Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1979

Volume IV. Receptors — Fish, Littoral, Benthos

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

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

VOLUME I	RECEPTORS -- MAMMALS
	BIRDS
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Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado

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DISCLAIMER

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RECEPTORS -- FISH, LITTORAL, BENTHOS

CONTENTS

ECOLOGICAL STUDIES OF INTERTIDAL AND SHALLOW SUBTIDAL HABITATS IN LOWER COOK INLET

Research Unit 417

Prepared for

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

Prepared by

DAMES & MOORE
Engineering & Environmental Consultants
510 L Street, Suite 310
Anchorage, Alaska 99501
(907) 279-0673

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SUMMARY

Field studies were initiated in intertidal and shallow subtidal habitats in Lower Cook Inlet to examine species composition, zonation and seasonal patterns, trophic structure, rates of production and energy pathways. Habitats examined included rocky intertidal and subtidal areas, sand beaches and mud flats.

Plant and animal assemblages on rocky habitats exhibited strong patterns in zonation and seasonal development. In Kachemak Bay, algal assemblages were well developed and highly productive out to a depth of at least 20 meters. Fucoid and laminarian algae were the dominant species. One dominant kelp, the canopy forming *Alaria fistulosa*, was estimated to produce annually between 7,140 and 18,580 g fresh tissue per m^2 where it forms beds (428 to 1,115 gC/m^2). Invertebrate assemblages are rich, especially in areas of high current flow. Functionally important forms include herbivores (e.g., sea urchins, chitons and limpets), suspension feeders (e.g., mussels, clams and polychaete worms) and predator/scavengers (e.g., starfish, crabs, and fish). It appears that sizeable quantities of plant tissue are exported to other habitats from rocky habitats in Kennedy Entrance and Kachemak Bay.

The animal assemblages studied in sand and mud habitats in Lower Cook Inlet differed distinctly among themselves and with those in rock habitats. Macrophytes were uncommon or absent on the soft bottoms. Sand beach faunas were dominated by short-lived gammarid amphipods (e.g., *Eohaustorius eous*) and polychaete worms (e.g., *Scolelepis* sp). The dominant feeding types were deposit and suspension feeders largely dependent on imported organic debris. Biomass was quite low (less than 5 g dry weight/m^2), and secondary production appeared low. Few resident predators were identified and it seems that transient predators, (birds, fish and crabs) were of greater consequence.

Mud flat faunas were dominated by long-lived clams (e.g., *Mya* spp. and *Macoma balthica*). The infaunal dominants were suspension and deposit

feeders largely dependent on imported organic debris. Resident predators were apparently of minor importance. Biomass was moderately high (up to 267 g dry tissue/m^2. Secondary production appeared moderately high. Predation by transient predators such as shorebirds, diving ducks and demersal fish appeared substantial and thus we concluded that this system probably contributes significantly to several other faunal assemblages and systems.

Zonation of the biological assemblages on soft substrates was readily apparent in the distribution of species abundance but generally not apparent in species composition. Many of the species were more abundant at the lower tidal levels.

Most of the species exhibited considerable seasonal changes in abundance. Generally, polychaete worms and amphipods were more abundant in summer, but clams were most abundant in spring. Juveniles of several species appeared in the samples only in the summer, a relatively mild period.

Evaluation of the trophic structures of these assemblages indicates that all are based on detritus. The great majority of the organisms are deposit feeders or suspension feeders. Resident predators are uncommon. Feeding observations suggest that a large proportion of the animals living in these habitats are eaten by transient predators from other assemblages and geographic areas. Some of the important groups that forage heavily in these habitats include crabs, fish (e.g., flatfish, cottids and juvenile salmon), shorebirds, and diving and dabbling ducks. Qualitative impressions of exploitation levels suggest that the mud flat assemblage is utilized much more heavily than the sand beaches. A comparison of abundance, biomass and growth data seems to support this hypothesis. Several bird species (e.g., Western Sandpipers and Dunlins) seem particularly dependent on mud flat assemblages during spring migration. Greater Scaup, Oldsquaw, Surf Scoters and Black Scoters feed extensively on mud flats in the winter.

These biological descriptions are crucial in arriving at several useful preliminary conclusions. First, by combining the biological attributes and contributions of the various assemblages with predicted ranking of various substrates to hydrocarbon uptake, storage and retention characteristics (based on geomorphological considerations and field observations at major oil spill sites, as described by Hayes et al., 1977), it appears that mud flats are the most sensitive of the substrates examined in this study to contamination by crude oil. Furthermore, based on the high probability that: (1) much of the seemingly high productivity of mud flats is used by animals from other systems, and (2) that mud flats are very important to a number of marine and terrestrial animals (some commercially important and others migrating across broad geographic ranges), the importance of protecting this habitat from pollution is quite obvious. Next, areas supporting large kelp stands probably contribute a substantial quantity of plant material to other systems in Lower Cook Inlet and may be of considerable importance in the economy of the Inlet. These habitats are concentrated in the southeast quadrant of the Inlet and thus planning can provide them considerable protection. Finally, because of the concentration of sand beaches in the northeastern quadrant of Lower Cook Inlet, and of mud flats in Kachemak Bay and on the west side of the Inlet, and most acceptable location for development of onshore facilities, in biological terms, is between Anchor Point and Nikiski.

1.0 INTRODUCTION

Potential development of oil and gas reserves in Lower Cook Inlet is accompanied by the prospect that the intertidal and shallow subtidal habitats of that estuary may be subjected to large scale chronic or acute contamination. The magnitude of this potential problem is based primarily on the overall importance of this littoral zone and its component habitats to the Inlet and associated systems, and secondarily, on the sensitivity of these habitats to the potential perturbations. Man tends to rank the importance of a resource according to his own observable utilization of the resource. Clamming is the most important human use of intertidal resources in Lower Cook Inlet directly perceived by most individuals, and, since only small segments of the coastline are used, the importance of intertidal habitats is often considered to be low. However, the importance and sensitivity of the zone cannot be evaluated until it has been adequately described and its relationships to other systems are at least generally defined. It is clear from experience in other parts of the world that the greatest observable impacts of oil-related problems occur in the intertidal and nearshore zones.

Intertidal and shallow subtidal habitats and assemblages in Lower Cook Inlet were generally undescribed until Dames & Moore biologists commenced rocky intertidal studies in Kachemak Bay in 1974 (Dames & Moore, 1976). Soft intertidal habitats (sand and mud) were not studied until spring and summer of 1976, when the Bureau of Land Management (BLM) initiated a reconnaissance of the physical, chemical and biological systems in Lower Cook Inlet through its Outer Continental Shelf Environmental Assessment Program (OCSEAP). These studies were initially designed to collect the information necessary to permit BLM to write the Environmental Impact Statement for the OCS oil and gas lease sale. As part of the reconnaissance, the first phase of this study (R.U. #417) was designed to examine beaches representative of the major intertidal and shallow subtidal habitats in Lower Cook Inlet (Dames & Moore, 1977).

The intertidal reconnaissance indicated that most of the rocky intertidal habitats in Lower Cook Inlet are located in Kachemak Bay and Kennedy Entrance, on the east, and in Kamishak Bay, on the west. In contrast, the intertidal areas north of Kachemak and Kamishak Bays are mainly soft, with the lower beaches in exposed areas being sand and in protected areas, mud. At lower tidal levels, approximately 50 percent of the shoreline on the west side is mud flats, largely as a consequence of the number of bays that deeply indent into the coastline. North of Kachemak Bay on the east side of the Inlet, the smooth shoreline is interrupted by just a few rivers and streams, and the lower tidal levels are almost exclusively sandy. The upper beaches (above MLLW) for a large proportion of the shoreline in the Lower Inlet are characterized by a steeper slope of coarse gravel and cobbles. Based on the slope, grain size, and impoverished fauna, this habitat appears to be the least stable of the soft, or unconsolidated, intertidal substrates in Lower Cook Inlet.

The reconnaissance study further indicated sharp differences, between the biotic assemblages of the sand and mud habitats. Although both habitats are characterized by detritus-based assemblages, and depend to varying degrees upon organic debris produced in other areas, the sand beaches support a rather impoverished assemblage with low biomass whereas the mud beaches support a more diverse assemblage with moderate biomass. The sand beach faunas are dominated by polychaete worms and gammarid amphipods whereas the mud flat faunas are heavily dominated by clams. The lower level of the gravel upper beach appears to be dominated by a gammarid amphipod and an isopod, both of which form dense aggregations under large cobbles (Dames & Moore, 1977).

It became suspected through the reconnaissance study that intertidal resources are important to several other organisms and systems. For instance, shorebirds, gulls and sea ducks feed heavily on soft intertidal substrates. At least one group is feeding there during each stage of the tide. Fish and crustaceans move into the intertidal zone during high tides to feed and some species remain there during low tide (Green 1968). Several investigators have reported that mud flats are important feeding areas for juvenile salmon (Sibert et al. 1977; Kaczynski et al. 1973).

However, only preliminary descriptions of the various systems examined were provided. The major objective of the research described in this report was to more fully describe the systems at specific sites, and identify the more important relationships and processes operating in these assemblages. This necessitated a fairly detailed examination of seasonal changes in species composition and structure. Trophic relationships were not emphasized because the most important predators (birds and fish) are the object of other research units.

The specific objectives of this study have been to:

1. Assess seasonal changes in composition and define trophic relationships among dominant intertidal and subtidal organisms in representative rock, sand and mud habitats in Lower Cook Inlet.

2. Determine the seasonal patterns of primary production, growth, and standing crop for the major macrophyte species.

3. Describe and evaluate the potential for impact by OCS oil and gas exploration, development and production on those intertidal and shallow subtidal habitats studied from FY 76 through FY 78.

Objectives 1 and 2 relate directly to objective 3 in that they provide the biological background necessary to accomplish objective 3. The research dictated by the first two objectives should provide reasonable descriptions of major intertidal biological assemblages and permit comparisons and discussions of relationships. These descriptions should permit identification of particularly important organisms, areas or relationships with potentially high susceptibility.

