m^2 van Veen grab will collect 1 ℓ of sediment, and states that a digging depth of at least 4 cm should be attained to assure adequate representation of the fauna. He was able to accomplish this on all muddy bottoms; a situation that was also true for our grab sampling activities in the Gulf of Alaska. Sufficient penetration occurred on all of our stations except three -- Station 30, with sandy bottom, and Stations 26 and 29, with sand-gravel bottoms. The compact nature of the sediment at the former station resulted in 1 to 2 ℓ samples on several tries in the July 1974 cruise (cruise 193), and the station was ultimately abandoned with only 1 grab retained for qualitative analysis. Further sampling at this station in February 1975 resulted in somewhat larger samples, but most of the volumes obtained were not over 3 ℓ. Six replicates were taken at this time. The replicability of species composition and numbers per grab suggest that Station 30 will be useful for quantitative analysis despite the small volumes taken. Certainly Station 30 will be valuable for species composition assessment for monitoring programs in the Gulf of Alaska (Feder and Mueller, 1975; data submitted to NODC for 1975 and 1976).

Number of Grab Samples Per Station

One of the primary objectives of the infaunal study was concerned with a qualitative inventory of species. Initially, limited ship time restricted the number of replicate samples to three to ensure maximum coverage of the study area. Three replicates were adequate to sample the most abundant species in similar soft sediments in Port Valdez, and recruitment of numbers of individuals in subsequent samples represented members of less abundant species (Feder *et al.*, 1973). The general applicability of the Port Valdez analysis to the Gulf of Alaska was tested in the second year by taking 8 to 10 replicates at a variable number of selected stations. This data is currently being analyzed by the grab-sampling simulation program developed by Feder *et al.* (1973), and will be discussed in the Final Report. Preliminary results of this analysis indicate that five replicates are adequate.

Five replicate samples per station were suggested by Longhurst (1964) and Lie (1968); this number of replicates was corroborated by the investigations of Feder *et al.* (1973) in Port Valdez. Thus, initiation of five grabs per station was begun on the cruise of May, 1975. This number of replicates was taken on all subsequent cruises.

Station Coverage

The intensive grab-sampling program, now completed, over the shelf from Yakatat Bay to Resurrection Bay and from lower Cook Inlet to Unamak Pass is the most comprehensive one carried out by an American research group to date. A somewhat parallel study by the Soviet Union, extending from the southern terminus of the Kenai Peninsula to Cape Spencer, is available from an earlier period for comparative purposes (Semenov, 1965). Although the latter study is broad, the bases for calculations used by the author (i.e., the station data -- number of replicate samples per station, the species taken per replicate, the number of individuals of each species taken per replicate, and the biomass for each species per replicate) are lacking. Thus, precise quantitative comparisons will not be possible. A review of Semenov (1965) and other published work from the Gulf of Alaska will be available this year (Feder and Mueller, 1977). Specific benthic data for a restricted area around two potential oil-drilling sites are available in Bakus and Chamberlain (1975).

Since grab station coverage was only as intensive as allotted ship time, weather conditions, and examination of samples in the laboratory would permit, it is recognized that vast unsampled areas exist in the study areas. It is possible that some unsampled regions support significant populations of hitherto uncollected benthic species, but our experience of the past two years in the Gulf of Alaska suggests that most, if not all, of the common infaunal species have been taken at the occupied stations (based on qualitative assessment of Appendix Table III in Feder and Mueller, 1975, and 1976 data submitted to NODC). Additional coverage was accomplished with samples from two new stations (68 and 69) established off Montague Island and Stations 37, 60, 61, 62, and 63.

The trawl program permitted further coverage of the lease area, and resulted in the collection of the more motile, as well as the larger, epifaunal species. The integrated trawl program (demersal fish, benthic invertebrates, fish stomach analysis, meristic analysis of fish species, trace metal, and hydrocarbon programs) represents a significant supplement to the data collected by grab, and broadens the data base available for assessment of the shelf ecosystem.

The major limitations of the trawl survey were those imposed by the selectivity of the otter trawl used, and the seasonal movements of certain species taken. Otter trawls of the type used can be fished only on relatively smooth bottom that are free of obstructions. Thus, rocky-bottom areas were never sampled.

Species Composition of the Stations

Additional species have been added as a result of field and laboratory activities of the 1976 period. The general distribution of benthic species in the projected lease area is now well documented (Semenov, 1965; Appendix Tables I, II, III, VII, and VIII in Feder and Mueller, 1975; Feder *et al.*, 1976a, present report; and data submitted to NODC). A variety of infaunal groups contribute to the biomass at stations sampled by grab (Appendix Table V in Feder and Mueller, 1975 and data submitted to NODC). Members of the major marine phyla were collected in both investigations. Polychaetous annelids were the most important infaunal group collected by the grab-sampling program (Appendix Table IV in Feder and Mueller, 1975 and data submitted to NODC); similar results are also reported for Port Valdez, Prince William Sound (an embayment of the Gulf of Alaska with similar fine sediments in its fjords and bays) (Feder *et al.*, 1973).

The molluscs and crustaceans were the major epifaunal invertebrate groups taken by trawl in our investigation. Sizable biomasses of echinoderms, especially sea stars, were typical of most of the trawl station samples, and many of the species were sufficiently abundant to represent suitable organisms for in-depth investigations of their biology. Availability of sufficient numbers of the latter types of organisms are a preliminary requirement for development of satisfactory monitoring schemes and acquisition of suitable predictive capabilities for stressed benthic systems.

Qualitative examination of the species composition at various grab stations by way of such listings as are included in the Results section of Feder and Mueller (1975), current data summaries now being analyzed, and data submitted to NODC suggests distinct regional differences in species are also apparent. Perhaps one of the obvious features of most stations is the patchiness of the infauna. Examination of infaunal species composition at stations occupied on separate sampling dates (e.g., Stations 42, 44, 50, 52, and 55) indicates species common to each series of grabs, but also demonstrates omission or addition of certain species on the two dates. As suggested in the section entitled, Number of Grab Samples Per Station, some of this patchiness and station variance may be reduced by the more intensive sampling accomplished at each station in the second year of this study. Utilization of quantitative techniques to demonstrate the presence of species aggregates has clarified some station differences; such an approach is still in progress (see Feder *et al.*, 1973 for use of a cluster analysis technique to delineate groups of benthic species in Port Valdez, and Feder *et al.*, 1976a), and is further discussed below (see Cluster Analysis of Grab Data).

It is impossible to return all invertebrates taken by trawling activities to the laboratory for verification; therefore, it is difficult to obtain total numbers and weights of every species found, especially those species that are very similar. However, by development of conversion factors in the laboratory, it has been possible to make total numbers and weights available for all stations occupied.

The intensity of the demersal fish program in the northeast Gulf of Alaska, the necessarily lower priority given to invertebrate weighing and counting activities, and the multiple role occupied by the benthic biologist on the vessels (i.e., identify, count, and weigh as many invertebrates as possible per station; collect, in cooperation with the biologists of the demersal fish program, many species of fishes for stomach and meristic analyses; and sample specific species for both the hydrocarbon and trace metal programs) made it difficult for him to do much more than collect species distribution and density data. Weight data were obtained at times but were only taken on a time-as-available basis. It should be emphasized that support of a demersal fish trawling program is essential if an integrated understanding of the trophic-dynamics of the benthos of the Gulf of Alaska is to be obtained. Lack of additional trawling activities will distinctly narrow the scope of an overall benthic program, and will hamper the development of an offshore monitoring plan.

Diversity Indices

It is generally accepted that an altered environment will result in changes in numbers of species and the population densities of these species (Pearson *et al.*, 1967). Thus, examination of species diversity can often serve as a basis for comparison in the future. In order to avoid subjective appraisal, a quantitative measure of diversity must be used. Such a measure should typically consider the number of species present, as well as the density of each species. Various diversity indices are available and at least two different types should be used to give the greatest insight into the faunal conditions present (Lloyd *et al.*, 1968). The indices included in Feder *et al.* (1976a) and the present report, are complementary since the Simpson Index reflects dominance of a few species and the Shannon-Wiener and Brillouin indices are weighted in favor of rare species. Calculated values tend to reflect these weightings. However, the calculated indices should be interpreted with caution, and no comparisons made until more data is available for each station. Although in most cases, samples taken at the same stations on separate occasions have approximately the same indices, there are exceptions. Presumably differences in indices with time typically reflect the general problem of infaunal patchiness; however, the possibility of changes in species composition over the sampling period cannot be overlooked. An in-depth interpretation of diversity and evenness values calculated from the northeast Gulf of Alaska stations will be included in the Final Report.

Biologically Important Taxa

As suggested by Lie (1968), "Most animal communities are so complex and rich in species that it is necessary to make a choice of the species that supposedly are most important to the communities and subject them to detailed analysis". Such species have been variously termed "characterizing species" (Thorson, 1957), and "ecologically significant species" (Ellis, 1969). The criteria used for selection of such species vary; criteria used in this investigation for distinguishing infaunal taxa of biological importance are listed in the section on Methods. See Appendix Table II in Feder *et al.* (1976a) for a compilation of all of the species designated as Biologically Important Taxa, and Feder *et al.* (1973) for further discussion on the application of this concept to species in Port Valdez.

The initial list of Biologically Important Taxa is large. Additional assessment of this list is necessary in order to reduce the number of taxa to a size that can be easily used in computations essential to assessment of species groupings. Nevertheless, it is apparent that a large number of species, occupying diverse ecological niches, are available to monitor once industrial activity in the Gulf of Alaska becomes a reality.

Feeding Methods

Initial information for the northeast Gulf of Alaska was presented by Feder and Mueller (1975) for the feeding methods used by the majority of the infaunal species collected. This information is basically a literature compilation, but some unpublished data are included as well. The fact that most of the food data presented in Appendix Table VI for Feder and Mueller (1975) is based on literature extrapolations from related species or the same species from other areas emphasizes the paucity of data on the feeding biology of Gulf of Alaska fauna. This lack of basic data also dictates the urgency of immediate support of food studies and experimental work on selected species from the benthos and elsewhere in the waters of the Gulf of Alaska.

Some insights into feeding biology can be gleaned from food analyses on collected and presently archived grab material. Particular attention should be paid to brittle stars and sea stars, two taxa occurring in great density in some areas (see Appendix Table VIII in Feder and Mueller, 1975 and data submitted to NODC).

Two other echinoderm species of considerable interest are the sea star *Ctenodiscus crispatus* and the large sea cucumber *Molpadia* sp. Both of these species are non-selective deposit feeders which pass large amounts of unsorted bottom material through their digestive tracts. The former species ingests surface and near-surface deposits, but the latter species is continually reworking deeper deposits. Thus, both species are probably important in their particular areas in terms of recycling nutrients that might otherwise be trapped in the sediments.

In a bottom trawling survey of the northeast Gulf of Alaska, Hitz and Rathjen (1965), reports that the deposit-feeding heart urchin, *Brisaster townsendi* accounted for about 50% of the invertebrate catch, i.e., as high as 534 kg (1177 pounds) per hour. *Brisaster townsendi*, collected in the present study by the M/V *North Pacific*, was found in the same areas as reported by Hitz and Rathjen (1965), i.e., in Kayak Canyon, Icy Canyon and in particular, Yakutat Canyon. Station 97-C (see Fig. 3 present report and Jewett and Feder, in press, for station data, also NODC submitted data) yielded the largest catch of this urchin at 212.7 kg (469 pounds) per hour or 21,272 urchins per hour. As a canyon dweller they can take fullest advantage of deposit feeding by living in an area to which food particles are carried and deposited by prevailing currents.

Some preliminary information on feeding habits of fishes was obtained in the trawl survey on the M/V *North Pacific* at several stations. Stations 94-A and 94-B were noteworthy for their large abundance of two species of fishes and the near-absence of invertebrates; this was especially true for the latter station. The starry flounder, *Platichthys stellatus*, dominated these two stations with 94-B yielding 3549 kg (7824 pounds) of these fishes per hour (average weight 2 kg). Examination of stomach contents of 35 *P. stellatus* revealed only lamellibranch species; the clams *Yoldia seminuda, Siliqua sloati,* and *Macoma dexiosttera*. All stomachs were full. There appears to be a definite seasonal trend in feeding intensity for *Platichthys stellatus* (Miller, 1965). Around January (month of the lowest bottom temperature) feeding stops, and does not begin again until about June. The fullness of the stomachs of the starry flounder on 3 June in the Gulf of Alaska may be evidence of a recently terminated fasting period. In view of the large population of this potentially important commercial species that feeds predominantly on clams (Orcutt, 1950; Miller, 1965; our study for the Gulf of Alaska) in the vicinity of Stations 94-A and 94-B, it seems reasonable that these areas, with their abundant clam populations, might play a vital role in the trophic dynamics of *P. stellatus*.

A second species of interest was juvenile (approximately 10 cm long) walleye pollock, *Theragra chalcogramma*. Station 94-B yielded approximately 544 kg (1199 pounds) per hour. Thus, this area may be ecologically important in terms of supporting another potentially commercial species or of serving as a rearing area for a species which is known to be an important trophic link in the North Pacific (Chang, 1974; Kamba, 1974; Takahashi and Yamaguchi, 1972).

The data from Station 74-C is also of considerable interest. At this station was wide diversity of invertebrates and a high abundance of Pacific halibut, *Hippoglossus stenolepis*. Of the 47 species of invertebrates that were found, 85% of the species were Mollusca (13 species), Crustacea (14 species), and Echinodermata (13 species). The biomass of the ascidian, *Halocynthia aurantium*, was 419.8 kg (925 pounds) per hour. Halibut were taken here at the rate of 1398.8 kg (3084 pounds) per hour with each fish averaging 18.5 kg or 41 pounds. Stomachs were not obtained at this station so it is not known what organism(s) halibut are feeding on there.

The major food items of Cook Inlet snow crab (*Chionoecetes bairdi*) are *Macoma* spp., hermit crabs, and barnacles (*Balanus* spp.) all of which were common or abundant at many stations. This contrasts with *Chionoecetes opilio* in the Bering Sea which feeds primarily on polychaetes and ophiuroids with hermit crabs and clams also being taken, but only incidentally. Hermit crabs were not abundant at the Bering Sea stations where snow crab feeding data were collected, however, polychaetes and ophiuroids were common there. Though *C. opilio* feeds heavily on ophiuroids in the Sea of Japan (Yasuda, 1967) and the Bering Sea, it is not clear if the total absence of these echinoderms in stomachs of *C. bairdi* indicates a difference in preference between *C. bairdi* and *C. opilio* or the absence of ophiuroids from Cook Inlet, since little ophiuroid abundance data is available from Cook Inlet.

Paralithodes camtschatica was not feeding on snails in Cook Inlet as it does in the Bering Sea. Bivalve molluscs were major components of the diet in both areas. *Nuculana*, a deposit feeder, is an important food source for King crabs in both Cook Inlet and the Bering Sea.

Clam Studies in Cook Inlet

Benthic bivalves are important contributors to the benthic biomass in Cook Inlet. The growth-history data generated by this study should provide information on the relative stability of the environment. 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 species examined will be suggested for the development of a long-range monitoring study in Cook Inlet.

Food Habits of the Cod

Preliminary analysis indicated that the relative importance of various items of food change with size of cod.

The principal food groups for cod at all sizes were fishes, crustaceans, and molluscs. There were some small quantities (less than 10% of the total occurrence) of coelenterates (= cnidarians), annelids, euphausids, isopods, and echinoderms.

This study found, similar to other studies on gadiformes, that as the cod size increased so did its consumption of fishes. During the 1973, 1974, and 1975 ADF&G Indexing Study, the frequency of occurrence of fish in 30 to 49 cm cod was 32%. At 50 to 69 cm length, the percentage of occurrence had risen to 54 and finally the frequency in the 70 to 89 cm cod size was 65%. This shows that as cod increase in size, their food requirements are met in the most efficient way, i.e., larger organisms rather than a large quantity of smaller organisms.

Larger crustaceans such as crabs and shrimps increased in importance as food items of larger cod in the same manner as fishes. Although the percentage of occurrence of shrimps increased with increasing cod size, the percent increase from small size (30 to 49 cm) to the large cod (70 to 89 cm) was less than 10%. Similarly, the percentage of occurrence of crabs in 70 to 89 cm cod was less than 3% above that in 50 to 69 cm cod. The greatest increase in percentage of occurrence of crabs as a food item is seen between the smallest cod (30 to 49 cm) and the intermediate size group (50 to 69 cm) an increase from 39 to 49% respectively. The commercially important snow crab, *Chionoecetes bairdi*, was a very important food item for the cod.

Smaller crustaceans such as euphausids, isopods, and especially amphipods decreased in percentage of occurrence with increasing cod size. Only 4.7% of 70 to 89 cm cod contained amphipods as opposed to 38.5% of 30 to 49 cm cod.

Upon examining 1500 haddock from Georges Bank, Clapp (1912) found 68 species of molluscs. During the 1973-1975 ADF&G Indexing Study many species of molluscs, such as the deposit-feeding clams, *Yoldia* spp. and *Nuculana fossa*, were also found in Pacific cod. These two genera are remarkably similar in size and appearance. Another mollusc, the octopus, had a relatively high percentage of occurrence in cod stomachs. Generally, the octopus itself had been digested completely and only the beak remained for identification. Occasionally squid beaks were found.

Comparing food of cod, sculpins, and miscellaneous fishes (Jewett, unpublished data), it can be generally stated that the cod is the most voracious species. Cod and sculpins feed occasionally upon their own kind. Sculpins were found to seek out non-commercial crabs more frequently than cod or other miscellaneous fishes. Numerous species of molluscs were found in bullhead as well as cod stomachs. The food items which were most frequently found in sculpins were amphipods and crabs (chiefly *C. bairdi*).

Information pertaining to food of miscellaneous fishes was difficult to assess. Often as fishes were ascending in the pots or while they were on the deck, they would regurgitate all or part of their stomach contents, thus making it difficult to enumerate food items. However, many of the miscellaneous fishes examined appeared to be feeding on other fishes.

Upon analysis of food with respect to sex, Homans and Vladykov (1954) reported there was no significant difference in the feeding rate between sexes of haddock on the offshore Nova Scotian banks. Also observations by Wigley (1956) of several hundred haddock from Georges Bank did not disclose any obvious differences in stomach-content volume between sexes. Powles (1958) found no appreciable difference between the diets of small male and female cod (*Gadus callarias* L.). Wigley and Theroux (1965) arrived at the same conclusions, that there were no statistically significant differences between sexes in stomach-content weight of haddock. Similarly, data of the present study also did not find any significant differences in feeding habits between sexes of *Gadus macrocephalus*.

Pollutants Taken by Trawl

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

Computerized Data Output

The major goals set for data management have been achieved. All infaunal taxa were given code numbers according to the 10 digit VIMS code (Mueller, 1975; Swartz *et al.*, 1972), data for all species from the July, October, November, February, and May cruises have been key punched, a printout has been generated that lists all species, and additional printouts with all available data on numbers and weights of collected species have been generated. All appropriate data has been submitted to NODC.

Cluster Analysis of Grab Data

A discussion of the current results of cluster analysis of grab data for the Gulf of Alaska is found in Appendix VI of this report (also see Feder *et al.*, 1976a for further comments).

Bering Sea

Performance of the 0.1 m^2 Van Veen Grab

The van Veen grab was a suitable instrument for sampling most of the stations of the shallow shelf of the Bering Sea; the grab typically collected moderate volumes of sediment (10 to 14 ℓ). Considerably smaller volumes were found at sandy stations. Lie (1968) indicates that 1 cm penetration of the 0.1 m^2 van Veen grab will collect 1 ℓ of sediment, and states that a digging depth of at least 4 cm should be attained to assure adequate representation of the fauna. He was able to accomplish this on all muddy bottoms; a situation that was also true for our grab sampling activities in the Bering Sea at stations with mud bottom.

Number of Grab Samples Per Station

One of the primary objectives of the study was a qualitative inventory of dominant species. Since sufficient ship time was available to cover the station grid, five to six replicate samples were taken per station to ensure adequate quantification per station. Three replicates were adequate to sample the most abundant species in the soft sediments of Port Valdez, Prince William Sound, Alaska.

Recruitment of numbers of individuals in subsequent samples represented members of less abundant species (Feder *et al.*, 1973). The general applicability of the Port Valdez analysis to the Bering Sea has been tested using 8 to 10 replicates at a variable number of selected stations with the grab-sampling simulation program developed by Feder *et al.* (1973). This analysis will be discussed in the Final Report. Five replicate samples per station have been suggested by Longhurst (1964) and Lie (1968) and further corroborated by the investigations of Feder *et al.* (1973). Thus, the five to six grabs per station should be adequate.

Station Coverage

The intensive grab-sampling program, now completed, on the Bering Sea shelf is the most comprehensive one carried out by an American research group to date. A somewhat parallel study by the Soviet Union is available from an earlier period for comparative purposes (see Alton, 1974 for review of Soviet literature; also Hood, 1973). Although the latter studies were broad, the bases for calculations used by them (i.e., the station data - number of replicate samples per station, the species taken per replicate, the number of individuals of each species taken per replicate, and the biomass for each species per replicate) are lacking. Thus, precise quantitative comparisons will not be possible.

Since grab station coverage was only as intensive as allotted ship time and weather conditions would permit, it is recognized that vast unsampled areas exist in the projected lease area. It is possible that some unsampled regions support significant populations of hitherto uncollected benthic species.

The trawl program permitted further coverage of the lease area, and made it possible to collect the more motile, as well as the larger, epifaunal species. Thus, the integrated trawl program (demersal fish, benthic invertebrates, fish stomach analysis, meristic analysis of fish species, trace metal, and hydrocarbon programs) represents a significant supplement to the data collected by grab-sampling activities.

Counterclockwise water circulation exists in the surveyed region, with an increase in average current velocity with an increase in depth

(Hebard, 1959). Bottom sediments have been found to vary from fine mud in the western part to dark and coarse sand inshore (McLaughlin, 1963; Feder, unpublished data). These environmental parameters may make it possible to understand larval dispersion and settlement as well as adult distribution of epifaunal species at the stations.

Species Composition of the Stations

The general distribution of benthic infaunal species in the projected lease areas is now well documented (present investigation and Soviet surveys: see Alton (1974), for review; see Appendix Table 1 in Feder *et al.* (1976b)). Members of the major marine phyla were collected in all investigations. Polychaetous annelids were the most important infaunal group in terms of numbers of species collected by the grab-sampling program. A variety of infaunal groups contributed noticeably to the biomass at the grab stations (see tabulated data in Feder *et al.*, 1976b and data submitted to NODC).

The molluscs and crustaceans were the major epifaunal invertebrate groups taken by trawl in 1975. In general, distribution of the most common species was similar to that found by McLaughlin (1963), i.e., *Pagurus ochotensis, Paralithodes camtschatica, Chionoecetes* spp., *Hyas coarctatus alutaceus, Erimacrus isenbeckii, Neptunea* spp., *Asterias amurensis,* and *Gorgonocephalus caryi.* McLaughlin (1963) also listed *Pandalus borealis* and the tunicate *Boltenia ovifera* as common species. These two species were present in the study area but they were not commonly found. Additional species which were commonly taken were the hermit crab *Pagurus trigonocheirus* and the tunicates *Halocynthia aurantium* and *H. igaboja.*

Most of the pelecypod molluscs (clams) were small and not abundant. The low densities of many of the less frequently occurring species, based on our dredge data for 1976 (Feder, unpublished data: available in Final Report), can now be attributed to inadequate sampling and gear selectivity, rather than to real changes in distribution. Although McLaughlin (1963) found *Neptunea lyrata* as the most widely distributed gastropod, it was not true in the present study. *Neptunea lyrata* was present, however, it was not as widely distributed as *N. heros* and *N. ventricosa*.

The genus *Pagurus* was the decapod with the most species collected. Two dominant members were *P. ochotensis* and, as already mentioned, *P. trigonocheirus*. The hermit crab *Labidochirus splendescens*, a small, rapidly moving crab, had a unique habitat arrangement. This crab was normally found to use the shells of the small gastropods such as *Natica* or *Polinices*. These portable shelters were too small to allow the inhabitant to withdraw in the event of danger, but this crab was uniquely equipped with a heavily calcified exoskeleton for protection. *Labidochirus splendescens* was often found with the shell replaced by a sponge that had assumed the same shape as the original shell by completely dissolving the shell. An advantage of this replacement is that the sponge is lighter than the original *Natica* or *Polinices* shell. The lighter shell may be a clue to the ability of this crab to move so rapidly and more efficiently avoid predators. Another advantage may be predator avoidance as sponges are seldom preyed upon.

The anomurans, *Paralithodes camtschatica* and *P. platypus*, and the brachyurans, *Chionoecetes bairdi* and *C. opilio*, are common, widely distributed, and are the only invertebrate species of significant commercial importance in the Bering Sea. *Paralithodes camtschatica*, the red King crab, is the target species fished primarily just north of the Alaska Peninsula extending west to Adak Island.

Chionoecetes opilio, a slightly smaller crab than *C. bairdi*, was the most widely distributed and dominant invertebrate species encountered. Distinction between these two species was not difficult, but hybrids were occasionally found showing characteristics of both species.

Asteroids (see stars) of the Bering Sea were much less diverse (11 species) than those of the Gulf of Alaska (24 species) (Feder *et al.*, 1976a), but were common at many Bering Sea stations. The forcipulate sea star *Asterias amurensis* was abundant at most of the stations sampled.

Tunicates were common at a few stations. McLaughlin (1963) found *Boltenia ovifera* as the most widely distributed tunicate. During Leg I of our study, less than 6% of the stations yielded *B. ovifera*; however, these stations were located above McLaughlin's sampling area, mostly between St. Matthew Island and Nunivak Island.

Qualitative examination of the species composition at various grab stations by way of such listings as are included in Appendix 1 of Feder *et al.* (1976b) and data submitted to NODC suggests distinct regional differences in species and biomass. However, widely dispersed or ubiquitous species are also apparent. Perhaps one of the obvious features of most stations is the patchiness of the infauna. Utilization of quantitative techniques to demonstrate the presence of species aggregates is essential to clarify station differences; such an analysis is underway (see Feder *et al.*, 1973 for use of a Cluster Analysis technique to delineate groups of benthic species in the Gulf of Alaska).

Major limitations of the trawl survey were those imposed by the selectivity of the otter trawl used and the seasonal movements of certain species. Otter trawls of the type used can be fished only on a relatively smooth bottom free of obstructions. In addition, it is impossible to return all invertebrates to the laboratory for verification; therefore, it is difficult to get total numbers and weights of every species found, especially those species that are very similar. However, by development of conversion factors in the laboratory, it has been possible to make total numbers and weights available for all stations occupied.

The intensity of the demersal fish program, the necessity of lower priority given to invertebrate weighing and counting activities on ship, and the multiple role occupied by the benthic biologist on the vessel (i.e., identify, count, and weigh as many invertebrates as possible per station; collect, in cooperation with the biologists of the demersal fish program, many species of fishes for stomach and meristic analyses; and sample specific species for both the hydrocarbon and trace metal programs) made it difficult for him to do much more than collect species distribution and density data. Weight data were obtained at times but were generally only taken on a time-as-available basis. Little effort was devoted to collection of sizable invertebrate samples for recruitment, growth, age and feeding studies. It should be emphasized that continuing support of a demersal invertebrate-fish trawling program in the Bering Sea is essential if an integrated understanding of the trophic-dynamics of the benthos is to be obtained.

The 1975 and 1976 trawl surveys covered slightly overlapping, areas. The 1976 area, mainly on the outer shelf, had an epifaunal standing stock of 5.0 g/m^2; the 1975 area had 3.3 g/m^2. Major differences in species dominance could be seen between the two areas. *Chionoecetes*, typically a dèepwater crab, increased from 32.7% of the invertebrate biomass in 1975 to 48.1% of the biomass in 1976 when the survey area moved to deeper waters. The decreasing importance of *Paralithodes camtschatica* and *Asterias amurensis* from 1975 to 1976 is probably also due to this shift in depth also. 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 area and 6.1 times as abundant in the 1976 area. This 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.

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 5.0 g/m^2 (1976) for trawl collected epifauna from similar areas. 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. Occasionally the trawl contained enough material to tear the net. These large tows were not weighed causing the average biomass figure to be slightly low.

Highest 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. 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. Alton (1974) shows that, on a world-wide basis, large demersal fish harvest, as occurs in the southeast Bering Sea, is not directly related to a large benthic standing stock.

A large proportion of the southeast Bering Sea benthos is made up not only of potential fish food species, but also 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 in the southeast Bering Sea. In addition, the area may support clam resources of commercial magnitude.

An OCSEAP trawl survey in the northeast Gulf of Alaska (NEGOA) in 1975 provided extensive information on epifauna which can be compared with similar data from the southeast Bering Sea (Ronholt *et al.*, 1976; Jewett and Feder, in press). Animals collected in NEGOA showed less diversity than those from the Bering Sea, 168 species vs. 225 species, respectively. NEGOA epifaunal invertebrate biomass was dominated by Arthropods (71.4%), Echinodermata (19.0%), and Mollusca (4.6%). These proportions are similar to those from the southeast Bering Sea. The family Majidae (snow crabs and spider crabs) was dominant in both NEGOA and the southeast Bering Sea with 66.2% of the total biomass for NEGOA and 33.0% and 48.4% of the southeast Bering Sea biomass in 1975 and 1976 respectively. Majidae may be the dominant epifaunal invertebrate family over much of the northern Pacific Ocean. *Chionoecetes* spp. support large commercial fisheries in the eastern as well as western north Pacific (Watson, 1969). Estimated standing stock of epifaunal invertebrates in the NEGOA survey area (2.6 g/m^2; Jewett and Feder, in press) is similar to that of the southeast Bering Sea (3.3 g/m^2 (1975) and 5.0 g/m^2 (1976)).

The southeast Bering Sea has a large proportion of invertebrates which are important both as demersal fish food and food for man. Arthropods, primarily King crabs and snow crabs, represent the greatest single contribution to the epifaunal invertebrate biomass in the areas surveyed (between 58 and 67%). Echinoderms and molluscs are also major components of the invertebrate biomass, however, their importance changes with area.

Diversity Indices

It is generally accepted that an altered environment will result in changes in both numbers of species and population densities of these species (Pearson *et al.*, 1967). Thus, examination of species diversity can serve as a basis for comparison in the event of environmental alteration. In order to avoid subjective appraisal, a quantitative measure of diversity must be used. Such a measure should typically consider the number of species present, as well as the density of each species. Various diversity indices are available and at least two different types should be used to give the greatest insight into the faunal conditions present (Lloyd *et al.*, 1968). The indices included in this report, Simpson, Shannon-Wiener, and Brillouin are complementary to each other since the former reflects dominance of a few species and the latter two are weighed in favor of rare species. The calculated indices (Table 4 and Appendix Table 1 in Feder *et al.*, 1976b) should be interpreted with caution, and no comparison made until more data is available for each station.

The trawl stations deeper than 91 m (50 fathoms) occupied in 1975, located immediately north and northeast of Unimak Pass, were the most diverse of the area examined to date. Some species limited to this area were the sea stars *Dipsacaster borealis*, *Ceramaster patagonicus*, *Solaster* *borealis*, and *S. endeca*; the brittle star *Ophiura sarsi*; the heart urchin *Brisaster townsendi*; and the gastropod *Fusitriton oregonensis*. Species which were most abundant in the shallow areas were less abundant or absent in deeper water.

Biologically Important Taxa

As suggested by Lie (1968), "Most animal communities are so complex and rich in species that it is necessary to make a choice of the species that supposedly are most important to the communities and subject them to detailed analysis." Such species have been variously termed "characterizing species" (Thorson, 1957), and "ecologically signficant species" (Ellis, 1969). The criteria used for selection of such species vary; criteria used in this investigation for distinguishing infaunal taxa of biological importance are listed in the section on Methods. See Feder *et al.* (1976b) for compilation of all of the species designated as Biologically Important Taxa, and Feder *et al.* (1973) for further discussion on the application of this concept to species in Port Valdez.

The initial printout of biologically important taxa was large. Additional assessment of this list may be necessary in order to reduce the number of taxa to a size that can be easily used in computations essential to assessment of species groupings. Nevertheless, it is apparent that a large number of species, occupying diverse ecological niches, are available for monitoring once industrial activity becomes a reality.

Feeding Methods

Some information is discussed in Feder *et al.* (1976b) on feeding methods used by some of the infaunal species collected. A lack of basic data for Bering Sea infauna dictates the urgency of immediate support of experimental work on selected species from the benthos there.

Sea stars, along with such organisms as sea anemones, jellyfishes, and sea urchins, are usually terminal members in food webs in marine ecosystems. 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 by the bottom fish population does not exceed 10,000 metric tons annually, yet food consumed by *A. amurensis* amounted to approximately 8,000 metric tons. If the food is similar for both bottom fishes and this sea star, the sea star population clearly has an important bearing upon the production of useful fish. However, sex products liberated into the water column annually by sea stars may contribute a considerable amount of carbon to the pelagic system (Feder and A. J. Paul, unpublished data).

Ascidians are sessile, benthic chordates that feed by filtering small plankters and suspended particles of organic detritus from the water. It is a relatively successful group in some parts of the Bering Sea. It is possible that the reason for the success of these filter feeders in the southeastern Bering Sea is a counterclockwise water circulation which plays an important role in delivering suspended food particles. Reduced sedimentation may also contribute to their success. Trawling activities in the Gulf of Alaska revealed few ascidians, presumably due to high sedimentation rates there. Ascidians were, however, an important part of the Bering Sea biomass. The only known predator on ascidians in the Bering Sea is the walrus (Stoker, 1973).

Of the major biomass components in the Bering Sea (i.e., King crab, snow crabs, and *Asterias amurensis*), only the King crab feeding habits have been examined intensively. McLaughlin and Hebard (1961) determined percent frequency of occurrence for food items of male and female Bering Sea King crab. Primary food items were molluscs (76.9%, male; 60.6%, female), echinoderms (48.5%, male; 35.6%, female), and decapod crustaceans (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-Kamtchatka shelf. Results presented in the present report match those of McLaughlin and Hebard (1961) as well as Takeuchi (1967) and indicate that echinoderms are an important food resource for King crab in the Bering Sea.

Food habits of *Chionoecetes opilio* are known for the Sea of Japan (Yasuda, 1967). Abundant food items there are *Ophiura, Chionoecetes opilio elongatus*, some protobranch clams, and *Coscinodiscus*; common food items included *Aphrodita, Pandalus*, other decapods, *Natica, Buccinum, Neptunea*, and some protobranch clams including *Nuculana*. Bering Sea snow crab feeding habits (present report) were quite dissimilar to those in the Sea of Japan. Polychaetes were the single major food item taken by Bering Sea crab rather than a minor element as in the Sea of Japan. No Bering Sea snow crab was found feeding on other snow crab.

Asterias amurensis is apparently a great 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 ascervata* fed solely on *Clinocardium*. This cockle is apparently quite abundant since it is an important prey item of *P. camtschatica* and *A. amurensis* as well as *L. p. ascervata*.

Pollock is unique among the fishes examined in the Bering Sea in that the major food source of large pollock is small pollock.

In addition, the pollock is a major food of several other large predatory fishes and some marine mammals. Anything that might cause drastic changes in the pollock population would affect a large segment of the Bering Sea food web.

Bering Sea flatfishes are feeding heavily on pelecypods (clams). Most pelecypods may be using a combination of suspension and deposit feeding methods (Rasmussen, 1973; Feder, unpublished data) with one feeding method dominant and the other employed occasionally. Thus, the addition of pollutants to the sediments may affect pelecypods not previously considered as deposit feeders. Pelecypods are fed on directly by King crab, 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.

Clam Studies in the Bering Sea

Benthic bivalves are important food resources for King crab and several species of demersal fishes (see Results section - Food Studies). The investigation of growth, age, recruitment, and mortality rates of bivalves of importance as food sources for benthic predators will be useful for future studies of secondary production on the bottom. Species currently being examined are *Nuculana* spp., *Yoldia* spp., *Tellina lutea*, and *Spisula polynyma*. Age, growth, and mortality data for *Macoma* *calcarea* and *Clinocardium ciliatum* from the Bering Sea are now available (S. Stoker and A. J. Paul, Institute of Marine Science, University of Alaska, unpublished data).

Computerized Data Output

The major goals set for data management were achieved. All infaunal taxa were given a code number according to the 10 digit VIMS code (Mueller, 1975; Swartz *et al.*, 1972), data for all species from 61 stations have been key punched, and preliminary printouts have been generated that list all species and an additional preliminary printout with all available data on numbers and weights of collected species has been generated (see Feder *et al.*, 1976b, for examples).

The key punched data is now being analyzed using various programs on file at the University of Alaska Computer Center. The primary programs that will be used are a cluster analysis initially used in the Port Valdez benthic study (Feder *et al.*, 1973), and the cluster techniques used for grab data of the Gulf of Alaska (Feder *et al.*, 1976a).

General Comments on Status of Grab Data

Time constraints permitted only a preliminary numerical analysis of the data available at this time. We have altered several of the computer programs used in the analysis of the Gulf of Alaska data to accommodate the larger number of samples and species found in the Bering Sea study area.

Inspection of field notes and species-abundance data from the first 27 stations suggested some hypotheses concerning the structure of benthic communities over the entire shelf. These are included in Feder *et al.* (1976b).

Ultimately a comparison of community structure must be made, and this should incorporate both grab, pipe dredge, and trawl programs. Since a wide range of bottom conditions was noted during the course of our field work, it is not unreasonable to hypothesize that carbon flow through the entire system might vary as well. Carbon input and substrate type have been found to significantly affect the structure of both the meio- and macro-benthic communities in several areas of the world. The program underway should detect any such differences in the structure of the 1 mm and larger category of organisms. In particular, sediment particle size has been found to be unimportant in determining structure of interstitial communities (Fenchel, 1969). While sediments in the Gulf of Alaska study area are predominantly of fine particle size, the Bering Sea shelf includes extensive sandy areas in which one would expect much more extensive interstitial communities. While meiofaunal-macrofaunal trophic interactions are not being studied at this point, the existence of an interstitial community might be a factor influencing both feeding and reproductive habits of some benthic organisms.

Production over the Bering Sea shelf is known to be variable and often associated with the retreat of the ice edge; some degree of productivity no more than several meters from the bottom has also been noted (Dr. Vera Alexander, personal communication). Seasonal upwelling has been documented in Bristol Bay (Dr. R. Muench and R. Myers, personal communication), and since, in general, depths at most of our stations are less than 75 m, we may expect fairly thorough mixing of the overlying water column on the shelf (in contrast with the Gulf of Alaska study area). These conditions indicate that carbon directly available to the benthic communities may be very different in form (ranging from copepod feces to plant matter) and quantity from that found in the Gulf of Alaska. Such variance could also provide a basis for the appearance of differing community structures in the Bering Sea (see Hood, 1973 for review).

The approach to be taken as the project progresses will be to determine, primarily through cluster analysis, areas of differing structure on the basis of species representation. Following this, community structure will be studied with emphasis on determining possible trophic interactions of feeding types to relate benthic biomass to surface productivity. These studies will utilize grab and trawl data simultaneously to better reflect overall community interactions.

VIII. CONCLUSIONS

Gulf of Alaska

Forty-two widely dispersed permanent stations have been established 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.

Twenty-nine widely dispersed stations were established in the northwestern Gulf of Alaska in conjunction with other programs there. Substrate characteristics (e.g., compact sand, gravel, rock) of this part of the shelf of the Gulf of Alaska made it impossible to occupy all planned stations and difficult to quantitatively occupy many of the stations sampled. Further sampling with other types of gear is indicated for this region. Higher priorities elsewhere necessitated archiving all samples pending future needs.

The sampling device chosen, the van Veen grab, functioned effectively in all weather and adequately sampled the infauna at most stations in the northeastern Gulf of Alaska. Penetration was excellent in the soft sediments characteristic of the majority of stations; poor penetration occurred at a few stations where substratum was sandy or gravelly. Problems concerned with sampling in the northwest Gulf of Alaska are considered above, and are generally applicable to stations occupied in Cook Inlet.

General patchiness of many components of the fauna at the quantitative stations of all areas suggests that at least five replicate grabs be taken per station. Quantitative field testing for the optimum number of replicates per station has been accomplished. Most of the latter samples have been processed at the Marine Sorting Center, and the data is now being analyzed.

There is now a satisfactory knowledge, for grab stations, of invertebrate species (infauna and epifauna) present and general species distribution on the shelf in the northeast Gulf of Alaska study area. Four-hundred fifty-seven (457) species have been identified to date. Fourteen marine phyla are represented in the collections. The important groups, in terms of number of species in descending order, are the polychaetous annelids, molluscs, arthropod crustaceans, and echinoderms. It is probable that all species with numerical and biomass importance have been collected during the intensive sampling of the past two years 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.*, 1976a), Simpson, Brillouin, and Shannon-Wiener are complementary to each other since the former reflects dominance of a few species and the latter two are weighted in favor of rare species. Values calculated in this report, 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 is available, and further detailed assessment of the meaning of the calculated values can be made.

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 will be the organisms most intensively studied for their general biology.

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. A food web, primarily based on data collected in this study, is available for Cook Inlet.

Although all of the station data was not been available up to the time of this report and the results of the various types of cluster analysis presented have not as yet been examined in depth (Feder *et al.*, 1976a), clustering techniques have supplied us with valuable insights into species distributions on the shelf of the northeast Gulf of Alaska. Using more complete data sets, inclusive of station data from a second year of sampling, in future calculations should clarify the ecological positions of some of the stations not clustering with other stations on the shelf. 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; this analysis was still in progress at the time of this Annual Report (preliminary data and analysis are included as Appendix Table V).

Initial qualitative assessment of data printouts of infaunal species (data to be stored at the National Environmental 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 National Marine Fisheries Service trawl charter for investigation of demersal fishes and epifaunal benthos was effective and maximum spatial coverage was achieved. Integration of this information with the infaunal benthic data will enhance our understanding of the shelf ecosystem.

To date the NEGOA study represents the first intensive taxonomic study of epibenthic invertebrates in the Gulf of Alaska. Although this is not the only data base for epifaunal invertebrates of the Gulf (Hitz and Rathjen, 1965), our work does result in more thorough and more complete numerical and weight determinations. Hitz and Rathjen (1965) surveyed invertebrates and bottom fishes on the continental shelf of the northeast Gulf of Alaska in 1961 and 1962, but the 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 (Echinoidea), snow crab (*Chionoecetes bairdi*), sea stars (Asteroidea), dungeness crab (*Cancer magister*), scallop (*Pecten caurinus*), shrimps (*Pandalus borealis*, *P. platyceros*, and *Pandalopsis dispar*), King crab (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.). Additional data on commercially important shellfishes are available in Ronholt *et al.* (1976).

Preliminary analysis of 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. Further, 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. Cod, a non-commercial species which has commercial potential (Jewett, 1977), is preying intensively on a species of great commercial significance. 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). The results of these experiments must be seriously considered during development of petroleum resources in the Gulf of Alaska.

Conclusions about Cook Inlet epifauna will be available in the Final Report. Bivalve molluscs and crustaceans were the major food items of the crabs and fishes examined from Cook Inlet. Analysis of dredge data from this area will allow us to make statements about food preferences related to availability of food items.

In conclusion, it can be stated that sampling by means of grabs, trawls, and/or dredges as well as stomach analysis of demersal fishes is necessary in order to fully comprehend trophic interactions in the benthic environment in the north Pacific.

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

Bering Sea

Seventy-seven widely dispersed permanent stations and seven stations of opportunity have been established in conjunction with the chemical, hydrocarbon, heavy metals, geological, and fish food analysis programs. These stations represent a reasonable nucleus around which a monitoring program can be developed. Fifty-nine (59) stations have been processed and analyzed to date. Additional stations are currently being analyzed.

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 MB 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. Quantitative field testing for the optimum number of replicates has been completed, and analysis of the data by the end of the project period should enable us to suggest the number of replicates for a monitoring program in the Bering Sea.

There is now a satisfactory data base for the invertebrate species (infauna and epifauna) for that portion of the Bering Sea shelf grid processed to date (i.e., 59 stations). Six-hundred 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 have been collected during the intensive sampling program of the spring, summer, and early Fall of 1975. It is assumed that mainly rare species will be added to the list in the future.

No information from the R/V *Miller Freeman* and R/V *Discoverer* cruises is currently available to test for seasonal fluctuations in species by station. The continuing series of cruises of these vessels in the spring, summer, and early Fall of 1975 have made available some seasonal station data; however, limited funding for processing of all samples collected on these cruises suggests that much of this information will <u>not</u> be available for the Final Report. Some midwinter quantitative grab data is 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 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 Shannon-Wiener 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.*, 1976b). 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.*, 1976b). 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 suggests 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 initially by way of 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 and demersal fishes 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 does result in more thorough and more complete numerical and weight determinations. The invertebrate species most commonly found at the trawling stations of the *Miller Freeman* cruises of 1975 (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 was generally not deeper than 73 m (40 fathoms). Depths greater than 73 m were only sampled immediately north and northeast of Unimak Pass. Obvious differences in species representation were noted in each of these two depth areas. The list of the epifaunal invertebrate species from this Bering Sea trawl study was further expanded when the data from the 1976 trawl survey was completed.

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

Gulf of Alaska

1. Although the van Veen grab is satisfactory for the soft sediments characteristic of the shallow shelf of the northeastern portion of the Gulf of Alaska, it is not the instrument of choice for the shelf of the northwestern Gulf of Alaska. Additional sampling in the latter area is necessary a variety of sampling devices must be tested to determine the optimum device.

2. 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 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 some baseline data for some of the larger unsampled areas.

3. All samples taken on a semi-seasonal basis in the northeast Gulf of Alaska 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.

4. Selected members of the 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.

5. The advantage of the cluster analysis technique is that it provides a method for delineating station groups that can be used as a basis for developing monitoring schemes and delimiting areas that can be used for intensive 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 the projected offshore monitoring program.

6. It appears that the 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 Stephensen'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. Therefore, it is suggested that a suitable research vessel and research program ultimately be made available for such sampling needs. In addition, it should be recognized that funds must then be available to workup the samples and data from these cruises.

7. The cruises on NOAA vessels for grab-sampling and dredging, and the extensive trawl program in conjunction with the National Marine Fisheries Service resulted in relatively 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, continuation of cod stomach analyses, and a continuing analysis of food relationships for the study areas. 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, completion of Pacific cod food study to include workup of all existing cod data (1973-1975; all data available from notes of S. Jewett), and further grab-sampling, dredging, and trawl sampling on the outer Kodiak shelf.

8. 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 Cook Inlet. The substantial body of data on trophic

interactions of organisms of the benthos, collected by Feder (current report) 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

1. 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.

2. 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.

3. 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.

4. Selected members of the 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.

5. The advantage of the cluster analysis technique is that it provides a method for delineating station groups that can be used as a basis for developing monitoring schemes and delimiting areas that can be used for intensive 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, 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.

6. A closer integration with the geological program is essential to better comprehend faunal-sediment interactions. It is recommended that our studies be closely coordinated in preparation of the Final Report.

7. 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 in trawling activity are development of a monitoring plan as well as additional trawl data on a seasonal basis. Additional food data is essential.

8. The substantial body of data on trophic interaction between organisms of the benthos in the Bering Sea (Feder, current Annual Report; Smith *et al.*, 1977, current Annual Report) 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 4th QUARTER OPERATIONS

Ship or Laboratory Activities

1. Ship or field activities: No ship or field activities occurred this quarter.

2. Scientific party: Not applicable.

3. Methods and results - laboratory analysis: Identification, counts, and weights of the remaining infauna was examined at the Marine Sorting Center (see Feder *et al.*, 1976a, 1976b for methodology). Stomach analysis of miscellaneous fishes and invertebrates was made with the frequency of occurrence method. Age and growth of two species of clams was made at the Seward Marine Laboratory (see Paul and Feder, 1973; Feder and Paul, 1973 for methodology).

4. Sample localities: See sampling grids in Feder *et al.* (1976a, and 1976b).

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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* BERING SEA CRUISE - 1975

Tow Number	Station Name	Comments
1	FF02	Snail eggs found here. *Chionoecetes bairdi* - 32 males. *Chionoecetes opilio* - 69 males and 2 females. *Chionoecetes* (hybrid) - 13 males.
2	GG02	Sex ratio for *Chionoecetes* based on 100% of sample. *Chionoecetes bairdi* - 17 males. *Chionoecetes opilio* - 369 males and 1176 females.
3	GG01	*Chionoecetes opilio* - 141 males and 607 females. *Chionoecetes bairdi* - 1 male and 4 females. Snail eggs found here.
4	GG18	Snail eggs on *Neptunea* spp. All *Chionoecetes* are males.
5	HH18	*Chionoecetes opilio* - 266 males and 2262 females. *Chionoecetes* (hybrid) - 9 males.
6	HH19	*Chionoecetes opilio* - 564 males and 96 females. *Chionoecetes bairdi* - 52 males and 4 females. *Chionoecetes* (hybrid) - 13 males and 4 females.
7	II19	*Chionoecetes opilio* - 156 males and 318 females. *Chionoecetes bairdi* - 4 males and 1 female. *Chionoecetes* (hybrid) - 2 males.
8	II20	*Chionoecetes opilio* - 259 males and 1508 females. *Chionoecetes bairdi* - 3 males. *Chionoecetes* (hybrid) - 4 males.
9	JJ20	*Chionoecetes opilio* - 1067 males and 1566 females. *Chionoecetes bairdi* - 3 males and 29 females.
10	JJ21	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	KK21	*Chionoecetes opilio* - 379 males and 1082 females. *Chionoecetes* (hybrid) - 2 males.
12	LL21	*Chionoecetes opilio* - 2864 males and 3670 females. *Chionoecetes* (hybrid) - 1 male.
13	LL22	*Chionoecetes opilio* - 1747 males and 2784 females. *Chionoecetes* (hybrid) - 1 male.
14	MM22	*Chionoecetes opilio* - 1260 males and 1348 females.
15	NN22	*Chionoecetes opilio* - 1411 males and 1665 females.
16	NN23	*Chionoecetes opilio* - 215 males and 281 females.
17	OO23	*Chionoecetes opilio* - 520 males and 794 females.
18	PP23	*Chionoecetes opilio* - 300 males and 323 females.
19	QQ22	*Chionoecetes opilio* - 118 males and 217 females.
20	QQ21	*Chionoecetes opilio* - 205 males and 107 females. *Chionoecetes* (hybrid) - 1 male and 5 females.
21	QQ20	*Chionoecetes opilio* - 363 males and 215 females.
22	QQ19	*Chionoecetes opilio* - 102 males and 53 females.
29	PP20	*Chionoecetes opilio* - 506 males and 578 females. *Chionoecetes* (hybrid) - 1 male and 5 females. One piece of plastic strapping found.
30	PP21	*Chionoecetes opilio* - 175 males and 156 females. *Chionoecetes* (hybrid) - 1 male and 1 female.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
32	0022	*Chionoecetes opilio* - 993 males and 2369 females.
33	0021	*Chionoecetes opilio* - 276 males and 364 females.
34	0020	*Chionoecetes opilio* - 88 males and 38 females.
35	0019	*Chionoecetes opilio* - 57 males and 25 females.
40	0004	Trawl ripped.
49	MM04	Plastic was found in this trawl. All *Theragra chalcogramma* were juveniles.
54	NN18	*Chionoecetes opilio* - 10 males and 14 females.
55	NN19	40% of *Argis dentata* were ovigerous. *Chionoecetes opilio* - 9 males and 1 female.
56	NN20	*Chionoecetes opilio* - 603 males and 344 females. *Chionoecetes* (hybrid) - 9 males.
57	NN21	*Chionoecetes opilio* - 290 males and 300 females. *Chionoecetes* (hybrid) - 11 males and 6 females.
58	MM21	*Chionoecetes opilio* - 203 males and 122 females.
60	MM19	*Chionoecetes opilio* - 22 males and 10 females. *Chionoecetes* (hybrid) - 2 males.
61	MM18	Juvenile *Theragra chalcogramma* - 18.144 Kg.
65	LL18	*Chionoecetes opilio* - 91 males and 10 females.
66	LL19	Plastic found here. *Chionoecetes opilio* - 473 males and 755 females. *Chionoecetes* (hybrid) - 13 males and 12 females.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
67	LL20	*Chionoecetes opilio* - 607 males and 1025 females. *Chionoecetes* (hybrid) - 19 males.
68	KK20	*Chionoecetes opilio* - 280 males and 455 females.
69	KK19	*Chionoecetes opilio* - 275 males and 516 females. *Chionoecetes* (hybrid) - 6 males.
70	KK18	*Chionoecetes opilio* - 291 males and 421 females. *Chionoecetes* (hybrid) - 3 males.
71	KK01	*Chionoecetes opilio* - 105 males and 62 females.
72	JJ01	*Chionoecetes opilio* - 171 males and 195 females.
73	JJ19	*Chionoecetes opilio* - 94 males and 127 females.
74	JJ18	*Chionoecetes opilio* - 367 males and 417 females. *Chionoecetes* (hybrid) - 55 males and 18 females.
75	II18	*Chionoecetes opilio* - 372 males and 220 females. *Chionoecetes* (hybrid) - 20 males and 8 females.
76	II01	*Chionoecetes opilio* - 680 males and 290 females. *Chionoecetes* (hybrid) - 25 males and 10 females.
77	HH01	*Chionoecetes opilio* 168 males and 291 females.
78	DD07	*Chionoecetes opilio* - 34 males and 71 females. *Chionoecetes bairdi* - 82 males and 18 females. *Chionoecetes* (hybrid) - 3 males and 1 female.
79	CC06	*Chionoecetes opilio* - 11 males and 2 females. *Chionoecetes bairdi* - 37 males and 5 females. *Paralithodes camtschatica* - 32 males and 676 females.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
80	BB05	Plastic found here. *Chionoecetes bairdi* - 23 males and 1 female. *Paralithodes camtschatica* - 11 males and 12 females.
81	AA04	*Paralithodes camtschatica* - 40 males and 3 females.
83	BB33	*Chionoecetes bairdi* - 19 males and 19 females. *Chionoecetes opilio* - 8 males. *Chionoecetes* (hybrid) - 1 male and 3 females.
84	AB23	*Chionoecetes bairdi* - 33 males and 88 females. *Chionoecetes opilio* - 1 male and 2 females. *Chionoecetes* (hybrid) - 5 males and 17 females.
85	ZA12	*Chionoecetes bairdi* - 1 male and 1 female. *Chionoecetes* (hybrid) - 1 male and 3 females.
86	AA22	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	FF11	*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	HH22	*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	II33	*Chionoecetes opilio* - 115 males and 34 females. *Chionoecetes* (hybrid) - 1 male. Snail eggs - 120 g. *Styela macrenteron*, *Eunepthya rubiformis* and snail eggs were found on snail shells.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
91	II33	*Chionoecetes opilio* - 604 males and 174 females. *Chionoecetes* (hybrid) - 56 males and 29 females. Snail eggs - 430 g.
92	II44	*Chionoecetes opilio* - 758 males and 189 females. *Chionoecetes* (hybrid) - 37 males and 36 females. Snail eggs - 2.513 Kg.
93	HH44	*Chionoecetes* (hybrid) - 9 males. *Chionoecetes bairdi* - 2 females. *Chionoecetes opilio* - 100 females and 195 males. Yellow snail eggs - 34 g.
94	GG55	*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	HH55	Snail eggs - 2.118 Kg. *Chionoecetes opilio* - 234 males and 416 females. *Chionoecetes* (hybrid) - 9 males.
96	II55	Snail eggs - 1.315 Kg. *Chionoecetes opilio* - 376 males and 10 females. *Chionoecetes* (hybrid) - 17 males.
97	-	Catch not enumerated.
98	HH66	*Chionoecetes bairdi* - 2 males and 1 female. *Chionoecetes opilio* - 131 males and 8 females. *Chionoecetes* (hybrid) - 1 male. Snail eggs - 3.835 Kg.
99	-	Catch not enumerated.
100	FG67	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	DD77	# 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	DD77	# 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	DD77	# 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	DD77	# 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	DD77	# 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	DD77	# 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.

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Tow Number	Station Name	Comments
107	DD77	# 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	DD77	# 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	-	Catch not enumerated.
110	AA33	*Chionoecetes bairdi* - 30 males and 1 female. *Chionoecetes opilio* - 7 males and 1 female. *Chionoecetes* (hybrid) - 4 males and 1 female.
111	AA33	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	-	Trawl contents emptied on deck in the process of removing a sea lion, not sampled.
113	AA33	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	AA33	*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	AB23	# 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	AB23	# 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	AB23	# 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	AB23	# 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	AB23	# 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	FF33	*Chionoecetes bairdi* - 3 males and 2 females. *Chionoecetes opilio* - 39 males and 7 females. *Chionoecetes* (hybrid) - 12 males and 1 female.
121	GG33	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	ZZ33	# comparative trawl 1. Snail eggs - 157 g.
123	ZZ33	# comparative trawl 2. *Argis ovifer* - 2 gravid females - eggs turquoise-green.
124	AZ23	Comments based on 100% of sample. *Chionoecetes bairdi* - 8 males and 5 females. *Chionoecetes* (hybrid) - 1 male and 6 females.
125	AZ34	*Chionoecetes bairdi* - 15 males and 34 females. *Chionoecetes opilio* - 4 males and 3 females. *Chionoecetes* (hybrid) - 2 males and 43 females.
126	AZ45	# comparative trawl 1. *Chionoecetes bairdi* - 337 males and 251 females. *Chionoecetes* (hybrid) - 8 males and 48 females.
127	AZ45	# comparative trawl 2. Snail eggs - 55 g. *Chionoecetes bairdi* - 35 males and 16 females. Comments based on 100% of sample.
128	AZ45	# 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	AZ45	# 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	AZ45	# 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	ZZ55	# 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	-	# comparative trawl 2. Catch not enumerated. Trawl ripped.
133	ZZ55	# comparative trawl 1. *Chionoecetes bairdi* - 114 males and 7 females. *Chionoecetes opilio* - 1 male. *Paralithodes camtschatica* - 5 males and 18 females.
134	ZZ55	# 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	DD66	*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	DE67	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	EE66	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	EF56	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	-	Catch no enumerated.
140	GG77	*Chionoecetes bairdi* - 68 males and 94 females. *Chionoecetes opilio* - 894 males and 743 females. *Chionoecetes* (hybrid) - 8 females. Snail eggs - 714 g.
141	GG88	Snail eggs - 726 g. *Chionoecetes bairdi* - 57 males and 81 females. *Chionoecetes opilio* - 570 males and 29 females. *Chionoecetes* (hybrid) - 24 males.
142	GH89	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	GG99	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	* Grid 9-10. 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	FF10	* Grid 10. 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

CONTINUED

Tow Number	Station Name	Comments
146	EF11-10	* Grid 11-10. 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	AZ56	*Chionoecetes bairdi* - 35 males and 70 females. *Chionoecetes opilio* - 2 males. *Paralithodes camtschatica* - 3 males and 1 female.
148	AA55	Snail eggs - 96 g. *Chionoecetes bairdi* - 151 males and 7 females. *Chionoecetes opilio* - 1 male. *Paralithodes camtschatica* - 27 males and 80 females.
149	BA45	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	BB44	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	AB34	*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	ZZ44	# 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

CONTINUED

Tow Number	Station Name	Comments
153	ZZ44	# comparative trawl 2. *Chionoecetes bairdi* - 18 males and 14 females. *Chionoecetes* (hybrid) - 1 female. *Chionoecetes opilio* - 4 females. Pollutants - glass, rope and plastic.
154	HH33	*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	GG44	*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	FF44	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	FF55	*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	II77	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

CONTINUED

Tow Number	Station Name	Comments
159	HH77	Empty shell 103.7 Kg. *Chionoecetes opilio* - 162 males and 1 female. *Chionoecetes bairdi* - 3 males and 4 females. *Chionoecetes* (hybrid) - 28 males.
160	HH88	*Chionoecetes opilio* - not sexed. *Chionoecetes bairdi* - 9 males and 9 females. *Chionoecetes* (hybrid) - 1 female. Empty shell - 26.7 Kg.
161	HH99	Calculated to 100% of sample. *Chionoecetes bairdi* - 799 males and 43 females. *Chionoecetes opilio* - 6 males. *Chionoecetes* (hybrid) - 2 males.
162	IH9-10	* Grid 9-10. 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	II12	* Grid 12. *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	* Grid 12-13. *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	JJ13	* Grid 13. *Hyas coarctatus alutaceus* - 1 male. *Paralithodes camtschatica* - 4 males and 7 females. Juvenile *Theragra chalcogramma* weight - 3.628 Kg.
166	JK13-14	* Grid 13-14. *Paralithodes camtschatica* - 6 females. *Pandalus coniurus* - 80 gravid, eggs aqua colored.
167	KK14	* Grid 14.
168	KK13	* Grid 13. Trawl ripped, specimens were not enumerated.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
169	JK12-13	* Grid 12-13. Empty shells - 5.79 Kg. Snail eggs - 454 g. *Paralithodes camtschatica* - 1 male and 4 females. *Telmessus cheiragonus* - 2 males.
170	JJ12	* Grid 12. *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	* Grid 11-12. 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	JJ11	* Grid 11. *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	* Grid 11-12. *Paralithodes camtschatica* - 8 males and 7 females, 6 gravid with eggs black colored. *Pandalus goniurus* - 20 gravid, eggs aqua colored. Snail eggs present.
174	KK12	* Grid 12. *Balanus* sp. and type 19 sea anemone attached to *Mytilus edulis. Telmessus cheiragonus* - 7 males and 1 female. *Paralithodes camtschatica* - 1 female.
175	JJ10	* Grid 10. *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

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Tow Number	Station Name	Comments
176	JK10-11	* Grid 10-11. 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	KK11	* Grid 11. Trawl ripped extensively, specimens were not enumerated.
178	KK11	* Grid 11. Trawl ripped extensively, a few interesting specimens collected, otherwise none were enumerated.
179	KK10	* Grid 10. *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	KK99	*Balanus* sp. attached to *Neptunea* shells. *Paralithodes camtschatica* - 7 males. *Telmessus cheiragonus* - 3 males. *Hyas coarctatus alutaceus* - 2 males and 1 female.
184	LL66	*Telmessus cheiragonus* - 2 males. Snail eggs - 1.31 Kg.
185	LL55	*Paralithodes camschatica* - 1 male.
187	QQ11	*Balanus* sp. attached to *Neptunea* shells.
188	LL22	*Erimacrus isenbeckii* - 4 males and 1 female. *Hyas lyratus* - 4 males. Juvenile *Theragra chalcogramma* weight - 33.240 Kg.
189	KK22	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	JJ22	Empty shells - 73.7 Kg.

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Tow Number	Station Name	Comments
191	LL33	*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	KK33	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	JJ33	Empty shell - 79.6 Kg. *Chionoecetes opilio* - 476 males and 34 females. *Chionoecetes* (hybrid) - 18 males and 10 females.
194	JJ44	Juvenile *Theragra chalcogramma* weight - 14.379 Kg.
195	KK44	*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	JJ55	*Argis dentata* - 10 gravid, eggs aqua colored.
197	KK55	*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	KK66	*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

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Tow Number	Station Name	Comments
199	KK77	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	KK88	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	JJ66	*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	JJ77	*Hyas coarctatus alutaceus* - 20 males and 1 female. *Balanus* sp., snail eggs, and bryozoan attached to *Neptunea* shells.
203	JJ88	*Balanus* sp., snail eggs, and *Styela macrenteron* attached to *Neptunea* shells. Empty shells - 6.2 Kg.
204	JJ99	*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	II99	*Paralithodes camtschatica* - 13 males and 3 females. 277.6 Kg of peat.
206	II88	*Paralithodes camtschatica* - 5 males. *Hyas coarctatus alutaceus* - 13 males and 1 female. *Chionoecetes bairdi* - 4 males and 1 female.
207	DE11-12	* Grid 11-12. *Paralithodes camtschatica* - 7 females. *Chionoecetes* - 4 males and 1 female.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
208	EE12	* Grid 12. 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	GG12	* Grid 12. *Erimacrus isenbeckii* - 4 males. *Paralithodes camtschatica* - 57 males and 34 females. *Chionoecetes bairdi* - 14 males and 8 females.
210	GH12-13	* Grid 12-13. *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	GG13	* Grid 13. *Paralithodes camtschatica* - 6 males and 63 females. *Chionoecetes bairdi* - 17 males and 2 females.
212	FF13	* Grid 13.
213	EE13	* Grid 13. Sponge attached to kelp hold-fast, 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. *Podo-desmus macrochisma* apparently settled in the upper portion of a *Neptunea* shell occupied by *Pagurus kennerlyi*.
214	FF14	* Grid 14. Trawl ripped, no specimens enumerated.
215	GG14	* Grid 14. *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	GG15	* Grid 15. 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	* Grid 11-12. 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	GG10	* Grid 10. *Chionoecetes bairdi* - not sexed.
219	FF99	*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* BERING SEA CRUISE - 1976

Tow Number	Station Name	Comments
1	Z05-1	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	Z05-2	*Paralithodes camtschatica*: 21 males, 46.3 kg. *Chionoecetes bairdi*: 1 male. *Erimacrus isenbeckii*: 3 males.
3	Z05-3	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	Z04-1	Encrusting sponges weighed with rock attached. Pollock: 6244 kg. *Chionoecetes bairdi*: 7 males, 0.64 kg; 14 females, 0.74 kg.
5	Z04-2	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	B07	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	B08	*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	Z02-2	Pollutants: 1-25 cm diameter metal bowl.
13	Z02-3	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

CONTINUED

Tow Number	Station Name	Comments
14	Z02-4	*Chionoecetes bairdi*: 3 males and 69 females. *C. opilio*: 1 male.
15	ZA23	Pollutants: 1 glove, 1-4.2 ℓ paint can. *Chionoecetes bairdi*: 14 males and 7 females. *C. opilio*: 1 male.
16	A03	*Chionoecetes bairdi*: 30 males and 4 females. *C. opilio*: 13 males. *C.* (hydrid): 3 males.
17	AB34	Pollutants: 0.454 g cottom webbing.
19	BC45	*Carcinobdella* sp. noted on ventral side of *Myoxocephalus* sp. and *Gadus macrocephalus*.
20	C05	Pollutants: 1 glass float. Yellowfin sole: 3190 kg.
24	DE34	Pollutants: 50 g plastic with leech egg cases attached. Juvenile pollock: 726 g.
28	BC12	Pollutants: 15 cm braided rope.
29	B01	Pollock weight 2452 kg.
30	A/B 18/1-1	Pollutants: 1 tin can.
31	A/B 18/1-2	Pollutants: 1 soda can, 1-1.5 ℓ glass bottle.
32	A/B 18/1-3	Pollutants: 1-20 ℓ glass jar, green plastic fragments.
33	A/B 18/1-4	Pollutants: 1 Asahi beer can.
35	C019-1	Pollutants: 1 tin can, 1 graduated sea water cylinder, 1-10 ℓ glass bottom (brown).
36	C019-2	Pollutants: 10 tin cans and soda cans.
37	C019-3	Pollutants: Piece of wire, 1 soda can.
38	C019-4	Pollutants: 1 bundle of wood stakes.
39	C019-5	Pollutants: 2 glass bottles - 1 ℓ and 1.5 ℓ.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
41	D018	Pollutant: Metal fragment
42	D/C 18/1	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	E/F 19/18	Juvenile pollock: 62 kg.
46	Z04-3	1 parasitized *Pandalus borealis*.
47	Z04-4	Pollock weight 8165 kg.
49	A05	Juvenile pollock: 0.050 kg.
50	AB56	Juvenile pollock: 2.59 kg.
51	B06	Neptunea shells covered with *Balanus* sp. 3 polynoidae in 3 *Pagurus capillatus* shells. Pollutants: 1 old crab pot. Rock sole: 3124 kg.
52	BC67	Two *Pagurus capillatus* parasitized by barnacle. Rock sole: 3748 kg. Juvenile pollock: 9.23 kg.
53	BC67	Non-standard tow. Invertebrates not enumerated.
54	C07	Trawl could not withstand the approximately 13,620 kg load of fish. Cod end of net broke. Station to be retrawled.
55	C07	Pollutants: 1-1800 ml glass bottle. Trawl could not withstand fish load, cod end broke. Approx. 22,700 kg.
56	D08	27 out of 66 *Pagurus capillatus* with polynoidae present within shell, 9 with parasitic barnacle attached to abdomen.
58	E/F 23/24	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	E/F 21/22	Pollutants: 1 can mandarin oranges with Japanese writing on label.
65	D/E 20/21	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	E/F 19/20	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	F/G 21/20	Hermit crabs weighed with shells.
72	G19	Juvenile pollock 10.4 kg.
73	F/G 19/18	Pollutants: 1 piece of string 15.2 cm long. Juvenile pollock: 11.8 kg.
74	F/G 19/20	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	E/F 24/25-2	Pollutants: cardboard with Japanese writing (60 x 60 cm).
81	F/G 24/23	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	G/H 25/26	Juvenile pollock: 70 kg.
86	F/G 27/26-1	Pollutants: 2 tin cans and 1 glove.
87	F/G 27/26-2	Pollutants: 1 pop bottle with Japanese labelling.
92	I27-2	Net snagged 3 minutes before 1/2 hour.
93	I27-3	Net torn, bad bottom.
94	I27-4	Net torn, bad bottom.
95	K/L 28/27-1	Pollutants: 1-10 oz. tomato juice can. Distance fished set equal to average distance fished for 11 randomly selected stations.
96	K/L 28/27-2	Pollutants: 1 Japanese coke can.
100	I24	Pollutants: Cotton cloth - no markings - 33 g.
101	F20-2	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 camschatica*: 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	MB04	*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	MB09	*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.

APPENDIX III

BERING SEA - *MILLER FREEMAN* CRUISE LEG III - 1976 STOMACH CONTENTS OF FISH AND INVERTEBRATES

R = radius in millimeters;
L = crab length in millimeters;
W = crab width in millimeters;
SL = standard length in millimeters;
HL = head length in millimeters.

Station MB-13 (20 May 1976)

Paralithodes camtschatica: All male animals.

a) L = 140, unidentified small crab, crab eggs (?), brittle star arm, great amount soft parts. Stomach full.

b) L = 140, empty

c) L = 130, empty

d) L = 163, empty

e) no measurement, full stomach; brittle star, fragment large *Neptunea*, soft parts (unidentified).

f) L = 140, stomach full; unidentified soft parts.

g) L = 145, stomach full; unidentified soft parts, snail operculum; brittle star arms and other fragments, shell fragments.

Summary: 7 stomachs; 3 empty - 4 full; feeding on brittle stars and snails.

Gadus macrocephalus:

a) SL = 470 mm, HL = 122 mm, 4 small *Chionoecetes*, full.

b) SL = 510 mm, HL = 135 mm, crab legs, fish skeletal parts.

c) SL = 470 mm, HL = 130 mm, 2 pinnotherid crabs, 1 large pollock, unidentified fish skeleton.

d) SL = 530 mm, HL = 163 mm, unidentified fish bones.

e) SL = 470 mm, HL = 135 mm, unidentified fish remains, euphausids (?) unidentified crab.

Summary: 5 stomachs; feeding on crabs and fish.

Hippoglossoides: 4 large animals with empty stomach.

Lepidopsetta bilineata: (rock sole).

a) SL = 430 mm, HL = 100 mm, stomach empty.

Myoxocephalus polyacanthocephalus:

a) SL = 315 mm, HL = 135 mm, small amount of crab legs.

Renhardtius hippoglossoides: (Greenland halibut).

a) SL = 305 mm, HL = 135 mm, empty.

b) SL = 290 mm, HL = 65 mm, empty.

c) SL = 305 mm, HL = 70 mm, empty.

d) SL = 310 mm, HL = 78 mm, empty.

e) SL = 280 mm, HL = 65 mm, empty.

Summary: 5 fish; all empty.

Pleuronectes quadrituberculatus: (Alaska plaice).

a) SL = 245 mm, HL = 75 mm, empty.

b) SL = 245 mm, HL = 70 mm, many polychaetes, 1 small clam.

c) SL = 285 mm, HL = 85 mm, 1 annelid like fragment, 2 amphipods, a few *Cerebratulus*-like nemerteans.

Glyptocephalus zachirus: (rex sole).

a) SL = 325 mm, HL = 55 mm, full; amphipods, leech (?), 1 large nemertean.

b) SL = 284 mm, HL = 52 mm, many polychaetes, many amphipods.

c) SL = 243 mm, HL = 44 mm, 1 polychaete, a few amphipods.

Raja stellulata:

a) TL = 450 mm, stomach full; amphipods, crangonids.

Station MB-9 (22 May 1976)

Asterias amurensis:

a) R = 150 mm, sand dollar.

b) R = 170 mm, sponge, jelly fish.

c) R = 125 mm, *Spisula* siphon, sponge.

d) R = 110 mm, *Pandalus goniurus*.

e) R = 95 mm, sand dollar.

f) R = 175 mm, 3 *Crangon dalli*.

g) R = 115 mm, unidentified clam.

h) R = 170 mm, *Pandalus goniurus*.

i) R = 90 mm, acorn barnacle.

j) R = 133 mm, *Pandalus goniurus*, barnacle.

k) R = 45 mm, sponge.

l) R = 75 mm, worm tube.

m) R = 160 mm, *Pandalus goniurus* with eggs, barnacle.

n) R = 100 mm, intact, closed *Spisula* (R = 24 mm) in oral area.

o) R = 174 mm, sponge, *Pandalus goniurus, Pagurus ochotensis*.

p) R = 115 mm, *Pandalus goniurus* with eggs.

q) R = 140 mm, a well digested female *Oregonia*.

r) R = 153 mm, *Crangon dalli*.

s) R = 125 mm, *Pandalus goniurus*, jelly fish.

Summary: 19 stomachs; major food: *Pandalus goniurus*, clams, sponge.

Station MB-22 (23 May 1976)

Asterias amurensis:

a) R = 145 mm, sand dollar fragments.

b) R = 135 mm, sand dollar.

c) R = 140 mm, sand dollar fragments.

d) R = 150 mm, 2 mysids.

Summary: 4 stomachs; sand dollars and mysids.

Note: Large, partially digested clams are coming in trawl, along with many sea stars in clam feeding posture.

Paralithodes camtschatica:

a) L = 110 mm, dark green-brown unidentified fragments.

b) L = 127 mm, same as above and shell fragments.

c) L = 115 mm, snailshell fragments, unidentified soft parts.

d) L = 110 mm, snailshell fragments, snail operculum, crab legs.

e) L = 105 mm, large soft mass; crustacean skeletal fragments.

f) L = 95 mm, soft parts, shell fragments.

Summary: 6 stomachs; feeding on snails and crustaceans.

Station MB-10 (23 May 1976)

Paralithodes camtschatica:

a) L = 155 mm, unidentified debris.

b) L = 133 mm, debris, clam fragments.

c) L = 145 mm, brittle star disc and arms, *Macoma* shell fragments, *Cyclocardia* shell fragments, soft debris.

d) L = 145 mm, soft debris, *Macoma* shells, *Cyclocardia* shell fragments.

e) L = 148 mm, soft debris, *Cyclocardia* fragments, *Macoma* fragments.

f) L = 165 mm, considerable amount of sand, fecal pellets (clam ?), soft debris, and *Macoma* fragments.

g) L = 50 mm, much soft brown debris.

h) L = 150 mm, small amount soft brown debris.

i) L = 150 mm, much soft debris, soft parts; clam fragments.

j) L = 144 mm, small amount soft debris.

k) L = 145 mm, small amount soft debris, clam fragments.

l) L = 140 mm, pink soft parts, clam shell fragments.

m) L = 158 mm, empty.

Summary: 13 stomachs; main food *Macoma*; *Cyclocardia*.

Note: All crabs relatively soft. *Cyclocardia* and *Macoma* common in pipe dredge.

Station MB-19 (24 May 1976)

Paralithodes camtschatica:

a) L = 119 mm, brown fluid and a few tissue fragments.

b) L = 134 mm, decapod skeletal fragments, eggs, soft parts.

c) L = 106 mm, sand, clam shell (*Cyclocardia* ?) fragments.

d) L =89.9 mm, *Cyclocardia* fragments.

e) L =95.6 mm, snail (*Solariella* ?), 4 opercula, crustacean legs, eggs, soft parts, clam fragments.

f) L = 123 mm, unidentified skeletal parts.

g) L =89.1 mm, *Cyclocardia* shell fragments.

Summary: 7 stomachs; main food: *Cyclocardia* and crustaceans.

Station MB-16 (25 May 1976)

Gadus macrocephalus:

a) SL = 550 mm, HL = 145 mm, full; pink shrimp, amphipods, unidentified fish skeleton.

b) SL = 585 mm, HL = 150 mm, full; *Pandalus borealis*, unidentified fish skeleton.

c) SL = 550 mm, HL = 113 mm, full; several pink shrimp, unidentified fish skeleton.

d) SL = 640 mm, HL = 160 mm, full; saved - not examined.

e) SL = 520 mm, HL = 158 mm, partially full; a few pink shrimp.

f) SL = 510 mm, HL = 145 mm, partially full; several pink shrimp.

g) SL = 600 mm, HL = 155 mm, partially full; some pink shrimp, unidentified fish bones.

h) SL = 450 mm, HL = 118 mm, 3/4 full; pink shrimp, unidentified small fish, large red amphipods, small amphipods.

*i) SL = 614 mm, HL = 116 mm, fish bones, many pink shrimp.

*j) SL = 560 mm, HL = 174 mm, amphipods, pink shrimp.

*k) SL = 600 mm, HL = 162 mm, 2 small fishes, 3 pink shrimp.

l) SL = 550 mm, HL = 152 mm, full; whole female tanner crab, 3 pink shrimp, 15 amphipods.

m) SL = 570 mm, HL = 154 mm, full; 1 large unidentified fish.

n) SL = 580 mm, HL = 150 mm, fish bones, 2 pink shrimp.

o) SL = 550 mm, HL = 130 mm, 3 pink shrimp, unidentified fish bones.

p) SL = 540 mm, HL = 140 mm, small snails (same as king crab feeding on) pink shrimp.

Summary: 16 stomachs; main food: *Pandalus borealis* and fish.

Note: One of the stomachs marked *, contained cephalopod beaks.

Hippoglossus stenolepis:

a) SL = 510 mm, HL = 123 mm, empty.

b) SL = 725 mm, HL = 165 mm, full of fish (saved).

c) SL = 930 mm, 1 large pollock filling stomach.

<u>Station MB-69</u> (27 May 1976)

Chionoecetes opilio:

a) W = 111 mm, *Ophiura* disc and arm plates, polychaete fragments.

b) W = 121 mm, *Ophiura* skeletal fragments, polychaete fragments.

c) W = 120 mm, empty.

d) W = 116 mm, full; hermit crab, chelipeds and skeleton, soft parts, and a few clam fragments.

e) W = 118 mm, large amount unidentified soft parts, decapod appendages.

f) W = 118 mm, empty.

g) W = 113 mm, large polynoid polychaete, ophiuroid arm fragments, shell fragments.

h) W = 112 mm, empty.

i) W = 115 mm, *Cyclocardia* (?) fragments, brittle stars, polychaete fragments.

j) W = 120 mm, empty.

k) W = 118 mm, many *Ophiura* arm plates, tube dwelling polychaete with tube.

l) W = 109 mm, empty.

m) W = 122 mm, empty.

n) W = 122 mm, polychaete soft parts, many setae.

o) W = 114 mm, large mass of ophiuroid plates, large polychaete fragments.

p) W = 115 mm, large amount *Ophiura* arm plates, many setae, few clam shell fragments.

q) W = 111 mm, debris, many setae and soft parts, some shell fragments.

r) W = 115 mm, unidentified fish vertebrae, large and small amphipods, skeletal fragments.

s) W = 115 mm, ophiuroid fragment, amphipod parts, many setae.

t) W = 120 mm, *Ophiura*, arm plates, amphipod skeletal fragments, snail shell fragments, small amphipods, many setae, unidentified fish vertebrae.

u) W = 116 mm, many setae and polychaete fragments, thin clam fragments, much debris, few *Ophiura* arm plates.

v) W = 113 mm, few large pieces of soft parts, fish bones, debris, setae.

w) W = 114 mm, empty.

Summary: 23 stomachs; main food: ophiuroids and polychaetes.

Gadus macrocephalus:

a) SL = 630 mm, full; sculpin, large unidentified fish, pink shrimp.

b) SL = 464 mm, HL = 136 mm, full; *Pagurus trigonocheirus*, soft parts, not long legged arthropod (possible pycnogonid - see Station MB-86B).

c) SL = 470 mm, HL = 130 mm, part full; 1 medium size recently molted snow crab.

Summary: 3 stomachs.

Station MB-86B (27 May 1976)

Cyclopteridae: (snail fish).

a) SL = 368 mm, small *Dasycottus*, *Ophiura*, pandalid shrimp, *Chionoecetes opilio*.

Gadus macrocephalus:

a) SL = 260 mm, HL = 85 mm, 1 small pollock.

b) SL = 302 mm, HL = 81 mm, 1 small pollock, 1 *Pandalus borealis*, large amphipod.

c) SL = 275 mm, HL = 69 mm, polychaete.

d) SL = 270 mm, HL = 73 mm, 2 small pollock.

e) SL = 258 mm, HL = 70 mm, 1 small pollock.

f) SL = 269 mm, HL = 65 mm, 1 *Pandalus*, unidentified fish remains.

Summary: 6 stomachs; main food: pollock.

Hemilepidotus papilio: (cottid).

a) SL = 240 mm, HL = 80 mm, 1 small pollock, *Crangon* remains.

b) SL = 232 mm, HL = 68 mm, unidentified fish remains (maybe 2).

c) SL = 200 mm, HL = 68 mm, 20 caprellid amphipods, 4 gammarid amphipods, 6 isopods, unidentified remains.

d) SL = 250 mm, HL = 50 mm, 1 small pollock, crab remains.

e) SL = 230 mm, HL = 45 mm, 1 squid, 2 brittle stars.

f) SL = 180 mm, HL = 55 mm, 2 caprellids, 1 unidentified fish, 1 polychaete, 2 unidentified decapods.

g) SL = 268 mm, HL = 55 mm, 1 large polychaete.

h) SL = 225 mm, HL = 68 mm, empty.

i) SL = 242 mm, HL = 85 mm, 1 small amphipod, unidentified pink mass.

Summary: 9 stomachs; important food items: amphipods, polychaetes.

Station MB-46 (28 May 1976)

Platichthys stellatus:

a) SL = 432 mm, HL = 120 mm, empty.

Limanda aspera:

a) SL = 244 mm, HL = 59 mm, empty.

b) SL = 260 mm, HL = 70 mm, empty.

c) SL = 252 mm, HL = 62 mm, empty.

d) SL = 236 mm, HL = 60 mm, empty.

Pleuronectes quadrituberculatus:

a) SL = 254 mm, HL = 79 mm, empty.

b) SL = 248 mm, HL = 62 mm, empty.

c) SL = 230 mm, HL = 56 mm, empty.

Summary: 1 Starry flounder, 4 yellowfin, 3 Alaska plaice: all stomachs empty.

Station MB-37 (29 May 1976)

Asterias amurensis:

a) R = 105 mm, few fin rays, fish skull bones and associated soft parts.

b) R = 88 mm, snow crab carapace fragment.

c) R = 70 mm, encrusting Bryozoa fragment (specimen collected, trawl material, check notes).

d) R = 115 mm, encrusting Bryozoa fragment.

e) R = 108 mm, encrusting Bryozoa fragment.

f) R = 97 mm, 2 fish parasites (copepod-gill type with eggs).

g) R = 105 mm, fragments of encrusting Bryozoa, polychaete worm and tube.

h) R = 60 mm, Bryozoa fragments as above.

i) R = 90 mm, 2 fish operculum bones.

j) R = 72 mm, encrusting Bryozoa fragments.

k) R = 105 mm, Bryozoa fragments, unidentified black soft parts, fish skull bones.

l) R = 110 mm, unidentified soft parts and parasite copepods (gill type with eggs - as above).

Summary: 12 animals; main food: Bryozoa.

Pteraster:

a) R = 45 mm, sandy worm tube inside stomach.

Myoxocephalus:

a) SL = 450 mm, HL = 172 mm, 1 large gammarid amphipod.

b) SL = 320 mm, HL = 124 mm, empty.

c) SL = 398 mm, HL = 150 mm, 2 unidentified fish, crab remains.

Station MB-28 (31 May 1976)

Leptasterias polaris ascervata:

a) R = 110 mm, cockles up to 10 mm.

b) R = 135 mm, cockles up to 10 mm.

c) R = 130 mm, cockle.

d) R = 118 mm, cockle.

e) R = 95 mm, cockle.

f) R = 84 mm, cockle.

g) R = 120 mm, 2 cockle - humped up with cockle in oral area.

h) R = 110 mm, cockle - humped up with cockle in oral area.

i) R = 115 mm, cockle - humped up with cockle in oral area.

j) R = 150 mm, cockle stomach still inverted between valves.

k) R = 138 mm, cockle.

l) R = 140 mm, cockle.

Summary: 12 animals, all feeding on cockles.

Asterias amurensis:

a) R = 90 mm, cockle.

b) R = 95 mm, cockle.

c) R = 96 mm, cockle.

d) R = 110 mm, cockle.

e) R = 85 mm, cockle.

f) R = 100 mm, cockle.

Summary: 6 animals; all feeding on cockles.

Myoxocephalus jaok:

a) 1 stomach examined, sculpin.

Myoxocephalus polyacanthocephalus:

a) 1 stomach examined, capelin, female snowcrab with orange eggs.

Limanda aspera:

a) 10 individuals with empty stomachs.

Pleuronectes quadrituberculatus:

a) 5 individuals with empty stomachs.

Chionoecetes opilio:

a) 1 examined superficially; miscellaneous soft parts.

Station MB-18A (31 May 1976)

Paralithodes camtschatica:

a) L = 150 mm, 1/2 full; cockles, brittle star, unidentified clam, polychaete setae, *Cyclocardia* ?, some debris.

b) L = 157 mm, full; cockle, brittle star, *Lebidochirus splendescens*, snail fragments.

c) L = 150 mm, 1/2 full; cockles, brittle stars (including whole discs).

d) L = 164 mm, <1/2 full; cockles, brittle stars.

e) L = 155 mm, <1/2 full; cockles, whole brittle stars.

f) L = 155 mm, full; cockles, polychaetes, 6 brittle stars.

g) L = 150 mm, full; *Solariella* opercle and soft parts, cockle fragments, brittle star arms.

h) L = 162 mm, empty.

i) L = 158 mm, <1/2 full; cockle and brittle star fragments, *Solariella operculum*.

j) L = 160 mm, 1/2 full; cockle, *Solariella*.

k) L = 150 mm, <1/2 full; *Solariella*, cockle, unidentified clam.

l) L = 160 mm, 1/2 full; cockle and unidentified shell.

m) L = 175 mm, <1/2 full; cockles, *Solariella*, brittle stars.

n) L = 140 mm, 1/2 full; brittle stars, cockles, *Solariella*.

o) L = 153 mm, 1/2 full; brittle stars, cockles, *Solariella*.

p) L = 155 mm, empty.

q) L = 154 mm, 1/2 full; cockles, *Solariella*, brittle stars.

r) L = 163 mm, 1/2 full; cockles, *Solariella*, brittle stars.

s) L = 140 mm, full; cockles, *Solariella*, brittle stars.

t) L = 147 mm, <1/2 full; cockles, *Solariella*, brittle stars.

u) L = 160 mm, empty.

v) L = 150 mm, empty.

w) L = 150 mm, empty.

Summary: 23 stomachs; main food: cockles, brittle stars, *Solariella*, polychaetes.

Myoxocephalus:

a) SL = 2 feet, 3 snowcrabs.