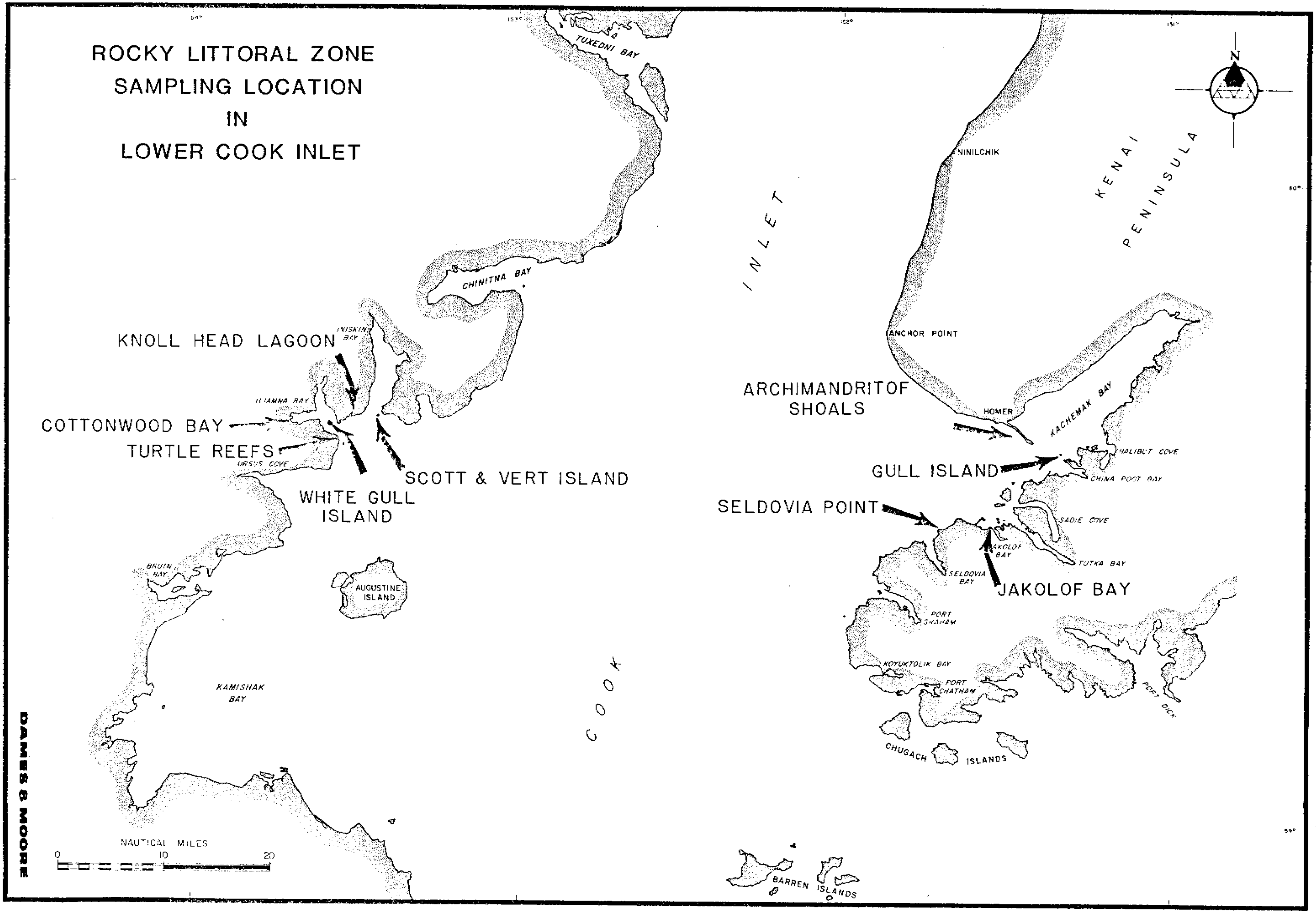
2.0 PHYSICAL SETTING

Cook Inlet is a large tidal estuary located on the northwest edge of the Gulf of Alaska in south-central Alaska. The axis of the inlet trends north-northeast to south-southwest and is approximately 330 km long, increasing in width from 36 km in the north to 83 km in the south. The inlet is geographically divided into the upper and lower portions by the East and West Forelands. The inlet is bordered by extensive tidal marshes, lowlands with numerous lakes, and glaciated mountains. Large tidal marshes and mud flats are common along much of the western and northern margins of the upper inlet. Tributary streams are heavily laden with silt and seasonally contribute heavy sediment loads, especially in the upper inlet. The range of the semi-diurnal tides is extreme with a normal amplitude of 9 m (30 ft) at the head of the inlet. Tidally generated currents are strong. The general net current pattern brings oceanic water through Kennedy Entrance and northward along the east side of the inlet. Turbid and usually colder waters from the upper inlet move generally southward along the west side of the inlet and through Kamishak Bay, leaving the inlet through Shelikov Strait (BLM 1976). It has been suggested, however, that a considerable proportion of the oceanic water entering Cook Inlet on an incoming tide is pumped back out on the subsequent outgoing tide (BLM 1976). During the winter and spring, ice conditions are much more harsh on the west side of the inlet. Thus, the oceanographic conditions on each side of the inlet are significantly different, resulting in notable differences in the nature of shallow water biological communities.

2.1 EAST SIDE OF INLET - ROCK

2.1.1 Gull Island

Gull Island is a series of rocky inlets located less than 4.8 km southeast of Homer Spit (Figure 2-1). The highest recorded land elevation on the island is 26 meters above sea level.


ROCKY LITTORAL ZONE
SAMPLING LOCATION
IN
LOWER COOK INLET
KNOLL HEAD LAGOON
COTTONWOOD BAY
TURTLE REEFS
SCOTT & VERT ISLAND
WHITE GULL
ISLAND
ARCHIMANDRITOF
SHOALS
GULL ISLAND
SELDOVIA POINT
JAKOLOF BAY
TUXEDNI BAY
CHINITNA BAY
ILIAMNA BAY
URSUS COVE
BRUIN BAY
AUGUSTINE
ISLAND
KAMISHAK
BAY
COOK
INLET
NINILCHIK
ANCHOR POINT
HOMER
KENAI
PENINSULA
KACHEMAK BAY
HALIBUT COVE
CHINA POOT BAY
SADIE COVE
TUTKA BAY
JAKOLOF
BAY
SELDOVIA
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DAMES & MOORE

FIGURE 2-1

Gull Island is a well known landmark to local residents because it is a nesting colony for sea birds. Peak usage by common murres, black-legged kittiwakes, and three species of cormorants is during the late spring and summer. The estimated population of birds on the island was 3,724 nesting pairs of birds in a 1976 census (Erikson 1977). Heavy sea bird utilization is obvious from the vast amount of bird excrement that forms a chalky-white discoloration below the roosting and nesting sites.

The study site on Gull Island was on a steeply sloping rock islet at the extreme southwest end of the island. This rock, named "Gorilla Rock" because of its silhouette when viewed from the west (Dames & Moore 1976), rises approximately 14 meters above mean lower low water (MLLW). At extreme low tides, approximately 4.85 meters (16.0 feet) of the macrophyte zone are exposed to the atmosphere. Below the littoral zone, the sea floor is composed of exposed bedrock that abuts the vertical rock face; farther offshore are found outcroppings and channels. At depths of 12-50 meters below MLLW is an expanse of silty clay.

Sampling at Gull Island was conducted on a transect established in 1974 (Dames & Moore 1976) down the southwest rib of this rock pinnacle by permanently placed pins at 0, 5, 10, 15, and 20 m from the upper edge of the littoral zone. The upper portion of the transect (0 to about 8 m) sloped steeply to a relatively low level, but narrow bench extending to the 20-m pin (Figure 2-2). Beyond this pin the bench dropped sharply about 1 m to a second algal cover bench. The approximate elevations of the fixed pins were 0 m: +3.8 m MLLW; 5 m: +1.5 m MLLW; 10 m: +0.5 m MLLW; 15m: +0.2 m MLLW; 20 m: +0.0 m MLLW (Dames & Moore 1976).

This study area can be classified as semi-protected in terms of exposure to oceanic conditions because the transect is exposed to some ocean swells coming into Kachemak Bay as well as wave action generated by local winds. As a result of tidal emersion, the littoral zone is frequently exposed to summer desiccation and winter freezing. Abrasion by floating ice is minimal, however. Strong currents move by the island four times a day and surface waters are typically somewhat turbid, especially during the warmer months when several nearby glacial streams are flowing.

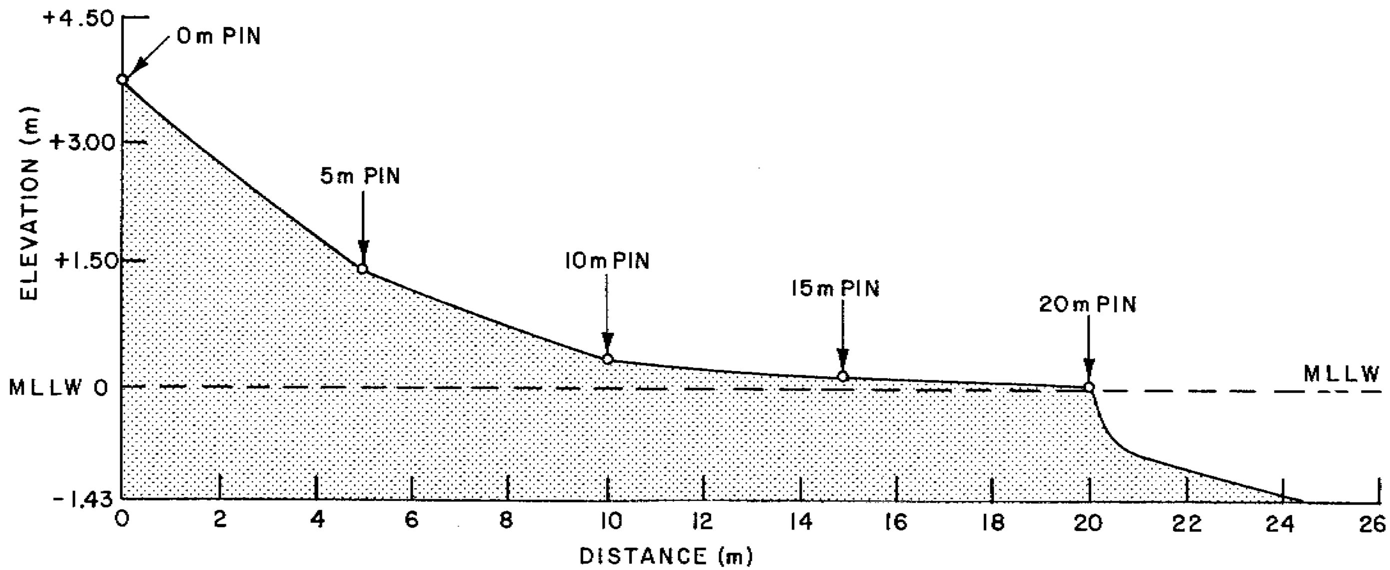

FIGURE 2-2

PROFILE OF PERMANENT TRANSECT ON GORILLA ROCK, GULL ISLAND

2.1.2 Archimandritof Shoals

The north side of Kachemak Bay west of Homer Spit is occupied by a broad, rocky shelf extending from Archimandritof Shoals, off the west side of Homer Spit, northwestward a distance of approximately 37 km (Figure 2-1). The shelf measured to the dramatic escarpment near the 18 km (10-fathom) isobath ranges from a minimum of about 2 km at Bluff Point to about 6.5 km at Anchor Point.

Surficially, the substrate of the shelf is a relatively flat bed of rock, cobble, boulders, and shell debris. The rock matrix was well consolidated by fine, silty sand and shell debris; small to medium boulders were scattered throughout the area. In several areas, the reefs or boulders are composed of coal (Dames & Moore 1976). Evidence of silt deposition varies locally on the shelf, being greatest from Archimandritof Shoals west to Bluff Point, perhaps in response to weaker currents and higher turbidities observed in this area (Dames & Moore 1976). Several sampling sites were examined in the Archimandritof Shoals study area (Figure 2-1). These ranged from about 1 km to about 5 km from the end of Homer Spit.

2.1.3 Jakolof Bay

Jakolof Bay, less than 0.5 km wide and only about 3.25 km long, is located on the south side of Kachemak Bay, approximately 18.5 km due south of the City of Homer (Figure 2-1). The bay is generally shallow and has a narrow entrance less than 11 meters deep. The head of the bay is shallow and fed by a freshwater stream. The shoreline is rocky and wooded.

Most observations and underwater sampling were confined to the shallow reef that projects off the rocky headland on the northwest side of the bay. This area has been studied since 1974 (Dames & Moore 1976). This reef, marked by a small islet, nearly occludes the entrance to the bay. An overhead power transmission line crossing the reef is another useful landmark. A prominent kelp stand grows along the reef with its floating canopy usually visible on a slack tide. The substrate underlying the vegetative canopy is composed of bedrock, cobbles, and small to medium sized boulders (Dames & Moore 1976). Slope is moderate and surface relief is somewhat terraced. Fine sands and calcareous shell debris are conspicuous features at certain locations on the reef. Strong tidal currents are typical of this location. On either a flood or ebb tide the floating portion of the kelp bed is usually pulled below the sea surface. The currents generated during spring tide cycles are estimated to range between 2 and 3 knots. Subsurface water movement is greatest across the rock reef. This observation has been substantiated by the proliferation of suspension feeding forms (i.e., sea anemones, barnacles, sabellid polychaetes, and nestling clams), which were visual dominants at this location and depth (Dames & Moore 1976).

Steel bands and bark from floating rafts of logs being transported out of Jakolof Bay have accumulated on the sea floor. Since 1974 these objects have continued to collect on the reef; accumulation and decay rates of these materials are unknown (Dames & Moore 1976).

2.1.4 Seldovia Point

Seldovia Point is a prominent land projection on the southern side of Kachemak Bay northeast of the entrance to Seldovia Bay (Figure 2-1). The intertidal zone is composed of cobbles, boulders, and rock pavement. Shallow surge channels are prominent features of the lower rock bench. A cliff approximately 60 meters in elevation rises sharply from the rocky shoreline (Dames & Moore 1976). The boulder field at the base of the cliff is apparently replenished by erosion and subsequent landslides from the cliff. Boulders produced by the sloughing eventually weather and break down. The finer materials are washed away, leaving the bedrock and coarser materials in the littoral zone. The rock bench and boulder field continues into the sublittoral zone adjacent to Seldovia Point. Exposed bedrock, cobbles, and expanses of sand are characteristic features of the sea floor. Shell debris is moderate in this location.

The largest and most conspicuous kelp bed in Kachemak Bay is found in the vicinity of Seldovia Point. From 1974 through 1978 a major part of the kelp bed has been located off the northeast side of the point (see Dames & Moore 1976) with a narrower arm extending southward into Seldovia Bay. There is historical evidence for the occurrence of the Seldovia kelp bed since the early 20th century (Rigg 1915).

Sampling was conducted along a permanently marked transect (Dames & Moore 1976) extending NNW along the major axis of the point. The levels sampled in 1977 and the three levels sampled in 1978 ranged from near MLLW to about +3 m MLLW (Figure 2-3). The near-shore subtidal zone was sampled from the intertidal-subtidal fringe out to the 18 fathom contour, approximately 2.7 km offshore. Seldovia Point is strategically located in terms of exposure to the surface waters of Lower Cook Inlet, receiving the full impact of northerly or northwesterly swells from the upper inlet, or swells have curved around from waves coming through the ocean entrances. Wave activity frequently amounts to only a moderate onshore break. During late spring and summer the fringing kelp bed probably dampens some of the sea surface water movement in the vicinity of the point (Dames & Moore 1976). However, conditions in fall and winter are somewhat more rigorous. Inshore currents are typically strong, especially during periods of spring tides. Silt is prominent on most of the solid substrate and associated vegetation in the sublittoral zone.

2.2 WEST SIDE OF INLET - ROCK

2.2.1 Scott Island

Scott Island is a low, relatively flat island of moderate size (30 hectare) on the east side of the entrance to Iniskin Bay (Figure 2-1). Large reefs marked by a number of small islets and emergent rocks provide the shorelines of the island considerable protection from the oceanic swells crossing Lower Cook Inlet from the ocean entrances, especially during low tides. The island is heavily wooded and is protected around much of its perimeter by steep cliffs, some 30 m in

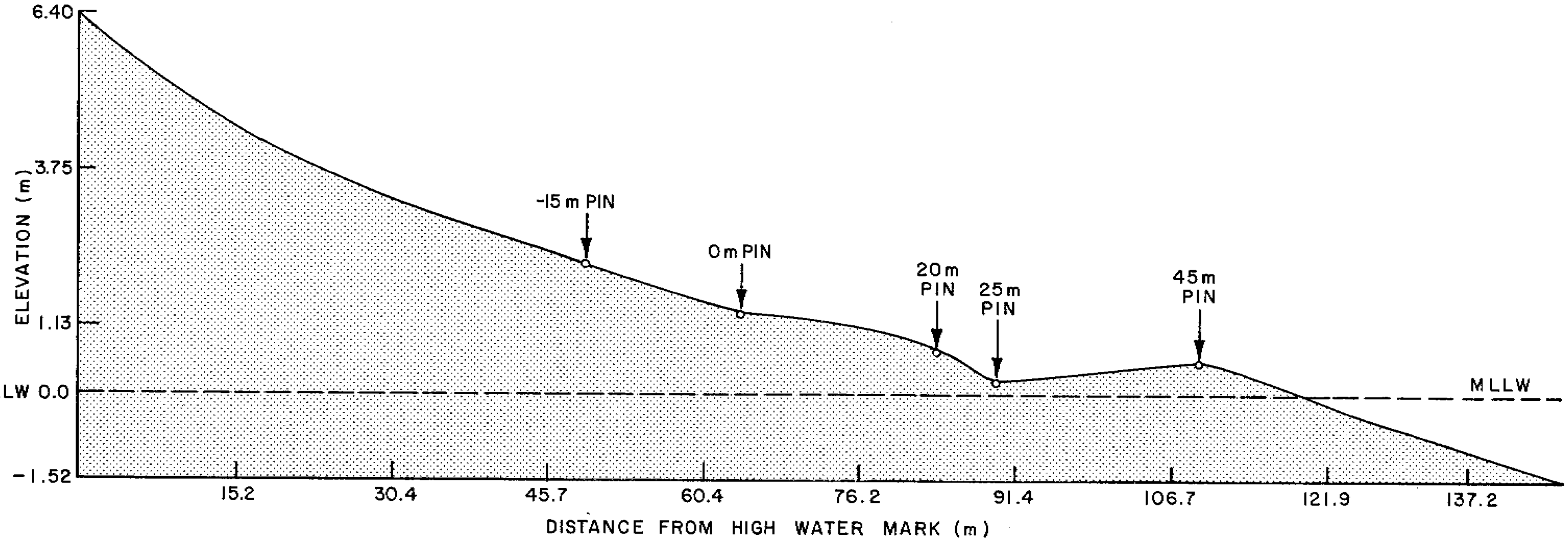

FIGURE 2-3

PROFILE OF PERMANENT TRANSECT AT SELDOVIA POINT height, that extend well down into the intertidal zone. Small gravelly beaches on the landward (NE, N, and W) sides of the island provide a boat landing and access to the wooded top of the island.

A transect was laid out in April 1978 across the intertidal zone of the southernmost corner of the island. From the base of the cliff the transect crosses a rock bench sloping generally seaward. The transect is cut by several shallow surge channels and two major lateral ridges. The upper level sampled is located shoreward of the uppermost ridge in the approximate center of the *Fucus* zone. The middle level sampled was on the seaward face of the second ridge in the center of the *Rhodymenia* zone. The lowest level sampled was on a lower bench at about -0.5 m MLLW. Several large shallow tide pools were scattered about this bench. Below this level, scattered channels of shelly gravel and sand interspersed with bedrock extended subtidally. Bedrock of Scott Island consists of a conglomerate of fist-sized or larger cobbles firmly cemented in a hardened sandy matrix. Very little loose material or even boulder-sized rocks are present except in the channels. Subtidally, scoured sand predominated and rock was limited to scattered medium to large boulders extending up to 2 m above the sand.

2.2.2 Vert Island

Vert Island is a small low island of bedrock situated 0.3 km south-southwest of Scott Island on the east side of the entrance to Iniskin Bay. The channel separating these islands is about 6 m deep. Maximum elevation is about 10 m. The flattened top of the island is grass covered and used extensively for nesting by glaucous-winged gulls, tufted puffins, and common eiders.

2.2.3 Knoll Head Lagoon

Knoll Head is a rocky headland rising steeply to 890 m in elevation on the west side of the entrance to Iniskin Bay. The complex shoreline west from the mouth of Iniskin comprises vertical rock cliffs, angular sea stacks, rocky islets and reefs; just east of the major unnamed stream between Knoll Head and Iliamna Bay are two moderate-sized embayments with gravel and even muddy sand beaches alternating with vertical rock faces. East of these bays is a less protected cove opening to the south that we have named Knoll Head Lagoon (Figure 2-1).

The study transect began at the base of a 5- to 6-m cliff rising to tundra and alder thickets above. The transect crossed an undulating bedrock beach comprising a descending series of rock benches separated by lower lying channels. The upper level sampled was on a rock "hogback" in the area of maximum *Fucus* cover. The middle level was on a lower, more gently rounded ridge. This level was largely in the *Rhodymenia* zone. However, drier outcrops supported considerable *Fucus*, while wetter pockets and channels were dominated by *Laminaria*. The lowest level sampled was also in the *Rhodymenia* zone on a similar but smaller rounded rock ridge at about MLLW. Below MLLW a series of low bouldery tide pools broke up the beach pattern.

Offshore, a series of low reefs oriented nearly parallel to shore protects these beaches from the southerly swells originating at the ocean entrances, except when the tide is fairly high.

Subtidal surveys were conducted between the intertidal zone and the offshore reefs. Bedrock extends down to a depth of about 6 m, where silty gravel becomes the dominant substrate.

2.2.4 White Gull Island

White Gull Island is a small low-lying island situated in mid-channel just inside the entrance to the Iliamna-Cottonwood Bay complex (Figure 2-1). The protected western and northern sides of the island have moderately sloped beaches of cobble, gravel and coarse sand interspersed with bedrock ribs and outcrops. The eastern shore, facing Lower Cook Inlet, has little protection from swells coming through the ocean entrances. This beach consists of a coarse cobble upper beach and an irregular lower bedrock bench punctuated with pinnacles and outcrops and interspersed with channels and tide pools. The pinnacles and outcroppings provide some protection for the cobble upper beach.

The study transect was on the exposed east side of the island. It ran due east across the bench between two elevated rock outcrops that extend to near or above the high tide line. Permanent markers (20-cm steel spikes) were placed at two levels. The upper level was in the *Fucus* zone on an irregular rock bench with ridges and gullies varying in elevation by up to 1 m. The lower level was on a relatively flat rock bench outside of the protecting rock pinnacles. This bench was near or slightly above MLLW but contained numerous tide pools and channels. The outer lip of this bench is a vertical to overhanging precipice dropping to a depth of about 10 m. From the base of this wall, a talus bottom with small to large boulders sloped down to about 13 m. Diving surveys were conducted mainly along the base of the wall on the talus slope. Because of the steepness and irregularity of the habitat, the complexity of the fauna, and the degree of siltation, quantitative work was not attempted.

2.2.5 Turtle Reef

Turtle Reef is a series of rock reefs and outcroppings fringing the shore of South Head, the southern headland guarding the entrance to Iliamna Bay (Figure 2-1). The reef extends to about 1 km offshore and most of the rocks are emersed at low tide.

2.3 SOFT SUBSTRATES IN LOWER COOK INLET

Hayes et al. (1977) provides useful characterizations of numerous beaches on both sides of Lower Cook Inlet. Most of the beaches from Kachemak Bay north, on the east side of the Inlet, are characterized by a narrow, fairly steep, unstable, gravel beach face extending down to an elevation of from about two feet to MLLW and a broad, flat, more consolidated fine sand low-tide terrace extending out into the subtidal zone (Figure 2-4). The boundary between the gravel and sand facies is generally sharply demarcated by changes both in slope and substrate. However, in some locations, it is interrupted by a narrow band of small boulders. In many instances, a small water-filled trough also occurs at the boundary, apparently as a consequence of the water draining out of the gravel slope above. This trough produces small drainage channels running perpendicularly to the shoreline at intervals along the beach (Figure 2-4).