APPENDIX TABLE IV

STOMACH CONTENTS OF SELECTED EPIFAUNAL INVERTEBRATES AND FISHES FROM COOK INLET, CRUISE OF NOAA SHIP *MILLER FREEMAN* OF OCTOBER 1976 (sizes of fishes are all total length in cm; sizes for king crab are all standard king crab lengths in cm; NS=not sexed, M=male, F=female, and U=unknown)

Station	Species/Size	Sex	Stomach Contents
Station 8			
17/10/76	*Theragra chalcogramma* 14.0 cm	NS	4 Crangonidae
	Lipidopsetta bilineata 26 specimens examined		
	13 = 18.3 to 22.5 cm	NS	All empty
	2 specimens	NS	Unid. Crustacea
	11 specimens	NS	Amphipoda
	Bathymaster sp. 12 specimens	NS	All empty
	1 specimen	NS	1 small anemone
	1 specimen	NS	1 small *Chionoecetes bairdi*
	Atheresthes stomias 5 animals	NS	All empty
	Gadus macrocephalus 55 cm	F	1 *C. bairdi*, Crangonidae, 1 unid. bivalve
	54 cm	M	Many Crangonidae, 3 *C. bairdi*, 1 Polychaeta, 1 Isopoda, unid. fish
	74 cm	F	Many Crangonidae, *C. bairdi*
	55 cm	M	4 *Pandalus borealis*, unid. fish, 1 *C. bairdi*
	61 cm	M	Many Crangonidae, 1 *C. bairdi*, 2 Amphipoda, unid. fish, 1 poacher, 1 Paguridae, 1 *Nuculana*

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	61 cm	M	10 *C. bairdi*, Crangonidae
	29 cm	F	Crangonidae, *Pandalus borealis*
	68 cm	F	Crangonidae, 10 *C. bairdi*
	66 cm	F	2 *C. bairdi*, *Pandalus borealis*
	Myoxocephalus 3 stomachs	NS	*C. bairdi*, *Hyas*
	Paralithodes camtschatica 15.8 cm	M	Empty
Station 7 10/18/76	*Bathymaster* 24.6 cm	NS	Empty
	27.0 cm	NS	Empty
	24.3 cm	NS	Empty
	26.0 cm	NS	Empty
	17.5 cm	NS	Empty
	300 cm	NS	Unid. Crustacea
	245 cm	NS	1 Crangonidae
	Theragra chalcogramma 23.0 cm	NS	1 *Pandalus borealis*
	23.5 cm	NS	1 *Pandalus borealis*
	21.0 cm	NS	Unid. Crustacea
	23.0 cm	NS	2 *Pandalus borealis*
	23.0 cm	NS	Unid. Crustacea
	19.4 cm	NS	Several unid. Crustacea
	19.0 cm	NS	Several unid. Crustacea

APPENDIX TABLE IV

CONTINUED

Station	Species/Si	Sex	Stomach Contents
	56.0 cm	NS	Empty
	41.4 cm	NS	Empty
	42.4 cm	NS	Empty
	47.0 cm	NS	Empty
	31.0 cm	NS	Empty
	22.0 cm	NS	Empty
	10.1 cm	NS	Empty
	18.0 cm	NS	Empty
	10.1 cm	NS	Empty
	Gadus macrocephalus 77 cm	M	Empty
	59 cm	F	1 scallop, 6 *C. bairdi*, 2 Crangonidae
	61 cm	F	*Natica* egg collar, 3 rocks, 5 *C. bairdi*, 1 *Crangon*
	50 cm	F	14 *C. bairdi*, bristle worms
	45 cm	F	Few Crangonidae, 3 *C. bairdi*
	48 cm	F	Many *C. bairdi*, Crangonidae
	65 cm	F	4 Crangonidae, 18 *C. bairdi*
	30 cm	F	Bristle worm, gray shrimp, *C. bairdi*
	26 cm	F	Amphipoda, 2 *Crangon*
	29 cm	F	5 *Crangon*, 1 *C. bairdi*
	46 cm	M	5 *C. bairdi*, 2 *Crangon*, 1 bristle worm
	64 cm	M	Unid. fish

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	Atheresthes stomias 14 specimens	NS	All empty
	Rex sole 6 specimens	NS	All empty
	Lepidopsetta bilineata 9 specimens	NS	All empty
	Agonūs sp. 22.1 cm	NS	Amphipoda
	6 specimens	NS	All empty
	Sculpins 41 cm	NS	2 *C. bairdi*
	45 cm	NS	2 *C. bairdi*
	42 cm	NS	2 *C. bairdi*
Station 14 10/19/76	*Myoxocephalus* 60 cm	NS	1 female *C. bairdi* with eggs; width=95 mm
	54 cm	NS	Empty
	48 cm	NS	*C. bairdi*
	40 cm	NS	Empty
	40 cm	NS	3 *C. bairdi*
	Gadus macrocephalus 73 cm	F	*C. bairdi*, unid. fish
	55 cm	M	12 *C. bairdi* (12-32 mm carapace width) few *Anonyx*
	61 cm	M	2 *Pandalus borealis*, unid. fish
	50 cm	M	Crangonidae, *C. bairdi*
	31 cm	F	*C. bairdi*

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	29 cm	M	Polychaeta, Crangonidae
	29 cm	F	Crangonidae
	27 cm	F	Crangonidae
	31 cm	F	Crangonidae
	31 cm	F	Unid. fish, Crangonidae, Isopoda
	32 cm	M	Empty
	25 cm	U	Crangonidae
	45 cm	M	3 *C. bairdi*, 2 Crangon-idae
	44 cm	F	1 *Hyas*, 6 *C. bairdi*
	30 cm	F	*C. bairdi*, Crangonidae
	45 cm	F	*C. bairdi*
	34 cm	F	Crangonidae, *Echiurus*, *C. bairdi*
	30 cm	M	*C. bairdi*
	30 cm	M	Crangonidae
	Hippoglossus stenolepis 70 cm	NS	*Octopus*
Station 54 10/20/76	*Hippoglossus stenolepis* 85 cm	NS	Unid. fish
	76 cm	NS	Unid. fish
	44 cm	NS	Crangonidae, 4 *Chionoe-cetes bairdi*, 2 *Pandalus hypsinotus*
	41 cm	NS	2 *C. bairdi*, 1 Crangon-idae

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	49 cm	NS	1 prickleback, 5 *C. bairdi*, 2 Crangonidae, 1 unid. fish, 1 *Serripes*
	44 cm	NS	7 *Pandalopsis dispar*, 1 Crangonidae
	42 cm	NS	2 Crangonidae, 3 *C. bairdi*
	Platichthys stellatus 47 cm	NS	*Crangon dalli*
	38 cm	NS	*Crangon dalli*
Station 28 10/21/76	*Hippoglossus stenolepis* 116 cm	NS	4 large *C. bairdi* (80 mm juvenile female)
	83 cm	NS	Empty
	91 cm	NS	Empty
	Dogfish (*Squalus*) 1 specimen	NS	Unid. fish, unid. leech
	Platichthys stellatus 1 specimen	NS	*Crangon dalli*
	1 specimen	NS	Empty
	1 specimen	NS	Empty
Station 53 10/20/76	*Hippoglossus stenolepis* 61 cm	NS	3 snake pricklebacks
	52 cm	NS	1 *Pagurus ochotensis*, 1 *C. bairdi*
Station 18 10/21/76	*Hippoglossus stenolepis* 19.1 kg (42 lbs)	NS	1 female juvenile *C. bairdi*
Station 27 10/21/76	*Platichthys stellatus* 52 cm	F	*Crangon*
	38 cm	M	Empty

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	39 cm	M	*Crangon*
	46 cm	M	*Crangon dalli, Pandalus borealis*
	39 cm	M	*Crangon dalli*
Station 41 10/22/76	*Hippoglossus stenolepis* 87 cm	NS	Unid. Cottidae
	80 cm	NS	*Cancer magister*
	77 cm	NS	*Trichodon*
	77 cm	NS	Unid. fish
	73 cm	NS	*Trichodon, cancer magister*
	68 cm	NS	Empty
	55 cm	NS	*Trichodon*
	Myoxocephalus 41 cm	NS	*Oregonia gracilis, Crangon dalli*
	49 cm	NS	*Crangon dalli*
	41 cm	NS	Large Liparidae
	44 cm	NS	*Crangon dalli*
	46 cm	NS	*C. bairdi*
	Platichthys stellatus 38 cm	M	Full; pinkneck clams
	38 cm	M	Full; pinkneck clams
	38 cm	M	Full; pinkneck clams
	37 cm	M	Full; pinkneck clams
	36 cm	M	Full; pinkneck clams

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	40 cm	M	Empty
	38 cm	M	Full; pinkneck clams
	41 cm	M	Full; pinkneck clams
	40 cm	M	Pinkneck clams
	37.5 cm	M	Pinkneck clams
	42 cm	M	Pinkneck clams
	32 cm	M	Pinkneck clams
	37 cm	M	Pinkneck clams
	40 cm	F	Pinkneck clams
	35 cm	M	Pinkneck clams
	Trichodon trichodon 19 cm	F	Empty
	25.5 cm	F	Empty
	25 cm	F	Empty
Station 40A 10/23/76	*Hippoglossus stenolepis* 7.7 kg (17 lbs)	NS	1 *C. bairdi*, 1 unid. fish
	5.5 kg (12 lbs)	NS	1 *C. bairdi* (recently molted)
Station 70 10/23/76	*Trichodon trichodon* 8.0 cm	NS	Capelin
	7.0 cm	NS	Capelin
	Liparidae 4 specimens	NS	All *Crangon dalli*
	Wattled eelpout 2 specimens	NS	All *Crangon dalli*

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
Station 76A 10/23/76	*Microgadus proximus* 20.0 cm	NS	*Crangon dalli*
	19.5 cm	NS	*Crangon dalli*
	20.5 cm	NS	*Pandalus borealis*
	27.0 cm	NS	*Pandalus borealis*
	18.5 cm	NS	*Pandalus borealis*
	24.0 cm	NS	*Pandalus borealis*
	24.0 cm	NS	Empty
	26.4 cm	NS	*Pandalus borealis*
	23.5 cm	NS	*Pandalus borealis*
	30.2 cm	NS	*Pandalus borealis*, *Pagurus ochotensis*
	29.3 cm	NS	*Pandalus borealis*
	20.5 cm	NS	*Pandalus borealis*
Station 62A 10/24/76	*Hippoglossus stenolepis* 90 cm	NS	1 amphipod, many *Crangon dalli*, unid. fish
	69 cm	NS	Unid. fish
	73 cm	NS	Unid. Cottidae, *Crangon dalli*
	Platichthys stellatus 35.5 cm	F	Empty
	27.5 cm	F	Empty
	34 cm	F	Empty
	28.5 cm	F	Empty
	29 cm	F	Empty
	24.5 cm	F	Empty

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	29.5 cm	F	Empty
	30.5 cm	F	Empty
	27 cm	F	Empty
	25.5 cm	F	Empty
	25.5 cm	F	Empty
	24 cm	F	Empty
	Myoxocephalus 31 cm	NS	1 snake prickleback, *Crangon dalli*
	28 cm	NS	1 *Liparis* sp.
	33.5 cm	NS	Caridean shrimp
	26.8 cm	NS	Empty
	39.5 cm	NS	1 *Crangon dalli*
	35 cm	NS	Empty
Station 53 10/24/76	*Hippoglossus stenolepis* 80 cm	F	1 eelpout, 1 *C. bairdi*
	1.36 kg (3 lbs)	F	3 *C. bairdi*
	86 cm	F	3 *C. bairdi*, unid. fish, 1 *Crangon dalli*, 1 *Pandalus goniurus*
	68 cm	F	1 snake prickleback, *C. bairdi*
	63 cm	F	1 *Pandalus goniurus*
	68 cm	F	2 snake pricklebacks
	60 cm	F	1 *Pagurus ochotensis*, 1 snake prickleback

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	58 cm	F	3 *C. bairdi*, 1 pea crab, 1 *Crangon dalli*
	59 cm	F	Snake prickleback
	64 cm	F	*C. bairdi*, unid. fish
	58 cm	F	Snake prickleback, *Crangon dalli, Pandalus goniurus*
	58 cm	F	*Crangon dalli, C. bairdi*
	Platichthys stellatus 48.5 cm	M	*C. bairdi, Crangon dalli*
	47 cm	M	Empty
	42 cm	M	Empty
	48 cm	M	Empty
	48.5 cm	F	Empty
Station 23 10/25/76	*Platichthys stellatus* 49 cm	F	Empty
	Gadus macrocephalus 59 cm	M	Full, *Trichodon, Pinnixia*, 2 *Crangon dalli*, 1 *C. bairdi*, 1 *Hippoglossoides elassodon*, unid. fish
	57 cm	F	1 unid. flatfish, 2 *Crangon dalli*, 1 *Pandalus*
	60 cm	F	2 *Atheresthes*
	Hippoglossus stenolepis 75 cm	M	Unid. fish
	52 cm	M	Unid. fish
	58 cm	F	Unid. fish
	98 cm	M	Empty

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
Station 25 10/25/76	*Platichthys stellatus* 1 specimen	NS	*Crangon dalli*
	Hippoglossus stenolepis 81 cm	NS	1 *Microgadus*
	66 cm	NS	*Trichodon*
	57 cm	NS	Snake prickleback, *C. bairdi, Pandalus hypsinotus*
	43 cm	NS	2 *C. bairdi*
	52 cm	NS	*Anonyx*, unid. fish
Station 5A 10/27/76	*Atheresthes stomias* 49 cm	NS	Empty
	Hippoglossoides elassodon 30 cm	NS	Ophiuroidea, *Macoma* sp.
	28 cm	NS	Ophiuroidea, Polynoidae
	30 cm	NS	Crangonidae
	29 cm	NS	Crangonidae, Ophiuroidea
	Paralithodes camtschatica 16.6 cm	M	*Macoma*
	18.8 cm	M	*Macoma*
	16.8 cm	M	Empty
	19.4 cm	M	Empty
Station 6 10/27/76	*Hippoglossoides elassodon* 39 cm	NS	*Nuculana*
	27 cm	NS	*Nuculana*, Crangonidae
	Lycodes 15 specimens	NS	*Macoma*, tiny Crangonidae

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	Paralithodes camtschatica		
	19.3 cm	M	Full, *Nuculana*
	16.3 cm	M	Part-full, *Nuculana*
	17.7 cm	M	Full, *Nuculana*
	16.5 cm	M	10 *Nuculana*
	16.3 cm	M	Full, *Nuculana*
	15.4 cm	M	Full, 25 *Nuculana*
	13.4 cm	M	Full, *Nuculana*, Polychaeta
	14.7 cm	M	Full, *Nuculana*, *Macoma*
	13.3 cm	M	Full, *Nuculana*
	14.4 cm	M	*Nuculana*, *Macoma*
Station 40A 10/29/76	*Myoxocephalus*		
	1 specimen	NS	2 *Cancer oregonensis*
	1 specimen	NS	*Hyas lyratus* female with eggs, Cottidae
	Hippoglossus stenolepis		
	77 cm	M	1 *Cancer magister*, unid. fish
	61 cm	M	*Trichodon*, unid. fish, 1 *Cancer magister*
	60 cm	M	*Pandalus goniurus*, unid. fish
	56 cm	M	2 *Trichodon*, 1 *Crangon dalli*, 1 *Pagurus ochotensis*
	43 cm	M	1 *Trichodon*, 1 unid. fish
	Platichthys stellatus		
	47 cm	M	Few Pelecypoda fragments

APPENDIX TABLE IV

CONTINUED

Station	Species/Size	Sex	Stomach Contents
	42 cm	F	Full; young *Spisula*
	43 cm	M	Full; young pinknecks
	38 cm	M	Part-full, pinkneck clams
	38.5 cm	M	Empty
	36.5 cm	M	Full; pinkneck clams
	38.0 cm	M	Full; pinkneck clams
	37.0 cm	M	Full; pinkneck clams
	38.0 cm	M	Empty
	42.0 cm	M	Empty
	Lepidopsetta bilineata 22.0 cm	M	Nudibranch
	25.0 cm	M	*Spisula, Crangon dalli*
	29.0 cm	M	Amphipoda
	31.0 cm	M	Unid. remains
	23.0 cm	M	Unid. Pelecypoda
	Limanda aspera 21 cm	M	Unid. Pelecypoda
	Myoxocephalus 38 cm	NS	Unid. fish
	38 cm	NS	*C. bairdi*
	40 cm	NS	*Crangon dalli*, unid. fish
	40 cm	NS	*Crangon dalli*
	42 cm	NS	*Pagurus ochotensis*, 1 female *Cancer magister*

APPENDIX TABLE V

NUMBER OF PREY SPECIMENS IN 715 *CHIONOECETES BAIRDI* STOMACHS COLLECTED IN COOK INLET, ALASKA (MF = mature female, MM = mature male, IF = immature female, IM = immature male)

Carapace Width	Number of Stomachs	Sex	Number of Prey in Stomachs	Number of Crab Feeding
Station 5A				
5 - 10	1	IM	Full of sediment	0
61 - 70	2	IM	No food	0
81 - 90	2	IM	Several *Nuculana fossa*	2
91 - 100	2	-	No food	0
101 - 110	2	IM	1 crustacean	1
111 - 120	6	MM	8 *Macoma* spp., 1 *Nuculana fossa*	6
121 - 130	4	MM	2 *Macoma* spp., 1 *Nuculana fossa*, 1 *Balanus* spp.	3
131 - 140	1	MM	Several *Macoma* spp.	1
141 - 150	3	MM	No food	0
71 - 80	2	MF	Several *Macoma* spp.	2
81 - 90	3	MF	Several *Macoma* spp.	3
91 - 100	2	MF	2 *Macoma* spp., 1 *Nuculana fossa*	2
101 - 105	1	MF	1 *Macoma* spp.	1
81 - 90	6	IF	3 *Macoma* spp.	3
91 - 100	2	IF	2 *Macoma* spp.	2
	Total 39		Total	26
Station 8B				
5 - 10	4	IM	1 Amphipod, 1 crustacean, sediment	2
11 - 20	3	IM	2 tissue, sediment	2
21 - 30	3	IM	1 Amphipod, 1 crangonidae	2

APPENDIX TABLE V

CONTINUED

Carapace Width	Number of Stomachs	Sex	Number of Prey in Stomachs	Number of Crab Feeding
81 - 90	1	IM	1 Paguridae, 1 *Macoma* spp.	1
101 - 110	1	IM	1 crangonidae	1
5 - 10	9	IF	2 amphipod, 1 tissue, sediment	3
11 - 20	2	IF	1 Natantia, 1 amphipod	2
21 - 30	1	IF	1 Paguridae	1
Total	24		Total	14
Station 18				
61 - 70	6	IM	4 *Serripes groenlandicus*	2
71 - 80	16	IM	2 *S. groenlandicus*, 2 paguridae, 3 crangonidae, 3 *Balanus* spp., sediment	11
81 - 90	19	IM	3 *S. groenlandicus*, 4 paguridae, 2 crangonidae, 2 *Balanus* spp., 1 *Pectinaria* spp., sediment	13
91 - 100	13	IM	1 *S. groenlandicus*, 4 *Balanus* spp.	5
101 - 110	15	IM	1 *Macoma* spp., 1 *Nuculana fossa*, 1 crangonidae, 3 *Balanus* spp., sediment	7
111 - 120	7	MM	No food	0
121 - 130	2	MM	No food	0
141 - 145	1	MM	No food	0
Total	79		Total	38
Station 23				
61 - 70	1	IM	2 *Macoma* spp.	1
71 - 80	9	IM	1 *Yoldia hyperborea*, 17 *Macoma* spp.	7

APPENDIX TABLE V

CONTINUED

Carapace Width	Number of Stomachs	Sex	Number of Prey in Stomachs	Number of Crab Feeding
81 - 90	42	IM	70 *Macoma* spp., 2 *Chionoecetes bairdi*	38
91 - 100	16	IM	13 *Macoma* spp., 1 *C. bairdi*, 1 Polychaete, 2 Paguridae, sediment	16
101 - 110	11	IM	4 *Macoma* spp., 2 *Balanus* spp., sediment	7
111 - 120	9	MM	1 Paguridae, 1 *Chionoecetes bairdi*, 1 *Balanus* spp., 1 Pelecypoda	4
121 - 130	7	MM	1 *Macoma* spp., sediment	1
131 - 140	1	MM	No food	0
141 - 150	2	MM	No food	0
161 - 165	2	MM	No food	0
81 - 90	17	MF	21 *Macoma* spp., 1 *Astarte* spp., 1 pelecypoda, 1 Gastropoda, 3 paguridae, sediment	15
91 - 100	12	MF	19 *Macoma* spp., 1 pelecypoda, 1 paguridae	9
101 - 110	3	MF	5 *Macoma* spp.	3
71 - 80	5	IF	6 *Macoma* spp.	3
81 - 90	4	IF	3 *Macoma* spp., sediment	3
	Total 141			Total 107
Station 25				
31 - 40	2	IM	1 *Macoma* spp.	1
61 - 70	2	IM	2 *Macoma* spp.	2
71 - 80	5	IM	1 *Macoma* spp., 1 *Astarte* spp., 1 *Pagurus ochotensis*	3

APPENDIX TABLE V

CONTINUED

Carapace Width	Number of Stomachs	Sex	Number of Prey in Stomachs	Number of Crab Feeding
81 - 90	22	IM	7 *Macoma* spp., 6 *P. ochotensis*, 5 *Balanus* spp., 2 polychaetes, sediment	18
91 - 100	9	IM	2 *Macoma* spp., 4 *P. ochotensis*, 2 paguridae, 2 *Balanus* spp.	10
111 - 120	3	MM	1 *P. ochotensis*, 1 paguridae, 1 crangonidae	3
121 - 130	5	MM	5 *Macoma* spp., 1 *Astarte* spp., 1 *Pandalus* spp., 2 Amphipods, 1 Polychaetea	5
131 - 140	3	MM	1 *P. ochotensis*, 1 *Chionoecetes bairdi*	2
81 - 90	8	MF	2 *Macoma* spp., 1 *Astarte* spp., 1 *P. ochotensis*, 1 *Balanus* spp.	4
91 - 95	1	MF	1 Pelecypoda, sediment	1
21 - 30	3	IF	5 *Macoma* spp.	3
61 - 70	4	IF	2 *Macoma* spp., 1 *Balanus* spp., sediment	3
71 - 80	15	IF	7 *Macoma* spp., 1 *Astarte* spp., 1 Pelecypoda, 1 paguridae, 1 *Balanus*	11
81 - 90	5	IF	24 *Macoma* spp., 1 paguridae, 1 crangonidae	5
Total	87		Total	71
Station 28				
91 - 100	2	IM	1 *Macoma* spp., 2 paguridae, 1 *Balanus* spp.	2
111 - 120	4	MM	1 paguridae	1
Total	6		Total	3

APPENDIX TABLE V

CONTINUED

Carapace Width	Number of Stomachs	Sex	Number of Prey in Stomachs	Number of Crab Feeding
<u>Station 40A</u>				
41 - 50	9	IM	1 Pelecypoda, 1 *Pagurus ochotensis*, 2 *Balanus* spp., 2 Polychaeta, sediment	5
51 - 60	23	IM	11 *P. ochotensis*, 2 paguridae, 5 *Balanus* spp., 2 Polychaeta, sediment	18
61 - 70	30	IM	2 *Spisula polynyma*, 3 *Nucella* spp., 4 *P. ochotensis*, 5 paguridae, 9 *Balanus* spp., 1 crustacean, 1 ophuridae, 1 tissue	22
71 - 80	3	IM	1 *P. ochotensis*, 1 paguridae, 1 *Balanus* spp., sediment	2
81 - 90	3	IM	1 *P. ochotensis*	1
41 - 50	13	IF	1 *P. ochotensis*, 1 paguridae, 3 *Balanus* spp., 1 Polychaeta	6
51 - 60	15	IF	3 *P. ochotensis*, 2 paguridae, 4 *Balanus* spp., 1 plant material, sediment	10
	Total 96			Total 67

APPENDIX VI

CLUSTER ANALYSIS OF BENTHIC INVERTEBRATE DATA

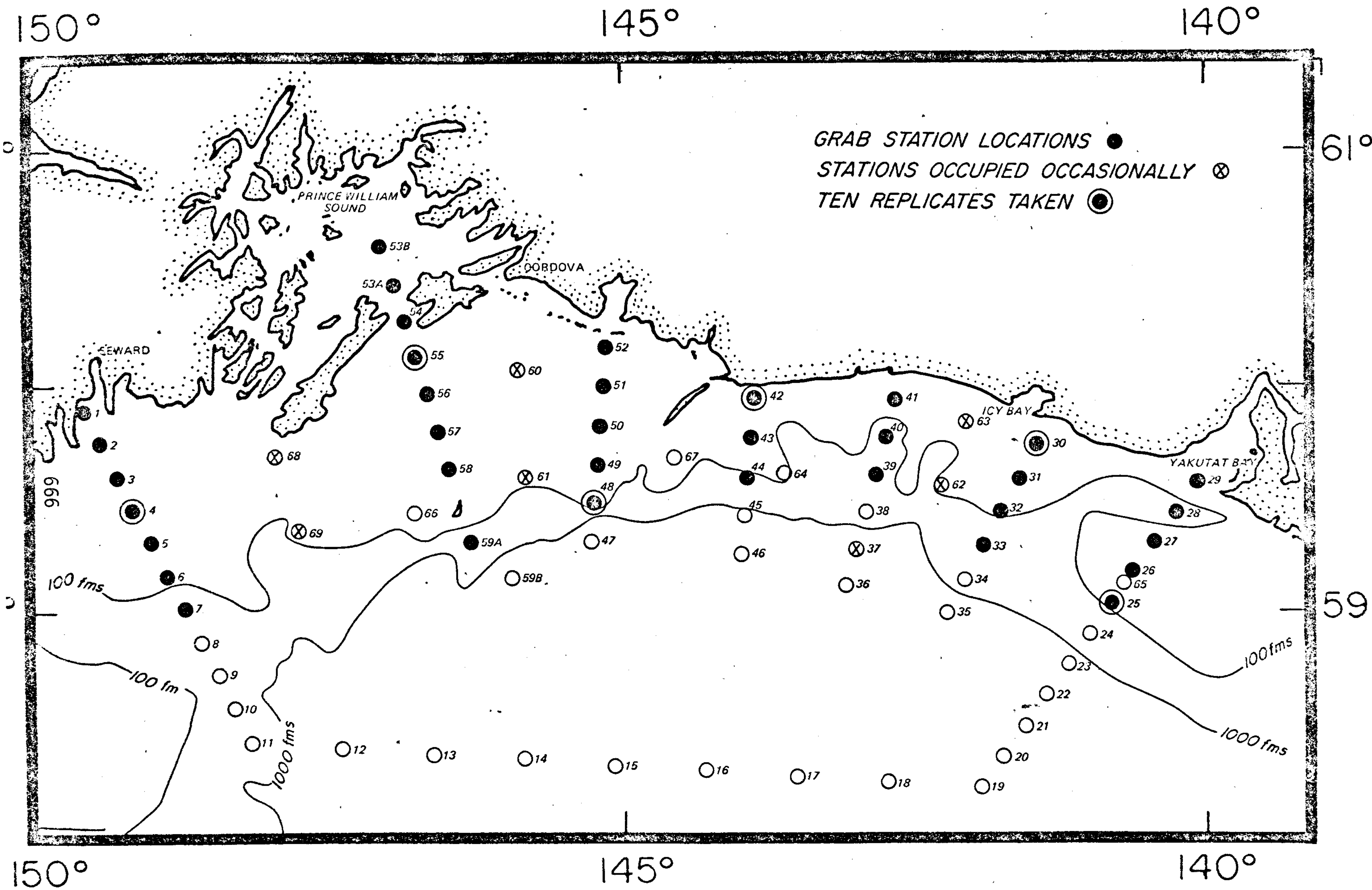
Cluster analysis was utilized to define groups of stations which had a similar faunal composition and groups of species which were characteristic of the station groups. We feel that this technique provides an excellent tool for proper selection of monitoring sites and for detection of changes in the fauna caused by environmental disturbances (Feder *et al.*, 1976).

Methods

A brief summary of the methods of analysis will be presented here. More detailed information is available in Feder *et al.* (1976). Since research vessel scheduling and inclement weather prevented seasonal coverage of the entire station grid during the first year of the study, data from the five cruises listed below had to be pooled to obtain complete coverage:

Cruise 193 R/V *Acona* - July 1974
Cruise 200 R/V *Acona* - October 1974
Cruise 202 R/V *Acona* - November 1974
Cruise 805 R/V *Oceanographer* - February 1975
Cruise 807 R/V *Townsend Cromwell* - May 1975

This data includes samples from part of cruise 805 and all of cruise 807, which were not available for inclusion in Feder *et al.* (1976). Analysis of the data collected on all of these cruises yielded 315 taxa collected from 50 stations (several stations were sampled on more than one occasion). The data matrix of 50 stations x 315 taxons was reduced by eliminating all organisms which occurred only at one station and in such low numbers that they would have little effect on the analysis. In addition, several stations which were inadequately sampled for reliable quantitative data (Stations 7, 29, 30, 33, 37, 39, 43, and 59; Fig. 1) were excluded from analyses using



Appendix VI - Figure 1. Station grid established for oceanographic investigations in the northeastern Gulf of Alaska.

quantitative data. Five separate cluster analyses were run using the following data:

1. Untransformed number of individuals/m^2.
2. Natural logarithm transformed number of individuals/m^2.
3. Untransformed wet weight/m^2 data.
4. Natural logarithm transformed wet weight/m^2 data.
5. Presence-absence data (all stations were included).

Both normal (comparing stations) and inverse (comparing species) cluster analysis were run on all data.

Samples from cruise 811, USNS *Silas Bent*, September 1975 and cruise 816, *Discoverer*, November-December 1975 have been processed by the Marine Sorting Center, and are now being prepared for submission to NODC. A listing of the stations occupied and the species identified are included in Tables I and II. These two cruises gave us complete coverage of the station grid established for the lease area. Cluster analyses have been run on this data, but they have not been examined in sufficient detail for inclusion in this report.

A more detailed evaluation of this data will be included either in the next quarterly report or as a special data report.

Results

Station groups formed by normal cluster analysis are shown in Figures 1 through 5. To avoid confusion, only the major station groups were plotted. Tables III through VII list all the station groups formed by the five cluster analyses utilized. A normal cluster analysis delineated three major station groups at the 30% similarity level (Fig. 2). One group of stations (labeled Inshore Group I) is located south of Prince William Sound and Cordova.

APPENDIX VI - TABLE I

LIST OF THE STATIONS PROCESSED FROM CRUISE 811
USNS *SILAS BENT*, SEPTEMBER 1975 AND CRUISE 816 R/V *DISCOVERER* NOVEMBER-DECEMBER 1975

GULF OF ALASKA BENTHIC GRAB DATA -- SEPTEMBER-DECEMBER 1975 03/04/77 PAGE 1

STATION-SAMPLE LISTING

		TOT CNT	TOT WWGT	CNT/SQM	WWGT/SQM	GRABS
CRUISE 811	STATION 001	166.	17.711	332.	35.423	0001 0002 0003 0005 0004
CRUISE 811	STATION 002	116.	14.146	232.	28.291	0001 0005 0004 0002 0003
CRUISE 811	STATION 003	230.	20.450	460.	40.900	0003 0002 0001 0004 0005
CRUISE 811	STATION 004	264.	11.825	264.	11.825	0001 0003 0007 0006 0005 0004 0010 0002 0009 0008
CRUISE 811	STATION 005	208.	5.719	416.	11.437	0001 0004 0003 0002 0005
CRUISE 811	STATION 006	724.	2.154	1448.	4.309	0002 0005 0004 0003 0001
CRUISE 811	STATION 007	370.	5.132	740.	10.265	0001 0002 0005 0004 0003
CRUISE 811	STATION 026	207.	0.953	518.	2.382	0002 0003 0001 0005
CRUISE 811	STATION 027	300.	1.321	600.	2.643	0001 0004 0005 0002 0003
CRUISE 811	STATION 028	272.	3.371	544.	6.743	0005 0004 0002 0001 0003
CRUISE 811	STATION 030	905.	4.100	905.	4.100	2. 5 9 7 4 6 10 8 3 1
CRUISE 811	STATION 031	492.	9.733	984.	19.465	0001 0002 0005 0004 0003
CRUISE 811	STATION 032	206.	6.757	412.	13.514	0001 0002 0005 0004 0003
CRUISE 811	STATION 033	315.	2.672	630.	5.343	0003 0001 0005 0004 0002
CRUISE 811	STATION 040	406.	4.947	812.	9.894	0003 0005 0002 0001 0004
CRUISE 811	STATION 041	722.	6.960	1444.	13.920	0003 0002 0004 0005 0001
CRUISE 811	STATION 042	914.	7.362	914.	7.362	0001 0002 0010 0008 0009 0007 0005 0006 0004 0003
CRUISE 811	STATION 043	556.	5.630	1112.	11.259	0002 0005 0004 0003 0001
CRUISE 811	STATION 048	143.	4.303	286.	8.606	0001 0005 0003 0004 0002
CRUISE 811	STATION 049	325.	8.691	650.	17.381	0005 0002 0004 0001 0003
CRUISE 811	STATION 050	208.	9.029	416.	18.058	0002 0005 0001 0003 0004
CRUISE 811	STATION 051	147.	9.928	294.	19.856	0001 0002 0005 0003 0004
CRUISE 811	STATION 052	97.	1.991	194.	3.983	0005 0003 0001 0004 0002
CRUISE 811	STATION 053	718.	10.607	1436.	21.213	0004 0002 0003 0005 0001
CRUISE 811	STATION 056	795.	9.717	1590.	19.434	0003 0004 0005 0002 0001
CRUISE 811	STATION 057	635.	8.935	1270.	17.869	0004 0002 0003 0005 0001
CRUISE 811	STATION 058	827.	7.189	1654.	14.377	0003 0001 0004 0002 0005
CRUISE 816	STATION 025	498.	2.453	498.	2.453	0003 0002 0001 0006 0004 0008 0010 0005 0009 0007
CRUISE 816	STATION 039	170.	1.367	340.	2.735	0002 0003 0004 0005 0001
CRUISE 816	STATION 044	490.	2.568	980.	5.135	0002 0001 0003 0004 0005
CRUISE 816	STATION 048	755.	3.212	755.	3.212	0010 0006 0004 0002 0008 0001 0003 0007 0005 0009
CRUISE 816	STATION 054	528.	18.510	1056.	37.019	0005 0004 0001 0002 0003
CRUISE 816	STATION 055	463.	22.591	463.	22.591	0007 0006 0002 0005 0009 0008 0001 0003 0004 0010
CRUISE 816	STATION 059	151.	1.911	302.	3.822	0002 0005 0003 0001 0004

TOTAL NUMBER OF STATIONS = 34.

APPENDIX VI - TABLE II

LIST OF SPECIES IDENTIFIED FROM SAMPLES COLLECTED DURING CRUISE 811 USNS *SILAS BENT* SEPTEMBER 1975 AND CRUISE 816 R/V *DISCOVERER* NOVEMBER-DECEMBER 1975

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
320000000000	PORIFERA			X	X	X	10
330100000000	HYDROZOA						7
330300000000	ANTHOZOA						1
330347000000	PENNATULACEA VIRGULARIIDAE		X		X		11
330350000000	ZOANTHINIARIA			X		X	4
400000000000	RHYNCHOCOELA	X					27
440000000000	NEMATODA			X			9
480100000000	POLYCHAETA	X			X		34
480101000000	POLYNOIDAE						11
480101020100	ANTINOELLA MACROLEPIDA						1
480101030000	ARCTEOBIA						1
480101030200	ARCTEOBIA SPINELYTRIS						4
480101050200	EUNOE DEPRESSA						2
480101060400	GATTYANA BRUNNEA						2
480101060500	GATTYANA IPHIONELLOIDES						1
480101060600	GATTYANA TREADWELLI						3
480101080000	HARMOTHOE SP						1
480101080600	HARMOTHOE IMBRICATA						5
480101110300	LEPIDONOTUS SQUAMATUS						2
480101150200	POLYNOE GRACILIS						1
480102000000	POLYNODONTIDAE						1
480102010000	PEISIDICE SP						1
480102010100	PEISIDICE ASPERA				X		9
480105000000	SIGALIONIDAE						3
480105010100	PHLOE MINUTA						7
480105030100	STHENELAIS FUSCA						3
480110000000	EUPROSINIDAE						0
480110010100	EUPHROSINE ARCTICA						1
480110010200	EUPHROSINE BICIRRATA						1
480112000000	PHYLLODOCIDAE						1
480112010000	ANAITIDES						3
480112010200	ANAITIDES GROENLANDICA						1
480112010400	ANAITIDES MUCOSA						1
480112010600	ANAITIDES MACULATA						4
480112020000	ETEONE SP.						1
480112020500	ETEONE LONGA						2
480112030000	EULALIA SP						1
480112030400	EULALIA BILINEATA						1
480120000000	HESIONIDAE						0
480120040100	OPHIODROMUS PUGETTENSIS						2
480121000000	PILARIGIDAE						0
480121020100	SIGAMBRA TENTACULATA						1
480122000000	SYLLIDAE						6
480122030400	SYLLIS SPONGIPHILA						1
480122050000	TYPOSYLLIS SP.				X		9
480122050100	TYPOSYLLIS ALTERNATA						4
480122050200	TYPOSYLLIS ARMILLARIS						2
480122050900	TYPOSYLLIS ADAMANTEA						1

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
480122051200	TYPOSYLLIS VARIEGATA						1
480122060200	EUSYLLIS BLOMSTRANDI						1
480122070000	EXOGONE SP				X		5
480122070600	EXOGONE VERRUGERA						2
480123000000	NEREIDAE						0
480123040000	NEREIS SP.						5
480123040300	NEREIS PELAGICA						4
480123040400	NEREIS PROCERA						2
480123040600	NEREIS ZONATA						5
480123060100	CERATOCEPHALE LOVENI		X		X		1
480124000000	NEPHTYIDAE						5
480124010000	NEPTHYS SP.	X					19
480124010200	NEPHTYS CILIATA						6
480124010300	NEPHTYS CAECA						2
480124010400	NEPHTYS CORNUTA						3
480124010500	NEPHTYS PUNCTATA	X			X		20
480124010600	NEPHTYS RICKETTSI						1
480124020000	MICRONEPTHYS SP						1
480124030200	AGLAOPHOMUS RUBELLA ANOPS						3
480125000000	SPHAERODORIDAE						0
480125020100	SPHAERODOROPSIS MINUTA						1
480125020300	SPHAERODOROPSIS SPHAERULIFER						1
480126000000	GLYCERIDAE						1
480126010000	GLYCERA SP.						1
480126010100	GLYCERA CAPITATA	X					21
480127000000	GONIADIDAE						0
480127010100	GLYCINDE PICTA						2
480127010300	GLYCINDE ARMIGERA						3
480127020100	GONIADA ANNULATA	X			X		21
480127020200	GONIADA MACULATA						2
480128000000	ONUPHIDAE						0
480128010000	ONUPHIS SP.						5
480128010100	ONUPHIS CONCHYLEGA						2
480128010200	ONUPHIS GEOPHILIFORMIS						4
480128010300	ONUPHIS IRIDESCENS	X			X		24
480128010500	ONUPHIS PARVA						3
480129000000	EUNICIDAE						0
480129010000	EUNICE SP						1
480129010200	EUNICE VALENS						3
480129010400	EUNICE KOBIENSIS						2
480130000000	LUMBRINERIDAE						0
480130010000	LUMBRINEREIS SP.	X			X		29
480130010100	LUMBRINEREIS BICIRRATA						4
480130010500	LUMBRINEREIS SIMILABRIS						7
480130010600	LUMBRINEREIS ZONATA	X			X		28
480130020200	NINOE GEMMEA	X			X		17
480132000000	ARABELLIDAE						0
480132010000	DRILONEREIS SP.						1

GULF OF ALASKA BENTHIC GRAB DATA -- SEPTEMBER-DECEMBER 1975

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
480132010400	ORILONEREIS FALCATA MINOR						15
480135000000	DORVILLEIDAE						0
480135010100	DORVILLEA PSEUDORUBROVITTATA						1
480139000000	PARAONIDAE						0
480139010200	HAPLOSCOLOPLOS ELONGATUS						4
480140020000	ARICIDEA SP.						3
480140020100	ARICIDEA SUECICA				X		8
480140020400	ARICIDEA JEFFREYSII						3
480140030000	PARAONIS SP.						1
480140030100	PARAONIS GRACILIS						5
480142000000	SPIONIDAE						2
480142020100	LAONICE CIRRATA				X		9
480142040000	POLYDORA SP.						2
480142050000	PRIONOSPIO SP.						1
480142050200	PRIONOSPIO CIRRIFERA						1
480142080200	BOCCARDIA NATRIX						1
480142100100	SPIOPHANES BOMBYX						2
480142100200	SPIOPHANES KROYERI				X		7
480142100300	SPIOPHANES CIRRATA		X		X		7
480142130200	PYGOSPIO ELEGANS						1
480143000000	MAGELONIDAE						0
480143010100	MAGELONA JAPONICA						5
480143010200	MAGELONA PACIFICA						1
480148000000	CHAETOPTERIDAE						0
480148030000	SPIOCHAETOPTERUS SP.						6
480148030200	SPIOCHAETOPTERUS COSTARUM				X		7
480149000000	CIRRATULIDAE						0
480149030000	THARYX SP.	X					18
480149040100	CHAETOZONE SETOSA						3
480152000000	FLABELLIGERIDAE						0
480152010000	BRADA SP.						1
480152010200	BRADA VILLOSA						4
480152020200	FLABELLIGERA AFFINIS						1
480152030000	PHERUSA SP.						1
480152030100	PHERUSA PAPILLATA						2
480152030200	PHERUSA PLUMOSA						3
480155000000	SCALIBREGMIDAE						0
480155010100	SCALIBREGMA INFLATUM						5
480156000000	OPHELIIDAE						1
480156010100	AMMOTRYPANE AULOGASTER						2
480156040100	TRAVISIA BREVIS			X			1
480156040200	TRAVISIA FORBESII						1
480156040300	TRAVISIA PUPA			X			2
480157000000	STERNASPIDAE						0
480157010100	STERNASPIS SCUTATA	X	X	X	X		25
480158000000	CAPITELLIDAE						1
480158010000	CAPITELLA SP						1
480158010100	CAPITELLA CAPITATA						14

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
480158030300	NOTOMASTUS LINEATUS						1
480161000000	MALDANIDAE	X					21
480161010000	ASYSCHIS S.						1
480161010200	ASYCHIS SIMILIS				X		6
480161030000	MALDANE SP.						3
480161030100	MALDANE SARSI				X		12
480161030200	MALDANE GLEBIFEX		X		X		12
480161040000	MALDANELLA SP						1
480161040100	MALDANELLA ROBUSTA						2
480161050000	NICOMACHE SP.						1
480161050100	NICOMACHE LUMBRICALIS						2
480161050200	NICOMACHE PERSONATA						2
480161060000	NOTOPROCTUS SP.						1
480161060100	NOTOPROCTUS PACIFICUS				X		9
480161090100	PRAXILLELLA GRACILIS	X			X		23
480161090200	PRAXILLELLA PRAETERMISSA						9
480161100100	RHODINE BIRORQUATA						6
480162000000	OWENIDAE						0
480162010200	OWENIA FUSIFORMIS		X		X		8
480162020000	MYRIOCHELE SP						1
480162020100	MYRIOCHELE HEERI	X	X		X		30
480163000000	SABELLARIDAE						0
480163010200	IDANTHYRSUS ARMATUS				X		5
480164000000	PECTINARIDAE						0
480164010100	AMPHICTENE AURICOMA						3
480164020100	CISTENIDES BREVICOMA						4
480164020300	CISTENIDES HYPERBOREA						1
480164030000	PECTINARIA SP.						1
480165000000	AMPHARETIDAE						11
480165010100	AMAGE ANOPS						3
480165020000	AMPHARETE SP.						8
480165020100	AMPHARETE ARCTICA	X			X		19
480165020800	AMPHARETE ACUTIFRONS						2
480165030000	AMPHICTEIS SP						2
480165030300	AMPHICTEIS ALASKANA						1
480165030600	AMPHICTEIS MACRONATA						2
480165040100	LYSIPPE LABIATA						7
480165050000	MELINNA SP						1
480165050100	MELINNA CRISTATA	X					17
480165050300	MELINNA ELIZABETHA						4
480166000000	TEREBELLIDAE						10
480166070000	PISTA SP.						7
480166070100	PISTA CRISTATA				X		16
480166070200	PISTA FASCIATA						1
480166070600	PISTA PACIFICA						1
480166080000	POLYCIRRUS SP.						1
480166120100	ARTACAMA CONIFERI						4
480167000000	TRICHOBRANCHIDAE						1

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
480167010100	TEREBELLIDES STROEMII	X					26
480167020100	TRICHOBRANCHUS GLACIALIS						1
480168000000	SABELLIDAE						13
480168010000	CHONE SP.						6
480168010100	CHONE GRACILIS						8
480168010200	CHONE INFUNDIBULIFORMIS						2
480168020100	EUCHONE ANALIS				X		8
480168040100	MEGALOMMA SPLENDIDA						2
480168060000	POTAMILLA SP						1
480168060100	POTAMILLA NEGLECTA						1
480168070300	PSEUDOPOTAMILLA RENIFORMIS						3
480168080100	SABELLA CRASSICORNIS						1
480168130000	FABRICIA SP						1
480170000000	SERPULIDAE						1
480170010200	CHITINOPOMA GROENLANDICA						5
480170020100	CRUCIGERA IRREGULARIS						1
480170040100	SERPULA VERMICULARIS						2
480170050000	SPIRORBIS SP				X		1
480174000000	APHRODITIDAE						0
480174010100	APHRODITA JAPONICA						1
480174010300	APHRODITA PARVA						1
480175000000	COSSURIDAE						0
480175010100	COSSURA LONGOCIRRATA						1
480179000000	AMPHINOMIDAE						0
480179010100	CHLOEIA SP.						1
480200000000	OLIGOCHAETA						2
480400000000	ARCHIANNELIDA						1
490000000000	MOLLUSCA				X		15
490100000000	APLACOPHORA						1
490103010100	CHAETODERMA ROBUSTA						16
490300000000	POLYPLACOPHORA						0
490302030200	ISCHNOCHITON ALBUS				X		8
490305040000	MOPALIA SP						1
490400000000	PELECYPODA	X					18
490402020100	NUCULA TENUIS	X	X		X		32
490403020000	NUCULANA SP.						1
490403020100	NUCULANA PERNULA	X	X		X		26
490403020200	NUCULANA MINUTA						1
490403020600	NUCULANA CONCEPTIONIS						1
490403050000	YOLDIA SP.		X		X		15
490403050100	YOLDIA AMYGDAIEA			X		X	5
490403050400	YOLDIA SCISSURATA			X		X	1
490403050800	YOLDIA SECUNDA	X	X		X		17
490407010100	MYTILUS EDULIS						1
490407020100	CRENELLA DECUSSATA		X		X		10
490407030100	MEGACRENELLA COLUMBIANA						1
490407040100	MUSCULUS NIGER						1
490407050100	DACRYDIUM VITREUM	X			X		19

LIST OF ALL TAXONOMIC GROUPS FOUND

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CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
490407060100	MODIOLUS MODIOLUS						1
490408050200	PROPEAMUSSIUM ALASKENSE						3
490408060100	DELECTOPECTEN RANDOLPHI						7
490409010300	LIMA HYPERBOREA						1
490411010000	ASTARTE SP.						5
490411010200	ASTARTE ALASKENSIS						1
490411010300	ASTARTE MONTEGUI						2
490411010400	ASTARTE POLARIS			X	X	X	9
490412010100	CYCLOCARDIA VENTRICOSA						7
490412010200	CYCLOCARDIA CREBRICOSTATA	X	X		X		19
490415020100	AXINOPSIDA SERRICATA	X	X		X		20
490415030000	THYASIRA SP						2
490415030100	THYASIRA FLEXUOSA	X	X		X		23
490418010000	MYSELLA SP.						1
490418020100	ODONTOGENA BOREALIS	X	X		X		24
490420010000	CLINOCARDIUM SP.						1
490420010100	CLINOCARDIUM CILIATUM						2
490420010200	CLINOCARDIUM NUTTALLII						1
490420020200	SERRIPES LAPEROUSII						1
490421030100	COMPSOMYAX SUBDIAPHANA						1
490421050100	PSEPHIDIA LORDI	X	X		X		22
490423010100	SPISULA POLYNYMA						1
490424010000	MACOMA SP.						2
490424010100	MACOMA CALCAREA						3
490424010300	MACOMA BROTA			X			1
490424010800	MACOMA MOESTA ALASKANA						9
490427010200	SILIQUA ALTA						1
490429020100	HIATELLA ARCTICA						2
490432010200	PANDORA FILOSA						5
490432010300	PANDORA BILIRATA						3
490433020400	LYONSIA NORVEGICA			X		X	2
490437010000	CARDIOMYA SP.						1
490437010100	CARDIOMYA PECTINATA						13
490437010200	CARDIOMYA PLANETICA						2
490437010300	CARDIOMYA OLDROYDI						4
490500000000	GASTROPODA						14
490503020000	PUNCTURELLA SP						2
490503020500	PUNCTURELLA COOPERI						1
490505010100	CRYPTOBRANCHIA CONCENTRICA						1
490505020100	LEPETA CAECA						2
490506040000	SOLARIELLA SP.						1
490506040200	SOLARIELLA OBSCURA				X		4
490506040300	SOLARIELLA VARICOSA						2
490511010000	ALVINIA SP						1
490511010600	ALVINIA COMPACTA						1
490518010200	TACHYRYNCHUS RETICULATUS						4
490523010100	CALYPTRAEA FASTIGATA						1
490525020000	NATICA SP.						1

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CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
490525020100	NATICA CLAUSA						4
490525040000	POLINICES SP.						2
490525040100	POLINICES NANUS						3
490525040200	POLINICES PALLIDUS						3
490530041600	TROPHONOPSIS LASIUS						2
490533030000	COLUS SP						1
490534010100	AMPHISSA COLUMBIANA						2
490534020100	MITRELLA ROSACEA						1
490541000000	TURRIDAE						2
490541010000	SUAVODRILLA						3
490541010200	SUAVODRILLA WILLETTI						4
490541030100	MANGELIA ALEUTICA						1
490541040000	OENOPOTA SP.						4
490541042000	OENOPOTA DECUSSATA						1
490541071700	LORA RETICULATA						1
490542010000	ODOSTOMIA SP.						5
490542020000	TURBONILLA SP.						4
490545010100	RETUSA OBTUSA						2
490546010000	DIAPHANA SP						1
490549020000	CYLICHNA SP						1
490549020300	CYLICHNA ALBA						7
490600000000	SCAPHOPODA						0
490601010000	DENTALIUM SP.				X		8
490601010100	DENTALIUM DALLI				X		12
490601010200	DENTALIUM INVERSUM						1
490602010000	CADULUS SP.						14
490602010200	CADULUS STEARNSI	X					17
490602010300	CADULUS TOLMEI				X		11
520000000000	PYCNOGONIDA						0
520002010100	PSEUDOPALLENE CIRCULARIS						1
530000000000	CRUSTACEA						2
530700000000	PODOCOPA	X			X		19
531700000000	BRANCHIURA						1
531700010000	ARGULUS SP						1
531800000000	THORACICA						1
531802010400	BALANUS CRENATUS						1
532800000000	CUMACEA						13
532802000000	LAMPROPIDAE						2
532802010500	LAMPROPS QUADRIPLICATA						1
532802010700	LAMPROPS SERRATA						1
532802020000	HEMILAMPROPS SP						2
532804000000	LEUCONIDAE						1
532804010000	LEUCON SP.	X					19
532804020000	EUDORELLA SP.						3
532804020100	EUDORELLA EMARGINATA	X			X		20
532804020200	EUDORELLA PACIFICA						5
532804030100	EUDORELLOPSIS INTEGRA						2
532804030400	EUDORELLOPSIS DEFORMIS						1

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
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CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
532805000000	DIASTYLIDAE						1
532805010000	DIASTYLIS SP.						15
532805010300	DIASTYLIS BIDENTATA						4
532805011500	DIASTYLIS PARASPINULOSA						2
532805012500	DIASTYLIS CF. D. TETRADON						3
532805012600	DIASTYLIS LORICATA						1
532805020000	DIASTYLOPSIS SP						1
532805020100	DIASTYLOPSIS DAWSONI						1
532807000000	CAMPYLASPIDAE						0
532807010000	CAMPYLASPIS SP						5
532807010100	CAMPYLASPIS RUFA						1
532807010300	CAMPYLASPIS RUBICUNDA						1
532807010900	CAMPYLASPIS UMBENSIS						3
532900000000	TANAIDACEA						0
532901000000	TANAIDAE						1
533000000000	ISOPODA						3
533001020300	ARCTURUS GLABER						1
533001030100	CALATHURA BRANCHIATA						2
533005010000	AEGA SP						1
533005020200	ROCINELA BELLICEPS						2
533011010000	GNATHIA SP.				X		12
533012000000	ANTHURIDAE						3
533100000000	AMPHIPODA	X					22
533102010000	AMPELISCA SP.						5
533102010100	AMPELISCA MACROCEPHALA	X	X		X		18
533102010200	AMPELISCA BIRULAI				X		4
533102010500	AMPELISCA ESCHRICHTI						1
533102020000	BYBLIS SP						4
533102020200	BYBLIS GAIMARDI				X		10
533102030100	HAPLOOPS TUBICULA						7
533104010000	AMPITHOE						1
533107010100	ARGISSA HAMATIPES						1
533112090100	OLIGOCHINUS LIGHTI						1
533115000000	COROPHIIDAE						1
533115030000	ERICTHONIUS SP						1
533115050100	NEOHELA MONSTROSA						1
533120000000	EUSIRIDAE						1
533120010000	ACCEDOMOERA						1
533120130700	RHACHOTROPIS OCULATA						1
533121000000	GAMMARIDAE						1
533121080000	MAERA SP						1
533121080100	MAERA DANAE						2
533121080200	MAERA LOVENI						4
533121100000	MELITA SP.						2
533121100200	MELITA DENTATA						2
533122040200	UROTHOE DENTICULATA				X		9
533126000000	ISAEIDAE						1
533126020000	PHOTIS SP.						1

LIST OF ALL TAXONOMIC GROUPS FOUND

CRITERIA 1- TAXON OCCURS IN 50 PCT OR MORE OF STATIONS
CRITERIA 2- AT LEAST 10 PCT OF INDIVIDUALS AT SOME STATION
CRITERIA 3- AT LEAST 10 PCT OF WET BIOMASS AT SOME STATION
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
533126020200	PHOTIS CF. P. REINHARDI				X		2
533126030000	PROTOMEDEIA SP.						4
533133020000	LILJEBORGIA						1
533134000000	LYSIANASSIDAE						1
533134030000	ANONYX SP.						7
533134030100	ANONYX OCHOTICUS						4
533134030200	ANONYX NUGAX						6
533134031200	ANONYX CF. A. LATICOXAE						1
533134031300	ANONYX MAGNUS						1
533134110100	CYPHOCARIS CHALLENGERI						1
533134140000	HIPPOMEDON SP						3
533134140500	HIPPOMEDON PROPINQUUS						1
533134140600	HIPPOMEDON KURILICUS						3
533134210300	LIPIDEPECREUM KASATKA						2
533134210400	LEPIDEPECREUM COMATUM						4
533134290000	ORCHOMENE SP.						2
533134290700	ORCHOMENE LEPIDULA						1
533134380100	SCHISTURELLA PULCHRA						1
533135010000	MELPHIDIPPA SP						1
533135010100	MELPHIDIPPA GOESI						1
533137000000	OEDICEROTIDAE						3
533137020100	ACEROIDES LATIPES						1
533137050000	BATHYMEDON SP.						3
533137050200	BATHYMEDON LANGSDORFI						1
533137050400	BATHYMEDON NANSENI						1
533137080000	MONOCULODES SP.						3
533137080500	MONOCLADES DIAMENSUS						4
533137080600	MONOCLADES LATIMANUS						1
533137080900	MONOCLADES MERTENSI						1
533137081600	MONOCLADES ZERNOVI						1
533137150200	WESTWOODILLA COECULA						2
533140010100	HALICE ABYSSI						1
533140020100	NICIPPE TUMIDA						7
533140030300	PARADALISCA TENUIPES						1
533142000000	PHOXOCEPHALIDAE				X		6
533142010200	HARPINIA KOBJAKOVAE						4
533142020100	HARPINIOPSIS SANPEDROENSIS				X		14
533142030100	HETEROPHOXUS OCULATUS	X			X		19
533142070000	PARAPHOXUS SP.						3
533142070100	PARAPHOXUS ROBUSTUS						2
533142070200	PARAPHOXUS SIMPLIX						5
533142080000	PHOXOCEPHALUS						1
533143030400	PARAPLEUSTES ASSIMILIS						1
533143060100	STENOPLEASTES UNCITGERA						1
533148000000	STENOTHOIDAE						2
533148020000	METOPA SP.				X		12
533148020100	METOPA ALDERI						2
533150000000	SYNOPIIDAE						1

LIST OF ALL TAXONOMIC GROUPS FOUND

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CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
533150030100	SYRRHOE CRENULATA						1
533150050200	TIRON BIOCULATA						1
533180100000	PARATHEMISTO SP						1
533198000000	CAPRELLIDAE						5
533200000000	EUPHAUSIACEA						0
533202000000	EUPHAUSIIDAE						1
533202090000	THYSANOESSA SP						1
533202090200	THYSANOESSA INERMIS						1
533202090600	THYSANOESSA RASCHII						1
533300000000	DECAPODA						2
533305000000	HIPPOLYTIDAE						1
533305041100	EUALUS AVINA						1
533306011100	CRANGON COMMUNIS						1
533311020000	PAGURUS SP.						2
533311050100	DISCORSOPAGURUS SCHMITTI						1
533317030000	CHIONOECETES SP.						10
533318010600	CANCER OREGONENSIS						1
590000000000	SIPUNCULIDA						0
590101010100	GOLFINGIA MARGARITACEA	X	X		X		22
590101010200	GOLFINGIA VULGARIS						10
590101020100	PHASCOLION STROMBI				X		13
610000000000	PRIAPULIDA						3
610101020200	PRIAPULUS CAUDATUS						2
660000000000	ECTOPROCTA		X	X	X	X	15
660306010100	CLAVIPORA OCCIDENTALIS				X		6
670000000000	BRACHIOPODA						0
670200000000	ARTICULATA			X		X	5
670203010000	TEREBRATULINA SP						1
670203010100	TEREBRATULINA UNGUICULA			X	X	X	7
670203010300	TEREBRATULINA CROSSEI				X		2
670205010100	DIESTOTHYRIS FRONTALIS						1
670205030100	LAQUEUS CALIFORNIANUS			X	X	X	8
670205040100	TEREBRATALINA TRANSVERSA			X		X	2
680000000000	ECHINODERMATA						0
680100000000	ASTEROIDEA						4
680104060200	PSEUDARCHASTER PARELII						1
680106000000	PORCELLANASTERIDAE						1
680106010100	CTENODISCUS CRISPATUS	X		X	X	X	19
680202010100	ECHINARACHNIUS PARMA						1
680203010100	BRISASTER TOWNSENDI			X	X	X	9
680204010100	ALLOCENTROTUS FRAGILIS						1
680300000000	OPHIUROIDEA						16
680302030100	DIAMPHIODIA CRATERODMETA						5
680302080100	UNIOPLUS MACRASPIS	X	X	X	X	X	21
680304020000	GORGONOCEPHALUS SP						1
680306010100	OPHIOPHOLIS ACULEATA						2
680309000000	OPHIURIDAE						1
680309050100	OPHIOPENIA DISACANTHA						2

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LIST OF ALL TAXONOMIC GROUPS FOUND

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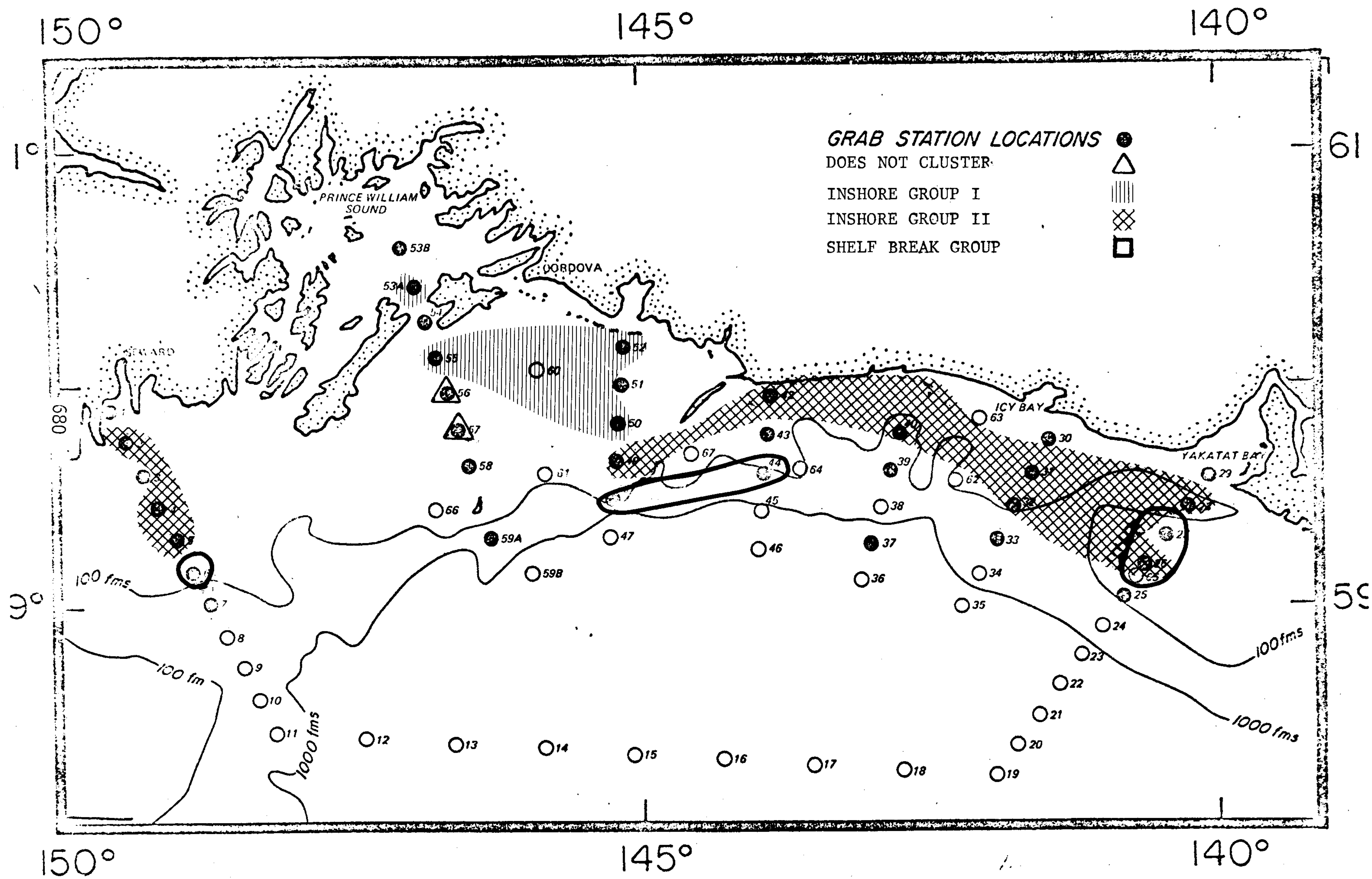
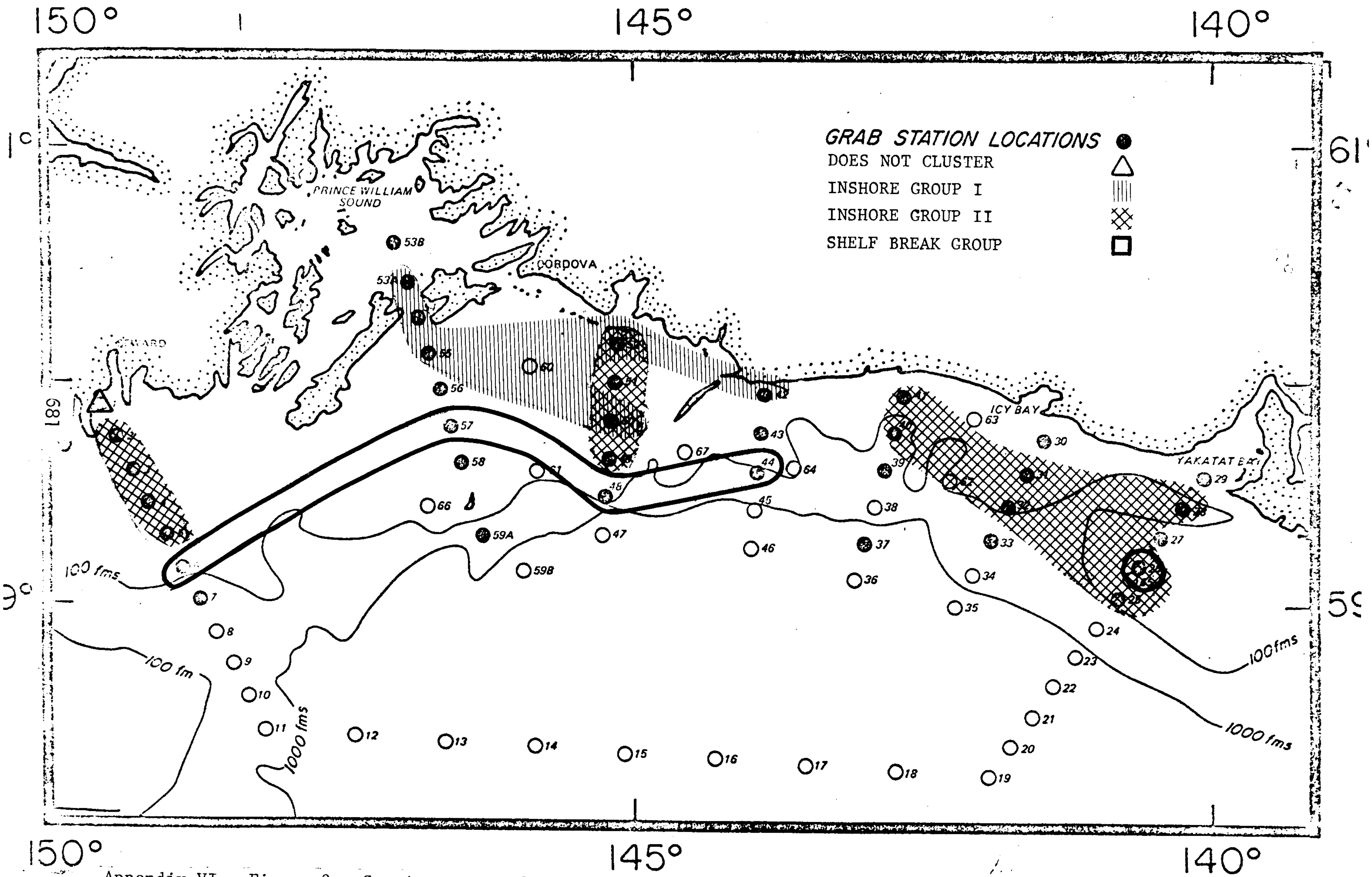
CRITERIA 4- ABUNDANT WRT NO. INDIVIDUALS AT SOME STATION
CRITERIA 5- ABUNDANT WRT TOTAL BIOMASS AT SOME STATION

TAXON CODE	TAXON NAME	CRIT1	CRIT2	CRIT3	CRIT4	CRIT5	STA OCC
680309061100	OPHIURA SARSI	X	X	X	X	X	30
680309080000	STEGOPHIURA SP						6
680400000000	HOLOTHUROIDEA			X		X	9
680405010100	MOLPADIA INTERMEDIA	X		X		X	19
680410010100	CUCUMARIA CALCIGERA						7
680412020000	PSOLUS SP.						2
680500000000	CRINOIDEA						4
720000000000	UROCHORDATA						8
999900000000	EGG CASES				X		9
999999999900	UNIDENTIFIBLE						11

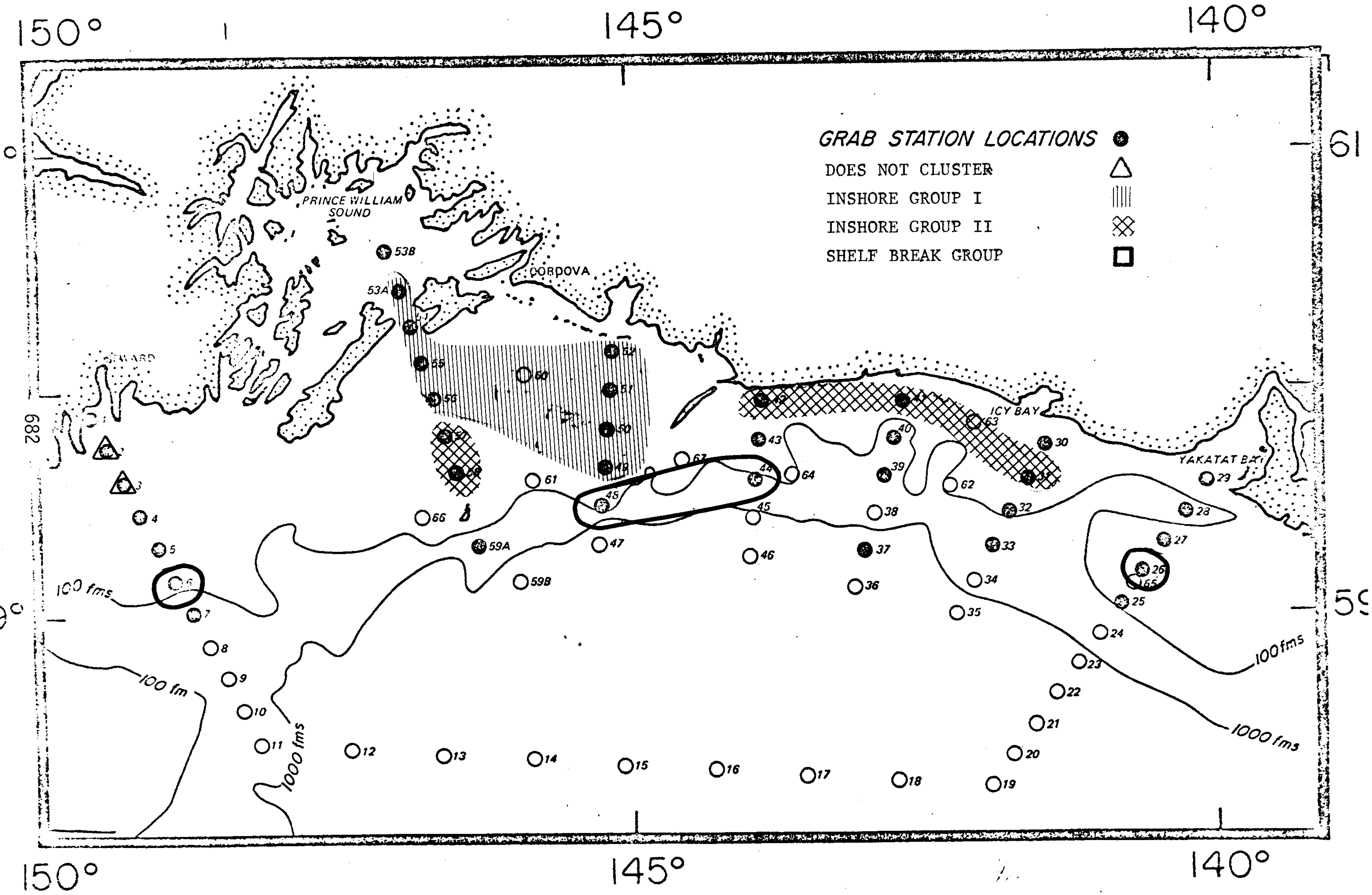
TOTAL NUMBER OF TAXONS = 457



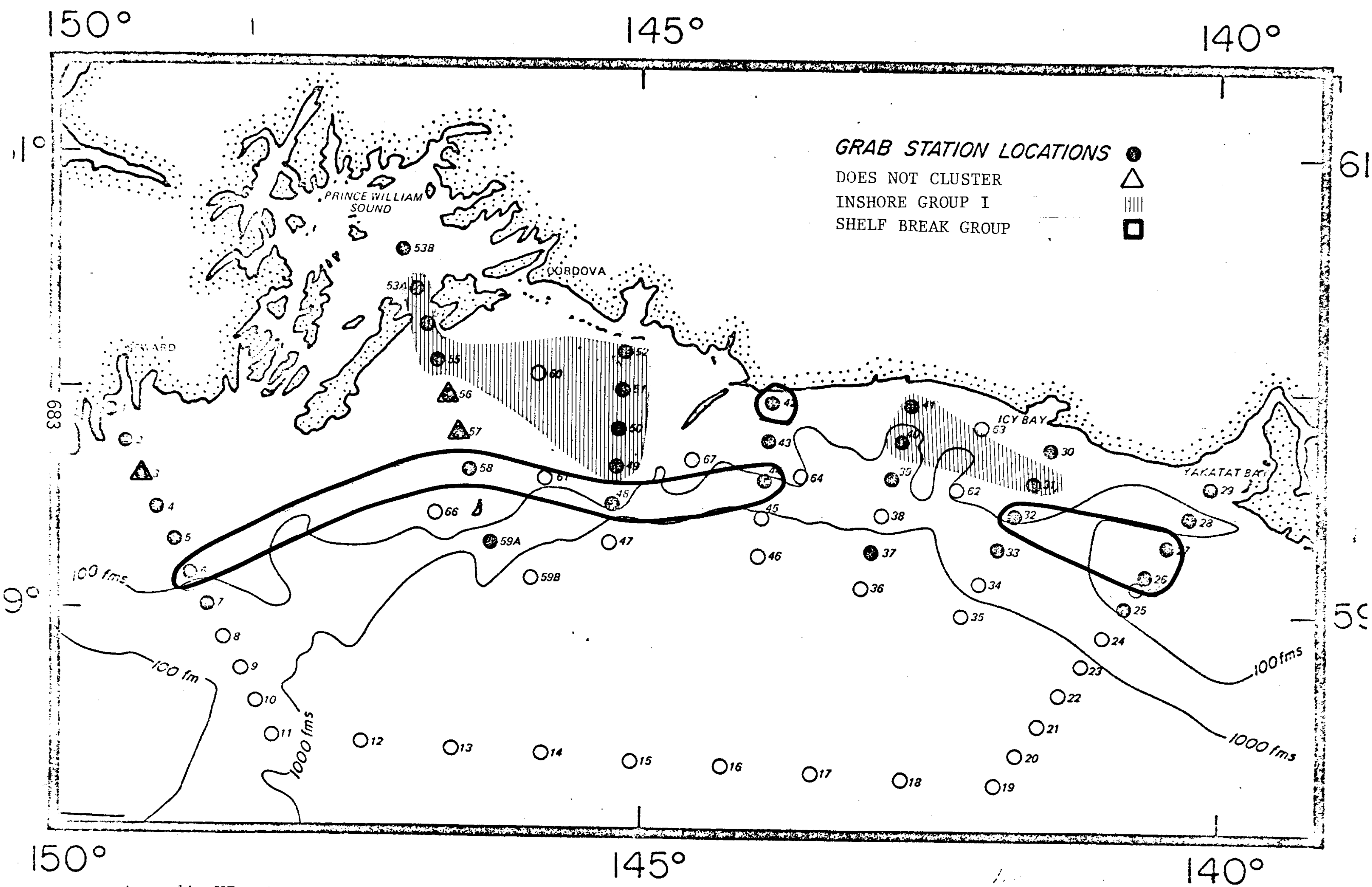
Appendix VI - Figure 2. Station groups formed by cluster analysis of quantitative stations using the number of individuals/m². Only major station clusters are shown.



Appendix VI - Figure 3. Station groups formed by cluster analysis of quantitative stations using a natural log transformation of the number of individuals/m^2. Only major station clusters are shown.



Appendix VI - Figure 4. Station groups formed by cluster analysis of quantitative stations using wet weight/m^2. Only major station clusters are shown.



Appendix VI - Figure 5. Station groups formed by cluster analysis of quantitative stations using a natural log transformation of wet weight/m^2. Only major station clusters are shown.

APPENDIX VI - TABLE III

STATION GROUPS DELINEATED BY CLUSTER ANALYSIS BASED ON THE NUMBER OF INDIVIDUALS PER SQUARE METER. FEEDING TYPES AS FOLLOWS: DF = DEPOSIT FEEDER, E = ECTOPARASITE, P = PREDATOR, S = SCAVENGER, SF = SUSPENSION FEEDER.

ID #	Station #	Brillouin Diversity	Brillouin Evenness	Simpson Diversity	Sediment %Gravel	Sediment %Sand	Sediment %Silt	Sediment %Clay	%Feeding Type
Station Group 1 (Inshore Group I)									
10	193052 *	1.036	0.715	0.125	Trace	0.44	37.83	61.72	DF 61%
13	200052	1.159	0.817	0.084	Trace	0.44	37.83	61.72	P 21%
12	200050	1.184	0.860	0.059	Trace	2.50	33.30	64.20	S 14%
14	200053	1.097	0.752	0.018	0	28.07	46.02	25.91	SF 4%
11	193055	1.104	0.825	0.091	0	1.26	48.22	50.52	
26	805055	1.098	0.895	0.057	0	1.26	48.22	50.52	
9	193050	1.098	0.933	0.041	Trace	2.50	33.30	64.20	
Station Group 2									
5	193041	1.012	0.727	0.127	Trace	0.31	49.57	50.12	DF 50%, SF 24%
6	193042	1.021	0.683	0.135	Trace	10.58	58.88	30.54	P 17%, S 9%
Station Group 3									
15	200057	1.416	0.824	0.047	26.59	14.20	29.39	26.83	SF 38%, DF 34% S 20%, P 8%
Station Group 4 (Shelf Break Group)									
3	193026	1.292	0.902	0.039	4.32	8.47	53.64	33.57	SF 32%
7	193044	1.335	0.884	0.040	3.01	50.64	22.95	23.40	S 30%
2	193006	1.507	0.870	0.031	6.27	37.69	23.42	32.62	DF 26%
8	193048	1.407	0.901	0.033	19.95	15.54	33.51	31.00	P 12%
35	807027	.871	0.583	0.279	13.17	10.49	43.46	32.88	
Station Group 5									
1	193003	0.993	0.991	0.061	Trace	0.40	31.92	67.68	
23	805051	0.987	0.881	0.071	0	0.27	39.54	60.19	
38	807052	0.948	0.936	0.052	Trace	0.44	37.83	61.72	

* The first three digits of the station code represent the cruise number and the last three represent the station name, i.e. 193003=Cruise 193 Station 3.

APPENDIX VI - TABLE III (cont'd)

ID #	Station #	Brillouin Diversity	Brillouin Evenness	Simpson Diversity	Sediment %Gravel	Sediment %Sand	Sediment %Silt	Sediment %Clay	%Feeding Type
Station Group 6 (Inshore Group II)									
33	807025	1.015	0.906	0.062	1.18	44.96	33.42	20.44	DF 65%
37	807050	1.032	0.886	0.070	Trace	2.50	33.30	64.20	SF 15%
4	193032	1.223	0.931	0.036	Trace	0.42	51.09	48.49	P 12%
18	805032	1.388	0.925	0.028	Trace	0.42	51.09	48.49	E 6%
19	805040	1.212	0.892	0.048	Trace	0.23	44.53	55.24	S 3%
36	807028	1.177	0.851	0.064	0.27	6.87	52.66	40.20	
20	805041	1.086	0.811	0.088	Trace	0.31	49.57	50.12	
22	805049	1.203	0.847	0.065	0	7.71	49.53	42.75	
17	805031	1.133	0.883	0.060	Trace	1.68	62.70	35.62	
31	807004	0.985	0.830	0.094	Trace	0.42	30.70	68.87	
34	807026	1.088	0.871	0.067	4.32	8.47	53.64	33.57	
30	807002	1.282	0.941	0.027	0	3.35	33.85	62.80	
32	807005	1.072	0.767	0.109	3.12	16.84	20.25	59.80	
21	805042	0.902	0.863	0.091	Trace	10.58	58.88	30.54	
Station Group 7									
25	805054	0.940	0.765	0.158	0	27.94	43.47	28.59	DF 44%, SF 31%
29	805058	0.883	0.692	0.185	0	3.41	47.00	49.59	P 13% S 13%
Station Group 8									
27	805056	1.311	0.765	0.102	24.39	42.49	18.05	15.07	P 34%, SF 28% DF 21%, S 17%
Station Group 9									
28	805057	1.189	0.941	0.031	26.59	14.20	29.39	26.83	DF 50%, S 25% P 13%, E 13%
Station Group 10									
24	805053	0.817	0.886	0.093	0	28.07	46.02	25.91	
39	807053	0.463	1.000	0.107	0	28.07	46.02	25.91	
16	202001	0.707	0.902	0.105	Trace	1.08	37.10	61.82	

APPENDIX VI - TABLE IV

STATION GROUPS DELINEATED BY CLUSTER ANALYSIS BASED ON A NATURAL LOG TRANSFORMATION OF THE NUMBER OF INDIVIDUALS/M^2 DATA

Station Group 1 (Inshore Group I)
193052*
200052
193042
200050
193055
193050
200053
805054

Station Group 2 (Inshore Group II)
193003
805051
807052
805032
805040
807028
805031
805041
193041
805049
193032
807004
807026
807005
807002
807050
807025

Station Group 3 (Shelf Break Group)
193006
193048
193026
193044
200057

Station Group 4
805054
807027

Station Group 6
805056
805057

Stations which do not join clusters
807042
805053
807053
202001

* The first three digits of the station code represent the cruise number and the last three represent the station name, i.e. 193003=Cruise 193 Station 3.

APPENDIX VI - TABLE V

STATION GROUPS DELINEATED BY CLUSTER ANALYSIS BASED ON WET BIOMASS PER SQUARE METER

Station Group 1 (Inshore Group I)
200053*
805049
805054
805056
805051
807052
193055
193050
805040

Station Group 2 (Inshore Group II)
193041
805031
805041
805042
805058
805057

Station Group 3 (Shelf Break Group)
193006
193026
193044
193048

Station Group 4
200050
807050

Station Group 5
200057
807027

Station Group 6
193042
193052

Station Group 7
202001
807004
807028

Stations which do not join clusters
805056
193003
807002
807053
200052
805053

* The first three digits of the station code represent the cruise number and the last three represent the station name, i.e. 193003=Cruise 193 Station 3.

APPENDIX VI - TABLE VI

STATION GROUPS DELINEATED BY CLUSTER ANALYSIS BASED ON A NATURAL LOG TRANSFORMATION OF WET WEIGHT/M^2 DATA

Station Group 1 (Inshore Group I)
193041*
805031
805041
805040
807050
200053
805054
805051
807052
193055
805055
805049
193050

Station Group 2 (Shelf Break Group)
193006
193048
193042
805042
805058
807027
193026
193044
193032
805032

Station Group 3
807025
807026
807005
200050

Station Group 4
202001
807004
807028
807002

Station Group 5
193052
200052

Stations which do not join clusters
193003
805056
200057
805058
807053
805053

* The first three digits of the station code represent the cruise number and the last three represent the station name, i.e. 193003=Cruise 193 Station 3.

APPENDIX VI - TABLE VII

STATION GROUPS FORMED BY CLUSTER ANALYSIS OF BOTH QUANTITATIVE AND AND QUALITATIVE STATIONS USING PRESENCE-ABSENCE DATA

Station Group 1 (Inshore Group I)
193055
805055
193050
805051
200050
200053
807052
805054
807050
193032
193041
193003
807004
807026
807005
805031
805049
805032
805040
805041
807028

Station Group 2 (Inshore Group II)
193042
193052
200052
805042
193029

Station Group 3 (Shelf Break Group)
193006
193048
193044
193026
200057

Station Group 4 (Deep Water I)
805033
807025
807007

Station Group 5 (Deep Water II)
193059
805037

Station Group 6
805043
805058

Station Group 7
805056
805057

Station Group 8
193030
805030

Stations which do not join clusters
807027
807053
202001
805053
805044
193039
805039

APPENDIX VI - TABLE VIII

SPECIES GROUPS DELINEATED BY CLUSTER ANALYSIS BASED ON THE NUMBER OF INDIVIDUALS PER SQUARE METER. FEEDING TYPES ARE AS FOLLOWS: DF = DEPOSIT FEEDER, E = ECTOPARASITE, P = PREDATOR, S = SCAVENGER AND SF = SUSPENSION FEEDER

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 1	8(70%)	
94	Pelecypoda *Astarte esquimaulti*		SF
132	Amphipoda *Ampeliscida birulai*		S?
31	Eunicidae *Eunice* sp.		DF
105	Pelecypoda *Thriacia beringi*		SF
111	Gastropoda *Cylichna alba*		P
117	Thoracica *Balanus rostratus*		SF
159	Brachiopoda *Terrebratulina frossei*		SF
160	Brachiopoda *Deistrothyris frontalis*		SF
161	Brachiopoda *Laques californianus*		SF
135	Amphipoda *Byblis gaimandi*		S
34	Orbiniidae *Haplosoloplos panamensis*		DF
93	Pelecypoda *Astarte polaris*		SF
75	Polyplacophora *Ischnochiton albus*		DF?
146	Amphipoda *Paraphoxus robustus*		S
11	Phyllodocidae *Eteone langa*		P
8	Sigaloinidae *Phloe minuta*		S
108	Gastropoda *Amphissa columbiana*		P
167	Amphiuridae *Pandellia charchara*		DF
109	Gastropoda *Amphissa reticulata*		P
19	Nereidae *Ceratonereis paucidentata*		P
87	Pelecypoda *Megacrenella columbiana*		SF
21	Nepthyidae *Nepthys* sp.		P
23	Nepthyidae *Nepthys coeca*		P
	Species Group # 2	8(40%)	
77	Polyplacophora *Hanleya* sp.		DF
78	Polyplacophora *Hanleya hanleyi*		DF
13	Syllidae *Syllis* sp.		P
14	Syllidae *Syllis sclerolema*		P
12	Syllidae		P
4	Polynoidae *Harmothoe imbricata*		S
	Species Group # 3	9(51%)	
2	Polynoidae *Gattyana iliata*		S
120	Cumacea *Leucon nasica*		DF
22	Nepthyidae *Nepthys ciliata*		P
152	Decapoda *Pinnixia occidentalis*		S

TABLE VIII (cont'd)

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 4	6(100%)	
139	Amphipoda *Hippomedon propinguus*		S
148	Amphipoda *Phoxocephalus* sp.		S
	Species Group # 5	7(32%)	
125	Cumacea *Diastylis hirsata*		DF?
145	Amphipoda *Heterophoxus occulatus*		S
66	Terebellidae *Arctecama conifera*		DF
119	Cumacea *Leucon* sp.		DF
73	Sabellidae *Potamilla neglecta*		SF
80	Pelecypoda *Malletia cuneata*		DF SF?
	Species Group # 6	7(91%)	
25	Nepthyidae *Nepthys longasetosa*		P
85	Pelecypoda *Yoldia amygdaiea*		DF SF
	Species Group # 7	9(50%)	
46	Scalibreamidae *Travista* sp.	6(31%)	DF
128	Isopoda *Gnathia* sp.		E
32	Lumbrineridae *Lumbrineris* sp.		DF
35	Paraonidae *Aricidea suecica*		DF
	Species Group # 8	6(32%)	
67	Terebellidae *Proclea emmi*		DF
110	Gastropoda *Oenopota* sp.		P
54	Maldanidae *Praxillella* sp.		DF
	Species Group # 9	4(76%)	
69	Sabellidae *Chone gracilis*		SF
114	Amphipoda *Halosoma* sp.		S
72	Sabellidae *Megalomma splendida*		SF
130	Amphipoda *Acanthonatozoma inflatum*		S
3	Polynoidae *Gattyana treadwelli*		S
	Species Group # 10	4(52%)	
100	Pelecypoda *Clinocardium ciliatum*		SF
125	Cumacea *Diastylis* sp.		DF
57	Owenidae *Owenia fusiformis*		DF SF
65	Terebellidae *Pista fasciata*		DF
18	Syllidae *Haplosyllis spongicola*		P
60	Ampharetidae *Ampharete arctica*		DF

TABLE VIII (cont'd)

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 11	4(30%)	
71	Sabellidae *Euchone analis*		SF
156	Bryozoa *Microporina borealis*		SF
133	Amphipoda *Byblis* sp.		S
158	Brachipoda *Terebratulina unguicula*		SF
26	Nepthyidae *Nepthys ferruginea*		P
134	Amphipoda *Byblis crassicornis*		S
	Species Group # 12	4(46%)	
17	Syllidae *Langerhansia cornuta*		P
144	Amphipoda *Harpiniopsis sandpedroensis*		S
7	Polydontidae *Peisidice aspera*		S
90	Pelecypoda *Cyclopecten randolphi*		SF
153	Sipunculida *Golfingia margaritacea*		DF
53	Maldanidae *Notoproctus pacificus*		DF
88	Pelecypoda *Dacrydium* sp.		SF
36	Paraonidae *Aricidea jeffreysii*	(selected deposit)	SDF
127	Isopoda *Gnathia* sp.		E
115	Copepoda *Harpacticoidea*		S
136	Amphipoda *Haploops tubicula*		S
52	Maldanidae *Maldane glebifex*		DF
15	Syllidae *Eusyllis bloomstrandi*		P
137	Amphipoda *Ericthonius heunteri*		S
142	Amphipoda *Harpinia* sp.		S
	Species Group # 13	3(67%)	
86	Pelecypoda *Crenella dessucata*		SF
95	Pelecypoda *Cyclocardia ventricosa*		SF
	Species Group # 14	3(82%)	
101	Pelecypoda *Clinocardium fucanum*		SF
157	Bryozoa *Clavopora occidentalis*		SF
131	Amphipoda *Ampelisca macrocephala*		S
92	Pelecypoda *Astarte montegui*		SF
107	Gastropoda *Lepeta caeca*		S?
118	Cumacea *Lamprops fuscata*		DF
50	Maldanidae *Asychis similis*		DF
70	Sabellidae *Chone infundibuliformis*		SF
61	Ampharetidae *Ampharete goesi*		SDF
149	Caprellidae *Caprella striata*		SF
129	Amphipoda *Hyssura* sp.		S
16	Syllidae *Exogene* sp.		P
45	Scalibregmidae *Scalibregma inflatum*		DF
147	Amphipoda *Paraphoxus simplex*		S
59	Sabellariidae *Idanthyrsus armatus*		SF

TABLE VIII (cont'd)

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 15	3(47%)	
6	Polynoidae *Hesperonoe complanata*	1(46%)	S
155	Priapulidae *Priapulus caudatus*		DF
1	Cnidaria Anthozoa "Sea Pan"		SF
56	Maldanidae *Rhodine bitorquata*		DF
	Species Group # 16	1(76%)	
43	Cirratulidae *Caulleriella* sp.		DF
18	Syllidae *Haplosyllis spongicola*		P
	Species Group # 17	1(40%)	
103	Pelecypoda *Macoma calcarea*		DF SF
143	Amphipoda *Harpinia emeryi*		S
37	Paraonidae *Paraonis gracilis*		DF
48	Capitellidae *Capitella capitata*		DF
49	Capitellidae *Heteromastis filiformis*		DF
122	Cumacea *Eudorella emarginata*		DF? S?
123	Cumacea *Eudorellopsis integra*		DF? S?
	Species Group # 18	2(42%)	
44	Cirratulidae *Tharyx* sp.		DF
62	Ampharetidae *Melinna cristata*		SDF
27	Glyceridae *Glycera capitata*		P
68	Terebellidae *Terebellides stromata*		SDF
24	Nepthyidae *Nepthys punctata*		DF
74	Aplacaphora *Chaetoderma robusta*		DF
98	Pelecyploda *Thyasira flexuosa*		SF
55	Maldanidae *Praxillella gracilis*		DF
112	Scaphapoda *Dentalium* sp.		SDF
172	Holothuroidea *Molpadia* sp.		DF
40	Spionidae *Spiophanes cirrata*		SDF
8	Sigalionidae *Phloe minuta*		S
79	Pelecypoda *Nucula tenuis*		SF DF
102	Pelecypoda *Psephidia lordi*		SF
33	Lumbrineridae *Lumbrineris similabris*		P
47	Sternaspidae *Sternaspis scutata*		DF
58	Owenidae *Myriochele heeri*		SDF
96	Pelecypoda *Axinopsida serricata*		SF
30	Onuphidae *Onuphis geofiliformis*		DF SF?
171	Echinodermata *Ophiura sarsi*		P

TABLE VIII (cont'd)

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 19	2(41%)	
106	Pelecypoda *Cardiomya serricata*		SF
113	Scaphopoda *Cadulus* sp.		DF P
89	Pelecypoda *Dacryduum pacificum*		SF
64	Terebellidae *Pista cristata*		DF
	Species Group # 20	6(39%)	
83	Pelecypoda *Portlandia arctica*		DF SF
163	Echinodermata *Ctenodiscus crispatus*		DF
168	Echinodermata *Pandellia carchara*		DF
28	Goniadidae *Goniada annulata*		P
	Species Group # 21	6(83%)	
99	Pelecypoda *Odontogenia borealis*		SF
164	Echinoidea *Brisaster townsendi*		DF
	Species Group # 22	6(69%)	
39	Spionidae *Spio filicornis*		DF
	Species Group # 23	1(96%)	
41	Megalonidae *Megalona japonica*		DF
	Species Group # 24	6(100%)	
121	Cumacea *Leucon acutirostris*		DF S
141	Amphipoda *Aceroides* sp.		S
76	Polyplacophora *Molpalia* sp.		DF
	Species Group # 25	3(76%)	
29	Coniadidae *Goniada maculata*		P
165	Echinodermata *Diamphiodia craterodermata*		DF
38	Spionidae *Laonice cirrata*		DF
84	Pelecypoda *Yoldia* sp.		DF SF
	Species Group # 26	4(66%)	
63	Terrebellidae *Pista cristata*		DF
116	Thoracica *Scapellum columbianum*		SF
166	Echinodermata *Diamphiodia periercta*		DF
173	Echinodermata *Psolus* sp.		SF
138	Amphipoda *Anonyx ochoticus*		S

TABLE VIII (cont'd)

ID No.	Species Groups	Station Groups ≥30%	Feeding Type
	Species Group # 27	2(98%)	
20	Nereidae *Nereis* sp.		P
150	Decopoda *Chionoecetes bairdi*		P S
	Species Group # 28	1(63%)	
42	Goniadidae *Goniada anulata*		P
140	Amphipoda *Lepideprecum comatum*		S
	Species Group # 29	2(72%)	
151	Decapoda *Pinnixia* sp.		S
154	Priajoulida *Halicryptus spinulosus*		SF
104	Pelecypoda *Hiatella arctica*		SF
	Species Group # 30	1(88%)	
162	Echinodermata *Ctenodiscus* sp.		DF
170	Echinodermata *Ophiura* sp.		P
169	Echinodermata *Ophiopenia disacantha*		DF
	Species Group # 31	5(70%)	
5	Polynoidae *Lepidonotus squamatus*		S
10	Phyllodocidae *Araitides mucosa*		P
9	Phyllodoridae *Phylodoce groenlandica*		P
	Species Group # 32	1(100%)	
97	Pelecypoda *Thyasira* sp.		SF

APPENDIX VI - TABLE IX

SOME CHARACTERISTICS OF STATION GROUPS FORMED BY CLUSTER ANALYSIS OF UNTRANSFORMED NUMBER/M^2 DATA. DIVERSITY INDICES AND SEDIMENT DISTRIBUTIONS ARE MEAN VALUES FOR ALL STATIONS WITHIN THE STATION GROUP

STATION GROUPS	BRILLOUIN INDEX OF DIVERSITY	SEDIMENT % GRAVEL	% SAND	% SILT	% CLAY	FEEDING TYPE % SF	% DF	% P	% S
Inshore Group 1	1.11 ± 0.05	0	5.21	40.67	59.92	4	61	21	14
Inshore Group 2	1.12 ± 0.12	0.63	7.48	40.55	47.22	15	65	12	3
Station 56	1.31	26.59	14.20	29.39	26.83	28	21	34	7
Station 57	1.42	24.39	42.49	18.05	15.07	38	34	8	20
Shelf Break Group	1.38 ± .09	9.39	24.56	35.39	30.69	32	26	12	30

Inshore Group II consists of a large block of stations to the east of Inshore Group I and several stations south of Resurrection Bay. A third group (labeled Shelf Break Group) consists of stations located at or near the 200 m coutour. Several stations including stations 56 and 57 have a unique enough fauna so that they do not enter any of the cluster groups formed (Fig. 2; Table III). The species groups formed by an inverse analysis of untransformed number/m^2 data are listed in Table VIII.

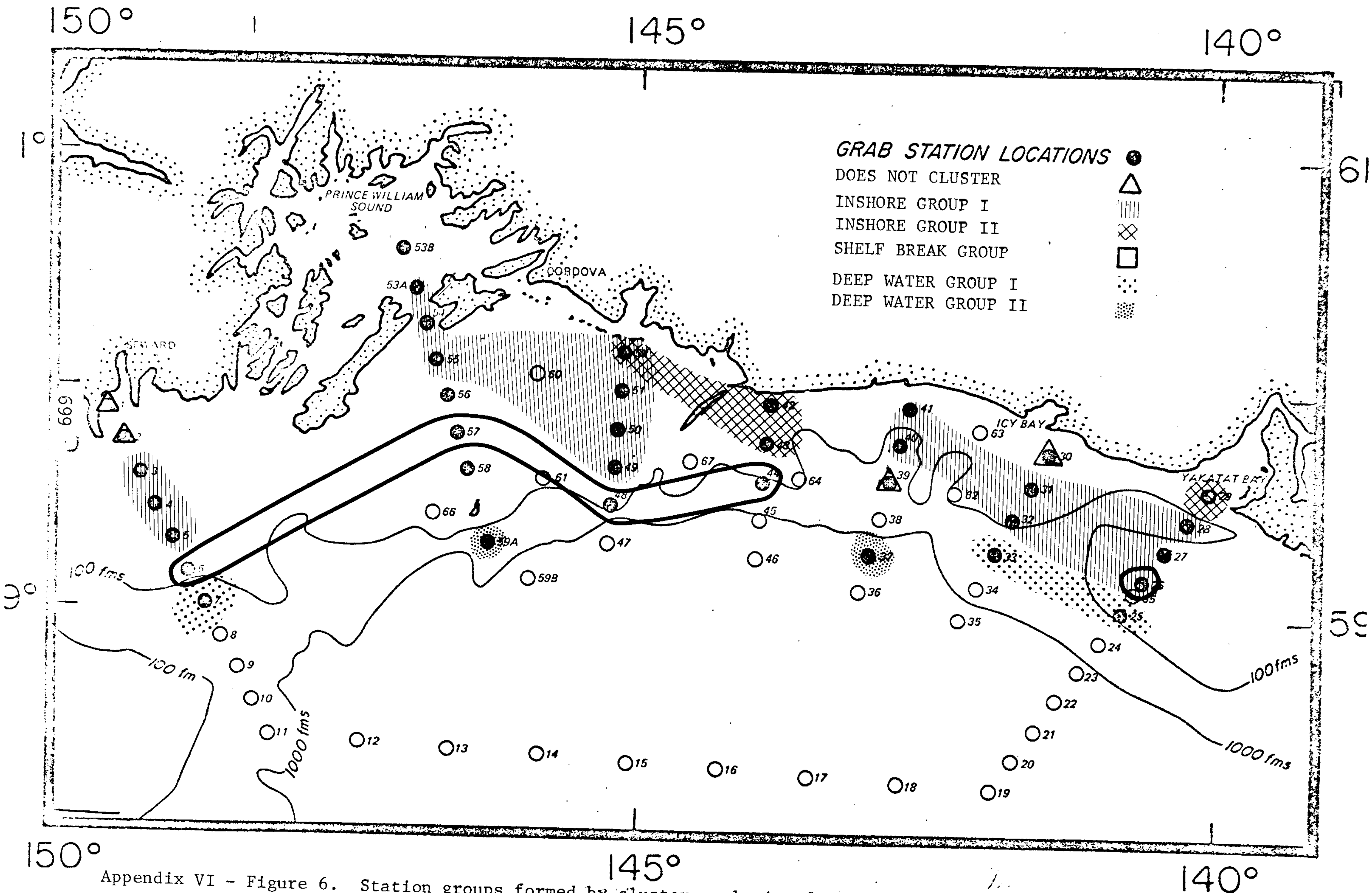
Tables III and IX list some of the properties of the stations in the various station groups. The values listed in Table IX are mean values for all stations in each group. The sediments in both of the inshore station groups are predominantly silts and clays while the shelf break stations and stations 56 and 57 have considerable quantities of sand and gravel mixed with silt and clay. An analysis of variance demonstrated that the diversity of the shelf break stations and stations 56 and 57 is significantly higher ($P < 0.05$) than that of the inshore stations (Table IX). Coincident with the difference in sediment types between the inshore station groups and the shelf break stations as well as stations 56 and 57, there is a shift in the distribution of feeding types within the fauna. The fauna of the inshore station groups is dominated by deposit feeders whereas suspension feeders are dominant in the shelf break stations and in stations 56 and 57 (Table IX).