The beaches initially selected for study in Lower Cook Inlet and discussed herein include two of sand and one of mud. The sandy beaches

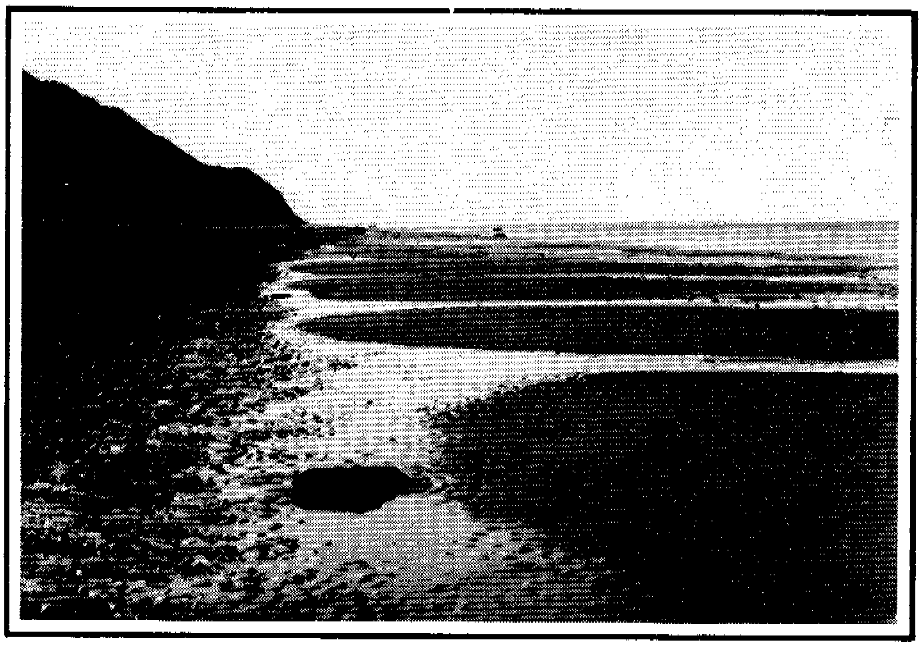

FIGURE 2-4 - VIEW OF BEACH AT DEEP CREEK, SHOWING STRUCTURE OF THE FORESHORE IN 1977 are located on the east side of Lower Cook Inlet (Figure 2-5). Both were accessible by vehicle. The Deep Creek site is fairly representative of beach conditions between Anchor Point and Clam Gulch. We selected the Homer Spit site because it appeared to support a richer fauna and higher standing stock than Deep Creek. The mud flat site is at Glacier Spit, Chinitna Bay, on the west side of the Inlet (Figure 2-5). It was chosen because it is typical of mud flats on the west side, has a year-round resident and shelter (Dames & Moore, 1977).

2.3.1 Sand Beaches - Homer Spit and Deep Creek

The sandy beaches are located on the east side of Lower Cook Inlet (Figure 2-5). Both were selected for accessibility. Based on his razor clam surveys, Mr. David Nelson, ADF&G (personal communication), indicated

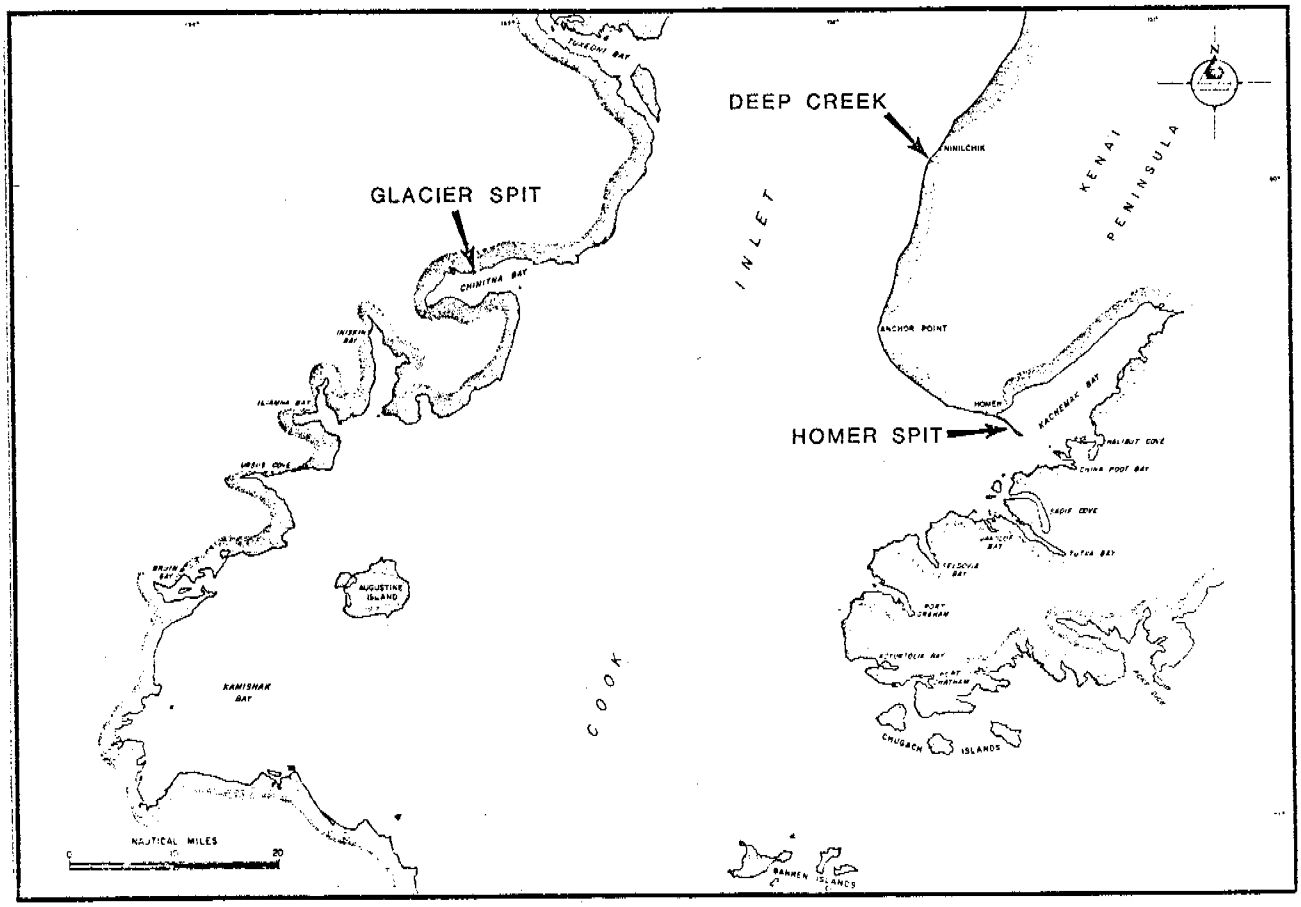

FIGURE 2-5 - SOFT SUBSTRATE LOCATIONS IN LOWER COOK INLET that the Deep Creek site, 1.5 miles south of the beach park, is fairly representative of beach conditions between Anchor Point and Clam Gulch. The base point for the transect is a room-sized triangular boulder at the base of the bluff (an erosional scarp). We selected the Homer Spit site, 2.5 miles south of the Kachemak Drive, because it appeared to support a richer fauna and higher standing stock than the Deep Creek site.

Corrected beach profiles for the Deep Creek and Homer Spit sites (Figure 2-6) provide two important pieces of information. First, it appears that the shape of the beaches change very little seasonally compared to beaches exposed to the open ocean (Bascom, 1964).

However, because of large inaccuracies in the original profile data, the accuracy of the corrected profiles is undetermined. Our notes and recollections of fixed features on the beach lead us to accept the general shape of the profiles, but to question the changes recorded for the gravel upper slopes at both sites.

Second, the gravel upper beach is considerably steeper at Deep Creek than at Homer Spit. According to Bascom (1964) this indicates that the beach at Homer is somewhat less exposed than at Deep Creek. Shepard (1963) also points out that the beach at Homer should be coarser and more porous.

Based on sediment samples collected at two levels from both lower beaches, sediment conditions are quite similar (Table 2-1). The sand may be slightly coarser at Homer Spit than at Deep Creek. The sediment in both areas is a moderate to well-sorted fine to medium sand with a significant quantity of small gravel; fine sand was mainly found at the lower levels. Also, thin strata of pulverized coal were common at both beaches. Evidence of anoxic conditions (blackened sand or sulfide odor) was lacking at both sites.

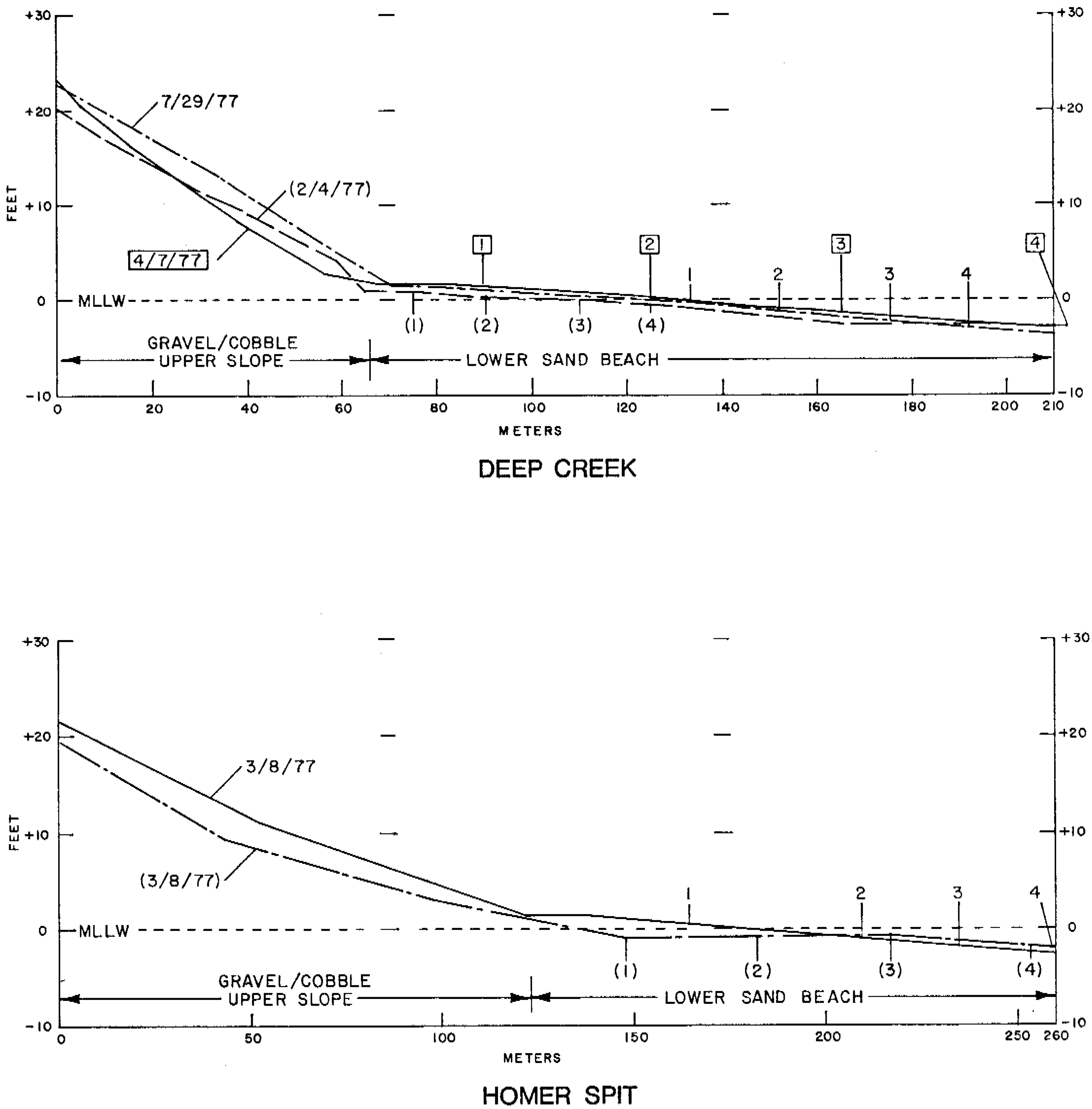

FIGURE 2-6

BEACH PROFILES FOR DEEP CREEK AND HOMER SPIT

TABLE 2-1. SEDIMENT PARAMETERS FOR SAND BEACH SAMPLING SITES IN LOWER COOK INLET, MAY 1978.