The major station groups delineated by cluster analyses using Ln transformed number/m^2 data, untransformed and Ln transformed wet weight/m^2 data and presence-absence data are shown in Figures 3 through 6. Although the boundaries of the major station groups change somewhat when different data bases are used, the major station groups illustrated in Figure 2 are still recognizable. When wet weight/m^2 data was used in the analysis, Inshore Group II was greatly reduced in size (Fig. 4).

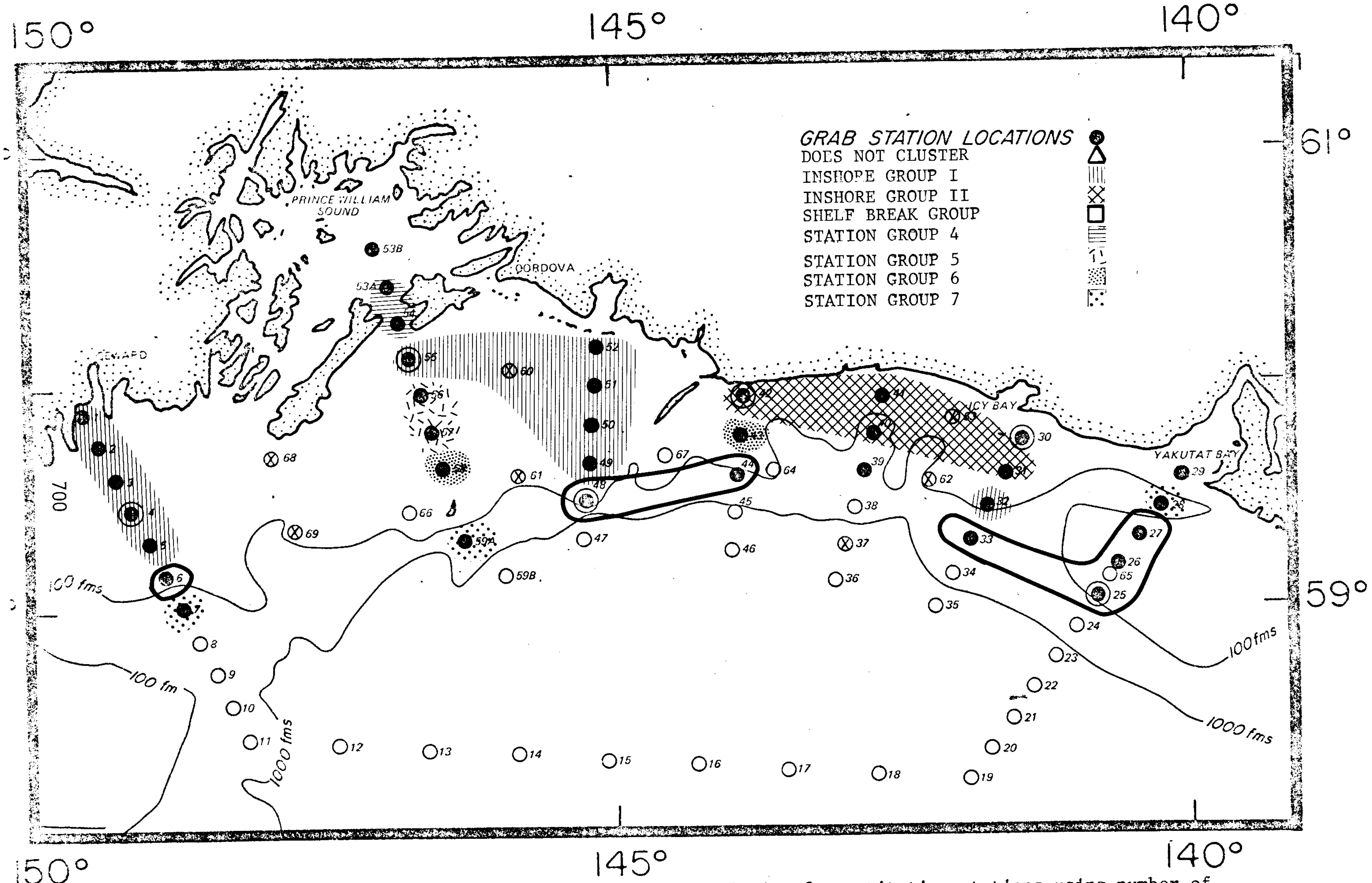
Species which have a large biomass but are present in low numbers will have little effect on station grouping when abundance data is used, but they will have a very great effect on those groupings when wet weight/m^2 data is used. The fragmentation of larger station groups into several smaller ones are caused by the distribution of these large species. The use of a natural log transformation reduces the effect of these species. When natural log transformed wet weight/m^2 data was used, Inshore Group I and Inshore Group II merged to form a single large inshore station group (Fig. 5). Cluster analysis of presence-absence data included those stations which could not be sampled quantitatively. The addition of these stations to the analysis added two new station groups seaward of the Shelf Break Group (Fig. 6).

Since the data from four different cruises had to be pooled to get complete coverage of the lease area, seasonal changes in the fauna may be confusing the results. For example, some of the stations which have been sampled on more than one occasion are classified into different station groups when sampled at different times. A great deal of caution must be applied in interpreting these results until they can be compared with data from the *Silas Bent* cruise of September 1975 and the *Discoverer* cruise of March 1976. However, a preliminary analysis of the data collected in the fall of 1975 (cruises 811 and 816) seems to indicate that there has been very little change in the structure of the station groupings (Fig. 7).

The results of the analyses appear to indicate that there is a change in the infaunal community along a gradient that is related to changes in depth and sediment grain size distribution.



Appendix VI - Figure 6. Station groups formed by cluster analysis of both quantitative and qualitative stations using presence-absence data. Only major station clusters are shown.



Appendix VI - Figure 7. Station groups formed by cluster analysis of quantitative stations using number of individuals/m^2. Data collected during September and November-December 1975.

APPENDIX VII

BERING SEA BENTHOS - INFAUNAL DATA ANALYSIS

All stations listed in Table I (a total of 59) were used in an agglomerative hierarchical cluster analysis. The actual clustering methods employed have been described in detail in another section of this report (see Section V, this report, on classification of Gulf of Alaska grab data). The similarity index chosen for use in this analysis was that of Czekanowski. Time permitted only the analysis of station clusters using numbers of individuals and wet weights as variables. No attempt was made to define clusters on a presence-absence basis, nor were species groups (as opposed to station groups) analyzed.

One-hundred forty-six (146) species were included in this analysis. They were chosen using the following criteria: a) all those species found to be biologically important under the five standard criteria (i.e., BIT's) were used, and b) any non-biologically important species that occurred at 7 or more stations were used.

The station groups resulting from the clustering are shown in Figures 1, 2, 3, and 4. All were produced by an average linkage algorithm. They represent, respectively, untransformed counts, ln-transformed counts, untransformed wet weights, and ln-transformed wet weights. Small and single station clusters have been eliminated but do cover most of the areas not in major station groups.

Figure 1 shows two inshore station groups (see Table II). That nearest to shore (Group I) is characterized by medium to coarse sand sediment (Wentworth size classes - all sediment information is from Dr. C. Hoskin, personal communication) and a measurable percentage of gravel. With the

APPENDIX VII
TABLE I

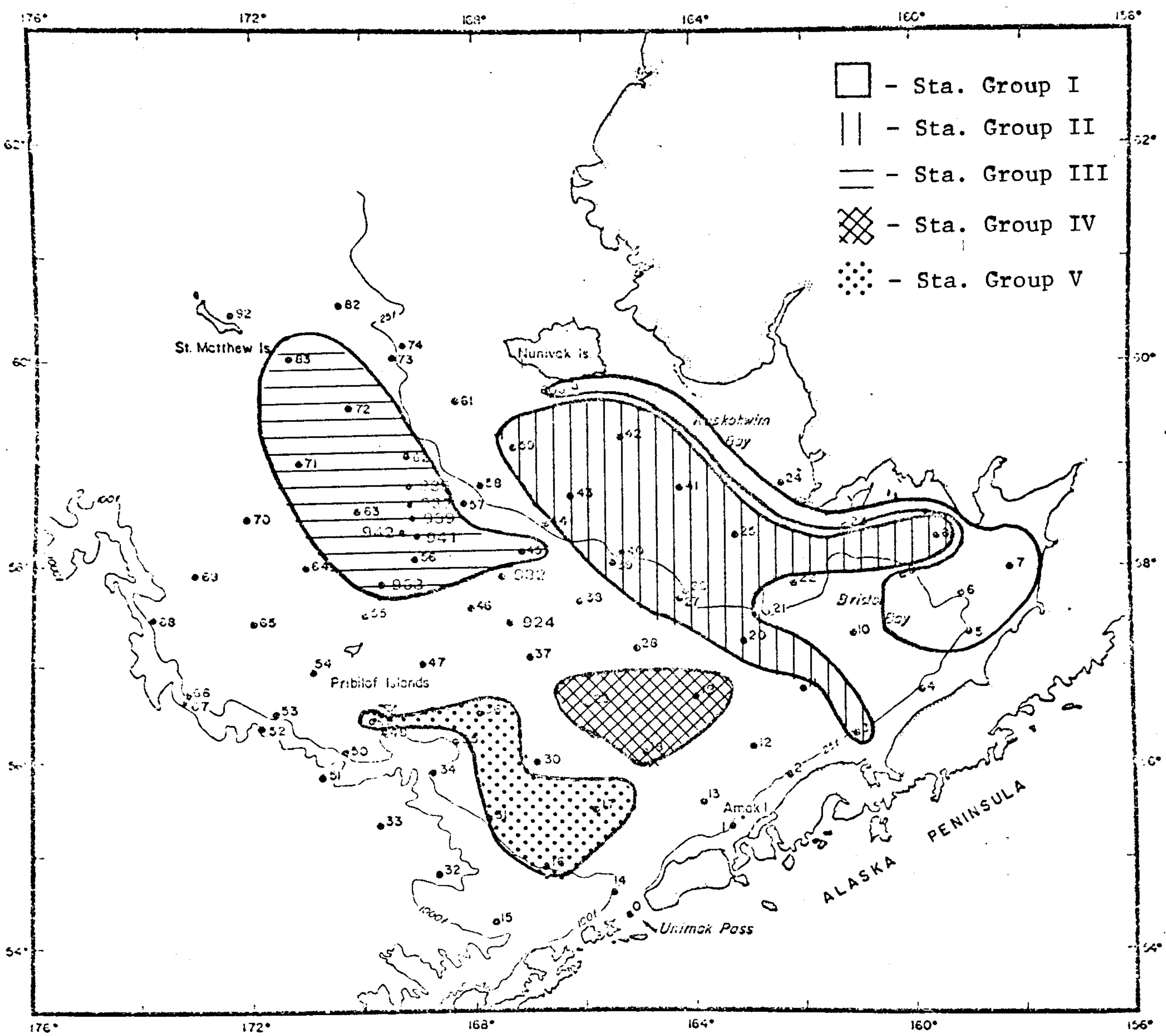
BERING SEA BENTHIC GRAB STATIONS USED IN THE AGGLOMERATIVE HIERARCHICAL CLUSTER ANALYSIS

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'

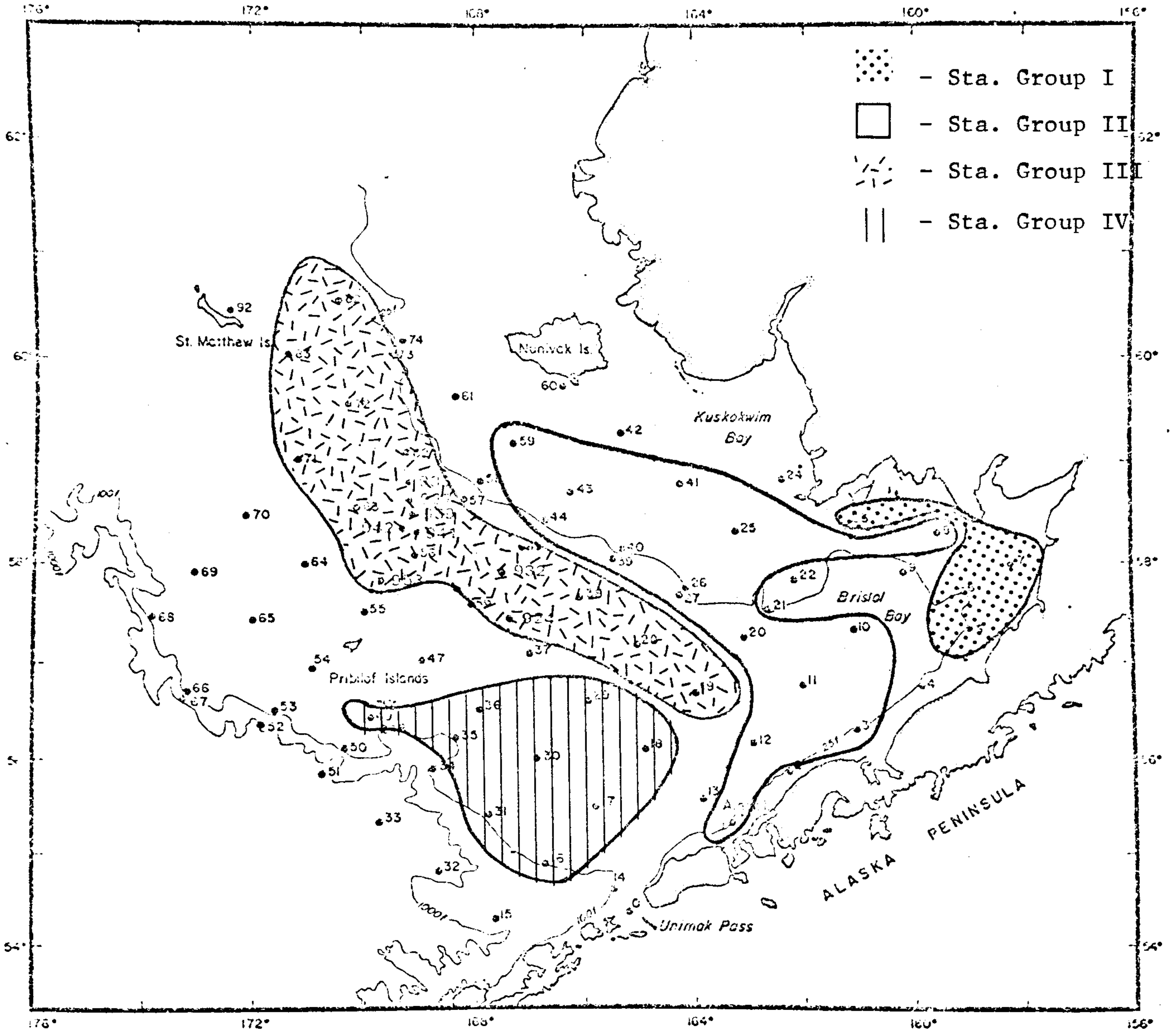
TABLE I

CONTINUED

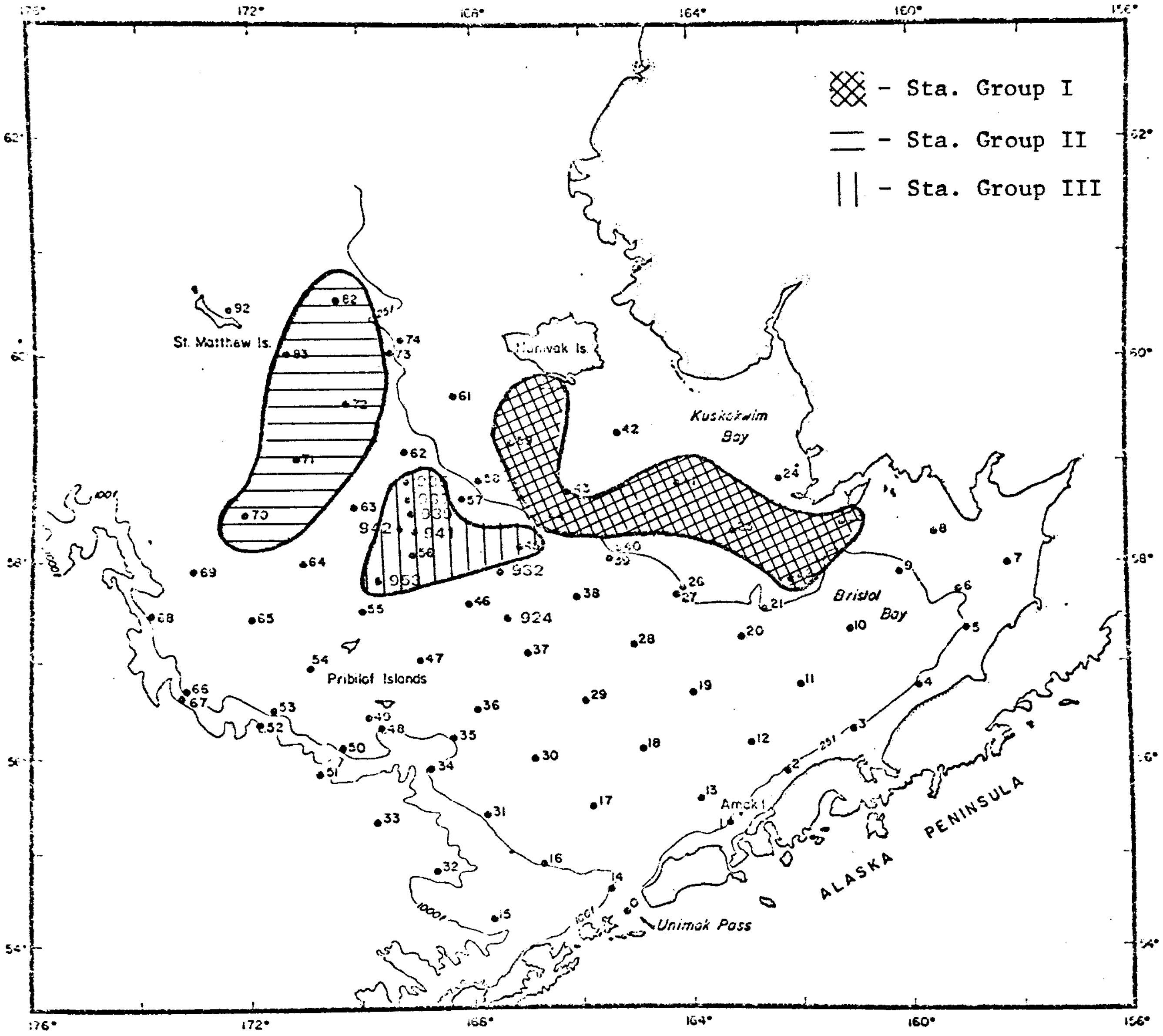
Station	Latitude	Longitude
36	56°31'	167°55'
38	57°40'	166°06'
39	58°03'	165°29'
40	58°08'	165°16'
41	58°47'	164°15'
42	59°16'	165°20'
43	58°42'	166°17'
44	58°26'	166°44'
45	58°10'	167°10'
49	56°25'	169°56'
57	58°36'	168°13'
59	59°12'	167°18'
60	59°43'	166°24'
924	57°28'	167°28'
932	57°48'	167°44'
935	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'



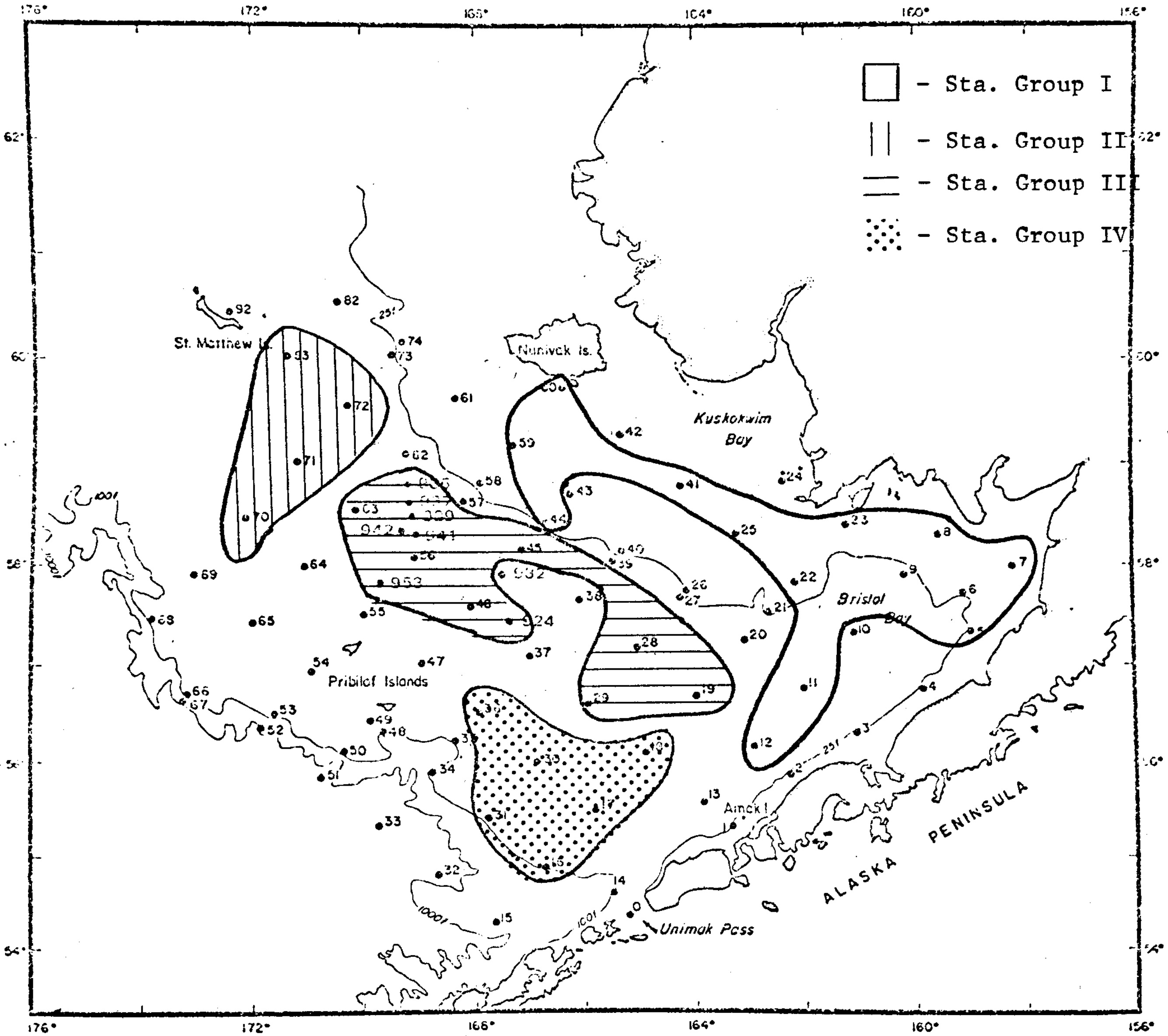
Appendix VII - Figure 1. Station Groups. Untransformed number of individuals per square meter.



Appendix VII - Figure 2. Station Groups. Ln-transformed number of individuals per square meter.



Appendix VII - Figure 3. Station Groups. Untransformed wet weights.



Appendix VII - Figure 4. Station Groups. Ln-transformed wet weights.

APPENDIX VII
TABLE II

STATION GROUPS FROM CLUSTER ANALYSIS OF BENTHIC INFAUNAL DATA - BERING SEA, 1975

Variable	Station Group	Composition
Untransformed Counts	I	5, 6, 7, 9, 60, 23
	II	3, 8, 20, 25, 26, 27, 41, 40, 39, 43, 42, 59
	III	45, 56, 62, 63, 71, 72, 83, 935, 937, 939, 941, 942, 953
	IV	18, 19, 29
	V	16, 17, 31, 36, 49
Ln-Transformed Counts	I	5, 6, 7, 23
	II	1, 3, 8, 11, 12, 20, 25, 26, 27, 39, 40, 41, 43, 44, 59
	III	19, 29, 38, 45, 56, 62, 63, 71, 72, 82, 83, 924, 932, 935, 937, 939, 941, 942, 953
	IV	16, 17, 18, 29, 30, 31, 35, 36, 49
Untransformed Wet Weight	I	22, 23, 25, 41, 44, 59, 60
	II	70, 71, 72, 82, 83
	III	45, 56, 935, 937, 939, 941, 953
Ln-Transformed Wet Weight	I	5, 6, 7, 8, 9, 11, 12, 22, 23, 25, 41, 44, 59, 60
	II	70, 71, 72, 83
	III	19, 28, 29, 45, 46, 56, 63, 924, 935, 937, 939, 941, 942, 953
	IV	16, 17, 18, 30, 31, 36

exception of station 28 and several other stations at the edges of the study area (70, 54, 48, 35, 14, 3 and 24) these are the only stations over the entire grid to yield a non-zero percentage of gravel. The further offshore grouping (Group II) is mostly confined to water less than 25 fm in depth and is comprised entirely of fine to very fine sand sediments. In mid-shelf waters, station Groups III and IV appear. The sediments associated with Group III are very fine sand to very fine silt, while station Group IV is characterized by very fine sand (based on data from stations 19 and 29 only). Finally, station Group V emerges as a shelf edge station group with its stations again showing very fine sand to very fine silt.

Analysis run after a ln-transformation of the number of individuals per square meter data yields large clusters at a high (34 to 36%) similarity level. It may be seen from Figure 2 that Group I changes only by the loss of station 60, Group II expands to pick up several stations further to the west off the Alaska Peninsula, and Group IV is lost completely (station 19 goes to Group III while 18 and 29 form part of V).

The results from clustering untransformed wet weight data are somewhat more complicated. Figure 3 shows that only three small groups were delineated. Group I appears to be similar to the nearshore station group (Group II) from the number of individuals per square meter data. Groups II and III in Figure 3 represent a division of the large mid-shelf station groups formed by clustering on the basis of counts. This split parallels a shift in sediment type from very fine silt to very fine sand for Groups II and III respectively.

Finally, Figure 4 illustrates the result of ln-transforming the wet weight data. The only effects seem to be an extension of Groups I and III and the synthesis of many smaller groups in a near shelf edge Group IV.

At this point, any attempts to state definite conclusions about this data would be premature. It does seem as though distinct nearshore, mid shelf, and offshore station groups exist, but their boundaries are unclear. In particular, the existence of the farthest inshore station group (Group I, analysis based on number of individuals) and the boundaries of the one or two mid-shelf groups need to be examined. This will certainly be facilitated by the discrimination of species groups and their incorporation into two-way tables (showing their relation to station groups). Also, the processing of stations 62 through 65 and 69 will help resolve the ambiguity concerning the relation of the northern Group II to Group III (wet-weight analysis). Processing of these stations will begin sometime in May of 1977.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 20 R.U. NUMBER: 281

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates From	Collection Dates To	Estimated Submission Dates[1] Batch 1	2	
Silas Bent Leg I #811	8/31/75	9/14/75	(c)	None	
Discoverer Leg IV #812	10/8/75	10/16/75	submitted[a]	None	
North Pacific	4/25/75	8/7/75	None	submitted	
Discoverer #816	11/23/75	12/2/75	(c)	None	
Contract #03-5-022-34	Last	Year	submitted		
Moana Wave	3/30/76	4/15/76	submitted		
Discoverer 001	3/17/76	3/27/76	(b)		
Miller Freeman			(b)		

Note: [1] Data Management Plan and Data Formats have been approved and are considered contractual.

(a) Only samples for Kodiak area were processed and submitted as requested.

(b) Selected samples will be processed to provide seasonal coverage as deemed necessary.

(c) Data has been keypunched, transfer to magnetic tape and submission is imminent.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 15 R.U. NUMBER: 5/303

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2		
Discoverer Leg I #808	5/15/75	5/30/75	*	None		
Discoverer Leg II #808	6/2/75	6/19/75	*	None		
Miller Freeman	8/16/75	10/20/75	(a)	submitted		
Miller Freeman	3/76	6/76	(a)	5/30/77		

Note: [1] Data Management Plan and Data Format have been approved and are considered contractual.

(a) Selected samples are being processed, date of submission not yet determined.

* That portion of cruise 808 grabs sorted, were submitted. The remainder are currently being sorted.

Institute of Marine Science
University of Alaska
Fairbanks, Alaska

SUMMARIZATION OF EXISTING LITERATURE AND UNPUBLISHED DATA ON THE DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF BENTHIC ORGANISMS OF THE GULF OF ALASKA AND BERING AND CHUKCHI SEAS

H. M. Feder
Principal Investigator

Prepared by
G. Mueller
Associate Investigator
with
Personnel of the Marine Sorting Center

Final Report

to

National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Contract 03-5-022-56
Task Order #10
Research Unit #282/301

March 31, 1977
Number of Pages: 7

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

Objectives: (1) To summarize the existing literature on or related to the systematics, distribution and biology of benthic organisms of the Gulf of Alaska, Bering Sea and Chukchi Sea using a key word bibliography. (2) Map the abundance of selected benthic infaunal species.

This information will provide an historical perspective of the abundance and distribution of benthic animals, and establish the current state of knowledge on the biology of these organisms in Alaskan waters. With this historical perspective, current OCS projects looking at the current distribution and biology of marine organisms can be interpreted in a larger time frame. In addition, gaps in information not currently funded under OCS or, not possible to understand in the time frame of the OCS funding period can be elucidated.

II. Introduction

See Section I

III. Current State of Knowledge

N.A.

IV. Study Area

Gulf of Alaska, Bering Sea, Chukchi Sea

V. Sources, Methods and Rationale of Data Collection

Objective (1) Standard library research techniques were used to prepare the bibliography. These techniques include:

(a) examination of general bibliographic works such as: Arctic Bibliography and Oceanic Index, (b) examination of specialized bibliographies such as Oceanography of the North Pacific Ocean, Bering Sea and Bering Strait (Grier 1941), (c) examination of the literature cited sections of located references, (d) examination of the contents of recent journals, (e) examination of the literature files of the University of Alaska Institute of Marine Science Sorting Center, and, consultation with specialists in various areas.

Literature citations located by the above methods were then examined for appropriateness for inclusion in this bibliography. The subject of the bibliography was interpreted broadly and if doubt existed as to the appropriateness of a citation, it was generally included.

Citations selected for inclusion were abstracted in the form of keyword suites. Keywords for each suite were selected to represent each of the following broad categories: (a) author, (b) geographic area, (c) taxon and common names, (d) dates of cruises, etc., (e) scientific discipline: i.e. physical oceanography, biological oceanography, (f) topical, i.e. behavior. reproduction, food and feeding, (g) other, keywords that would not necessarily by searched but are added for additional information.

The bibliography was compiled using the QUICKNDX program of the University of Alaska Institute of Marine Science. The resultant printout consists of two parts; a listing of key-words, and, a citation section. These two sections are linked together by accession numbers on the right side of the page. In the keyword section all keywords of all keyword suites are listed in alphabetical order. As each keyword is alpha-betized the rest of the keywords in the suite are carried with it. By quickly scanning the rest of the keywords in a suite, as if it were an abstract, the usefulness of each reference can be determined. If the reference is useful, then the citation can be located in the citation section by use of the accession number. The citation section is listed in numerical order by accession number.

Objective (2) The distrubution of thirty species of benthic infaunal organisms was plotted (Table 1). Where quantitative data was available a series of four different sized points were used to indicate abundance. The species selected satisfied all of the BIT criteria of Dr. Howard Feder (OCS contract #03-5-022-65 and #03-5-022-56). Additional species were selected from unpublished data (the property of the Institute of Marine Science, University of Alaska) on the basis of composing more than 90% of the individuals collected at any one station. Records of species occurrence were taken from various references and unpublished records of the University of Alaska Museum Invertebrate Collection. The various cruises and references from which the data were compiled are listed in Table (2).

It was assumed that four points of different size were sufficient to represent the relative distribution of the species selected above. More than four sizes becomes visually confusing and less than four is insufficient for presentation of quantitative information. A separate scale was determined for each species. The maximum number of individuals collected at a single station from all sites was determined. This value was rounded and divided by four and then used to determine the scales of abundance used for each species, i.e., zero to one-fourth of the value equals the smallest point, one-fourth to two-fourths of the value equals the second size point, etc.

Collection records where no qualitative data is available are represented by a "P". The average weight of one individual was determined from all data available to permit a crude approximation of biomass. This average weight is recorded in the ledger of each map.

VI. Results

Objective (1) 6,500 references were located and are available in the keyword format.

Objective 2) The distribution of thirty species representing the most widely distributed and abundant infaunal species has been plotted.

VIII. Discussion

N.A.

IX. Conclusions

N.A.

X. Needs For Further Study

(1) The keyword bibliography should be expanded to include references from other sub-disciplines, such as plankton, to provide a comprehensive literature survey for the area studied.

(2) The keyword bibliography should be tied to the species list for the study area and should include additional biological information such as breeding habits from other geographical areas. This would result in an annotated checklist of Alaskan marine organisms.

In bringing together the literature available, and producing an annotated checklist of species, an extremely useful literature-data base would become available. This literature-data base could then be used to provide a predictive base for the understanding of the marine environment and the potential effects of petroleum on all levels of the marine biotic environment.

Table 1 List of Species

Annelida

Nephtys ciliata
Nephtys rickettsi
Onuphis geophilaformis
Myriochele heeri
Cistenides hyperborea
Haploscoloplos elongatus
Phloe minuta
Praxillella praetermissa
Praxillella gracilis
Maldane sarsi
Sternapis scutata

Mollusca

Nuculana pernula
Nuculana radiata
Yoldia hyperborea
Axinopsida serricata
Nucula tenuis
Astarte borealis
Macoma calcarea
Clinocardium ciliatum

Arthropoda

Protomedia fasciata
Pontoporeia femorata
Ampelisa birulai
Byblis gaimardi
Ampelisca macrocephala

Echinodermata

Strongylocentrotus droebachiensis
Echinarachinius parma
Ophiura sarsi
Diamphiodia craterometa
Ctenodiscus crispatus

Chordata

Molgula siphonalis

Table 2 List of Cruises and Literature

Unpublished data

Vessel	Year
R/V Virginia City	1967, 1971
R/V Thomas G. Thompson	1969
M/V USCGC North Wind	1970
M/V USCGC Burton Island	1972
R/V Acona	1973
R/V Alpha Helix	1973, 1974

Current OCS data

Vessel	Cruise	Year
R/V Acona	193, 200	1974
R/V Oceanographer	805	1975
R/V Townsend Cromwell	807	1975
R/V Discoveror	808	1975
R/V Moana Wave	002	1976

References:

Clark, Hubert L. 1911. North Pacific Ophiurans in the Collection of the United States National Museum. Bull. 75 U.S.Nat.Mus. xyi +302 pp.

Fisher, Walter K. 1911-1930. Asteroidea of the North Pacific and adjacent waters. Bull. 76, U.S.Nat.Mus. Part 1 (1911): vi +419 pp.; Part 2 (1928): iii +245 pp.; Part 3 (1930): iii +356 pp.

Hood, D. W. etal. 1974. Environmental Study of the Marine Environment Near Nome, Alaska. Institute Marine Science Report 74-3 Sea Grant Report 73-14, July.

Reish, Donald J. 1965. Benthic Polychaetous Annelids from Bering, Chukchi and Beaufort Seas. Proceeding of the U.S.Nat.Museum. No. 3511, vol. 117, pg. 131-158.

Rowland, Robert W. 1973. The Benthic Fauna of the Northern Bering Sea. U.S.Dept. of the Interior, Geological Survey, Open File Report.

ANNUAL REPORT

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NUMBER OF PAGES 31

FOOD AND FEEDING RELATIONSHIPS IN THE BENTHIC AND DEMERSAL FISHES OF THE GULF OF ALASKA AND BERING SEA

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31 March 1977

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I. SUMMARY OF OBJECTIVES AND IMPLICATIONS

The objectives of this year's study were to:

1. present preliminary food analyses for additional benthic and demersal fishes sampled in the first and second years of this study,

2. make additional collections of fish stomachs from the Bering,

3. develop a computer program to perform computations and summaries of feeding data for individual predator species.

Our ultimate goal is to construct a detailed picture of the food and feeding relationships of the fishes in these two study areas. This will (or should) include analyses of predator size vs. prey composition; bottom type, temperature and location vs. prey composition; prey composition in diets vs. prey abundance; prey composition vs. season. The rationale behind this study is to develop an ability to predict the impact of oil development activities on the fishes in these two areas. Clearly, for example, activities which affect benthic invertebrates will directly affect those fish species which feed on them. This study, coupled with others designed to study acute and chronic toxic effects on the fish populations, will establish the predictive base necessary to make management decisions. It is already known that certain specific geographic areas are fairly critical as overwintering areas or feeding areas for some of the fishes. Exploration and drilling activity could have a much greater impact in these areas than in others. Again, one of the ultimate goals of this study is to elucidate some of these area effects.

II. INTRODUCTION

General Nature and Scope of Study

This study has been, in its second year, very limited in scope due to the very low funding level. This level of funding obviously reflects the very low priority placed on trophic studies by NOAA OCS environmental assessment programs. It will not be possible to complete analyses on the limited collections we already have curated. Nevertheless, the results of such a study are sorely needed to develop an ability to predict the effects of environmental perturbations on the benthic and demersal fish faunas of Alaskan waters. These faunas are, and will continue to be, the basis of extensive fisheries by the fishing fleets of the U.S. and a number of foreign countries. In spite of the very limited scope of our study, we will continue to strive to develop a picture of the food and feeding relationships of most of the fishes present in the study area. The bulk of our findings will, undoubtedly, be generated after this project has ended.

Specific Objectives

The objectives of this year's work were presented in Section I. We secured additional, although limited, collections from the Bering Sea. We have spent a great deal of effort developing a computer program to analyze in a timely fashion the new data we have been collecting. The primary objective, of course, has been to continue the food analyses.

Relevance to Problems of Petroleum Development

The fishing industry is the most important economically in the state of Alaska. Commercial fishing in Alaskan waters contributes heavily to the landings of at least three other countries: Japan, Russia, and Korea. To an unknown extent, oil exploration and development on the outer continental shelf will impact these fisheries. Impacts other than economic will also occur but will be difficult to assess. The relevance of this project is to add to the total fund of information available on the risks of oil development.

III. CURRENT STATE OF KNOWLEDGE

Knowledge about the trophic relationships of fishes from the Gulf of Alaska and Bering Sea is scattered widely through the literature and includes papers in English, Russian and Japanese. Other works with pertinent information on congeneric species are even more prevalent in the scientific literature. These latter papers deal with food and feeding of *Hippoglossus*, *Limanda*, *Glyptocephalus*, *Gadus* and other relevant genera from the Atlantic and also from east Asia. We have not attempted to summarize the existing knowledge on these congenerics but have briefly discussed what is known of eight of the fish species common to the study area. The eight are the flathead sole, rock sole, Pacific Ocean perch, Pacific halibut, rex sole, arrowtooth flounder, Dover sole and pollock. Similar summaries are possible on several other species common in the area. However, the vast majority of fishes from the study area are very poorly studied. Summaries of the eight species follow.

Flathead Sole *Hippoglossoides elassodon*

A survey of available information on this species indicates that studies have been largely restricted to the Bering Sea and Washington coast.

In the Bering, feeding intensity varies seasonally and geographically. This species does feed during the winter but much less intensely than during the summer months. On the basis of percentages of fish with empty stomachs, feeding is more intensive in the southeast Bering, least intensive in the central Bering. A ranking of food items according to % frequency of occurrence is ophiuroids > shrimps > amphipods > fish remains > molluscs. As *H. elassodon* migrates from southern wintering grounds in the Bering its diet shifts from predominantly echinoderms and *Pandalus borealis*. The shrimp is replaced by hyperiids, euphausiids and chaetognaths, while the echinoderms drop out entirely.

Studies from Washington state indicate this species ingests both benthic and pelagic food organisms. Changes in diet with age are evident, the smallest fish feeding primarily on mysids, larger fishes beginning to eat shrimps and then fishes. Mature fishes have the highest percentage of empty stomachs at the peak of spawning. Other food items reported from this area include clams and worms.

Basic life history information from the Gulf of Alaska is apparently nonexistent. This present study will partially fill the void, and, hopefully, add to existing knowledge of this species in the Bering. It would seem that the southeast Bering in the summer is a sensitive period in the life of this species from the viewpoint of food and feeding. This summary was drawn from the following: Smith (1936), Mineva (1968), Skalkin (1968), and Miller (1970).

We have examined 254 flathead sole from the northeast Gulf of Alaska. In terms of frequency and volume the brittle star *Ophiura sarsi* is the major food item. Euphausiids, especially *Thysanoessa spinifera*, are also consumed. In the sample taken near Hinchinbrook Island, euphausiids were the dominant food item. Miscellaneous decapod crustaceans and molluscs were taken infrequently (Table I).

An examination of 54 individuals from the southeast Bering Sea indicated that decapod crustaceans were most abundant with clams, amphipods, ophiuroids and pollock all of equal importance (Table II).

Rock Sole *Lepidopsetta bilineata*

As with the flathead sole, there seems to be little information on this species from the Gulf of Alaska, yet quite a bit from the Bering Sea. Like several other fishes in this region, the rock sole exhibits feeding and distributional changes over the course of a year.

Little or no feeding occurs on the wintering grounds in the Bering with slight feeding activity beginning in April. Most intensive feeding occurs in June and July. One report lists summer diets consisting mainly of polychaeta, 62%F; molluscs, 37%; crustacea (mostly shrimps) 14% and some fishes and echinoderms. Diets apparently differ from one region to another.

Although *L. bilineata* is found all over the southern half of the Bering, two major concentrations have been delineated for purposes of commercial exploitation. One is located just north of Unimak and the other in central Bristol Bay. These concentrations move in the spring as indicated by Figure 1. Dense schools are reported to form during both the winter and summer.

Food items reported from Washington and California include clams, clam siphons, polychaetes, shrimps, small crabs, ophiuroids and *Ammodytes* (Forrester and Thomson, 1969; Roedel, 1948). Other references used above are Skalkin (1968) and Shubnikov and Lisovenko (1968).

TABLE I

FEEDING HABITS OF THE FLATHEAD SOLE, EXPRESSED IN PERCENT FREQUENCY OF OCCURRENCE IN FEEDING FISHES (%F), FOR THE N.E. GULF OF ALASKA (n = 151 FEEDING INDIVIDUALS, AND 103 NONFEEDING)

Prey Taxa	Hinchinbrook Island	Offshore Shelf	Combined Gulf of Alaska
Pelecypods	-	1	1
Gastropods	-	1	1
Cephalopods	-	1	1
Euphausiids (*Thysanoessa* spp.)	92	24	46
Decapods			
Shrimp remains	-	1	1
Hyas sp.	-	2	1
Paguridae	2	-	1
Ophiuroids			
Ophiura sarsi	2	90	58
Teleost Fishes	4	-	1

TABLE II

FEEDING HABITS OF THE FLATHEAD SOLE, EXPRESSED IN PERCENT FREQUENCY OF OCCURRENCE IN FEEDING FISHES (%F), FOR THE BERING SEA (n = 31 FEEDING INDIVIDUALS AND 23 NONFEEDING)

Prey Taxa	Frequency of Occurrence
Polychaetes	3
Pelecypods	16
Amphipods	13
Mysids	32
Decapods	
Pandalus borealis	19
Ophiuroids	
Ophiura sarsi	13
Teleost Fishes	
Theregra chalcogramma	13

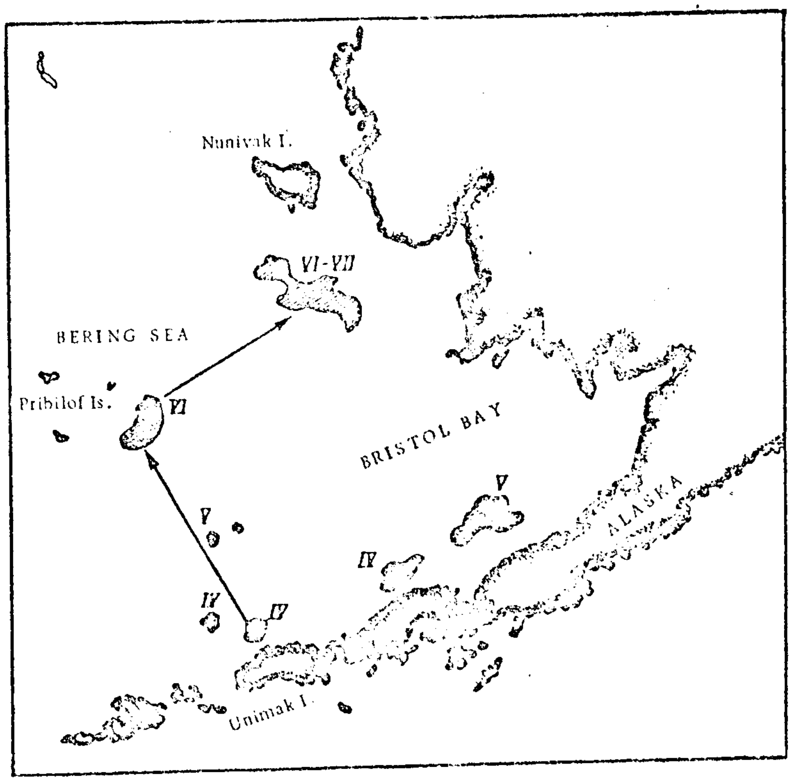

Figure 1. Distribution and migrations of rock sole in the southeastern Bering Sea. Roman numerals indicate months. Hatched areas indicate hauls of more than 100 Kg per hour. From Shubnikov and Lisovenko, 1968.

In the 124 individuals we have examined to date polychaetes were the predominant food item. Pelecypods and amphipods were of secondary importance, occurring with equal frequency. Other prey organisms included gastropods, euphausiids, decapods, ophiuroids, and fishes (Table III).

The two concentrations mentioned above are important and would be particularly vulnerable during the intensive feeding period. Impacts affecting their major food organisms, the polychaetes, could also have a major impact on the rock sole.

Pacific Ocean Perch *Sebastes alutus*

Marked seasonal shifts are evident in this species with respect to both geographic distribution and feeding habits. In the Bering from January to May densest concentrations of adult fishes are found in Bristol Bay and south of the Pribilofs. During the rest of the year they extend well into the central Bering. In the Gulf of Alaska during the periods from May through September, concentrations occur near Unimak Pass, near the Shumagins, Kodiak, and Yakutat (Fig. 2). Vertical segregation according to size is suggested by catch data; larger sized fish being caught at greater depth (Fig. 3).

Existing information on food habits indicate that in the Gulf juveniles feed on planktonic crustacea. Benthic juveniles feed very heavily on euphausiids and pandalid shrimps. Adult stomach contents contained 75% crustacea (again euphausiids and pandalids, primarily), 15% squids and 6 to 7% fishes. In the Bering relative importance of food items varies with both depth and size. On the shelf *S. alutus* feeds mainly on calanids while at 200 to 300 m on euphausiids, and on mysids and squids below 300 m.

Summer populations in the Gulf of Alaska appear to be foraging aggregations. Some of the Russian work suggests that mature fish do not feed during the rest of the year (October through April) (Fig. 4).

TABLE III

FEEDING HABITS OF THE ROCK SOLE FROM THE BERING SEA (SPRING 1976) EXPRESSED AS %F (n = 48 FEEDING AND 76 NONFEEDING INDIVIDUALS)

Prey Taxa	Frequency of Occurrence
Polychaetes	75
Pelecypods	15
Gastropods	2
Amphipods	15
Euphausiids	2
Decapods	
Hyas sp.	2
Ophiuroids	2
Teleost Fishes	2

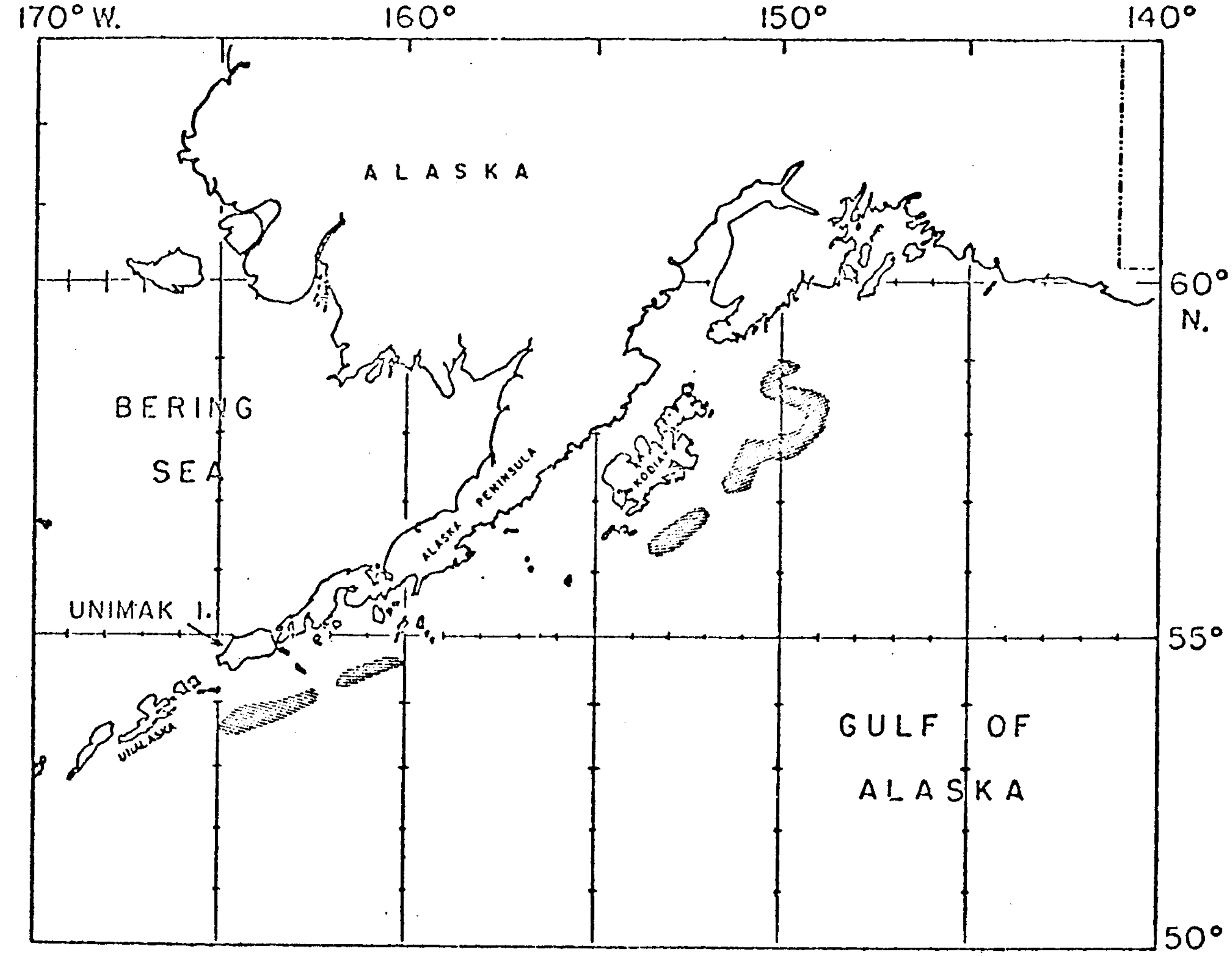

Figure 2. Distribution of Pacific Ocean perch in the Gulf of Alaska during the principal feeding period (from Lyubimova, 1968).

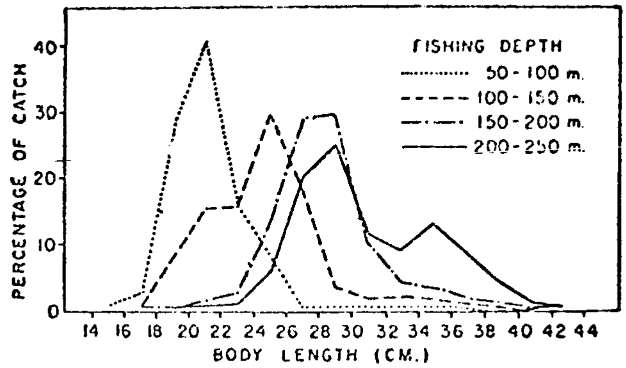

Figure 3. Body lengths of Pacific Ocean perch taken in the Gulf of Alaska at various depths (from Lyubimova, 1964).

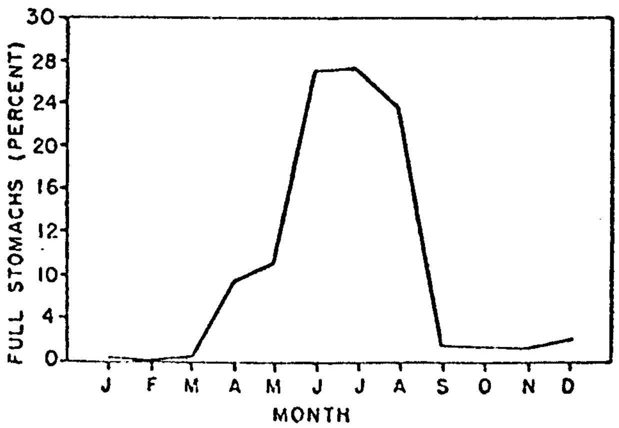

Figure 4. Percentage of full stomachs in samples of Pacific Ocean perch taken each month in the Gulf of Alaska (from Lyubimova, 1963).

From the standpoint of impact from oil exploration and development, the concentrations in Bristol Bay in the spring and the summer concentrations present in the Gulf would be important. Information on this important but declining species was gathered from Lyubimova (1968), Skalkin (1968), Quast (1969), Major and Shippen (1970), and Isakson *et al.* (1971). Additional information on feeding habits and seasons in the Bering Sea would be very useful in determining the most sensitive periods and geographical areas for Pacific Ocean perch.

Pacific Halibut *Hippoglossus stenolepis*

This species continues to be an important fish from a commercial standpoint. Impacts felt farther down in the food chain will certainly have an effect on this large carnivore.

Young halibut become established on the bottom after 6 to 7 months of pelagic larval existence. The earliest juveniles occur in water shallower than 100 m. During ontogeny individuals tend to move offshore to deeper water. Immature halibut are relatively nonmigratory while adults from the Gulf of Alaska are known to migrate rather long distances, up to 700 miles in some cases.

Some information on food of halibut from the northeastern Pacific has been gathered by the International Pacific Halibut Commission. Analysis of stomach contents has largely been confined to sub-commercial size individuals since the stomach contents of longline-caught halibut are not typical of halibut in general (Skud, pers. comm.). Based on a sample size of over 2000 individuals lumped from different years and from southern British Columbia to Kodiak, the following conclusions are offered.

Halibut less than 4 inches long, not yet one year old, feed primarily on small crustaceans. At larger sizes, halibut begin feeding on shrimps, crabs and fish. The latter food category, especially sand lances becomes the predominant food item in individuals over 10 inches long (IPHC Rept. 29, 1960). An exception to this latter generalization may be found in Cook Inlet, Alaska, where halibut up to 16 inches in length feed largely upon shrimp (IPHC Rept. 27, 1959).

Unpublished information on food of juvenile halibut from the Bering Sea has kindly been provided by Dr. Skud of the International Pacific Halibut Commission. Information on a sample of 132 individuals indicates that the major food organisms in terms of frequency of occurrence are shrimp (32%); digested fish (25%); sand lance (15%); and crab (6%). Other food items included sculpin (3%), cod (2%), poacher (1%), sandfish (1%); snow crab (1%); amphipods (1%); and smelt (1%).

Novikov (1968) has reported on the food habits from the southeastern Bering Sea. Small halibut (30 cm or less) fed primarily on crustaceans (89%F) while medium sized fishes (30 to 60 cm) shift to a largely fish diet (61%F). Flatfishes, smelt, capelin, pollock and sand lances are included while crustaceans appear in 33% of the stomachs. Fishes larger than 60 cm fed predominantly on fishes, especially the yellowfin sole. Feeding intensity was greater in summer than in winter. Marked seasonal movements of halibut in the southeast Bering have been reported (Fig. 5).

Information for this species was abstracted from Gray (1964), Hart (1973) and Novikov (1968).

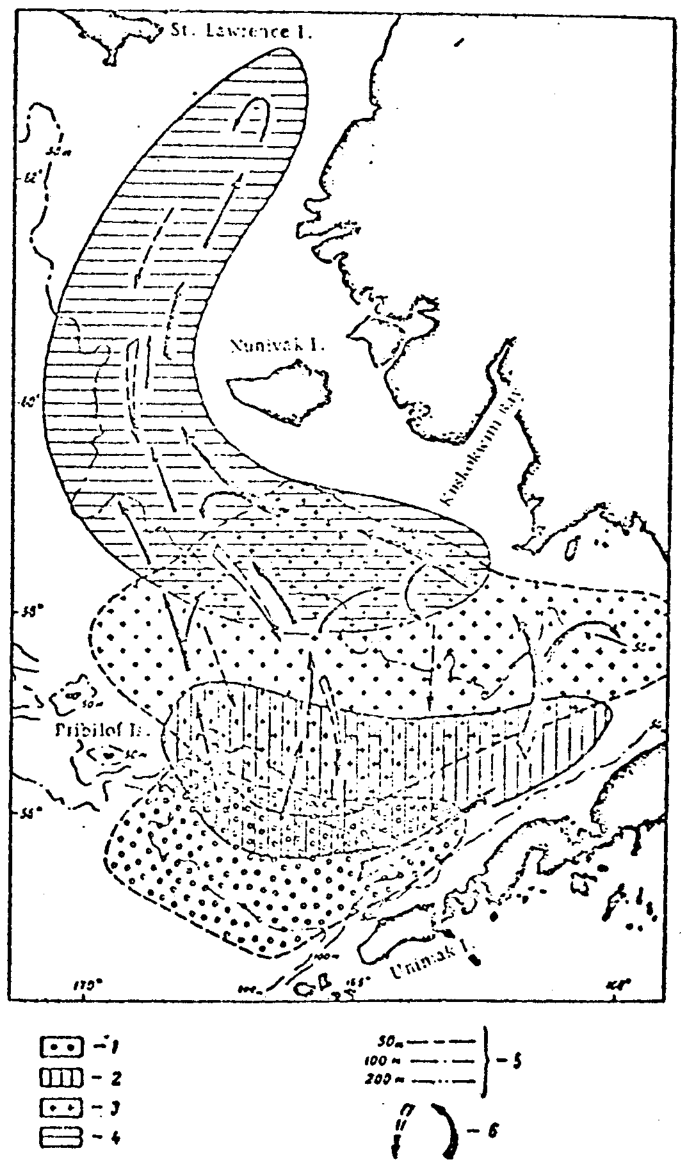

Figure 5. Diagram of the seasonal distribution and migration of the halibut in the southeastern Bering Sea: 1-January-April; 2-May; 3-June; 4-June-September; 5-iso-baths; 6-direction of migrations.

Rex Sole *Glyptocephalus zachirus*

Very little is known of the life history of this species. Spawning apparently occurs in March in British Columbia and in September in the Bering Sea. Only the sketchiest information is available on feeding, suggesting that feeding intensity in the Bering is somewhat less in mid-September than in early September (Mineva, 1968). Our OCS work included an analysis of feeding in the rex sole from the Northeast Gulf of Alaska. The stomachs from a sample of 317 individuals were examined from a number of different trawl stations. We haven't yet been able to run our data through the computer program for analysis but a preliminary examination was made of 80 individuals ranging from 11.0 to 34.0 cm standard length (Table IV).

Polychaetes were the most important food item both in terms of frequency occurrence (%F) and by volume (%V). Postlarval snow crabs, *Chionocetes bairdi*, were the next most frequent prey, but the volumetric contribution was negligible. Euphausiids (*Thysanoessa* spp.) were the third most frequent prey item, but appeared to be the second most important item by volume. Cumaceans and pandalid shrimps (*Pandalus borealis*) were also taken frequently. Other invertebrates were consumed, but represent a small volumetric input into the diet. Fishes were rarely taken.

Although no information exists on seasonality of feeding in the rex sole, its congener *G. cynoglossus* from the Atlantic exhibits seasonal differences. Peak feeding for this species occurs in June and July, with a decline from August to November and a minimum in December (Rae, 1969).

TABLE IV

FOOD OF REX SOLE FROM GULF OF ALASKA

Prey Taxa	Frequency of Occurrence
Polychaetes	66%
Pelecypods	3%
Euphausiids	28%
Decapods	
Pandalus spp.	25%
Chionocetes bairdi	55%
Cumaceans	22%
Amphipods	5%
Ophiuroids	2%
Teleost Fishes	2%
Unidentifiable Animal Matter	33%

Arrowtooth Flounder *Atheresthes stomias*

This widely distributed species has received little attention by fish biologists. British Columbia larvae in the 10 to 19 mm size range were found to be eating the eggs, juveniles and adults of copepods. Adults from California relied on shrimps, euphausiids, and a variety of fishes (Hart, 1973). Personal observation of *A. stomias* from Port Fredrick, Alaska, showed they were ingesting large holothurians. Again, our OCS data has not been processed but a preliminary look at 151 individuals from the Gulf of Alaska was made (a total of 587 stomachs have been examined).

The specimens ranged in size from 82 mm to 680 mm, standard length. Of the 151 stomachs examined, 78 were found to have contents, the other 73 were empty. The breakdown of the contents can be seen in Table V in frequency of occurrence. On considering the volumetric measurements of the various prey groups, the teleost fishes probably constitute 65 to 75% of the total volume of prey consumed.

Dover Sole *Microstomus pacificus*

This interesting flatfish produces long-lived pelagic larvae. These larvae are distributed widely along the Pacific coast by currents, and remain unmetamorphased at 48 mm. After metamorphosis a soft bottom habitat is preferred where this species concentrates its feeding on burrowing forms of invertebrates (Hart, 1973).

Apparently no feeding studies have been made on Dover sole from northern waters. Hagerman (1952) found California populations feeding chiefly on molluscs, polychaetes and echinoderms. Hart (1973) comments that all metamorphased stages concentrate on infaunal food organisms. Andriyashev

TABLE V

FOOD OF ARROWTOOTH FLOUNDER FROM GULF OF ALASKA

Prey Taxa	Frequency of Occurrence
Teleost Fishes	40%
Pleuronectiformes	1%
Pollock	1%
Arrowtooth flounder	1%
Herring	1%
Zoarcids	3%
Capelin	4%
Unidentified Teleosts	29%
Euphausiids	36%
Decapods	24%
Pelecypods	1%
Ophiuroids	1%
Unidentified Animal Matter	10%

(1964) reports that the closely related *Microstomus microcephalus* feeds predominantly on sedentary polychaetes, benthic crustaceans, small molluscs and sea stars. Diet composition in this European species varies with geographic location. De Groot (1971) reports that the Pacific congeneric, *Microstomus achne*, feeds largely on polychaetes and crustaceans.

We have examined 130 Dover sole from the Gulf of Alaska. Detailed analysis with our computer program has not yet been made. A preliminary examination was made in terms of frequency of occurrence. Only 9 of the 130 had empty stomachs. Polychaetes were the most important food item followed by ophiuroids (Table VI). *Ophiura sarsi* was the most commonly taken brittle star, but *Ophiopenia disacantha* was locally important. Other food items included pelecypods, amphipods, cumaceans, snow crabs, euphausiids, teleosts, gastropods, cephalopods and scaphopods.

Pollock *Theragra chalcogramma*

The Alaska pollock has received quite a bit of attention in recent years from Japanese fishing fleets. It has largely supplanted the yellowfin sole and Pacific Ocean perch in importance since both those species have been "fished out" of the Bering. Greatest concentrations of pollock occur in the southeast Bering. The NMFS involvement in OCS studies of the Bering has shown that two areas are particularly rich during summer months: to the west of St. Matthew Island; and, between the Pribilofs and Unimak Pass (Fig. 6). There appear to be seasonal differences in depth distribution, and feeding intensity in this species. Spawning in the Bering occurs from May to mid-July during which time these fish are found far into Bristol Bay. During spawning season pollock are thought not to feed. Feeding habits have been reported from several localities. Young

TABLE VI

FEEDING HABITS OF THE DOVER SOLE FROM THE GULF OF ALASKA
NUMBERS ARE EXPRESSED AS FREQUENCY OF OCCURRENCE
(n = 121 FEEDING INDIVIDUALS AND 9 NONFEEDING)

Prey Taxa	Frequency of Occurrence
Polychaetes	71
Pelecypods	22
Gastropods	1
Cephalopods	1
Scaphopods	
Cadalus sp.	2
Cumaceans	6
Amphipods	15
Euphausiids	
Thysanoessa spp.	4
Decapods	
Chionoecetes bairdi	6
Asteroids	2
Ophiuroids	40
Ophiura sarsi	
Ophiopenia disacentha	
Teleost Fishes	1

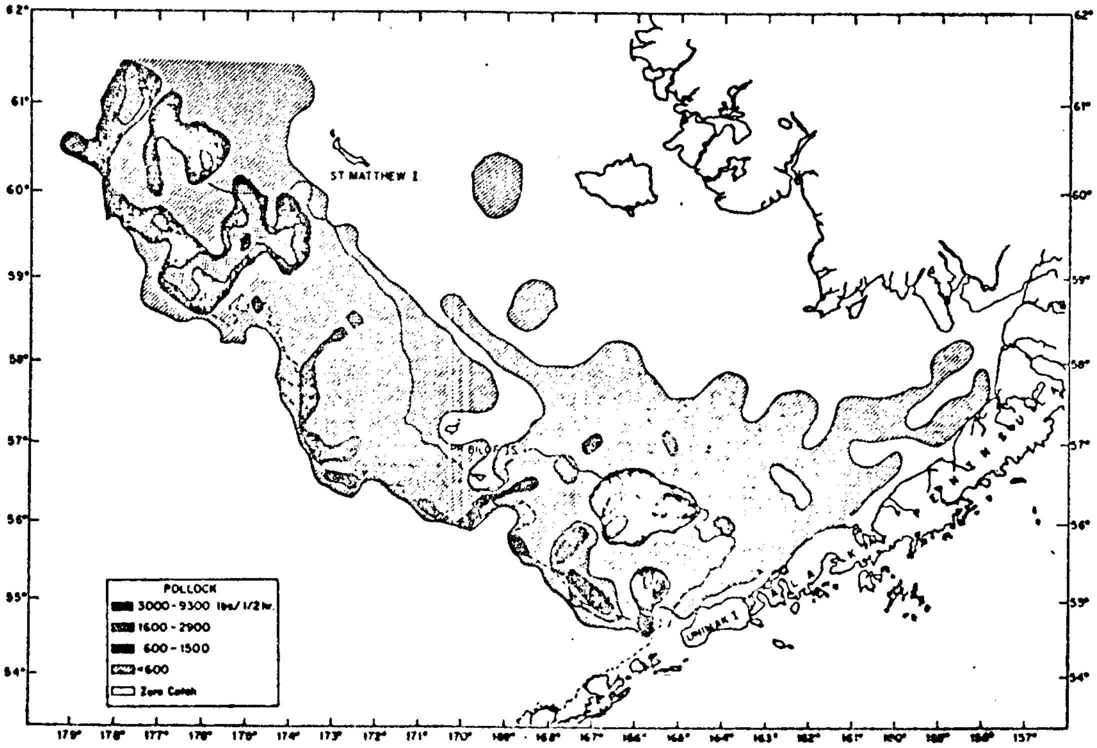

Figure 6. Summer distribution of pollock in the southeastern Bering Sea. Taken from Northwest Fisheries Center Monthly Report, February 1976.

British Columbia pollock (4 to 22 mm S.L.) feed on copepods and their eggs while adults take shrimps, sand lance and herring. In one instance, Alaskan pollock took young pink, chum and coho salmon. Asian pollock feed on mysids, euphausiids, silver smelt and capelin (Hart, 1973). We have examined pollock from the Gulf of Alaska and the southeast Bering Sea (N = 535). A preliminary look at 84 individuals from the Gulf has been made and is representative of the larger sample size even though the frequency of occurrence figures will change slightly. Individuals were drawn from a size range of 26.2 cm to 56.0 cm S.L. Five percent of the stomachs were empty. Data in frequency of occurrence are presented in Table VII. In terms of volumetric composition the euphausiids, *Thysanoessa* spp., were most important followed by fishes, shrimps and cephalopods.

Analysis of gut contents from Bering Sea pollock yielded much the same sort of pattern as shown above. Clearly, the pollock is feeding largely in the water column. The euphausiids are pelagic and so are the amphipods (Family Hyperiidae). Occasionally, however, benthic organisms are found in the diet and their partially digested condition suggests they are not an artifact of the trawling.

IV. STUDY AREA

The study area includes the Gulf of Alaska, primarily the area bounded by Yakutat on the east and Resurrection Bay on the west. The Bering Sea study area lies principally in the southeast. Almost all collections came from stations south of Nunivak Island. Collections include fishes from Bristol Bay, the vicinity of the Pribilof Islands and along the continental slope.

TABLE VII

FOOD OF POLLOCK FROM GULF OF ALASKA

Prey Taxa	Frequency of Occurrence
Euphausiids	90%
Amphipods	19%
Fishes	17%
Decapods	
Chionocetes bairdi	11%
Shrimp	8%
Cephalopods	2%
Pelecypods	2%
Copepods	2%
Gastropods	1%
Polychaetes	1%
Unidentified material	31%

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Fish Stomachs

Sources we have drawn upon:

North Pacific charter, summer 1975, Gulf of Alaska

Miller Freeman fall 1975, spring 1976 Bering Sea

Surveyor spring 1976, Bering Sea

Halibut Commission charter, *Tordenskjold*, summer, 1976, Gulf of Alaska

Methods employed in obtaining stomachs:

Capture: otter trawl

Selection of individuals to be retained: unknown but undoubtedly depended on what was in catch.

Disposition of samples: various, dependent largely on personal bias of collectors. Some fishes were preserved whole, others had stomachs removed and placed in cloth bags, still others were preserved as anterior halves of fishes only.

Rationale for collections:

Original concept was to obtain a representative sampling of fish guts from a variety of bottom types, locations and times of the year. These collections were to be made simultaneously with benthic invert collections (trawls and grabs) so that the effects of invert abundance and fish selectivity could also be studied. Relatively few of our stations correlate with grab stations and few station samples were adequate. We don't know if our samples are representative. The chief problem lies in the fact that collections have been made, when made at all, by personnel whose primary interests have been elsewhere.

Stomach Analyses

Methods employed in analysis:

Methods are those outlined in the work statement. If stomachs only are present we sort the prey items to the lowest taxonomic level possible, complete the identifications we can and retain the organisms preserved in vials awaiting final identification. When intact fishes are processed we record data on standard length, sex, gonadal maturity and stomach fullness.

Rationale for analytical procedures:

Only preliminary data are being amassed since we do not have budgeted funds to pay the Marine Sorting Center for the identifications we need.

VI. RESULTS

The results of feeding analyses conducted to date are incorporated into Section III. We do have other analyses in progress but results are presently too preliminary to report.

Interpretation of our findings has been very limited up to the present time. However, our computer program is just now operational and we expect to be transmitting to the Juneau project office the much more complete evaluations of our raw data as fast as we can receive the outputs.

VII. DISCUSSION

Current information, including our own contributions, has been summarized for eight species from the Gulf of Alaska and the Bering Sea. That information indicates that, in terms of frequency of occurrence, benthic organisms are very important in the diets of Dover sole, halibut, rock sole and rex sole. The pollock and Pacific Ocean perch rely heavily on pelagic organisms and must, therefore, feed up off the bottom to a great extent. Intermediate in feeding habits are the arrowtooth flounder and the flathead sole. These two species take large numbers of pelagic euphausiids and also feed intensively on benthic prey organisms. From our studies it appears that major predators on fishes are the halibut and arrowtooth flounder. Euphausiids are the major food item of pollock and Pacific Ocean perch. Polychaetes are consumed intensively by Dover sole, rock sole, and rex sole.

Activities which impact the benthic environment and its invertebrate fauna will have an impact on the benthic feeders mentioned above. Activities which primarily affect the pelagic environment will have effects on the pelagic feeders quickly. However, since the benthic fauna is ultimately dependent on primary production in the pelagic environment, it too will be affected, as will the fishes feeding on the benthos.

From the little information at hand on seasonal variation in distribution and feeding, a number of critical areas can be suggested. In the Bering, winter concentrations of halibut, yellowfin sole, rock sole and perhaps flathead sole as well are all found just to the northwest of Unimak Island. Pacific Ocean perch concentrate just south of the Pribilofs and in Bristol Bay. Although feeding is not intense at this time, large numbers of fishes could be affected in a very few locations. In the Gulf, Pacific Ocean perch would be particularly vulnerable to effects of development during the feeding season when dense feeding aggregations apparently form south of Unimak, southeast of the Shumagins, and east and south of Kodiak.

Much more data is needed on the feeding habits and seasonality of feeding within the fish fauna. This is especially true of the Gulf of Alaska, which has not come under as much scrutiny by the Russian workers. Much information will be supplied by this present study but seasonal information for the Gulf of Alaska will still be largely unavailable.

VIII. CONCLUSIONS

See discussion section

IX. NEEDS FOR FURTHER STUDY

1. More information on trophic relationships is needed on the continental slope in the Bering and at the proposed lease sites in both Bering and Gulf of Alaska.

2. Seasonality of feeding has been shown to be very important. Further work on seasonality of feeding is critical, expecially in the Gulf of Alaska.

3. More complete information is needed on the relationship between fish size and food habits.

4. A critical area for further study is the relationship between occurrence of prey organisms in the diet and prey availability. This seems most feasible in benthic feeders and involves close coordination with Dr. Feder's benthic studies.

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X. SUMMARY OF FOURTH QUARTER OPERATIONS

Ship and Laboratory Activities

1. Ship or field work: None

2. Scientific party involved in project:
   R. L. Smith, IMS, Principal Investigator
   A. C. Paulson, IMS, Research Technician
   J. R. Rose, IMS, Research Assistant

3. Methods: Same as previous methods

4. Sample localities: Same as previous, no new samples have been obtained

5. Date analyzed: Stomach analyses performed this quarter include:

rock sole	122 specimens
yellowfin sole	10 specimens
flathead sole	308 specimens
wattled eelpout	10 specimens

The computer program is now operational and one set of data from a single haul has been analyzed as a check on the functional systems in the program. At this time the data on rex sole is being put through the computer. Although a data submission has been made on this species we will forward the results of these analyses to Juneau as soon as they are in final form. Additional data submissions and analyses will be made as early as 1 April on the arrowtooth flounder and pollock.

Problems Encountered

The two major problems affecting our scientific output in this quarter have been: (1) delays in the development of the program for computer analysis of existing data, and (2) low level of funding for this project, resulting in the accumulation of inadequate amounts of new data for analysis. The first problem has been resolved to our satisfaction. The second problem has not been solved and will not be solved.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 21 R.U. NUMBER: 284

PRINCIPAL INVESTIGATOR: Dr. R. L. Smith

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1			
North Pacific	4/25/75	8/7/75	(a)(b)			
Miller Freeman	8/16/75	10/20/75	(a)			
Miller Freeman	3/76	6/76	(a)			

Note: [1] Data Management Plan has been approved and made contractual.

(a) Data are currently being transferred to magnetic tape for four species of predators.

(b) Rex sole data were submitted.

Institute of Arctic Biology
University of Alaska
Fairbanks, Alaska

Illustrated Keys to Otoliths of Forage Fishes of the Gulf of Alaska, Bering Sea and Beaufort Sea

James E. Morrow
Principal Investigator

Final Report

to

National Oceanic and Atmospheric Administration
Outer Continental Shelf Environmental Assessment Program
Contract 03-5-022-56
Task Order #9 and #22
Research Unit #285

Date: March 17, 1977

Total Number of Pages: 69

ANNUAL REPORT

I. Summary of Objectives--The objective was to prepare keys to otoliths of forage fishes. Identification of otoliths found in stomachs of carnivores will help to assess importance of organisms in the food web and possible effects of OCS oil and gas development.

II. Introduction

A. General nature and scope of study. This study is basically taxonomic in nature. It has involved scrutinizing as many otoliths as possible of as many species of forage fishes as possible, with a view to determining the characteristics by which the otoliths could be identified. Specimens were obtained from the Gulf of Alaska, Bering Sea and Beaufort Sea and 142 species are included in the work.

B. Specific objectives. The specific objective was to prepare a set of keys by means of which otoliths could be identified.

C. Relevance to problems of petroleum development. Because otoliths are often the last portions of fishes to remain more or less intact in the stomachs of piscivorous carnivores, they can be valuable in determining the position and relative importance of both prey and predator in the food web. The food web is one of the biological aspects of the areas under consideration most liable to be affected by OCS oil and gas development. The keys to otoliths will help in identifying the fishes eaten by larger fishes, marine mammals and birds, and thus will be useful in assessing potential and actual effects of offshore development on food relationships.

III. Current state of knowledge--Although otoliths have been studied, illustrated and described by a number of workers, nearly all of these studies have been directed at the use of otoliths to elucidate evolutionary relationships. The only attempt known to me to produce a key is that of Casteel [Casteel, R.W., 1974. Identification of the species of Pacific salmon (Genus *Oncorhynchus*) native to North America based upon otoliths. *Copeia* 1974(2):305-311].

IV. Study area--Gulf of Alaska, Bering Sea, Beaufort Sea.

V. Sources, methods and rationale of data collection--Some material was collected by the trawling cruises of NOAA and NMFS vessels involved in the OCSEAP project. Additional specimens were borrowed from Jack Lalanne and Hiro Kajimura, NMFS, Seattle; Kathy Frost and Lloyd Lowry, Alaska Department of Fish and Game, Fairbanks; University of Alaska Museum Fish Collection; and John E. Fitch, California Department of Fish and Game, Long Beach. We tried to obtain material representing as many as possible of the more common species of fishes, those which might reasonably be supposed to be the ones most likely to be fed upon.

VI. Results--Results are shown in the set of keys which follows.

VII. Discussion--Not applicable.

VIII. Conclusions--Not applicable.

IX. Needs for further study--Because of the nature of the collecting gear and the emphasis on the food habits of fishes, shore fishes, such as the Pholididae, are under-represented. Since fishes of the inshore zone may be important to birds, an attempt should be made to expand the coverage of these forms.

X. Summary of 4th quarter operations--

A. Ship or laboratory activities
   1. Ship or field trip schedule. One trip was made to southern California to consult with Dr. John E. Fitch and utilize his extensive collection of otoliths, especially those of the Scorpaenidae.

   2. Scientific party. Dr. James E. Morrow, University of Alaska, Principal Investigator.

   3. Methods. Not applicable.

   4. Sample localities. Not applicable.

   5. Data collected or analyzed. Not applicable.

   6. Milestone chart and data submission schedule. All preliminary work had been accomplished on schedule. The completed keys were sent to Dr. John E. Fitch, the leading expert on otoliths, who pointed out a number of ways in which the keys could be improved and made more reliable. Most of the past quarter was devoted to re-examining otolith material and incorporating Dr. Fitch's suggestions.

B. Problems. The only serious problems encountered were with the family Scorpaenidae. In this group, it was found that virtually all the material available either had been mis-identified or was from juveniles. Otoliths of juvenile scorpaenids cannot be reliably identified. Hence, the trip to southern California mentioned in paragraph XA1 became necessary.

C. Estimate of funds expended.

ILLUSTRATED KEYS TO OTOLITHS OF FORAGE FISHES --GULF OF ALASKA, BERING SEA AND BEAUFORT SEA

by

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Introduction

The preparation of these keys was undertaken as a part of the Outer Continental Shelf Environmental Assessment Program of the Bureau of Land Management and the National Oceanic and Atmospheric Administration. The objective was to provide a means of identifying otoliths found in the stomachs of fishes, sea birds and marine mammals, thus providing clues to their food habits and the relative positions of both prey and predators in the food web. The geographic area inhabited by the various species included in the keys ranges from the Gulf of Alaska northward through the Bering and Chukchi seas to the Beaufort Sea. These are the waters off the western and northwestern coasts of North America which are currently under consideration for large scale offshore explorations for oil and which are, consequently, liable to be heavily impacted. It is hoped that these keys will be of some assistance in mitigating that impact.

Definitions

The following terms are used to designate certain features of the otolith (see also Fig. A). This terminology is slightly modified from that used by Frizzel and Dante (1965).

Antirostrum--The antero-dorsal corner of the otolith, just dorsal to the notch of the excisura major.

Cauda--The posterior portion of the sulcus, posterior to the collum.

Colliculum--The raised portion of the floor of the sulcus. May exist in the ostium, cauda, both or neither. In some groups (the Scorpaenidae, for example), the anterior colliculum may be so large as to obscure the notch of the excisura major.

Collum--A constriction of the sulcus, usually (if present) located near the middle of the sulcus.

Crista inferior--The ventral rim of the sulcus. If present as a distinct, raised ridge, it is termed "well developed." If no ridge is present, the crista is "poorly developed."

Crista superior--The dorsal rim of the sulcus. Same descriptive terms as for the crista inferior.

Dorsal area--That portion of the otolith dorsal to the sulcus.

Excisura--The opening of the sulcus on the margin of the otolith. The anterior opening of the sulcus is the excisura major, the posterior opening is the excisura minor. The excisurae often open into an excisural notch. If the sulcus does not reach the margin of the otolith, there is no excisura, even though a notch may be present.

Height of dorsal area or ventral area--The greatest straight line distance from the center line of the sulcus to the dorsal or ventral margin of the otolith.

Height of otolith--The greatest straight line distance from the dorsal to the ventral margin of the otolith, taken at right angles to the long axis.

Height of rostrum--The distance, measured at right angles to the long axis, between the apex of the excisural notch and the ventral margin of the otolith. If the notch is occluded by the colliculum, the height of the rostrum is measured to a horizontal through the point where the dorsal edge of the colliculum meets the margin of the otolith.

Length of otolith--The straight line distance from the most anterior to the most posterior margin of the otolith.

Length of rostrum--The straight line distance from the tip of the rostrum to the apex of the excisural notch. If the notch is occluded by the colliculum, the length of the rostrum is measured to a vertical through the point where the dorsal edge of the colliculum meets the margin of the otolith.

Ostium--The anterior portion of the sulcus, anterior to the collum.

Postcaudal trough--A groove or depression on the postero-ventral portion of the otolith, extending (when present) from the posterior end of the sulcus to the postero-ventral margin of the otolith.

Rostrum--The anterior extension of the ventral portion of the otolith below the excisural notch.

Sulcus--The longitudinal groove on the medial surface of the otolith.

Ventral area--That portion of the otolith ventral to the sulcus.

Remarks

These keys are based on normal otoliths of adult fishes. Because considerable changes in the shape of the otolith often occur during development, the otoliths of post-larvae and young juveniles cannot be identified accurately by the use of these keys. Freakish, abnormal otoliths occur occasionally, even frequently in some groups, and these, likewise, cannot be reliably identified, although they can usually be carried to the family and sometimes the generic level. There will also be a small percentage of normal, adult otoliths which will not key out properly.

The otoliths of some species are highly variable. Whenever possible, these appear more than once in the keys, to cover as much variation as possible. In some genera, the otoliths of various species are so similar that the reliability of identification is low. Such genera or groups of species are combined in the keys, without attempting to carry the identification to the species level. However, an otolith of each species available has been illustrated.

These keys include 142 species of fishes known from Alaskan waters. Because of the nature of the collecting gear, shore fishes and pelagic species, in particular, are under-represented. No attempt has been made to include scarce forms which are rarely encountered. Likewise, species which may be common elsewhere and occasionally venture into the area covered have not been included. It is therefore quite possible that species not included in the keys will be wrongly identified. However, the chances are good that correct identification can be made to the family level, perhaps even to genus. For those families where all Alaskan species are included, identification to the species level should be at least 75% accurate, often 90% accurate. Where 75% accuracy could not be achieved, species have been lumped.

The arrangement of groups and the use of scientific and common names follows, with a few exceptions, Bailey et al. (1970) and Quast and Hall (1972).

Acknowledgements

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office. Some specimens were obtained from trawling cruises made by NOAA and National Marine Fisheries Service vessels as part of the overall program. Additional material was lent by Jack Lalanne and Hiro Kajimura, National Marine Fisheries Service, Seattle; by Kathy Frost and Lloyd Lowry, Alaska Department of Fish and Game, Fairbanks; by the University of Alaska Museum Fish Collection; and specimens of 66 of the 142 species included were lent by John E. Fitch, California Department of Fish and Game, Long Beach. In addition, Dr. Fitch has given most generously of his time and expertise. My assistants, Edmond Murrell and Sverre Pedersen, graduate students in the Division of Life Sciences of the University of Alaska, labor conscientiously in extracting and preparing otoliths and other skeletal materials, prepared preliminary versions of several family keys and helped test all the keys. Timothy Sczawinski made the drawings. I am most grateful to all these people and institutions for their help and support. Faults or errors in the keys are, however, solely my responsibility.

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Frizzel, D. L., and J. H. Dante. 1965. Otoliths of some early Cenozoic fishes of the Gulf Coast. J. Palaeontol. 39(4):687-718.

Quast, J. C., and E. L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. Nat. Mar. Fish. Serv. Spec. Sci. Rept. Fisheries No. 658. 47 p.

LIST OF SPECIES INCLUDED

Clupeidae

Clupea harengus pallasi - Pacific herring

Osmeridae

Hypomesus olidus - Pond smelt

Hypomesus pretiosus - Surf smelt

Mallotus villosus - Capelin

Osmerus eperlanus - Rainbow smelt

Spirinchus thaleichthys - Longfin smelt

Thaleichthys pacificus - Eulachon

Moridae

Antimora microlepis - Longfin cod

Gadidae

Boreogadus saida - Arctic cod

Eleginus gracilis - Saffron cod

Gadus macrocephalus - Pacific Cod

Merluccius productus - Pacific hake

Microgadus proximus - Pacific tomcod

Theragra chalcogramma - Walleye pollock

Zoarcidae

Bothrocara brunneum - Twoline eelpout

Bothrocara molle - Soft eelpout

Bothrocara pusillum - Alaska eelpout

Embryx crotalina - Snakehead eelpout

Lycodes brevipes - Shortfin eelpout

Lycodes diapterus - Black eelpout

Lycodes palearis - Wattled eelpout

Lycodopsis pacifica - Blackbelly eelpout

Trichodontidae

Arctoscopus japonicus - Sailfin sandfish

Trichodon trichodon - Pacific sandfish

Bathymasteridae

Bathymaster caeruleofasciatus - Alaskan ronquil

Bathymaster signatus - Searcher

Ronquilus jordani - Northern ronquil

Stichaeidae

Acantholumpenus mackayi - Pighead prickleback

Lumpenella longirostris - Longsnout prickleback

Lumpenus fabricii - Slender eelblenny

Lumpenus maculatus - Daubed shanny

Lumpenus sagitta - Snake prickleback

Poroclinus rothrocki - Whitebarred prickleback

Stichaeus punctatus - Arctic shanny

Pholididae

Apodichthys flavidus - Penpoint gunnel

Pholis ornata - Saddleback gunnel

Anarhichadidae

Anarichas orientalis - Bering wolffish

Anarrhichthys ocellatus - Wolf-eel

Cryptacanthodidae

Delolepis gigantea - Giant wrymouth

Lyconectes aleutensis - Dwarf wrymouth

Ammodytidae

Ammodytes hexapterus - Pacific sandlance

Scorpaenidae

Sebastes aleutianus - Rougheye rockfish

Sebastes alutus - Pacific ocean perch

Sebastes aurora - Aurora rockfish

Sebastes babcocki - Redbanded rockfish

Sebastes borealis - No common name

Sebastes brevispinis - Silvergray rockfish

Sebastes caurinus - Copper rockfish

Sebastes ciliatus - Dusky rockfish

Sebastes crameri - Darkblotched rockfish

Sebastes entomelas - Widow rockfish

Sebastes maliger - Quillback rockfish

Sebastes melanops - Black rockfish

Sebastes melanostomus - Blackgill rockfish

Sebastes mystinus - Blue rockfish

Sebastes polyspinis - Northern rockfish

Sebastes proriger - Redstripe rockfish

Sebastes ruberrimus - Yelloweye rockfish

Sebastes variegatus - Harlequin rockfish

Sebastes zacentrus - Sharpchin rockfish

Sebastolobus alascanus - Shortspine thornyhead

Sebastolobus altivelis - Longspine thornyhead

Anoplopomatidae

Anoplopoma fimbria - Sablefish

Erilepis zonifer - Skilfish

Hexagrammidae

Hexagrammos decagrammus - Kelp greenling

Hexagrammos lagocephalus - Rock greenling

Hexagrammos octogrammus - Masked greenling

Hexagrammos stelleri - Whitespotted greenling

Ophiodon elongatus - Lingcod

Pleurogrammus monopterygius - Atka mackerel

Cottidae

Artedius fenestralis - Padded sculpin

Artedius harringtoni - Scalyhead sculpin

Blepsias bilobus - Crested sculpin

Blepsias cirrhosus - Silverspotted sculpin

Dasycottus setiger - Spinyhead sculpin

Enophrys bison - Buffalo sculpin

Enophrys diceraus - Antlered sculpin

Enophrys sp.

Gymnocanthus galeatus - Armorhead sculpin

Gymnocanthus tricuspis - Arctic staghorn sculpin

Hemilepidotus hemilepidotus - Red Irish lord

Hemilepidotus jordani - Yellow Irish lord

Hemilepidotus spinosus - Brown Irish lord

Hemitripterus bolini - Bigmouth sculpin

Icelinus borealis - Northern sculpin

Icelus canaliculatus - No common name

Icelus spatula - Spatulate sculpin

Icelus spiniger - No common name

Leptocottus armatus - Pacific staghorn sculpin

Malacocottus kincaidi - Blackfin sculpin

Megalocottus platycephalus - Belligerent sculpin

Myoxocephalus jaok - Plain sculpin

Myoxocephalus polyacanthocephalus - Great sculpin

Myoxocephalus quadricornis - Fourhorn sculpin

Myoxocephalus scorpius - Shorthorn sculpin

Nautichthys robustus - No common name

Psychrolutes paradoxus - Tadpole sculpin

Radulinus asprellus - Slim sculpin

Rhamphocottus richardsoni - Grunt sculpin

Triglops forficata - Scissortail sculpin

Triglops macellus - Roughspine sculpin

Triglops pingeli - Ribbed sculpin

Triglops scepticus - Spectacled sculpin

Agonidae

Agonus acipenserinus - Sturgeon poacher

Anoplagonus inermis - Smooth alligatorfish

Bathyagonus alascanus - Gray starsnout

Bathyagonus infraspinatus - Spinycheek starsnout

Bathyagonus nigripinnis - Blackfin poacher

Bathyagonus pentacanthus - Bigeye poacher

Hypsagonus quadricornis - Fourhorn poacher

Ocella dodecaedron - Bering poacher

Ocella verrucosa - Warty poacher

Pallasina barbata - Tubenose poacher

Sarritor frenatus - Sawback poacher

Sarritor leptorhynchus - Longnose poacher

Cyclopteridae

Careproctus furcellus - No common name

Careproctus melanurus - Blacktail snailfish

Careproctus sp.

Eumicrotremus orbis - Pacific spiny lumpsucker

Liparis dennyi - Marbled snailfish

Liparis gibbus - No common name

Liparis liparis - Striped seasnail

Liparis pulchellus - Showy snailfish

Nectoliparis pelagicus - Tadpole snailfish

Bothidae

Citharichthys sordidus - Pacific sanddab

Pleuronectidae

Atheresthes stomias - Arrowtooth flounder

Eopsetta jordani - Petrale sole

Glyptocephalus zachirus - Rex sole

Hippoglossoides elassodon - Flathead sole

Hippoglossoides robustus - Bering flounder

Hippoglossus stenolepis - Pacific halibut

Isopsetta isolepis - Butter sole

Lepidopsetta bilineata - Rock sole

Limanda aspera - Yellowfin sole

Limanda proboscidea - Longhead dab

Liopsetta glacialis - Arctic flounder

Microstomus pacificus - Dover sole

Parophrys vetulus - English sole

Platichthys stellatus - Starry flounder

Pleuronectes quadrituberculatus - Alaska plaice

Psettichthys melanostictus - Sand sole

Reinhardtius hippoglossoides - Greenland halibut

KEYS TO FAMILIES

A. Both excisurae present....................................Key I

B. Both excisurae absent....................................Key II

C. Excisura major present, excisura minor absent............Key III

KEY I. BOTH EXCISURAE PRESENT

1a. Sulcus divided into dorsal and ventral chambers by a long, thin, blade-like colliculum

Antimora microlepis (Fig. 1)

1b. Sulcus not divided as in 1a....................................2

2a. Height of otolith 55% or less of its length....................3

2b. Height of otolith more than 55% of its length..................5

3a. Notch of excisura major deep and narrow, forming an angle of much less than 90°. Dorsal and ventral margins of otolith roughly parallel. Ventral margin incised

Clupea harengus pallasi (Fig. 2)

3b. Notch of excisura major broad, usually about 90° or more, always greater than 60°. Margins various..........................4

4a. Ends of sulcus extremely deep. Collum well developed. A prominent notch in ventral margin below collum (except in juveniles). Tiny otoliths, never more than 2 mm long

Family Pholididae

Apodichthys flavidus (Fig. 39)

4b. Without the above combination of characters

*Family Salmonidae (some *Oncorhynchus*)

5a. Sulcus deep and well defined....................................6

5b. Sulcus shallow, rather poorly defined

Family Trichodontidae

6a. Greatest height of ventral area distinctly behind middle of otolith length

Family Osmeridae

6b. Greatest height of otolith about at middle of otolith length....7

7a. Angle of notch of excisura major less than 90°. A deep channel present below crista inferior

Family Anarhichadidae

Anarrhichthys ocellatus (Fig. 41)

7b. Angle of notch of excisura major about 90° or more. No deep channel below crista inferior................................8

8a. General shape more or less an equilateral triangle. Height of otolith 90% or more of its length, or thickness of otolith more than 50% of its length. A fan-shaped area dorsal to sulcus

Family Zoarcidae (Genus Bothrocara)

8b. Not as in 8a

*Family Salmonidae (some Oncorhynchus)

[*For a key to otoliths of Oncorhynchus, see: Casteel, R. W., 1974. Identification of the species of Pacific salmon (Genus Oncorhynchus) native to North America based upon otoliths. Copeia 1974(2):305-311.]