Location	Grain Size M_d (mm)	Grain Size M (mm)	Dispersion $\sigma\phi$	Dispersion $\alpha\phi$
Homer Spit - 30m level				
Replicate 1	0.24	0.24	0.39	0.06
2	0.28	0.28	0.54	0.04
3	0.35	0.41	0.70	-0.31
$\bar{x}$	0.29	0.31	0.54	-0.07
s	0.06	0.09	0.16	0.20
Homer Spit - 135m level				
Replicate 1	0.21	0.22	0.45	-0.14
2	0.25	0.25	0.56	-0.01
3	0.22	0.24	0.57	-0.19
$\bar{x}$	0.23	0.24	0.53	-0.11
s	0.02	0.02	0.07	0.09
Deep Creek - Level 1				
Replicate 1	0.26	0.27	0.50	-0.10
2	0.28	0.28	0.45	0.01
3	0.24	0.25	0.56	-0.17
$\bar{x}$	0.26	0.27	0.50	-0.09
s	0.02	0.01	0.06	0.09
Deep Creek - Level 3				
Replicate 1	0.22	0.21	0.40	0.06
2	0.21	0.20	0.48	0.05
3	0.21	0.20	0.42	0.06
$\bar{x}$	0.21	0.20	0.43	0.06
s	0.01	0.01	0.04	0.01

2.3.2 Mud Flat at Glacier Spit, Chinitna Bay

The mud beach study site is adjacent to the Byer homestead, on Glacier Spit, Chinitna Bay, on the west side of the Inlet. It was chosen because it is a typical mud flat, and has a year-round resident and shelter. The base point for the transect is a solitary group of large boulders at the border between the gravel upper slope and the mud low-tide terrace.

The basic structure of the beach at the Chinitna site is similar to that described for the two sand beaches (Figure 2-7). An important difference is the flatter slope of the mud flat. However, the slope of the gravel upper beach at Glacier Spit is steeper than at either sand beach site.

Sediment samples from Glacier Spit have not yet been processed. However, the sediment is basically a sandy silt with appreciable clay. It appears to be moderately well consolidated. Evidence of anoxic conditions (blackened sediment and shells, odor of sulfides) occur within 10 cm of the surface.

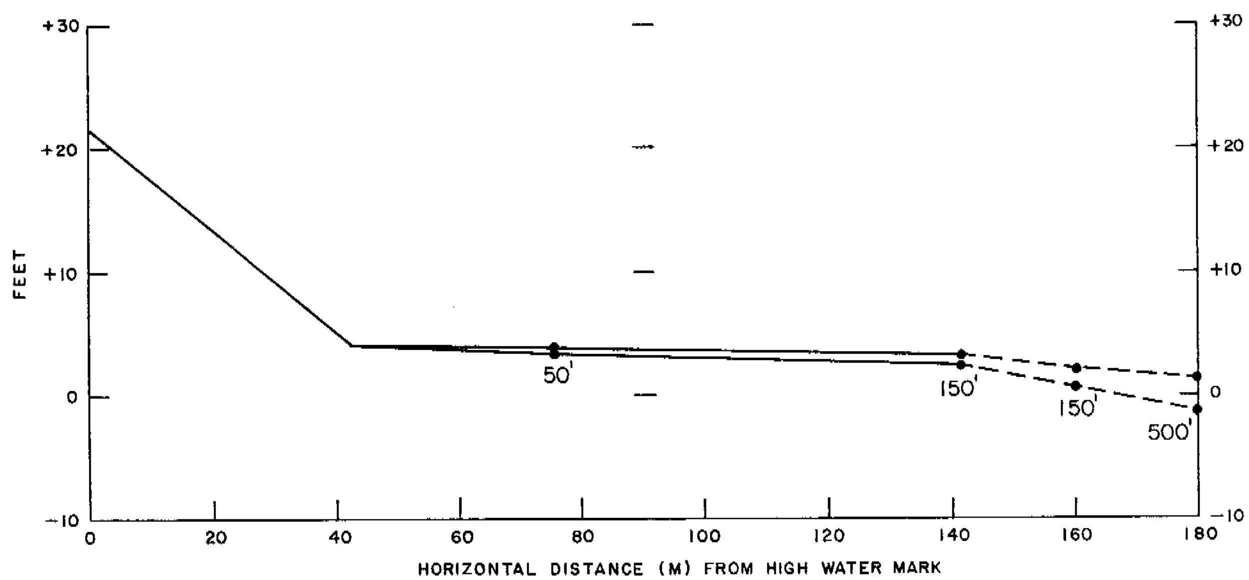

FIGURE 2-7 - ESTIMATED BEACH PROFILE FOR GLACIER SPIT, CHINITNA BAY

2.3.3 Sampling Levels

At the Homer Spit and Chinitna Bay sites, the sampling levels were established at predetermined distances from the gravel-sand interface. The location of these levels and their approximate elevations are indicated in Table 2-2.

At the Deep Creek site, we attempted to locate the levels according to predetermined elevations, specifically, MLLW, -1, -2 and -3 feet below MLLW. This was not successful because of the various sources of error inherent to the surveying method used and the unreliable or incomplete nature of the tidal information upon which we operated. The approximate elevations sampled at Deep Creek are indicated in Table 2-3.

On the sand beaches, neither of these methods of relocating sampling levels was completely satisfactory but the method used on the mud flat was satisfactory. A major technical problem on sand beaches is that the movement of the sand associated with changes in profile or elevation will cause some animals (e.g., amphipods) to relocate quickly to a suitable elevation but others such as deep-burrowing polychaetes cannot respond rapidly. Therefore, sampling at a set distance from a known point permits reasonable samples of polychaete populations, but any seasonal changes in elevation may cause problems for sampling amphipods. On the other hand, sampling at pre-determined elevations appears difficult to accomplish and also can result in large differences in the horizontal position of sequential sample sets at the same level. This would preclude sampling the same polychaete populations.

A completely satisfactory solution to this problem seems unlikely. However, based on the preliminary information that seasonal changes in the beach profiles are small, it seems most acceptable to sample at given distances from a fixed feature on the beach.

2.3.4 General Environmental Conditions

A comparison of environmental conditions at the three sites reveals some distinct differences. The factors considered are sediment tempera-

TABLE 2-2. LOCATION AND APPROXIMATE ELEVATION OF SAMPLING LEVELS AT HOMER SPIT AND GLACIER SPIT, CHINITNA BAY, 1977.

	Homer Spit			Glacier Spit, Chinitna Bay	
Sampling Level	Distance from Interface (meters)	Approximate Elevation (feet) 3/8/77	Approximate Elevation (feet) 7/28/77	Distance from Interface (meters)	Approximate Elevation (feet)
1 (Upper)	30	+0.75	-1.0	50	3.8 to 3.6
2	75	-0.75	-0.75	150	3.25 to 2.5
3	100	-1.75	-0.5	350	2.1 to 0.9
4 (Lower)	135	-2.5	-1.5	500	1.3 to -1.2

TABLE 2-3. VARIATION IN APPROXIMATE ELEVATION (FEET) OF SAMPLING LEVELS AT DEEP CREEK IN 1977.

Sampling Level	2/4/77	4/7/77	7/29/77
1 (Upper)	+1.0	+1.5	0.0
2	+0.5	+0.5	-1.0
3	0.0	-1.25	-2.0
4 (Lower)	-0.5	-2.75	-2.75

ture, ice cover and scour, salinity, turbidity, wave action and tidal currents. The comparisons are qualitative and frequently based on inference.

Severe winter air temperatures are somewhat lower at Chinitna Bay and Deep Creek than at Homer Spit. Surface sediment temperatures at the Spit are probably less severe during night low tides than at the other two sites. Chinitna Bay may also experience stronger winds than the other sites, causing greater wind chill effects. The surface layer of sediment freezes at all three sites during low tides in late fall and winter, but our impression is that it freezes deeper at Chinitna.

The scouring effects of sea ice range from substantial at Chinitna to low at both Deep Creek and Homer Spit. Wayne Byer, a resident on Glacier Spit, reports that during winter low tides, thickness of stranded ice approaches 2 m opposite his homestead (personal communication). In contrast, stranded ice blocks are not common at either of the sand beaches, but can occur during harsh winters. Floe ice at Glacier Spit may protect the sediment from extremely low temperatures in many cases, but can scour extensively.

Based on location, it would appear that salinity would be highest, and least variable, at Homer Spit, and lowest and most variable at Glacier Spit, which is essentially estuarine and situated in a bay near a number of streams. This inference is supported by the salinity patterns described by Kinney et al. (1970).

Our observations indicate that turbidity (suspended solids) is lowest, but highly variable, at Homer Spit, and highest and least variable at Glacier Spit. This agrees with the basic pattern reported by Sharma et al. (1974).

Wave action is a powerful influence at both Homer Spit and Deep Creek. Homer Spit has a maximum fetch for direct wind waves of 100 miles, and is only slightly protected from waves generated in Skelikof Straits. Breakers up to 2.5 m high have been observed there, and Hayes et al. (1977) predicts 3 m. However, Homer Spit is generally protected from northerly storms. Although Deep Creek is exposed to waves from south, west and north, and so is probably disturbed by wave action more regularly, the maximum fetch for direct waves is only about 30 miles. Because the stronger north and south waves will approach at an oblique angle, their force will be greatly reduced. Glacier Spit is generally protected from all but waves from the southeast, and surf over 1 m high is probably rare.

The influence of tidal currents varies greatly among the three sites. Exposure is greatest at Deep Creek, as it is located directly on the shoreline of the Inlet. The Homer Spit site is only slightly affected by tidal currents because of the protection provided by the Spit, particularly during outgoing tides. Glacier Spit, located near the head of Chinitna Bay, is subjected to only minimal tidal currents.

The differences in exposure to wave action and tidal currents are clearly reflected in the contrasting sediment regimes at Homer Spit and Deep Creek, on one hand, and Glacier Spit, on the other. Furthermore, slope of the upper beach indicates that Homer Spit is exposed to heavier surf; fall storms are particularly strong. However, tidal currents are stronger at Deep Creek and occur four times daily, so their overall effect may be greater.

3.0 METHODS AND MATERIALS

Methods used to sample rocky littoral substrates in Lower Cook Inlet during 1977 and 1978 largely evolved from techniques used by Dames & Moore (1976, 1977) in previous surveys in the area. Based on results from these early works, methods were trimmed to distribute field and laboratory effort more efficiently and tailored to focus on the major objectives of the continuation studies.

3.1 DISTRIBUTION AND ABUNDANCE - ROCKY SUBSTRATES

A variety of techniques was used to document the distribution and abundance of littoral organisms. At all of the intertidal and some of the subtidal sites described in Section 2.0, sampling was focused on permanently marked transects at discrete intertidal levels or subtidal depths.

3.1.1 Quadrat count and removals

A stratified random sampling design was used to gather the majority of distribution and abundance information obtained in this study. At each level to be sampled a 30- or 50-m tape was laid out along the beach or depth contour perpendicular to the transect. Intertidally, square, quarter-square meter quadrats were positioned along the tape (the sampling transverse) at locations dictated by random numbers. From each quadrat the following information was recorded:

a) density and/or percent cover of individual algal species
b) percent cover of sessile or colonial animals (barnacles, mussels, bryozoans, sponges, etc.)
c) numbers of other macrofauna

Moreover, these quadrats were used to obtain samples to estimate plant biomass. During 1977 all nonencrusting algae were removed from the quadrats sampled at Gull Island and Seldovia Point. These samples were placed in distinctly labelled bags and returned to the laboratory for length and/or weight measurements. During 1978, algal removal was terminated at Gull Island because of our concern over sampling effects due to the limited size of the study site. Also during 1978, other changes in the seaweed removal program were instituted to increase efficiency at Seldovia Point. Only Fucus was removed from the upper level (+2.1 m), all algae were removed from the +1.4 m level, and only brown algae were removed from the lowest level (0.0 m). Data from 1977 had previously indicated that these groups included the vast majority of algal biomass at these levels. At the intertidal sites on the west side, only Fucus was removed from upper level quadrats and all algae were removed from middle and lower level quadrats.

Subtidally, the quadrat size used for estimating densities of plants, invertebrates, and fish ranged up to 50 m^2 depending on the size and density of the various target species because it was not practical to gather all of the above data from a single-sized quadrat. For the larger quadrat sizes (usually 2.5, 5, or 25 m^2), organisms along the transect line were enumerated by delimiting the prescribed area along the transect line with a hand-held staff 0.5 m long. The diver would move the staff perpendicularly along the transect line for a set distance (e.g. 5 m), counting all individuals of a given species in the path of the staff.

Fish densities were assessed by this same method using 25 or 50 m^2 quadrats. Generally, the diver would count the more motile species (e.g. greenling) on a quick pass along the transect line, and then count the more sedentary or cryptic species during a return pass along the line.