KEY II. BOTH EXCISURAE ABSENT

1a. Sulcus well defined, consists either of a fairly deep, straight groove or of one or two pits....................................4

1b. Sulcus shallow and poorly defined..............................2

2a. Sulcus constricted at collum, broad at each end. Anterior end of otolith highest, otolith tapers posteriorly

Family Gadidae

2b. Sulcus not constricted at collum, about the same width throughout its length. Otolith not shaped as in 2a...........3

3a. Sulcus straight. Surface of otolith like frosted glass. Otolith nearly round in cross-section. Otolith of small to moderate size

Family Cryptacanthodidae

Lyconectes aleutensis (Fig. 3)

3b. Sulcus arched dorsad. Surface of otolith not like frosted glass. Otolith compressed laterally, oval in cross-section. Otolith tiny, never longer than 2 mm

Family Cottidae

Psychrolutes paradoxus (Fig. 73)

4a. Otolith almond-shaped. Sulcus reaches or nearly reaches anterior tip...5

4b. Not as in 4a..6

5a. Dorsal margin smooth. Height of otolith about 50% of its length. Sulcus fails to reach posterior end of otolith by more than 20% of otolith length. No crista superior. Otolith never longer than 3 mm

Ammodytes hexapterus (Fig. 6)

5b. Dorsal margin crenulate or wavy. Height of otolith about 36% of its length. Sulcus fails to reach posterior margin of otolith by less than 10% of otolith length. Crista superior high, sharp. Otolith larger than in 5a

Family Anoplopomatidae

some Anoplopoma fimbria (Fig. 65)

6a. Otolith thick, heavy, massive. Always a deep notch anteriorly, often a posterior notch also. A thick, rounded ridge separates ostium of sulcus from cauda

Family Cryptacanthodidae

Delolepis gigantea (Figs. 4 and 5)

6b. Not as in 6a..7

7a. Dorsal area with a deep, fan-shaped depression

Family Zoarcidae

Embryx crotalina (Fig. 19)

7b. Not as in 7a..8

8a. Lateral side of otolith distinctly concave

Family Cottidae

8b. Lateral side of otolith flat to convex, not distinctly concave

Pleuronectiformes

KEY III. EXCISURA MAJOR PRESENT, EXCISURA MINOR ABSENT

1a. Long axis straight or nearly so when viewed from above..........2

1b. Long axis distinctly curved....................................13

2a. Otolith almond-shaped. Sulcus opens at extreme tip

Ammodytes hexapterus (Fig. 6)

2b. Otolith not almond-shaped. Sulcus opens somewhere behind extreme anterior tip...3

3a. Ends of sulcus extremely deep. Collum well developed. Tiny otoliths, never longer than 2 mm

Family Pholididae

Apodichthys flavidus (Fig. 39)

3b. Not as in 3a...4

4a. Dorsal area of medial side with definite radiating lines........5

4b. Dorsal area without radiating lines............................7

5a. Excisural notch shallow or absent. Rostrum not or scarcely longer than antirostrum...6

5b. Excisural notch generally obvious. Rostrum much longer than antirostrum

Family Cyclopteridae

6a. Height of otolith more than 65% of its length, usually more than 70% of length

Family Trichodontidae

6b. Height of otolith less than 65% of its length, usually less than 60% of length

Family Cyclopteridae

7a. Medial side flat, surfaces of dorsal and ventral areas in same plane. Rostrum not sharply separated from antirostrum

Family Cyclopteridae

7b. Medial side more or less rounded, or surfaces of dorsal and ventral areas not in same plane, or rostrum prominent and clearly separated from antirostrum........................8

8a. Ventral margin of otolith distinctly curved....................9

8b. Ventral margin straight or nearly so, at least in its middle portion..11

9a. Sulcus not parallel with long axis of otolith.................10

9b. Sulcus parallel with long axis of otolith

Family Cottidae

10a. Excisural notch distinct, V-shaped. Rostrum pointed

Family Stichaeidae

Poroclinus rothrocki (Fig. 34)

10b. Excisural notch various. Rostrum rounded or blunt

Family Agonidae (Genus _Sarritor_)

11a. Crista inferior forming at least a slight ridge

Family Stichaeidae

11b. Crista inferior poorly developed, not forming a ridge.........12

12a. Rostrum short, blunt

Family Agonidae

12b. Rostrum long, pointed

Family Anarhichadidae

13a. Otolith heavy, massive. A thick, rounded ridge projects anteriorly in the sulcus and separates ostium from cauda horizontally

Family Cryptacanthodidae

Delolepis gigantea (Figs. 4 and 5)

13b. Not as in 13a...14

14a. Surface of otolith like frosted glass. Sulcus shallow, with a well developed colliculum

Family Cryptacanthodidae

Lyconectes aleutensis (Fig. 3)

14b. Surface not like frosted glass, or sulcus deep and without a colliculum...15

15a. Crista superior well developed, appears as a distinct ridge...18

15b. Crista superior poorly developed, not raised as a ridge above surface of dorsal area...............................16

16a. Ostium V-shaped, its bottom (lateral surface) flat, without a colliculum

Family Pholididae

Pholis ornata (Fig. 40)

16b. Ostium various, but not with above combination of characters...17

17a. Excisural notch prominent and without a colliculum. Dorsal margin of otolith not deeply crenulate

Family Agonidae

17b. Excisural notch not prominent, or if prominent, there is a well developed colliculum in the notch or the dorsal margin of the otolith is markedly crenulate

Family Cottidae

18a. Central axis of sulcus with a distinct ventrad bend at its posterior end..20

18b. Central axis of sulcus without a ventrad bend at its posterior end..19

19a. Height of otolith less than 45% of its length. Rostrum long and narrow, well separated anteriorly

Family Bathymasteridae

Bathymaster signatus (Fig. 30)

19b. Height of otolith more than 45% of its length. If less, then rostrum short and broad and poorly separated from antirostrum

Family Scorpaenidae

20a. Postcaudal trough broad, well developed, meets posterior end of sulcus

Family Hexagrammidae

20b. Postcaudal trough absent (one or twogrooves with V-shaped cross-sections may be present), or, if present and broad, meets posterodorsal end of sulcus............................21

21a. Medial surface of otolith curved dorso-ventrally

Family Bathymasteridae

21b. Medial surface of otolith nearly flat dorso-ventrally

Family Anoplopomatidae

FAMILY OSMERIDAE

1a. Antero-ventral margin rounded....................................3

1b. Antero-ventral margin straight...................................2

2a. Postero-dorsal and dorsal margins curved. Otolith height greatest at about 2/3 of length

Mallotus villosus (Fig. 7)

2b. Postero-dorsal and dorsal margins straight or nearly so. Otolith height greatest at posterior end

Thaleichthys pacificus (Fig. 8)

3a. Rostrum broad, its tip blunt. Dorsal rim of sulcus curves ventrad at posterior end. Postcaudal trough indistinct or absent

Hypomesus pretiosus (Fig. 9)

3b. Rostrum narrow, more or less pointed. Dorsal rim of sulcus straight. Postcaudal trough distinct.........................4

4a. Posterior margin more or less truncate, approximately at right angles to long axis of sulcus

Osmerus eperlanus (Fig. 10)

4b. Posterior margin rounded...5

5a. Height of otolith 59% (56-61%) of its length

Spirinchus thaleichthys (Fig. 11)

5b. Height of otolith 67% (65-68%) of its length

Hypomesus olidus (Fig. 12)

FAMILY GADIDAE

1a. Medial surface strongly convex, lateral surface distinctly concave...2

1b. Medial surface only moderately convex, lateral surface flat or nearly so, or concave only above mid-line.................3

2a. Height of otolith more than 44% of its length. Postero-dorsal (more pointed end) margin forms angle of about 60° with longitudinal axis

Gadus macrocephalus (Fig. 13)

2b. Height of otolith 44% or less of its length. Postero-dorsal margin forms angle of about 45° with longitudinal axis

Theragra chalcogramma (Fig. 14)

3a. Lateral surface smooth, without rounded lumps..................4

3b. Lateral surface with rounded lumps, especially near center of otolith...5

4a. Antero-dorsal (higher end) margin forms angle of 30-45° (usually about 30°) with long axis. Anterior end rounded or with numerous, small lobules. Otoliths of adults may exceed 20 mm in length

Merluccius productus (Fig. 15)

4b. Antero-dorsal margin forms angle of 15-25° (usually 20° or less) with long axis. Anterior end bilobed, a distinct notch separating the two lobes. Otoliths small, rarely over 8 mm long

Boreogadus saida (Fig. 16)

5a. Postero-dorsal margin slightly concave, forms angle of 25-30° (usually about 30°) with long axis. Postero-dorsal rim quite thin

Microgadus proximus (Fig. 17)

5b. Postero-dorsal margin straight to slightly convex, forms angle of about 20° with long axis. Postero-dorsal rim slightly thickened

Eleginus gracilis (Fig. 18)

FAMILY ZOARCIDAE

1a. Sulcus ends on rostrum, usually does not open on anterior margin. A deep groove, usually in the form of two elongate pits, below sulcus. A deep pit in dorsal area

Embryx crotalina (Fig. 19)

1b. Not as in 1a..2

2a. General shape approximately an equilateral triangle. Height of otolith 90% or more of its length, or thickness more than 50% of length (Genus *Bothrocara*)........................3

2b. General shape more or less triangular, but not equilateral. Height of otolith less than 85% of length, thickness less than 50% of length..5

3a. Lateral side and exaggerated, round dome. Thickness more than 50% of length. Large specimens with ventral area expanded antero-posteriorly

Bothrocara brunneum (Fig. 20)

3b. Lateral side convex, but not dome-like. Thickness less than 50% of length. Ventral area not expanded both anteriorly and posteriorly...4

4a. Antero-ventral corner expanded to form a short, rounded lobe

Bothrocara pusillum (Fig. 21)

4b. Antero-ventral corner not expanded

Bothrocara molle (Fig. 22)

5a. Height of otolith 66% or less of its length

Lycodopsis pacifica (Fig. 23)

5b. Height of otolith 69-83% of its length (Genus Lycodes)..........6

6a. Dorsal margin more or less rounded. Greatest height of otolith at or behind middle of length. Postero-dorsal margin typically convex

Lycodes palearis (Fig. 24)

6b. Dorsal margin usually with a distinct angle. Greatest height of otolith at or before middle of length. Postero-dorsal margin straight or concave...7

7a. Greatest height distinctly anterior to middle of length. Texture smooth

Lycodes brevipes (Fig. 25)

7b. Greatest height near center of length. Texture less smooth

Lycodes diapterus (Fig. 26)

FAMILY TRICHODONTIDAE

1a. Rostrum short, blunt. Inner face of otolith thickened below center of sulcus

Trichodon trichodon (Fig. 27)

1b. Rostrum long, pointed. Inner face of otolith flat, not thickened

Arctoscopus japonicus (Fig. 28)

FAMILY BATHYMASTERIDAE

1a. Posterior end of otolith pointed

Ronquilus jordani (Fig. 29)

1b. Posterior end of otolith rounded or lobate......................2

2a. Dorsal margin crenulate. Posterior end of sulcus bent ventrad at angle of 10-15°. Height of otolith 40% or more of its length. Lateral surface with distinct radiating lines

Bathymaster signatus (Fig. 30)

2b. Dorsal margins wavy, not crenulate. Posterior end of sulcus bent ventrad at an angle of 20°. Height of otolith less than 40% of its length. Lateral surface smooth; if radiating lines are present, they are few in number and hard to see

Bathymaster caeruleofasciatus (Fig. 31)

FAMILY STICHAEIDAE

1a. Height of otolith 65% or more of its length....................2

1b. Height of otolith less than 65% of its length, usually less than 60%...3

2a. Excisural notch very shallow

Lumpenella longirostris (Fig. 32)

2b. Excisural notch deep and obvious

Lumpenus maculatus (Fig. 33)

3a. Excisural notch deep and obvious. Anterior end of sulcus opens in notch..4

3b. Excisural notch poorly defined and/or sulcus does not open in the notch. A groove may be present from the notch to the dorsal edge of the sulcus.......................................5

4a. Tip of rostrum pointed (rarely blunt), antirostrum angular

Poroclinus rothrocki (Fig. 34)

4b. Both rostrum and antirostrum broadly rounded

Acantholumpenus mackayi (Fig. 35)

5a. Excisural notch present, forming an angle of more than 45°. Height of dorsal area 1.0-1.2 times that of ventral area

Lumpenus fabricii (Fig. 36)

5b. Excisural notch virtually absent, if present forms an angle of about 45°. Height of dorsal area 1.5-2.0 times that of ventral area..6

6a. A prominent lobe on postero-dorsal margin

Lumpenus sagitta (Fig. 37)

6b. No prominent lobe on postero-dorsal margin

Stichaeus punctatus (Fig. 38)

FAMILY PHOLIDIDAE

1a. Sulcus very deep, reaches or almost reaches posterior margin. Crista inferior deeply undercut. Often a notch near middle of ventral margin

Apodichthys flavidus (Fig. 39)

1b. Sulcus moderately deep, does not reach posterior margin. Crista inferior not undercut. No notch in ventral margin

Pholis ornata (Fig. 40)

FAMILY ANARHICHADIDAE

1a. Excisura major deep and narrow. A deep furrow present below crista inferior. Lateral surface usually with a clump of nodules in nuclear area

Anarrhichthys ocellatus (Fig. 41)

1b. Excisura major a rather shallow, V-shaped notch. Crista inferior scarcely evident, no furrow below it. Lateral surface smooth

Anarhichas orientalis (Fig. 42)

FAMILY SCORPAENIDAE

This key to the otoliths of Alaskan Scorpaenidae is based on adult specimens. The otoliths of juveniles (ie, otoliths less than about 10 mm long) are all very similar, generally resembling the otoliths of the dwarf species *Sebastes variegatus*. They cannot be distinguished with any degree of reliability.

1a. Height of dorsal area about 2X height of ventral area (only about 1.2X in small juveniles)

Sebastolobus altivelis (Fig. 43) and
Sebastolobus alascanus (Fig. 44)

1b. Height of dorsal and ventral areas about equal..................2

2a. Height of otolith usually less than 45% of its length, always less than 50%..3

2b. Height of otolith more than 45% of its length...................7

3a. Height of otolith 38-43% of its length. Dorsal margin nearly straight, although incised

Sebastes entomelas (Fig. 45)

3b. Height of otolith 43-48% of its length. Dorsal margin slightly but distinctly convex..4

4a. Dorsal margin with coarse, broad irregularities................5

4b. Dorsal margin with small, fine incisions and irregularities.....6

5a. Anterior portion of dorsal margin behind colliculum rounded. Postcaudal trough absent; if present, shallow and ends in a broad, shallow indentation of postero-ventral margin

Sebastes brevispinis (Fig. 46)

5b. Anterior portion of dorsal margin behind colliculum nearly straight. Postcaudal trough prominent, ends in a deep notch in postero-ventral margin

Sebastes proriger (Fig. 47)

6a. Tip of rostrum pointed. Postcaudal trough prominent

Sebastes caurinus (Fig. 48)

6b. Tip of rostrum blunt. Postcaudal trough poorly developed

Sebastes mystinus (Fig 49)

7a. Dorsal margin with fine, irregular incisions....................8

7b. Dorsal margin not as in 5a, except on posterior portion in some species. If deeply incised, the incisions are coarse, the projections usually tooth-like................................10

8a. Height of ventral area 80% or more of height of dorsal area

Sebastes maliger (Fig 50)

8b. Height of ventral area less than 80% of height of dorsal area...9

9a. Postero-ventral margin usually with one or two deep indentations

Sebastes caurinus (Fig. 48)

9b. Postero-ventral margin without deep indentations

Sebastes melanostomus (Fig. 51)

10a. Ventral margin smooth (sometimes a few weak irregularities in Sebastes melanops).....................................11

10b. Ventral margin with crenulations, teeth or noticeable irregularities, at least on rostrum...........................14

11a. Height of otolith 60-68% of its length. Thickness of otolith about 30% of its height

Sebastes aurora (Fig. 52)

11b. Height of otolith less than 55% of its length. Thickness much less than 30% of height.................................12

12a. Height of otolith 50-54% of its length

Sebastes ciliatus (Fig. 53)

12b. Height of otolith less than 50% (usually 45-49%) of its length...13

13a. Postcaudal trough follows axis of sulcus to posterior margin of otolith (a ventrally directed branch of the trough may by present)

Sebastes melanops (Fig. 54)

13b. Postcaudal trough forms an angle of about 30° with axis of sulcus

Sebastes polyspinis (Fig. 55)

14a. Crista inferior raised above surface of ventral area 15

14b. Crista inferior not sharply set off from surface of ventral area (a longitudinal groove may be present in ventral area) 22

15a. Height of otolith 46% or less of its length

Sebastes brevispinis (Fig. 46)

15b. Height of otolith 49% or more of its length...................16

16a. A prominent postcaudal trough present.........................17

16b. Postcaudal trough absent, or at least not prominent...........20

17a. Postcaudal trough does not end in a notch on postero-ventral margin

Sebastes babcocki (Fig. 56)

17b. Postcaudal trough ends in an indentation in postero-ventral margin...18

18a. Dorsal margin smoothly rounded, except at posterior end

Sebastes aurora (Fig. 52)

18b. Dorsal margin irregular and/or incised........................19

19a. Ventral margin smooth or nearly so

Sebastes zacentrus (Fig. 57)

19b. Ventral margin with numerous, small teeth

Sebastes maliger (Fig. 50)

20a. Posterior margin rounded, usually deeply incised, often almost frilly or fish-tail-like..................................21

20b. Posterior margin truncate, not frilly or fish-tail-like, sometimes with small, irregular projections

Sebastes borealis (Fig. 58)

21a. Usually one or two large indentations in postero-dorsal margin

Sebastes brevispinis (Fig. 46)

21b. No large indentations in postero-dorsal margin

Sebastes crameri (Fig. 59)

22a. Dorsal margin quite smooth (may have a few shallow crenulations)

Sebastes variegatus (Fig. 60) and juvenile Sebastes aleutianus

22b. Dorsal margin crenulate or irregularly incised.................23

23a. Excisural notch fairly obvious, rostrum clearly set off from antirostrum...24

23b. Excisural notch shallow or absent, rostrum not clearly separated from antirostrum.................................25

24a. Posterior part of ventral margin of rostrum usually toothed or crenulate. Dorsal area usually with fine, radiating lines

Sebastes alutus (Fig. 61)

24b. Posterior part of ventral margin of rostrum not toothed, but may have shallow crenulations or irregularities. Dorsal area without radiating lines.

Sebastes aleutianus (Fig. 62)

25a. Posterior margin of otolith crenulate to moderately incised

Sebastes polyspinis (Fig. 55)

25b. Posterior margin of otolith deeply incised, frilly, often fish-tail-like...26

26a. Ventral margin more or less crenulate or toothed. Dorsal margin usually rather deeply incised, often frilly. Height of otolith 43-48% of its length (usually more than 45%)

Sebastes caurinus (Fig. 48)

26b. Ventral margin smooth or slightly irregular. Dorsal margin with shallow incisions or crenulations, these usually deeper towards posterior end of otolith. Height of otolith 48% or more of its length

Sebastes ruberrimus (Fig. 63)

FAMILY ANOPLOPOMATIDAE

1a. Height of otolith 50-60% of its length. Crista superior over-hangs sulcus, especially in large specimens

Erilepis zonifer (Fig. 64)

1b. Height of otolith 40-45% of length. Crista superior does not over-hang sulcus

Anoplopoma fimbria (Fig. 65)

FAMILY HEXAGRAMMIDAE

1a. Crista superior a well-defined ridge; crista inferior rises smoothly from surface of ventral area........................2

1b. Both cristae prominent and well-defined. Crista superior a sharp ridge; crista inferior rounded and heavy (Genus Hexagrammos).3

2a. Rostrum pointed. Otolith small, rarely longer than 6 mm
Pleurogrammus monopterygius (Fig. 66)

2b. Rostrum blunt. Otolith may exceed 12 mm long
Ophiodon elongatus (Fig. 67)

3a. Tip of rostrum rounded...4

3b. Tip of rostrum pointed...5

4a. Crista inferior extremely prominent, undercut on ventral side. Collum prominent
Hexagrammos lagocephalus (Fig. 68)

4b. Crista inferior a broad, thick ridge rising smoothly from surface of ventral area. Collum not especially prominent
Hexagrammos stelleri (Fig. 69)

5a. Lateral surface without concentric rings
Hexagrammos octogrammus (Fig. 70)

5b. Lateral surface with numerous concentric rings
Hexagrammos decagrammus (Fig. 71)

FAMILY COTTIDAE

1a. Both excisurae absent...2

1b. Excisura major present, excisura minor present or absent.......7

2a. Long axis curved, lateral side concave........................4

2b. Long axis straight...3

3a. Dorsal margin crenulate. Otoliths large, often exceed 8 mm long

Dasycottus setiger (Fig. 72)

3b. Dorsal margin smooth. Otoliths tiny, never longer than 2 mm

Psychrolutes paradoxus (Fig. 73)

4a. Ventral margin smooth or irregularly wavy.....................5

4b. Ventral margin more or less crenulate

Genus Myoxocephalus (Figs. 75, 76, and 77)

5a. Ventral margin curved. Height of otolith about 60% of its length

Myoxocephalus quadricornis (Fig. 74)

5b. Ventral margin irregular, but nearly straight. Height of otolith about 50% of its length...................................6

6a. Dorsal margin with a few broad crenulations

Enophrys bison (Fig. 97)

6b. Dorsal margin with more numerous, deeper crenulations

Enophrys diceraus (Fig. 96)

7a. Both excisurae present. Dorsal margin deeply crenulate, ventral margin smooth

Malacocottus kincaidi (Fig. 78)

7b. Excisura major present, excisura minor absent. Margins various.8

8a. Long axis straight or nearly so...............................9

8b. Long axis distinctly curved, usually strongly so..............19

9a. One or more prominent bulges on lateral side, or ventral area notably thicker than dorsal area...........................10

9b. No prominent bulges on lateral side..........................13

10a. A moderate bulge on ventral area of lateral side with a central bulge dorsal to it and clearly outlined by grooves

Nautichthys robustus (Fig. 79)

10b. A single, extremely prominent bulge on lateral side of ventral area, or ventral area notably thicker than dorsal area......11

11a. Dorsal margin with numerous, deep crenulations

Malacocottus kincaidi (Fig. 78)

11b. Dorsal margin with few, shallow crenulations or irregularities.12

12a. Rostrum short, blunt

Blepsias bilobus (Fig. 80)

12b. Rostrum long, pointed

Blepsias cirrhosus (Fig. 81)

13a. Height of otolith about 80% of its length

Hemitripterus bolini (Fig. 82)

13b. Height of otolith much less than 80% of its length, usually les- than 65%...14

14a. Dorsal margin crenulate (some *Radulinus* almost in 14b)........15

14b. Dorsal margin smooth or irregular.............................18

15a. Sulcus reaches anterior margin at or near tip of rostrum......17

15b. Sulcus ends anteriorly in excisural notch, does not reach tip of rostrum..16

16a. Sulcus bends dorsad anteriorly. Colliculum poorly developed or absent

Icelus spiniger (Fig. 83)

16b. Sulcus straight anteriorly. Colliculum generally well developed and prominent

Icelus canaliculatus (Fig. 84)

17a. Rostrum pointed, excisural notch absent or very shallow

Radulinus asprellus (Fig. 85)

17b. Rostrum blunt, excisural notch obvious

Gymnocanthus galeatus (Fig. 86)

18a. Rostrum blunt

Icelus spatula (Fig. 87)

18b. Rostrum pointed

Icelinus borealis (Fig. 88) and
Gymnocanthus tricuspis (Fig. 89)

19a. Dorsal margin smooth..20

19b. Dorsal margin with at least a few definite crenulations.......21

20a. Central part of dorsal margin arched, antero- and postero-dorsal margins concave. Texture like frosted glass. Posterior end of otolith thickened

Rhamphocottus richardsoni (Fig. 90)

20b. Dorsal margin evenly curved, may be concave only at excisural notch. Texture not like frosted glass. Posterior end not thicker than rest of otolith

Genus *Artedius* (Figs. 91 and 92)

21a. Both dorsal and ventral margins crenulate....................22

21b. Dorsal margin crenulate, ventral margin smooth................23

22a. Postcaudal trough generally prominent except in very small specimens. Surface, especially on lateral side, rough and/or bulbous

Genus _Hemilepidotus_ (Figs. 93, 94, and 95)

22b. Postcaudal trough absent. Surface smooth

Genus _Myoxocephalus_ (Figs. 75, 76 and 77)

23a. Dorsal margin with a few, broad crenulations....................24

23b. Dorsal margin with fairly numerous crenulations.................26

24a. Rostrum short, 15-20% of otolith length, or not distinguishable.25

24b. Rostrum long, 30% or more of otolith length

Enophrys sp. (Fig. 97A)

25a. Height of otolith about 60% of its length

Icelus canaliculatus (Fig. 84)

25b. Height of otolith about 50% of its length

Enophrys bison (Fig. 97)

26a. Crista superior present along almost entire dorsal edge of sulcus

Enophrys diceraus (Fig. 96)

26b. Crista superior either virtually absent or well developed only on anterior or posterior half of sulcus......................27

27a. Crista superior poorly developed, virtually absent (Genus _Triglops_)...29

27b. Crista superior well developed on either anterior or posterior half of sulcus...28

28a. Crista superior well developed on anterior half of sulcus

Leptocottus armatus (Fig. 98)

28b. Crista superior well developed on posterior end of sulcus

Megalocottus platycephalus (Fig. 99)

29a. Excisural notch prominent

Triglops scepticus (Fig. 100)

29b. Excisural notch poorly developed, antero-dorsal margin of otolith not or only slightly indented..............................30

30a. Tip of rostrum broadly rounded, slightly upturned. Height of otolith 45% or less of its length

Triglops forficata (Fig. 101)

30b. Tip of rostrum more or less pointed, not upturned. Height of otolith 48% or more of its length..........................31

31a. Posterior end broadly rounded (may show one or two crenulations), notably broader than anterior point

Triglops pingeli (Fig. 102)

31b. Posterior end pointed, similar to anterior point

Triglops macellus (Fig. 103)

FAMILY AGONIDAE

1a. Longitudinal axis distinctly curved when viewed from above.....2

1b. Longitudinal axis straight or nearly so.......................3

2a. Postcaudal trough deep and obvious

Angonus acipenserinus (Fig. 104)

2b. Postcaudal trough shallow or absent

Occella dodecaedron (Fig. 105) and

Occella verrucosa (Fig. 106)

3a. Otolith notably thicker near ventral edge than near dorsal edge. Medial side flat..4

3b. Otolith of nearly uniform thickness. Both sides of similar curvature..5

4a. Rostrum well defined. Dorsal area rises abruptly from base of rostrum or they are separated by a notch and the colliculum is bulbous

Bathyagonus nigripinnis (Fig. 107) and
Bathyagonus pentacanthus (Fig. 108)

4b. Rostrum not clearly separated from margin of dorsal area. If separated by a notch, the colliculum is absent or concave

Bathyagonus infraspinatus (Fig. 109) and
Bathyagonus alascanus (Fib. 110)

5a. Height of otolith less than 45% of its length

Anoplagonus inermis (Fig. 111)

5b. Height of otolith more than 45% of its length..................6

6a. Both dorsal and ventral margins smooth........................7

6b. Dorsal margin and sometimes ventral margin crenulate..........8

7a. No postcaudal trough

Pallasina barbata (Fig. 112)

7b. Postcaudal trough present, prominent, reaches posterior margin

Hypsagonus quadricornis (Fig. 113)

8a. Postcaudal trough obvious, reaches postero-ventral margin of otolith. No dorsal branch to postcaudal trough

Sarritor frenatus (Fig. 114)

8b. Postcaudal trough shallow, divided into channels to postero-ventral and postero-dorsal margins, the dorsal branch more obvious than the ventral

Sarritor leptorhynchus (Fig. 115)

FAMILY CYCLOPTERIDAE

Because of the large number of species in this family, the difficulties involved in identifying them accurately and the small amount of material available, the members of this group are not keyed out to species. Such reliably identified material as has been available has been illustrated.

1a. Height of otolith less than 65% of its length

Genus *Liparis* (Figs. 121-124)

1b. Height of otolith more than 70% of its length.................2

2a. Rostrum present, distinct

Genus *Careproctus* (Figs. 118-120)

2b. No rostrum..3

3a. Margins very smooth. Thickness of otolith more than 43% of its height. Otolith dense, opaque, porcelainous

Genus *Eumicrotremus* (Fig. 116)

3b. Margins roughened. Thickness of otolith less than 40% of its height. Otolith translucent, glassy

Genus *Nectoliparis* (Fig. 117)

PLEURONECTIFORMES

1a. Otolith very thin and delicate, flat to slightly concave on medial side, usually a raised center on both sides. Shape highly variable, larger ones with deeply incised margins

Reinhardtius hippoglossoides (Fig. 125)

1b. Not as in 1a..2

2a. Margins notably smooth except for a small postero-dorsal notch. Medial surface flat, lateral surface a smooth dome. Sulcus a shallow, oval pit with undeveloped cristae

Citharichthys sordidus (Fig. 126)

2b. Margins various, but usually at least a few irregularities, indentations or projections. Medial surface usually slightly rounded, lateral surface concave or irregularly convex. Sulcus with cristae present......................................3

3a. Outline of otolith resembles a slice of bread  4

3b. Outline of otolith not as in 3a..............................7

4a. Medial side flat or nearly so................................6

4b. Medial side convex...5

5a. Otolith thin, its thickness less than 20% of its length

Liopsetta glacialis (right) (Fig. 127B)

5b. Otolith more robust, its thickness more than 20% of its length

Hippoglossoides robustus (Fig. 128) and

Isopsetta isolepis (Fig. 129)

6a. Axis of sulcus parallel with dorsal margin of otolith

Limanda proboscidea (Fig. 130)

6b. Axis of sulcus slants ventrad anteriorly

Glyptocephalus zachirus (Fig. 131)

7a. A distinct, well defined notch in antero-dorsal margin, usually about 90° or less....................................8

7b. Notch absent or poorly defined; if present, usually broader than 90°..9

8a. Notch V-shaped, forming angle of 60-90°. Postero-dorsal corner of otolith square or rounded, without a distinct projection. Height of dorsal area averages 90% (87-107%) of height of ventral area. Ventral margin sometimes irregular, but not lobed

Hippoglossus stenolepis (Fig. 132)

8b. Notch usually forms angle of 90° or more. Postero-dorsal corner of otolith usually with a distinct projection. Height of dorsal area averages 86% (75-93%) of height of ventral area. Ventral margin lobate

Platichthys stellatus (Fig. 133)

9a. Dorsal margin rounded, usually with almost same curvature as ventral margin. Otolith oval to almond-shaped.............10

9b. Dorsal margin straight or nearly so, often indented. Otolith not oval or almond-shaped....................................12

10a. Posterior end of otolith much thicker than anterior end. Dorsal margin crenulate

Liopsetta glacialis (left) (Fig. 127A)

10b. Both ends of otolith about the same thickness. Dorsal margin not crenulate..11

11a. Height of otolith 65% (62-67%) of its length. Otolith large, may exceed 15 mm long. Otolith thin, one of 8 mm length will be less than 1 mm thick

Atheresthes stomias (Fig. 134)

11b. Height of otolith 58% (56-62%) of its length. Otolith small, rarely longer than 8 mm. Thick, an 8 mm otolith will be more than 1.5 mm thick

Microstomus pacificus (Fig. 135)

12a. Anterior end of otolith broadly rounded......................13

12b. Anterior end of otolith more or less tapered.................16

13a. Left sulcus shorter than 75% of height of otolith. Right otolith thicker posteriorly than anteriorly. Right sulcus generally shorter than 65% of otolith height...............14

13b. Left sulcus longer than 75% of height of otolith. Right otolith not much thicker posteriorly than anteriorly. Right sulcus generally longer than 65% of otolith height................15

14a. Postero-dorsal corner sharp, usually forming an angle of 90-95°. Ventral margin of otolith almost always crenulate or lobate

Pleuronectes quadrituberculatus (Fig. 136)

14b. Postero-dorsal corner not particularly sharp, generally forming an angle of 110° or more. Ventral margin of otolith smooth to irregular, rarely crenulate

Hippoglossoides elassodon (Fig. 137)

15a. Ventral margin of otolith nearly straight. Dorsal and ventral margins of sulcus parallel

Psettichthys melanostictus (Fig. 138)

15b. Ventral margin of otolith rounded. Dorsal and ventral margins of sulcus flare apart anteriorly

Limanda aspera (Fig. 139)

16a. Dorsal margin of otolith usually with a prominent notch near its middle. Lateral surface with a prominent, deep groove opening into the notch, groove present even when notch is absent...18

16b. No notch on dorsal margin of otolith. Groove on lateral surface, if present, broad and shallow, not prominent.......17

17a. Greatest height of otolith near middle of its length

Hippoglossus stenolepis (Fig. 132)

17b. Greatest height of otolith near posterior end

Lepidopsetta bilineata (Fig. 140)

18a. Margins of otolith usually lobate or crenulate. Dorsal margin of otolith parallel to sulcus. Posterior margin of otolith usually rounded

Parophrys vetulus (Fig. 141)

18b. Margins of otolith usually smooth, rarely lobate. Dorsal margin diverges from sulcus posteriorly. Posterior margin of otolith nearly always straight

Eopsetta jordani (Fig. 142)

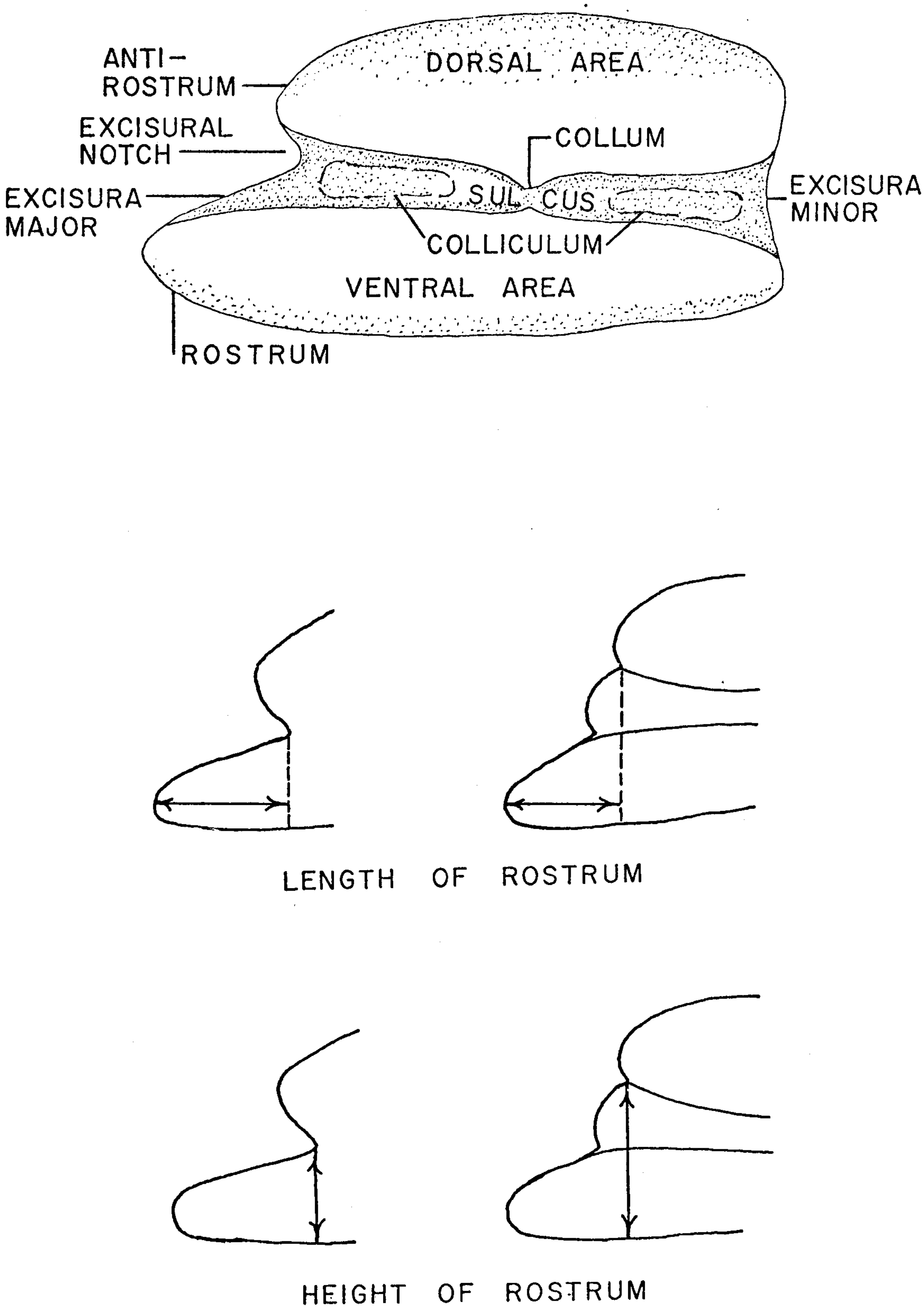


Figure A. Diagrams of otoliths, showing major features and measurements.

Plate I. Figures 1 through 16. Medial side (except as noted) of otoliths of Antimoridae, Clupeidae, Cryptacanthodidae, Ammodytidae, Osmeridae and Gadidae. Fig. 1.

Fig. 1. Antimora microlepis - Longfin cod. Left otolith 10.4 mm long.

Fig. 2. Clupea harengus pallasi - Pacific herring. Right otolith 4.2 mm long.

Fig. 3. Lyconectes aleutensis - Dwarf wrymouth. Right otolith 4.5 mm long.

Fig. 4. Delolepis gigantea - Giant wrymouth. Right otolith 8.5 mm long.

Fig. 5. Delolepis gigantea - Giant wrymouth. Right otolith 7.9 mm long.

Fig. 6. Ammodytes hexapterus - Pacific sandlance. Left otolith 1.3 mm long.

Fig. 7. Mallotus villosus - Capelin. Left otolith 2.4 mm long.

Fig. 8. Thaleichthys pacificus - Eulachon. Right otolith 3.8 mm long.

Fig. 9. Hypomesus pretiosus - Surf smelt. Right otolith 5.0 mm long.

Fig. 10. Osmerus eperlanus - Rainbow smelt. Right otolith 4.0 mm long.

Fig. 11. Spirinchus thaleichthys - Longfin smelt. Right otolith 4.5 mm long.

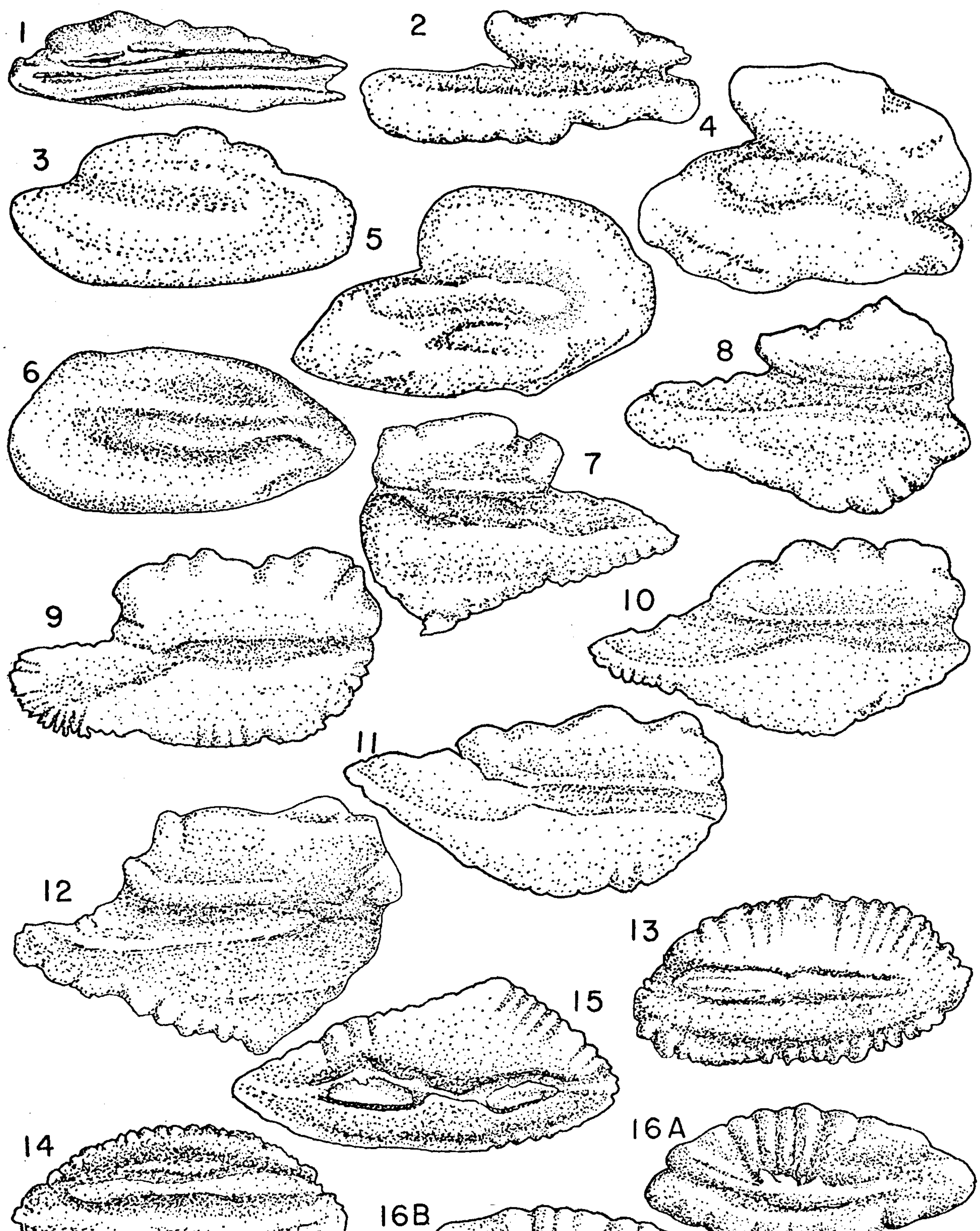
Fig. 12. Hypomesus olidus - Pond smelt. Right otolith 2.5 mm long.

Fig. 13. Gadus macrocephalus - Pacific cod. Right otolith 14.0 mm long.

Fig. 14. Theragra chalcogramma - Walleye pollock. Left otolith 15.0 mm long.

Fig. 15. Merluccius productus - Pacific hake. Left otolith 16.0 mm long.

Fig. 16. Boreogadus saida - Arctic cod. A Medial side of right otolith 6.8 mm long. B. Lateral side of same otolith.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16A
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Plate II. Figures 17 through 31. Medial side (except as noted) of otoliths of Gadidae, Zoarcidae, Trichodontidae and Bathymasteridae.

Fig. 17. Microgadus proximus - Pacific tomcod. A. Medial side of left otolith 7.5 mm long. B. Lateral side of same otolith.

Fig. 18. Eleginus gracilis - Saffron cod. Left otolith 11.2 mm long.

Fig. 19. Embryx crotalina - Snakehead eelpout. Right otolith 2.9 mm long.

Fig. 20. Bothrocara brunneum - Twoline eelpout. A. Right otolith 5.0 mm long. B. Cross-section.

Fig. 21. Bothrocara pusillum - Alaska eelpout. Right otolith 2.0 mm long.

Fig. 22. Bothrocara molle - Soft eelpout. Left otolith 1.9 mm long.

Fig. 23. Lycodopsis pacifica - Blackbelly eelpout. Right otolith 4.5 mm long.

Fig. 24. Lycodes palearis - Wattled eelpout. Right otolith 5.0 mm long.

Fig. 25. Lycodes brevipes - Shortfin eelpout. Right otolith 5.0 mm long.

Fig. 26. Lycodes diapterus - Black eelpout. Right otolith 5.7 mm long.

Fig. 27. Trichodon trichodon - Pacific sandfish. Right otolith 4.3 mm long.

Fig. 28. Arctoscopus japonicus - Sailfin sandfish. Right otolith 6.0 mm long.

Fig. 29. Ronquilus jordani - Northern ronquil. Right otolith 5.3 mm long.

Fig. 30. Bathymaster signatus - Searcher. Right otolith 5.0 mm long.

Fig. 31. Bathymaster caeruleofasciatus - Alaska ronquil. Left otolith 8.0 mm long.

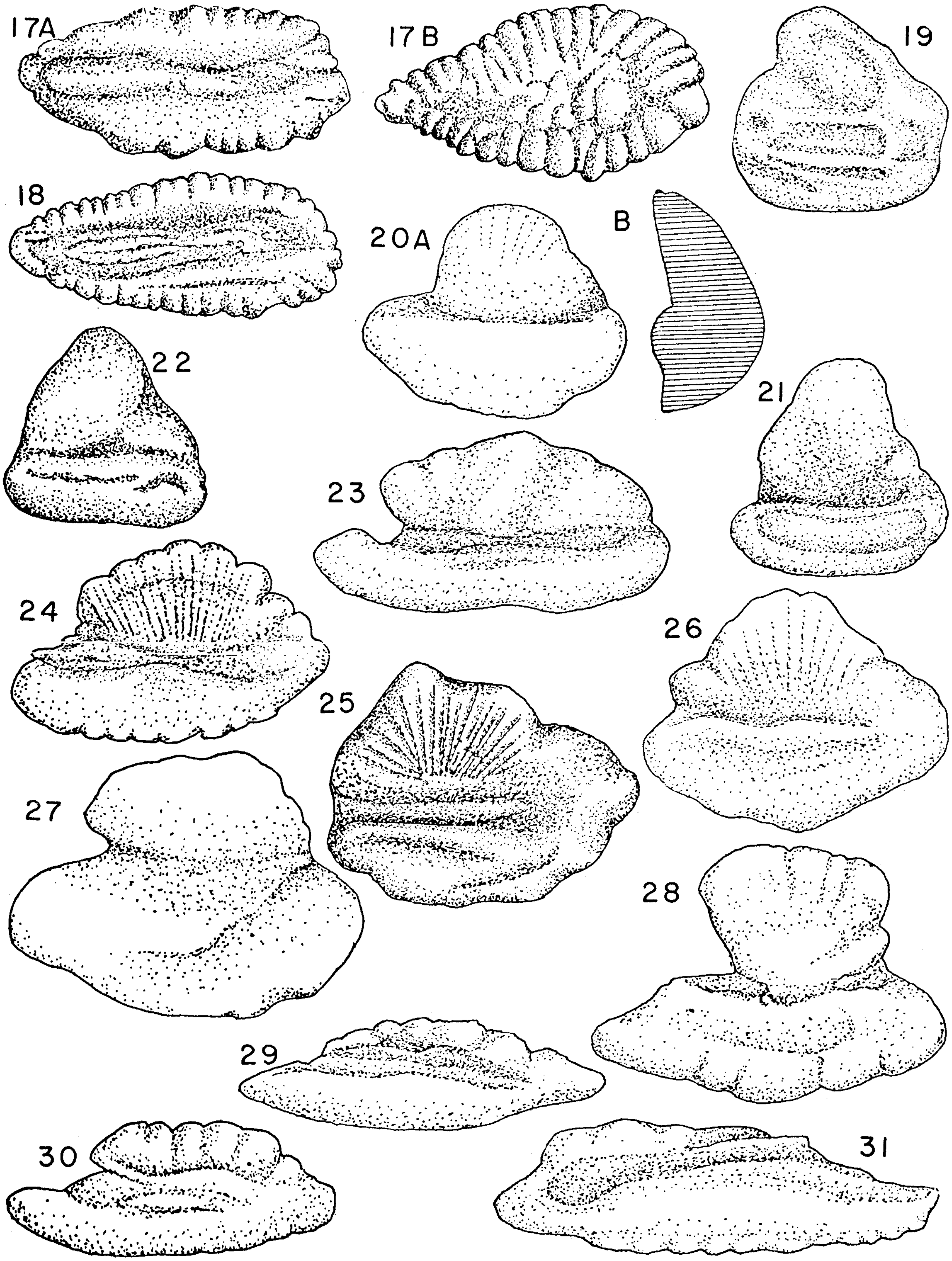
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Plate III. Figures 32 through 46. Medial side of otoliths of Stichaeidae, Pholididae, Anarhichadidae and Scorpaenidae.

Fig. 32. Lumpenella longirostris - Longsnout prickleback. Left otolith 3.6 mm long.

Fig. 33. Lumpenus maculatus - Daubed shanny. Right otolith 1.9 mm long.

Fig. 34. Poroclinus rothrocki - Whitebarred prickleback. Right otolith 2.9 mm long.

Fig. 35. Acantholumpenus mackayi - Pighead prickleback. Right otolith 2.8 mm long.

Fig. 36. Lumpenus fabricii - Slender eelblenny. Right otolith 2.3 mm long.

Fig. 37. Lumpenus sagitta - Snake prickleback. Right otolith 3.5 mm long.

Fig. 38. Stichaeus punctatus - Arctic shanny. Right otolith 3.2 mm long.

Fig. 39. Apodichthys flavidus - Penpoint gunnel. Right otolith 2.2 mm long.

Fig. 40. Pholis ornata - Saddleback gunnel. Right otolith 2.0 mm long.

Fig. 41. Anarrhichthys ocellatus - Wolf-eel. Right otolith 4.3 mm long.

Fig. 42. Anarhichas orientalis - Bering wolffish. Right otolith 3.4 mm long.

Fig. 43. Sebastolobus altivelis - Longspine thronyhead. Right otolith 12.0 mm long.

Fig. 44. Sebastolobus alascanus - Shortspine thornyhead. Right otolith 12.0 mm long.

Fig. 45. Sebastes entomelas - Widow rockfish. Right otolith 17.0 mm long.

Fig. 46. Sebastes brevispinis - Silvergray rockfish. Right otolith 17.0 mm long.

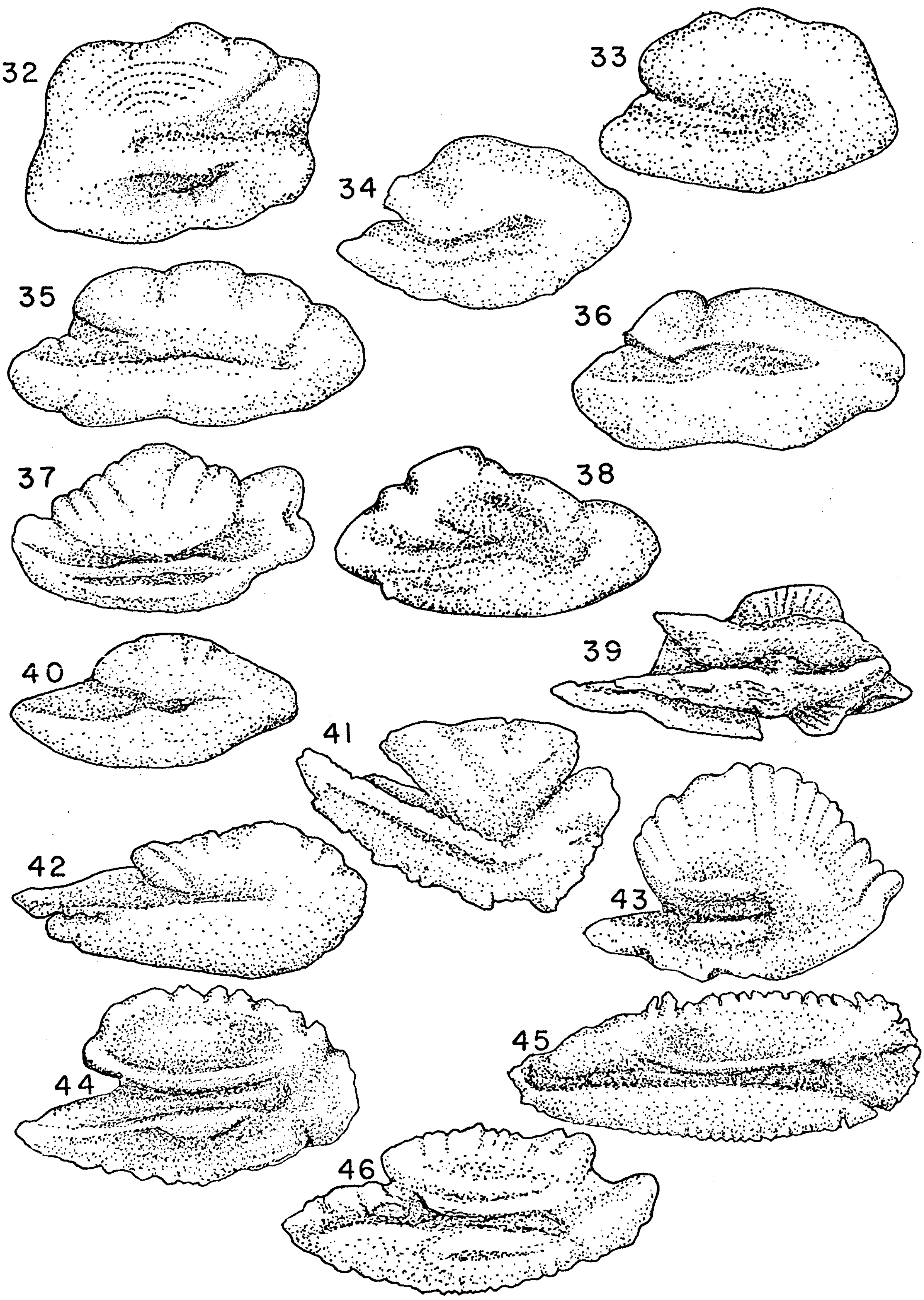
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Plate IV. Figures 47 through 59. Medial side of otoliths of Scorpaenidae.

Fig. 47. Sebastes proriger - Redstripe rockfish. Right otolith 13.0 mm long.

Fig. 48. Sebastes caurinus - Copper rockfish. Right otolith 20.5 mm long.

Fig. 49. Sebastes mystinus - Blue rockfish. Right otolith 16.0 mm long.

Fig. 50. Sebastes maliger - Quillback rockfish. Right otolith 14.5 mm long.

Fig. 51. Sebastes melanostomus - Blackgill rockfish. Right otolith 20.0 mm long.

Fig. 52. Sebastes aurora - Aurora rockfish. Right otolith 12.0 mm long.

Fig. 53. Sebastes ciliatus - Dusky rockfish. Right otolith 13.0 mm long.

Fig. 54. Sebastes melanops - Black rockfish. Right otolith 17.0 mm long.

Fig. 55. Sebastes polyspinis - Northern rockfish. Right otolith 14.0 mm long.

Fig. 56. Sebastes babcocki - Redbanded rockfish. Right otolith 18.0 mm long.

Fig. 57. Sebastes zacentrus - Sharpchin rockfish. Right otolith 13.0 mm long.

Fig. 58. Sebastes borealis - No common name. A. Right otolith 23.0 mm long. B. Posterior end of another otolith to show typical projections.

Fig. 59. Sebastes crameri - Darkblotched rockfish. Right otolith 17.0 mm long.

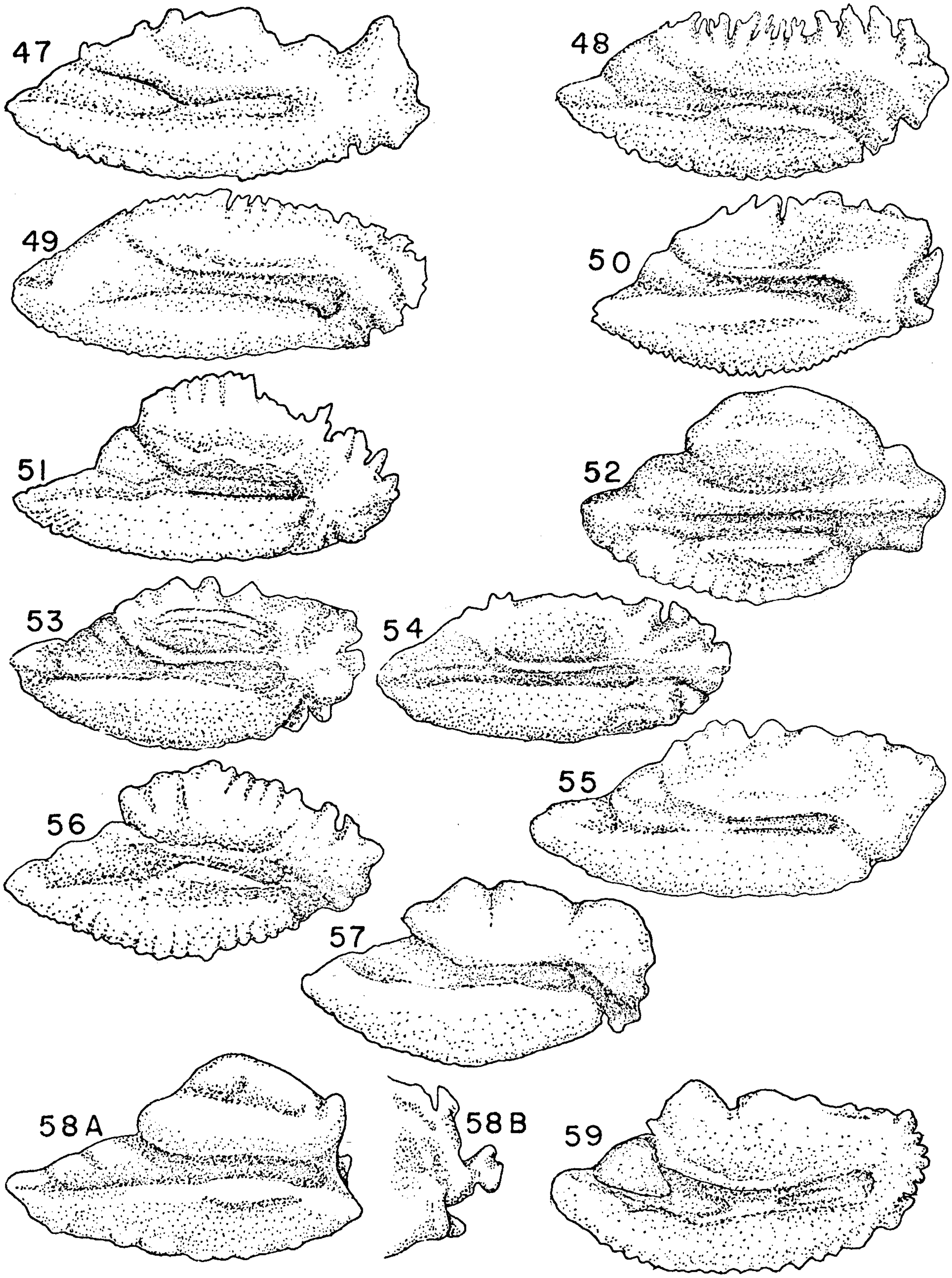
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Plate V. Figures 60 through 76. Medial side of otoliths of Scorpaenidae, Anoplopomatidae, Hexagrammidae and Cottidae.

Fig. 60. Sebastes variegatus - Harlequin rockfish. Right otolith 6.8 mm long.

Fig. 61. Sebastes alutus - Pacific ocean perch. Right otolith 14.2 mm long.

Fig. 62. Sebastes aleutianus - Rougheye rockfish. Right otolith 14.5 mm long.

Fig. 63. Sebastes ruberrimus - Yelloweye rockfish. Right otolith 22.0 mm. long.

Fig. 64. Erilepis zonifer - Skilfish. Right otolith 7.5 mm long.

Fig. 65. Anoplopoma fimbria - Sablefish. Right otolith 7.5 mm long.

Fig. 66. Pleurogrammus monopterygius - Atka mackerel. Right otolith 5.0 mm long.

Fig. 67. Ophiodon elongatus - Ling cod. Right otolith 5.8 mm long.

Fig. 68. Hexagrammos lagocephalus - Rock greenling. Right otolith 5.7 mm long.

Fig. 69. Hexagrammos stelleri - Whitespotted greenling. Right otolith 2.2 mm long.

Fig. 70. Hexagrammos octogrammus - Masked greenling. Right otolith 4.5 mm long.

Fig. 71. Hexagrammos decagrammus - Kelp greenling. Right otolith 6.5 mm long.

Fig. 72. Dasycottus setiger - Spinyhead sculpin. Right otolith 8.9 mm long.

Fig. 73. Psychrolutes paradoxus - Tadpole sculpin. Right otolith 2.0 mm long.

Fig. 74. Myoxocephalus quadricornis - Fourhorn sculpin. Right otolith 8.2 mm long.

Fig. 75. Myoxocephalus polyacanthocephalus - Great sculpin. Right otolith 8.5 mm long.

Fig. 76. Myoxocephalus jaok - Plain sculpin. Right otolith 10.5 mm long.

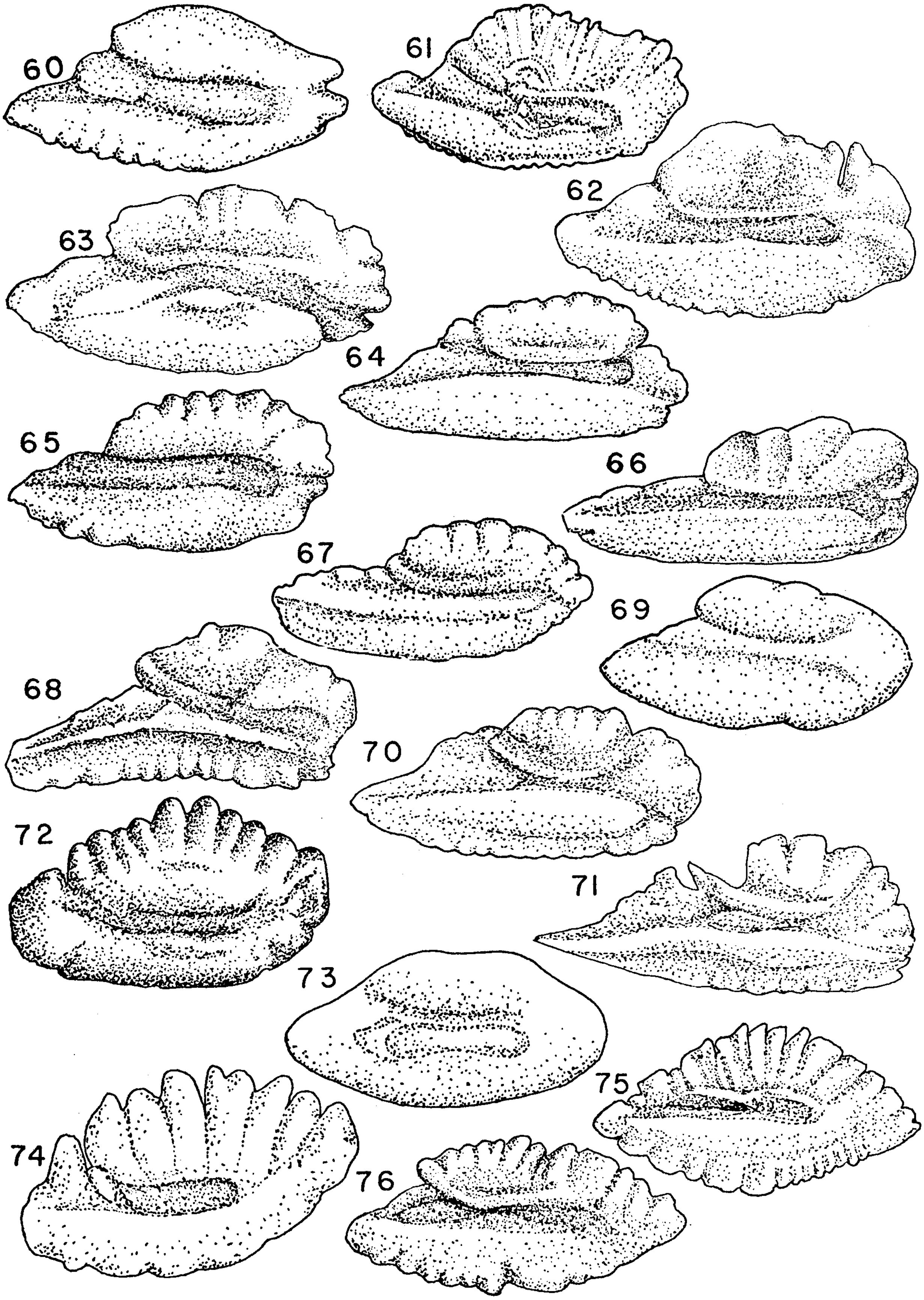
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Plate VI. Figures 77 through 92. Medial side of otoliths of Cottidae.

Fig. 77 _Myoxocephalus scorpius_ - Shorthorn sculpin. Right otolith 8.6 mm long.

Fig. 78. _Malacocottus kincaidi_ - Blackfin sculpin. Right otolith 8.5 mm long.

Fig. 79. _Nautichthys robustus_ - No common name. Right otolith 1.4 mm long.

Fib. 80. _Blepsias bilobus_ - Crested sculpin. Right otolith 1.8 mm long.

Fig. 81. _Blepsias cirrhosus_ - Silverspotted sculpin. Right otolith 1.9 mm long.

Fig. 82. _Hemitripterus bolini_ - Birmouth sculpin. Right otolith 4.5 mm long.

Fig. 83. _Icelus spiniger_ - No common name. Right otolith 4.7 mm long.

Fig. 84. _Icelus canaliculatus_ - No common name. Right otolith 6.5 mm long.

Fig. 85. _Radulinus asprellus_ - Slim sculpin. Right otolith 4.4 mm long.

Fig. 86. _Gymnocanthus galeatus_ - Armorhead sculpin. Right otolith 8.5 mm long.

Fig. 87. _Icelus spatula_ - Spatulate sculpin. Right otolith 4.3 mm long.

Fig. 88. _Icelinus borealis_ - Northern sculpin. Right otolith 3.8 mm long.

Fig. 89. _Gymnocanthus tricuspis_ - Arctic staghorn sculpin. Right otolith 3.8 mm long.

Fig. 90. _Rhamphocottus richardsoni_ - Grunt sculpin. Right otolith 2.0 mm long.

Fig. 91. _Artedius harringtoni_ - Scalyhead sculpin. Right otolith 2.7 mm long.

Fig. 92. _Artedius fenestralis_ - Padded sculpin. Right otolith 4.6 mm long.

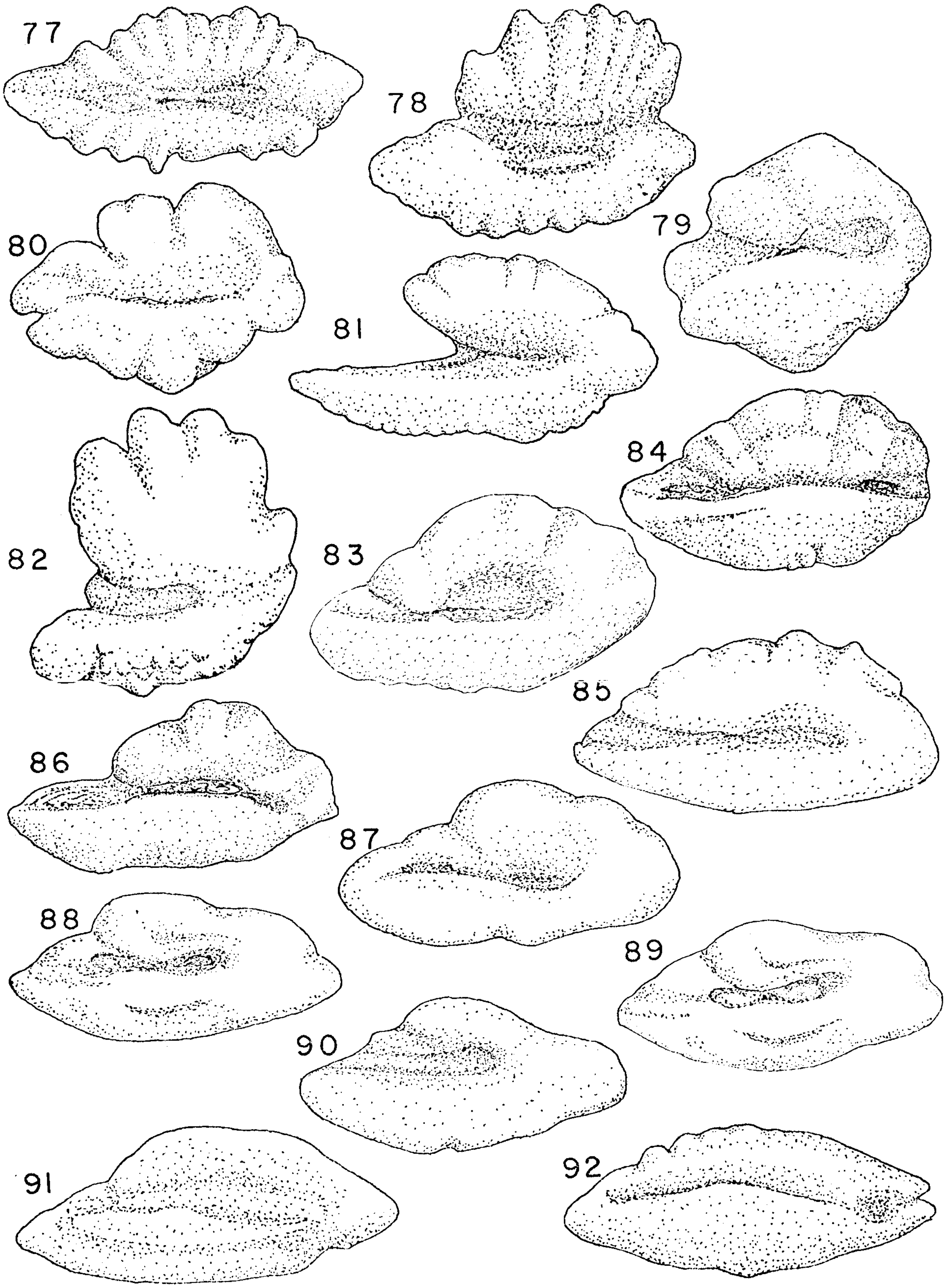
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Plate VII. Figures 93 through 107. Medial side of otoliths of Cottidae and Agonidae.

Fig. 93. *Hemilepidotus hemilepidotus* - Red Iris lord. Right otolith 6.0 mm long.

Fig. 94. *Hemilepidotus jordani* - Yellow Irish lord. Right otolith 4.0 mm long.

Fig. 95. *Hemilepidotus spinosus* - Brown Irish lord. Right otolith 9.0 mm long.

Fig. 96. *Enophrys diceraus* - Antlered sculpin. Right otolith 9.5 mm long.

Fig. 97. *Enophrys bison* - Buffalo sculpin. Right otolith 9.5 mm long.

Fig. 97A. *Enophrys* sp. Right otolith 3.4 mm long.

Fig. 98. *Leptocottus armatus* - Pacific staghorn sculpin. Right otolith 9.5 mm long.

Fig. 99. *Megalocottus platycephalus* - Belligerent sculpin. Right otolith 7.2 mm long.

Fig. 100. *Triglops scepticus* - Spectacled sculpin. Right otolith 7.0 mm long.

Fig. 101. *Triglops forficata* - Scissortail sculpin. Right otolith 5.8 mm long.

Fig. 102. *Triglops pingeli* - Ribbed sculpin. Right otolith 4.3 mm long.

Fig. 103. *Triglops macellus* - Roughspine sculpin. Right otolith 6.8 mm long.

Fig. 104. *Agonus acipenserinus* - Sturgeon poacher. Right otolith 3.5 mm long.

Fig. 105. *Ocella dodecaedron* - Bering poacher. Right otolith 4.8 mm long.

Fig. 106. *Ocella verrucosa* - Warty poacher. Right otolith 3.9 mm long.

Fig. 107. *Bathyagonus nigripinnis* - Blackfin poacher. Right otolith 4.9 mm long.

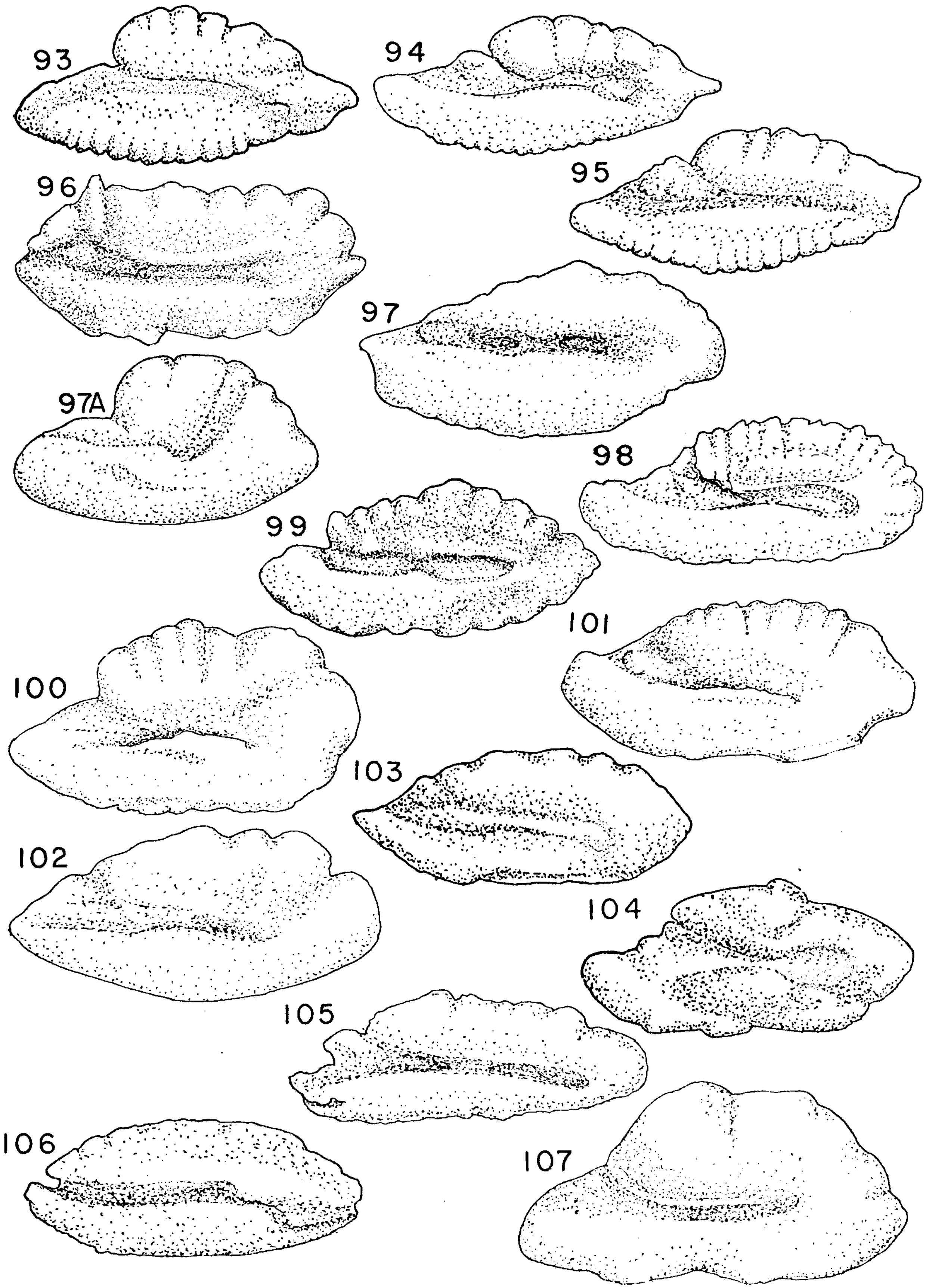
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Plate VIII. Figures 108 through 123. Medial side of otoliths of Agonidae and Cyclopteridae.

Fig. 108. *Bathyagonus pentacanthus* - Bigeye poacher. Right otolith 3.7 mm. long.

Fig. 109. *Bathyagonus infraspinatus* - Spinycheek starsnout. Right otolith 3.4 mm long.

Fig. 110. *Bathyagonus alascanus* - Gray starsnout. Right otolith 3.2 mm long.

Fig. 111. *Anoplagonus inermis* - Smooth alligatorfish. Right otolith 2.8 mm long.

Fig. 112. *Pallasina barbata* - Tubenose poacher. Right otolith 1.5 mm long.

Fig. 113. *Hypsagonus quadricornis* - Fourhorn poacher. Right otolith 2.2 mm long.

Fig. 114. *Sarritor frenatus* - Sawback poacher. Right otolith 7.1 mm long.

Fig. 115. *Sarritor leptorhynchus* - Longnose poacher. Right otolith 5.7 mm long.

Fig. 116. *Eumicrotremus orbis* - Pacific spiny lumpsucker. Right otolith 1.2 mm long.

Fig. 117. *Nectoliparis pelagicus* - Tadpole snailfish. Right otolith 0.7 mm long.

Fig. 118. *Careproctus* sp. Right otolith 2.9 mm long.

Fig. 119. *Careproctus furcellus* - No common name. Right otolith 4.0 mm long.

Fig. 120. *Careproctus melanurus* - Blacktail snailfish. Right otolith 3.5 mm long.

Fig. 121. *Liparis pulchellus* - Showy snailfish. Right otolith 3.0 mm long.

Fig. 122. *Liparis dennyi* - Marbled snailfish. Right otolith 2.9 mm long.

Fig. 123. *Liparis liparis* - Striped seasnail. Right otolith 4.1 mm long.

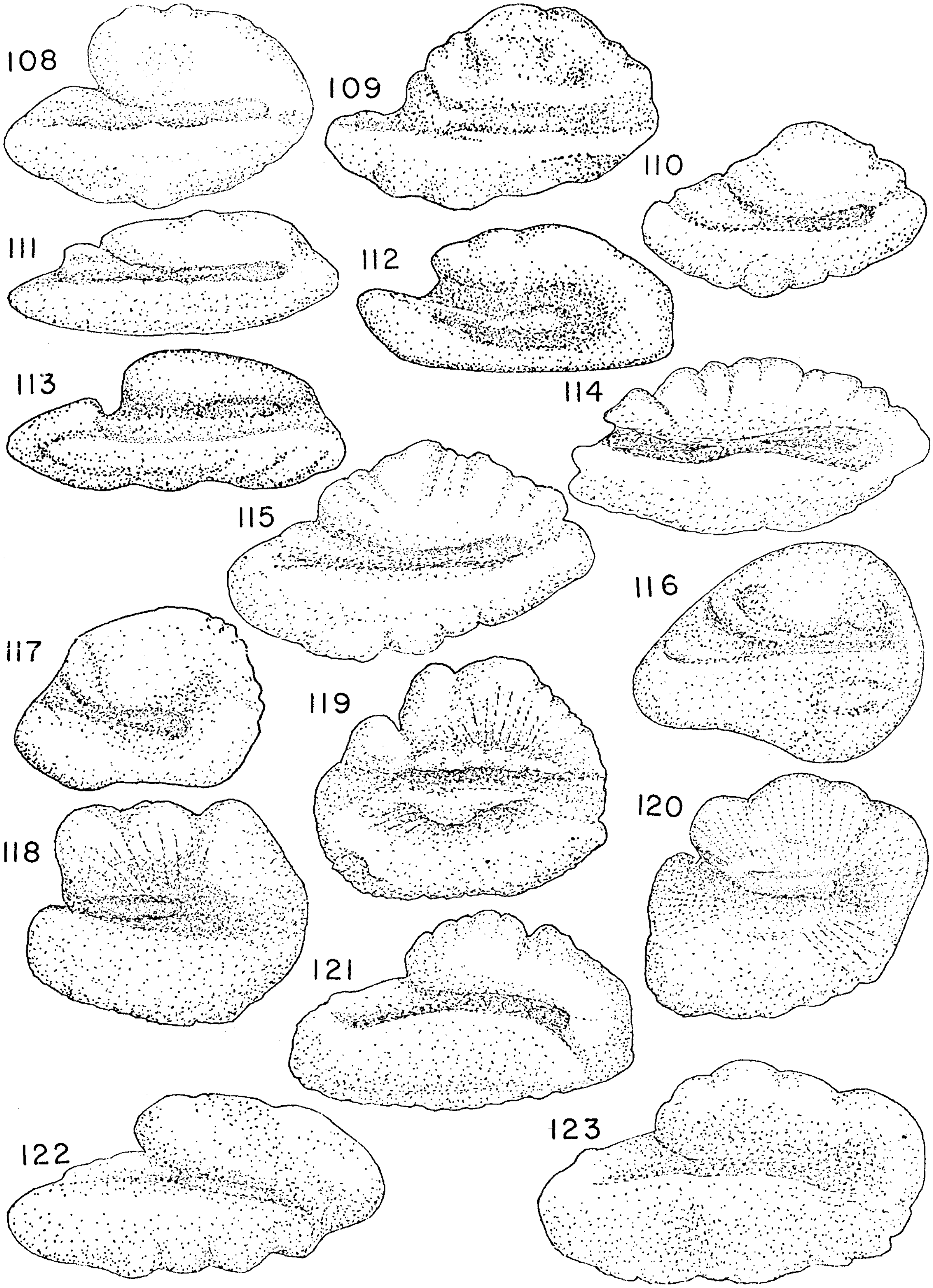
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Plate IX. Figures 124 through 133. Medial side of otoliths of Cyclopteridae, Bothidae and Pleuronectidae.

Fig. 124. Liparis gibbus - No common name. Right otolith 2.2 mm long.

Fig. 125. Reinhardtius hippoglossoides - Greenland halibut. A. Right otolith 2.4 mm long. B. Left otolith 4.5 mm long. C. Left otolith 6.5 mm long.

Fig. 126. Citharichthys Mordidus - Pacific sanddab. Right otolith 8.2 mm long.

Fig. 127. Liopsetta glacialis - Arctic flounder. A. Left otolith 6.8 mm long. B. Right otolith 4.7 mm long.

Fig. 128. Hippoglossoides robustus - Bering flounder. Right otolith 5.0 mm long.

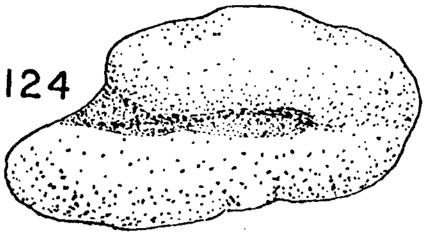
Fig. 129. Isopsetts isolepis - Butter sole. Left otolith 5.8 mm long.

Fig. 130. Limanda proboscidea - Longhead dab. Left otolith 4.2 mm long.

Fig. 131. Glyptocephalus zachirus - Rex sole. Left otolith 4.9 mm long.

Fig. 132. Hippoglossus stenolepis - Pacific halibut. Right otolith 6.4 mm long.

Fig. 133. Platichthys stellatus - Starry flounder. Right otolith 7.2 mm long.



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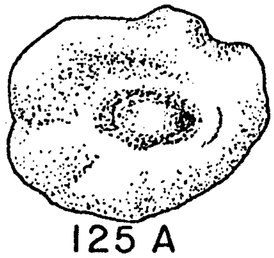

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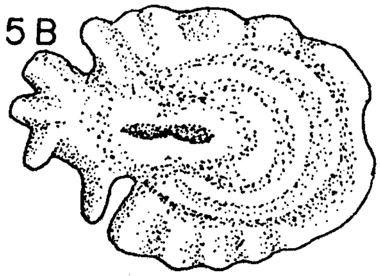

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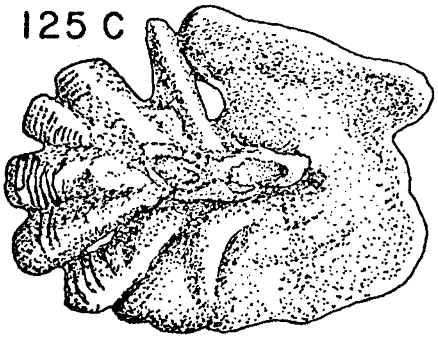

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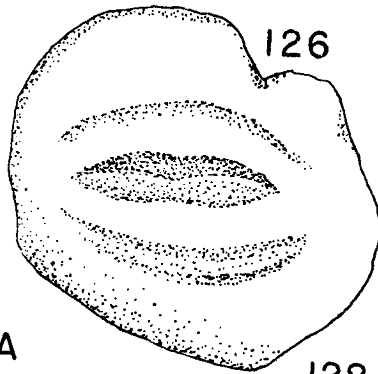

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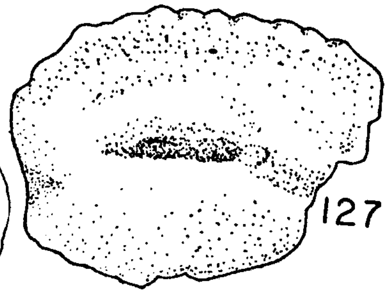

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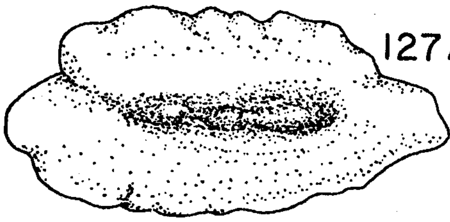

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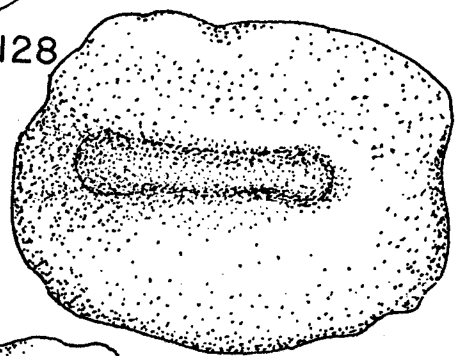

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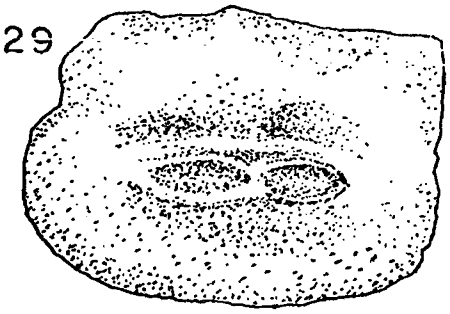

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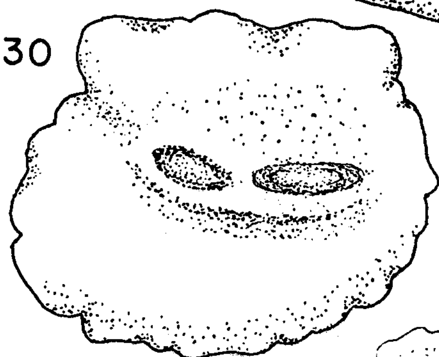

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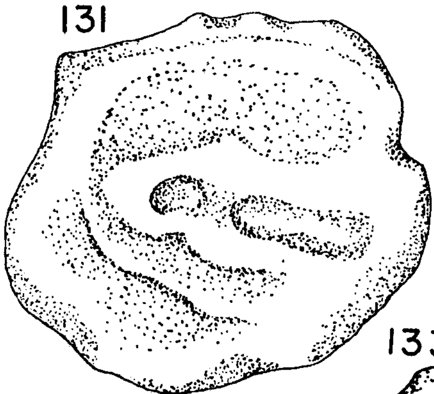

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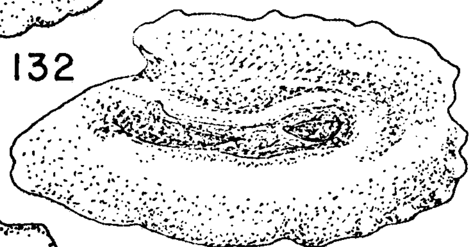

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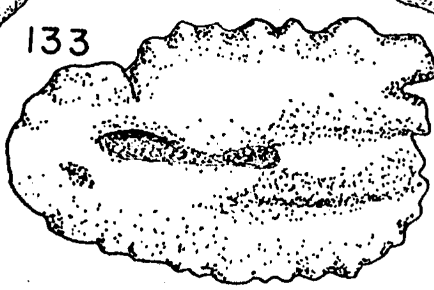

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Plate X. Figures 134 through 142. Medial side of otoliths of Pleuronectidae.

Fig. 134. Atheresthes stomias - Arrowtooth flounder. Right otolith 8.0 mm long.

Fig. 135. Microstomus pacificus - Dover sole. Right otolith 6.5 mm long.

Fig. 136. Pleuronectes quadrituberculatus - Alaska plaice. A. Left otolith 8.0 mm long. B. Right otolith 8.0 mm long.

Fig. 137. Hippoglossoides elassodon - Flathead sole. Left otolith 7.7 mm long.

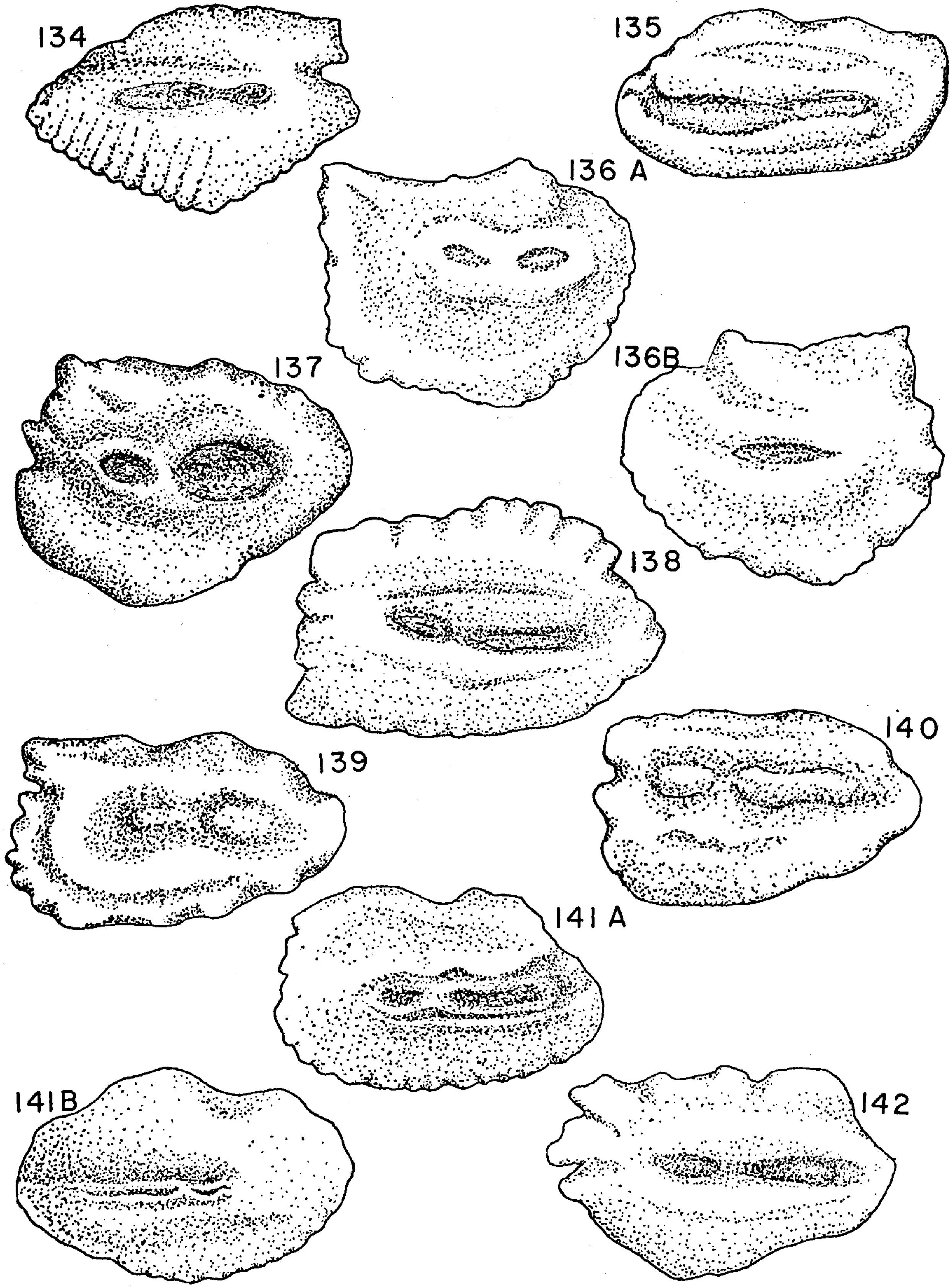
Fig. 138. Psettichthys melanostictus - Sand sole. Left otolith 5.0 mm long.

Fig. 139. Limanda aspera - Yellowfin sole. Left otolith 7.3 mm long.

Fig. 140. Lepidopsetta bilineata - Rock sole. Left otolith 6.1 mm long.

Fig. 141. Parophrys vetulus - English sole. A. Left otolith 5.9 mm long. B. Right otolith 5.8 mm long.

Fig. 142. Eopsetta jordani - Petrale sole. Left otolith 7.0 mm long.



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