We attempted to obtain 10 replicates of the 0.25 m^2 quadrats at each zone or level sampled in order to obtain reliable estimates of density, relative cover, and biomass of the major species present. The desire was to reduce variance to the lowest practical level. However, the number of replicates was often reduced because of the constraints imposed by water and tide conditions, available working time, weather, boat safety, etc. Working time at intertidal sites was controlled by emersion periods and, at subtidal sites, by the duration of slack tidal currents.

Generally, sampling adequacy was examined by a comparison of the mean and variance of a parameter. Collection of replicate samples provides an estimate of the sampling distribution. Subsequent comparison of sampling distributions from two or more sampling periods by one of a number of statisical tests permitted evaluation of the observed differences. We routinely used a significance level of $\alpha = 0.05$ to decide if a difference was real and due to natural changes or sampling variability. This is a relatively simple procedure in population studies. However, it is not really practical for broad, descriptive ecological assessments where densities of important species may range from less than $1/m^2$ for large plants and predators more than $1,500/m^2$ for mussels, etc., and biomass of functionally important species may range from 20 gm/m^2 to over 50 kg/m^2. Because temporal and financial constraints limited sampling severely, our ability to detect differences between natural and sampling variability was limited. However, despite this limitation, changes were so dramatic that identification of seasonal and bathymetric patterns for dominant species was often possible. Selected specimens of flora and fauna were preserved for taxonomic verification and added to the reference collection from previous studies in Kachemak Bay and Lower Cook Inlet.

3.1.2 Color photography

The appearance of the intertidal zone was recorded photographically during each sampling period on 35-mm color slides. At each fixed pin on the intertidal transects, photographs were taken of a 0.25 m^2 quadrat in a fixed position relative to the pin; the same beach surface area was photographed each time. An electronic flash was used during periods of poor ambient lighting.

3.1.3 Laboratory techniques

The algal samples removed from the quadrats were returned to the laboratory where they were sorted to species or major taxon. In 1977 red and green algae were then weighed wet and recorded by the lowest practical taxon. Because separation of the red and green algae was quite time-consuming and appeared to contribute only minimally to our objectives in 1978, we separated those groups only to major taxon (Rhodophyta and Chlorophyta) and measured aggregate wet weights. Brown algae were separated by species both years. For the laminarians, stipe and total length and whole wet weight were measured for individual plants to provide data on age-stucture and length-weight relationships. In 1977 aggregate weights were obtained for *Fucus*, but in 1978 we obtained individual plant weights as well.

3.2 GROWTH

Information on growth and growth rates of major laminarian algae was obtained by (1) direct tagging experiments, and (2) by analysis of length-frequency and biomass data. Limited growth data for certain key animals were also obtained using the latter method.

3.2.1 Plant growth experiments

Basically, the procedure employed in the kelp growth rate studies was to tag individual plants with unique identification labels and then place a mark on each blade to permit measurement of growth. The greatest component of blade growth in kelp takes place in the meristematic area at junction of the stipe and the base of the blade (intercalary meristem) (Dawson 1966). The migration of a mark from the base to the tip of a blade is evidence of growth. Measuring the position of such marks at various points in time, then, permits determination of growth rates.

These operations were performed by divers. Identification labels were fabricated by affixing an individually imprinted piece of DYMO labelling tape to an electrical wire "tie-wrap" (Figure 3-1). Divers placed these individual labels around the stipes of plants so as to fit fairly snugly, but loose enough to allow an increase in stipe diameter (growth).

Blades were marked in several ways to permit measurement of growth. The basic method used was dictated by blade structure. The simple structure and thickness of the blades of Laminaria groenlandica permitted marking by simply punching a small, neat hole in the blade with a sharpened piece of tubing or a large caliber rifle cartridge. Such holes were generally easy to follow and recognizable for several months (Figure 3-1). This method was unsatisfactory for Agarum cribrosum and Alaria fistulosa, however, because of more complex structure. Both species have a heavy midrib bisecting the blade. Furthermore, the laminae of Agarum are perforated by numerous holes and those of Alaria are thin and rather filmy (Figure 3-2). These conditions combined to preclude the use of a punched hole for following growth. Several other methods were used with varying degrees of success. With Agarum we first threaded a loop of bright colored yarn through natural perforations and around the midrib near the base of the blade. This method worked fairly well but was not considered satisfactory for several reasons. It was difficult to pass the thread through the natural perforations without tearing their edges. Furthermore, waves and tidal currents tended to unravel the yarn and foul it with filamentous algae or the arms of sea stars and spines of sea urchins. A more satisfactory method was to manually place a 0.5-inch long staple of stainless steel suture wire through the midrib with the axis oriented longitudinally so as to disturb the least amount of tissue (Figure 3-2). This method was quite satisfactory and was also employed on Alaria plants. However, we did have two problems with the staple method. First, the midrib tended to split above the distal limb of the staple and below its proximal limb, apparently as a result of secondary cell expansion. Second, the staples were frequently rather difficult to detect underwater because of poor light, turbidity, and water turbulence. We therefore tried Petersen disc tags with yellow or international red discs and stainless steel pins. This brightly colored tag, which only pierces the midrib at a single

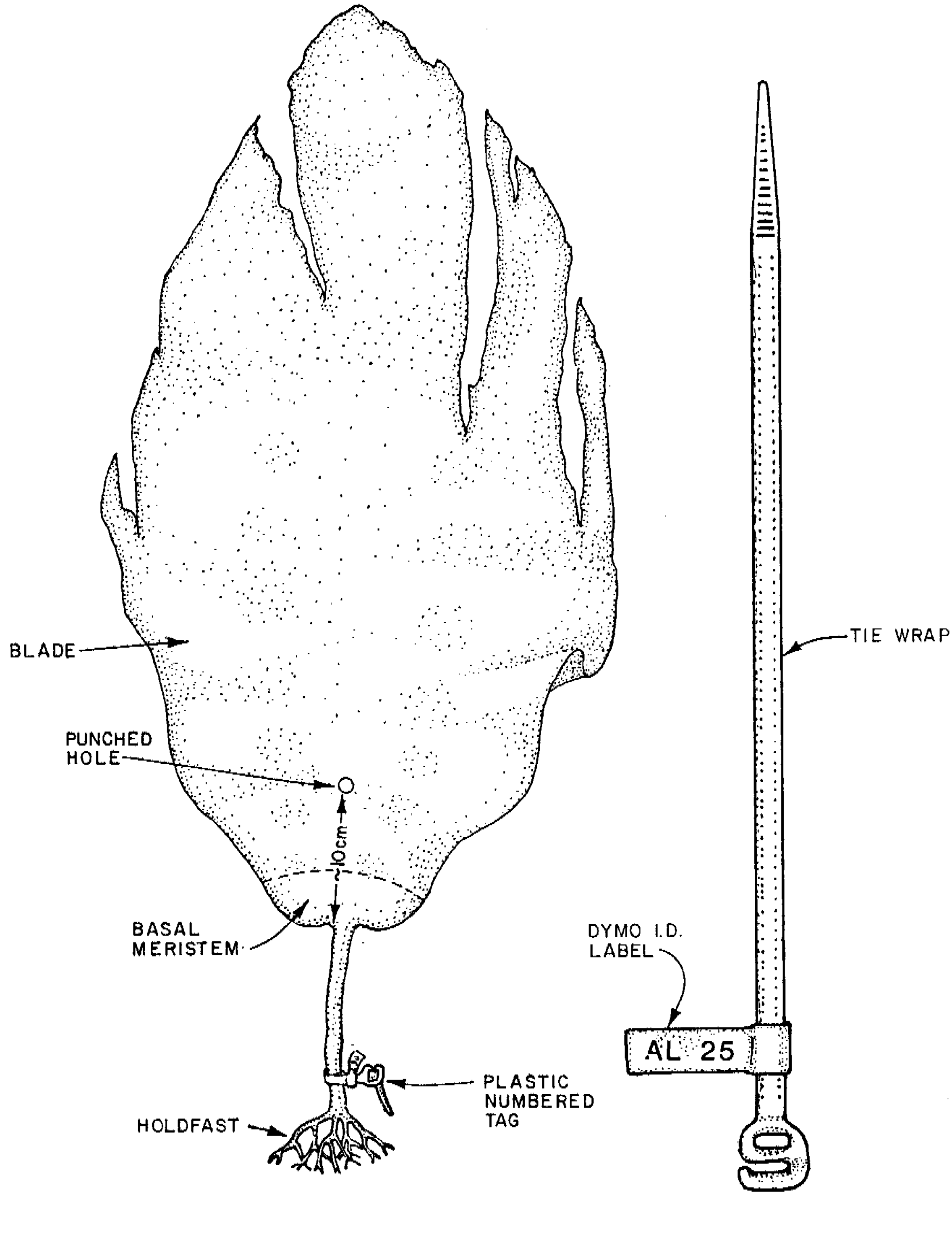

FIGURE 3-1

CONSTRUCTION OF PLANT IDENTIFICATION TAG
AND METHOD OF MARKING BLADE
FOR MEASURING GROWTH FOR LAMINARIA GROENLANDICA

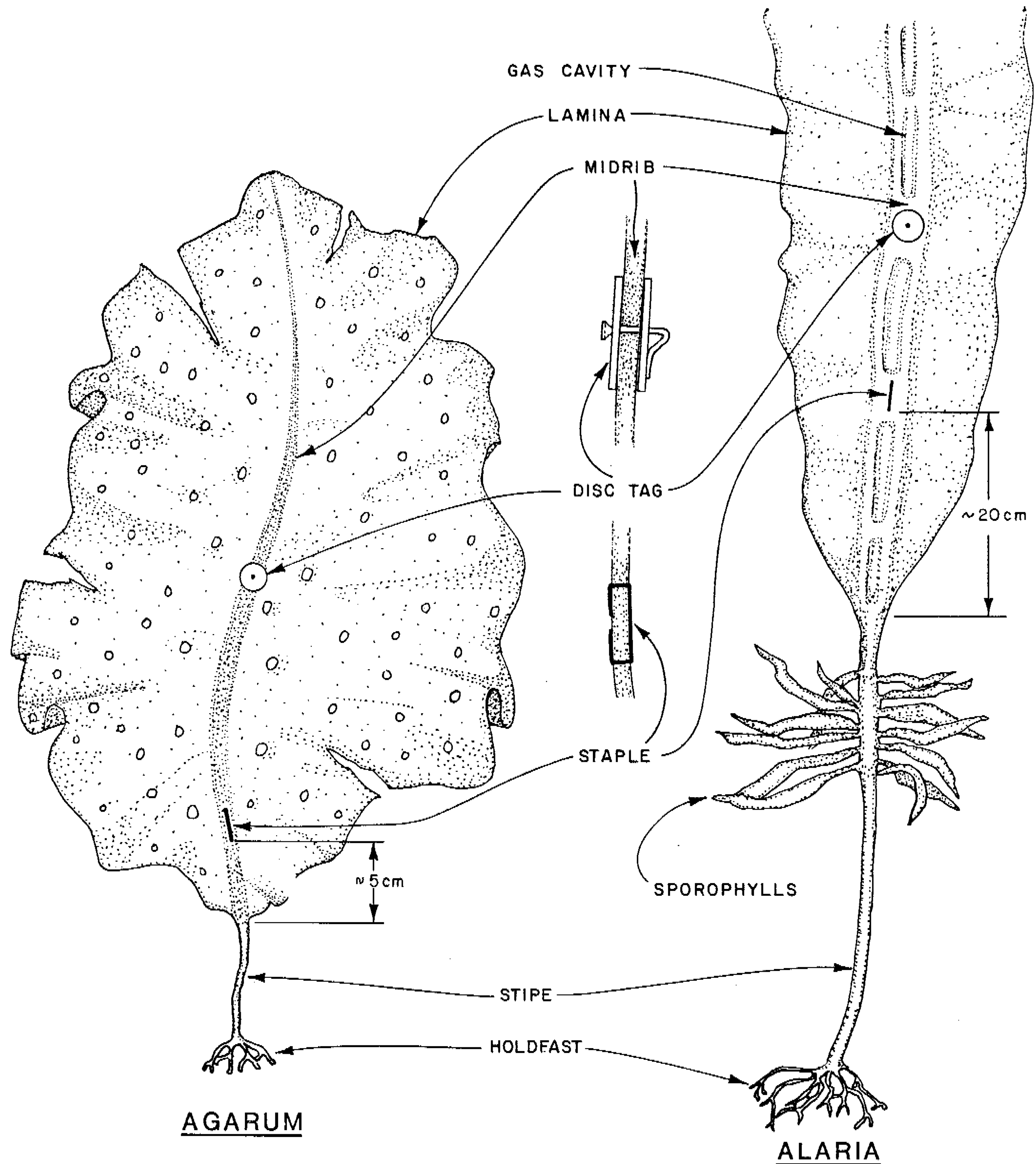

FIGURE 3-2

METHODS OF MARKING BLADE FOR MEASURING GROWTH FOR AGARUM CRIBROSUM AND ALARIA FISTULOSA location, resolved both drawbacks of the staple, and was also somewhat quicker and gentler to install on the plant (Figure 3-2).

After each plant was marked with an identification (ID) label and the blade marked, its ID and the position of the blade mark were recorded (centimeters from the stipe/blade junction). The position of the initial blade mark varied with the species. It was located about 5 cm, 10 cm, and 20 cm from the stipe/blade junction, respectively, for Agarum, Laminaria, and Alaria. If time permitted, stipe length, total plant height, and sporophyll length (for Alaria) were recorded. At subsequent observations, the same measurements were recorded and, when necessary, the blade was remarked near the basal meristem.

Plants were tagged in groups on or near prominent landscape features (e.g. conspicuous sponge-covered boulders, ledges, or near permanent transect lines). This procedure was adopted to facilitate relocation of tagged plants. The locations of these groupings were chosen to provide a general gradient of environmental parameters, in some cases permitting a rough assessment of environmental effects of growth rates.

An attempt was made to measure growth in Nereocystis luetkeana but was discontinued because of constraints in available time and funds. The methods used were the same as employed for Laminaria but several problems developed. Because of stipe structure, it would have been necessary to develop a new method for installing identification labels. Stipe growth is rapid in young plants, and it appears that growth rates may vary directly with size (because of shading, etc.). Also, it was necessary to measure stipe length concurrently with blade growth. However, measurement of stipe length is a rather difficult task, frequently requiring two divers, and commonly damaging the stipe or the pneumatocyst (gas bladder). Furthermore, it was frequently impossible to extricate the bladder and blades of an adult plant from the surface canopy without damaging them severely or inducing partial blade loss.

3.2.2 Indirect methods

Size data for selected invertebrates were used to develop life tables including estimates of growth and mortality rates. This was done using the method developed from the Brody-Bertalanffy growth equations by Ebert (1973).

3.3 NUMERICAL ANALYSIS

As indicated above (Section 3.1.1), standard statistical techniques were used to differentiate between sampling and natural differences in species composition, density, biomass, plant growth rates, etc., between sampling periods, tide levels, or sampling sites. Generally, confidence limits *per se* were not calculated. Instead, we routinely calculated standard deviation (not standard error) for all replicated data sets. Where confidence limits were deemed beneficial or could be applied to the analysis, we used the 95 percent confidence limits to describe the variability (or precision) of the sample means. These were calculated as follows:

$$\text{Lower Limit} = \bar{x} - t\sqrt{\bar{x}/n}$$

$$\text{Upper Limit} = \bar{x} + t\sqrt{\bar{x}/n}$$

where:

$\bar{x}$ = the arithmetic mean of a sample set
n = the number of observations
t = is the Student's "t" value for $\alpha = 0.05$ with degrees of freedom = n-1.

In most cases, sample size was too small to permit calculation of confidence limits using the sample variance (s^2), and frequently it was not advisable to assume a Poisson distribution. In these instances, these calculations were limited to standard deviation "s" or the standard error ($\sqrt{s^2/n}$, the standard deviation of the mean).

Depending on the type of data, we made statistical comparisons with either the Student's t-test, or one of a number of nonparametric tests. These included the Wilcoxin matched-pairs signed-ranks test, the Kolmogorov-Smirnov two sample test, the Mann-Whitney U test, χ^2 tests, the Kruskal-Wallis one-way, or Friedman two-way analysis of variance (Siegel 1956).

After tabulation of the field data, proper statistical tests were determined depending on the type of data under consideration, and parameters were compared between sampling levels within a survey, or between surveys at a specific level. The relationship between density, biomass, and size structure was examined to gain insight into the mechanics involved in observed changes. Frequently, where the data exhibited strong patterns, graphical presentations were more appropriate. This was often the case with the intertidal data, where strong seasonal and zonal (elevation) patterns were present. Also, the growth rate data and trophic structures were conducive to graphic presentation. However, in all cases, the complete data summaries (mean density or cover of all species at all sampling times) are presented in appendix form to permit other investigators access to them. Raw data have been submitted to NOAA in the NODC digital data format.

3.4 TAXONOMY

As expected, many problems were encountered in attempting to identify organisms found in this study with standard taxonomic references for the northeast Pacific Ocean. Intertidal and shallow subtidal organisms of Lower Cook Inlet have not been previously studied in a systematic way and few extensive collections from this area have been examined by taxonomists. Thus, many organisms were encountered with characters intermediate to or outside the ranges of variation considered definitive for separate species in standard keys. In some cases, it was possible to clear up these questions by reference to the original literature. In others, questions remain which must await a rigorous investigation by taxonomic specialists. Problematic individuals of some groups were submitted to such specialists for examination. Some groups of apparently minor ecological and economic importance that require extensive histological preparation and microscopic examination for positive identification (e.g. Nemertea) were not identified further. Thus, in the species lists in this report there are many organisms where identification was not pursued to the genus or species level and others where the identification as listed is considered questionable and is denoted with a question mark.

In several instances, we have submitted large collections of organisms to taxonomic specialists for verification or identification. This has been a definite benefit to our taxonomic capabilities and the validity of our data. The taxa and associated systematic specialists are listed below.

TAXON	SPECIALIST
Phaeophyta	Dr. Thomas Widdowson
Rhodophyta - Chlorophyta	Dr. Robert Scagel University of British Columbia
Rhodophyta	Dr. Isabel Abbott Stanford University
Rhodophyta - Delesseriaceae	Dr. Joan Stewart Scripps Institution of Oceanography
Polychaeta	Dr. Rita O'Clair University of Alaska - Juneau
Polychaeta	Mr. Rick Rowe University of Southern California
Paguridae	Ms. Janet Haig University of Southern California
Mollusca	Mr. Rae Baxter Alaska Department of Fish and Game
Tunicata	Mr. James Vallee Pacific Bio-Marine
Fish	Dr. Robert Lavenberg Los Angeles Couty Museum of Natural History

Two taxa, Hydroida and Bryozoa, have been examined extensively in-house, but the identifications have not been verified by outside authorities.

3.5 DISTRIBUTION AND ABUNDANCE - SOFT SUBSTRATES

3.5.1 Field Procedures

A stratified random sampling design was employed to examine the infauna of sand beaches at Homer Spit and Deep Creek, and the mud flat at Glacier Spit, Chinitna Bay. A transect extending across the beach from a specified point was established on each beach. Samples were collected at four specified levels or distances from the base of each transect. At each level, a measured line was laid out parallel to the shoreline and a set of vertical core samples was collected at random points along that line. All sample sets included ten replicate cores per level, except that only five per level were collected at Homer Spit in February 1977. The core sample collected was 10 cm in diameter (78.5 cm^2) by 30 cm in length (2356.2 cm^3). Each core sample was placed in a separate polyethylene bag and labelled. Subsequently, the core samples were sieved through a 1.0 mm screen to reduce the amount of inorganic material and the sample rebagged and preserved with a 10 percent formaldehyde-sea water solution.

Approximate beach profiles were determined using a measured PVC stadia rod, an expedient monopod and a telescopic level. Starting at the drift line of the previous high tide (estimated from the litter line and sediment dampness) a measured line was extended across the intertidal zone to the lower water line at low slack tide. Profile data were acquired by determining elevation changes over a measured horizontal ground distance with the level and stadia rod. Profile data were collected from high water to low water and back to high water; plotted profiles were averages of the two.

This method is subject to several inaccuracies. It is based on the accuracy of the published tide information on time and changes. Therefore, meteorological phenomena and correction factors are important sources of error.

3.5.2 Laboratory Analysis

In the laboratory each core was rough sorted under a dissecting microscope to separate the animals from the remaining sediment and to divide them by major taxa, mainly polychaete worms and crustaceans. At this time they were placed in a 30 percent isopropyl alcohol preservative. Subsequently, the samples were examined to identify the species and count the individuals. Initially, all specimens were also sent to taxonomic specialists to verify or obtain identifications. Subsequently, only difficult species have been sent out. The specialists consulted were: Bruce Benedict, formerly of Marine Biological Consultants, Inc., for gammarid amphipods, and Rick Rowe, Allan Hancock Foundation, University of Southern California, for polychaetes.

Following identification, the samples were reexamined to obtain length and weight data. Lengths of gammarid amphipods and small clams were measured on a dissecting microscope equipped with an ocular micrometer. Whole wet weights of animals were obtained by draining the specimens for about 15 seconds on damp paper towels and weighing them on a Torsion DWM2 balance accurate to ± 5 mg.

3.5.3 Numerical Analyses

Quantitative samples (cores) produced several numerical parameters useful in describing and comparing faunal assemblages. Used to describe abundance were 1) the total number of specimens per level (N), 2) the average number of specimens per core sample (± one standard deviation), and 3) the number of organisms per m^2. Species richness was described with 1) the total number of species per level (S), 2) the average (± s) number of species per core, and 3) the Brillouin diversity index ($H = 1/N \left(\log_2 \frac{N!}{n_1!n_2!\ldots n_j!}\right)$, where n_1, $n_2 \ldots n_j$ are the number of individuals in species 1 through j). The equitability, or evenness of the distribution of specimens among species was described by N/S and E, which was defined as $2^{H/S}$. Standard deviations are included to provide an indication of variability among the samples.

In addition, species-area curves were constructed to demonstrate the rate at which species were accrued within the assemblage observed at each level. This technique provided additional insight into the adequacy with which a level, or the area, was sampled.

To assist in describing zonation on the sand beaches, the abundance of each species was compared among levels to determine distribution patterns and composition at each elevation. Species that occurred at a given level in all three surveys and had a density exceeding $100/m^2$ at least once were categorized as "Dominants". "Subdominants" also occurred in each survey but their density never exceeded $100/m^2$. Species that occurred in only two surveys were categorized as "Frequent", regardless of density, and those that appeared only once, but at a density exceeding $100/m^2$, were considered "Seasonal". The categories for the mud beach, where data for only two surveys are included, are somewhat different. Species that occurred at a given level in both surveys and for which density exceeded $100/m^2$ at least once were categorized as "Dominant". "Subdominants" also occurred in both surveys but ranged between $100/m^2$ and $10/m^2$ in both surveys. Those which occurred in both surveys with densities ranging between $5/m^2$ and $10/m^2$ at least once were classified as "Frequent". Finally, species that occurred only once at densities of greater than $20/m^2$ were designated as "Seasonal".

4.0 RESULTS

4.1 ROCKY HABITATS - EAST SIDE

4.1.1 Gull Island

The general characteristics of rocky intertidal communities on the Gull Island ("Gorilla Rock") transect have been described by Dames & Moore (1976) based on the 1974-1976 studies. These characteristics are summarized here.

Uppermost intertidal rock surfaces wetted only by spray or the highest tide had a patchy band of the green alga Prasiola meridionalis. Rock crevices that retained spray and freshwater runoff had growths of the tubular green alga Enteromorpha. Slightly lower in the area wetted by most high tides (about +5.5 to 5 m) the acorn barnacle Balanus glandula formed dense colonies covering much of the substrate along with the tufted red alga Endocladia muricata. In the damper portions of this barnacle zone (mostly between 2.8 to 4.9 m) were dense growths of the red algae Halosaccion glandiforme, Odonthalia floccosa, and Rhodomela larix; in the drier portions, the brown rockweed Fucus distichus formed a dense cover over the barnacles. The bay mussel Mytilus edulis was also abundant in scattered patches in this area and continued to some extent throughout lower intertidal areas. The littorine snail Littorina sitkensis and the limpets Collisella spp. and Notoacmaea spp. were the most abundant grazers at this level.

Below the Fucus/Halosaccion zone barnacle dominance shifted to the thatched barnacle B. cariosus. Algal dominance shifted to the brown laminarian alga Alaria crispa.* During spring and summer of 1974-1976 this species formed an extensive band (62 to 85 percent cover) from about +2.8 m (near MSL) to near MLLW with an understory of several reds (O. floccosa, Rhodymenia spp.,** Polysiphonia sp., Pterosiphonia sp., Gigartina spp.,*** and the filamentous green Spongomorpha sp. Encrusting species (Ralfsia pacifica and a coralline) covered much of the unoccupied

* Called A. ?praelonga in Dames & Moore (1976).
** Includes forms called Callophyllis in Dames & Moore (1976).
*** Includes forms called Iridaea in Dames & Moore (1976).

rock surface. The Alaria plants in this zone were largely attached to the shells of B. cariosus (Figure 4-1) and died back to much lower coverage during fall 1974 (34.7 percent) and winter 1975 (3.4 percent).

In addition to the limpets, the chitons Katharina tunicata and Tonicella lineata were important grazers throughout this zone with young specimens of the green sea urchin Strongylocentrotus droebachiensis becoming increasingly common at lower levels. Major predators included the six-rayed starfish (Leptasterias ?hexactis) and the muricid snail Nucella lamellosa.

From near MLLW, the Alaria thinned sharply leaving as the dominants several species, especially O. floccosa, that had occurred largely in understory roles at higher levels. Below this relatively narrow zone the larger laminarians, especially Laminaria groenlandica, assumed a dominance that persisted well into the subtidal zone. The larger starfish predators such as Evasterias troschelii were much more abundant at this lowest intertidal zone and limited survival of mussels and barnacles.

Levels marked by fixed pins (+3.8 to 0.0 m MLLW) on the Gull Island transect were sampled five times in both 1977 (February 15, May 2 and 3, June 29 and 30, August 27 and 30, October 13) and 1978 (March 8, May 22 and 23, June 19, July 18, October 15). Sampling was in accordance with procedures described in Section 3.1.1 and 3.1.2. These data constitute a continuation of some types of data that were reported by Dames & Moore (1976) in their 1974 to 1976 studies. Thus, they permit examination of long-term fluctuations in distribution and abundance of some important species.

Density of faunal dominants at the various tide levels are given in Tables 4-1 and 4-2 while complete distribution data for all species are contained in Appendix Tables

FIGURE 4-1

ATTACHMENT BY THE KELP <u>ALARIA CRISPA</u>
TO THE THATCHED BARNACLE <u>BALANUS CARIOSUS</u>

TABLE 4-1

GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS, 1977

Level/Species	Date/Average Percent Cover or No./m²				
	2/16/77	5/23/77	6/27-30/77	8/27-30/77	10/13/77
3.8 m					
(% Cover)					
Balanus cariosus	0	2.9	4.4	2.8	12.4
Balanus glandula	36.7	20.0	21.7	37.0	61.4[a]
Mytilus edulis	21.7	27.1	19.7	24.0	24.0
(#/m²)					
Acmaeidae	48.0	76.4	276.0	238.4	192.0
Katharina tunicata	17.2	0	0	0	0
Littorina sitkana	P[b]	P	P	P	P
Nemertea	0	1.2	P	0	5.6[c]
Siphonaria thersites	0	0	4.8	0	0.8
1.5 m					
(% Cover)					
Balanus cariosus	14.6	31.0	22.1	33.0	41.0
Chthamalus dalli	4.5	0	3.4	2.7	17.0
Mytilus edulis	18.2	5.4	10.0	0.2	6.4
Rynchozoon bispinosum	1.2	0	2.5	1.2	0
(#/m²)					
Acmaeidae[f]	7.0	5.6	42.0	112.0	132.8
Katharina tunicata	0	9.6	47.4	66.4	37.6
Leptasterias ?hexactis	6.5	2.4	21.1	21.6	21.6
Metridium senile[e]	0	0	17.1	52.0	28.0
Schizoplax brandtii	0	3.2	16.0	48.8	21.6
Siphonaria thersites	0	48.8	55.3	68.8	117.6
Tealia spp.[d]	8.4	0	0.6	1.6	0.8
0.5 m					
(% Cover)					
Balanus cariosus	4.1	3.2	4.2	26.2	16.0
Chthamalus dalli	0.7	0	2.3	0.8	3.4
Halichondria panicea	12.7	6.0	12.5	7.1	0.8
Mytilus edulis[a]	0	0	6.7	15.8	18.6
(#/m²)					
Acmaeidae	0	218.0	75.0	241.6	354.4
Evasterias troschelii	1.6	1.6	0	0	0.8
Katharina tunicata	35.5	31.2	28.5	32.8	42.4
Leptasterias ?hexactis	2.4	12.0	1.5	0.8	14.4
Metridium spp.	0	3.2	2.5	21.6	32.8
Nemertea	0	9	1.0	0	2.4
Schizoplax brandtii	0	44.0	22.5	23.2	88.0
Strongylocentrotus drobachiensis	6.4	16.0	14.5	1.6	14.4
Tealia spp.	5.6	0.8	1.5	0	0.8
Tonicella lineata	15.5	12.8	11.0	5.2	19.2

(a) Adults and juveniles combined.
(b) P = present.
(c) Unidentified sp. and *Emplectonema* sp. combined.
(d) Includes *T. crassicornis* and *Tealia* sp. (juveniles).
(e) Includes *M. senile* and *Metridium* sp. (juveniles).
(f) Includes all *Notoacmaea* and *Collisella* spp.

TABLE 4-1

Level/Species	2/16/77	5/23/77	6/27-30/77	8/27-30/77	10/13/77
	Date/Average Percent Cover or No./m^2				
0.2 m					
(% Cover)					
Balanus cariosus	P	0	0	1.4	8.2
Chthamalus dalli	0	0	5.3	0.5	0.4
Halichondria panicea	6.4	0	0	0.4	0
Hydrozoa(g)	1.6	2.0	0.8	0.3	5.8
Mytilus edulis	0	0	2.5	8.5	3.2
Rynchozoon bispinosum	P	0	1.4	0.3	0
(#/m^2)					
Acmaeidae	0	49.6	161.2	192.0	146.4
Anthozoa-unidentified	0	14.4	6.0	0	0
Cancer sp.(h)	0	0	3.2	0	0.8
Katharina tunicata	37.6	29.6	36.0	44.8	42.4
Leptasterias ?hexactis	1.2	0	3.3	0.8	0.8
Metridium spp.	0	1.6	63.3	46.4	57.6
Mopalia ciliata	3.6	0	1.3	1.6	1.6
Schizoplax brandtii	0	0.8	13.3	13.6	14.4
Siphonaria thersites	0	0.8	0	0	14.0
Strongylocentrotus drobachiensis	40.0	15.2	17.3	9.6	73.6
Tealia spp.	1.2	4.0	2.7	4.0	9.6
Tonicella lineata	22.4	7.2	22.0	27.2	32.0
0.0 m					
(% Cover)					
Balanus cariosus	0	0	0	0.2	9.1
Hydrozoa(g)	0.8	6.0	11.4	0.7	2.6
Mytilus edulis	0	P	18.4	36.8	18.8
Ritterella ?pulchra	0	3.7	5.4	5.7	0
(#/m^2)					
Acmaeidae	27.2	16.0	26.4	83.2	102.0
Anthozoa-unidentified	57.6	5.2	1.6	0	0
Cancer spp.	0	1.2	0	0	4.0
Crucigera zygophora	0	28.0	0.8	9.0	0
Evasterias troschelii	0	4.0	1.6	0	2.0
Katharina tunicata	39.2	8.0	31.2	38.4	30.0
Leptasterias ?hexactis	0	0	8.8	2.4	6.0
Metridium spp.	0	0	0	236.0	8.0
Mopalia ciliata	0	10.8	11.2	12.8	6.0
Nucella lamellosa	0	2.8	1.6	4.0	0
Paguridae	3.2	0	7.2	1.6	0
Pugettia gracilis	0	0	0.8	8.0	0
Schizoplax brandtii	0	4.0	3.2	0.8	20.0
Serpulidae	160.0	P	15.2	P	P
Strongylocentrotus drobachiensis	38.4	25.2	64.0	76.0	11.0
Tealia spp.	1.6	2.8	9.6	8.8	7.0
Tonicella lineata	26.4	62.8	53.6	54.4	8.0

(g) Includes all species.
(h) Includes Cancer sp. and C. oregonensis.

TABLE 4-2

GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS, 1978

Level/Species	Date/Average Percent Cover or No./m^2 3/8/78	5/23-24/78	6/19/78	7/18/78	10/15/78
3.8 m					
(% Cover)					
Balanus cariosus	1.2	24.0	3.2	3.5	2.7
Balanus glandula	44.2	0.3	33.8	44.4	49.0
Chthamalus dalli	1.3	2.0	0.7	1.1	0.5
Mytilus edulis	24.5	33.6	29.0	35.0	42.0
(#/m^2)					
Acmaeidae	170.8	300.0	277.6	256.0	221.0
Leptasterias ?hexactis	0	0	0	0	1.2
Littorina sitkana	P[a]	P	P	P	P
Nemertea[b]	1.3	0.3	0.6	2.7	5.6
Siphonaria thersites	0	0	13.1	8.0	0.8
1.5 m					
(% Cover)					
Balanus cariosus	30.3	28.4	33.3	33.3	52.5
Balanus glandula	0.4	0	1.2	5.5	9.6
Chthamalus dalli	9.3	18.6	12.5	14.3	8.7
Mytilus edulis	30.8	4.3	8.5	6.2	13.2
(#/m^2)					
Acmaeidae	160.7	400	429.3	298.0	24.0
Anthopleura artemisia	0	3.2	2.7	2	0
Cucumaria spp.	0	4	54	12.8	1.3
Katharina tunicata	5.3	13.6	19.3	11.3	13.3
Leptasterias ?hexactis	6	19.3	13.3	9.3	16.7
Metridium senile	18	40.8	57.3	108.3	14.7
Onchidella borealis	0	0	6.0	0.7	2.7
Schizoplax brandtii	0.7	7.2	10.0	0.7	8.7
Siphonaria thersites	6	99.2	240.7	28.0	21.3
0.5 m					
(% Cover)					
Balanus cariosus	15.2	40.0	59.2	61.7	66.2
Chthamalus dalli	1.0	4.7	0.9	0.8	0.8
Mytilus edulis	15.2	30.8	64.2	70.0	55.2
(#/m^2)					
Acmaeidae	253.4	637.3	612.0	448.0	302.0
Anthopleura artemisia	0.7	2.0	2.7	0.7	0
Easterias troschelii	0	1.3	0	0	1.3
Ischnochiton ?albus	10	0	0		
Katharina tunicata	27.3	48	10.0	14.0	28.0
Leptasterias ?hexactis	16.7	54.0	61.3	22.0	36.7
Metridium senile	11.3	6.7	12.3	6.0	40.0
Nemertea[b]	0	1.3	10.6	4.1	0
Nucella lamellosa	0	1.3	0	0	0.7
Onchidoris bilamellata	2.7	0.7	0	0	7.3
Schizoplax brandtii	5.3	18.7	11.3	2.3	2.0
Strongylocentrotus drobachiensis	2	4.7	0.7	0	3.3
Tonicella lineata	8.7	4	2.0	0.7	4.0

(a) P = present.
(b) Includes all species.

TABLE 4-2

Level/Species	Date/Average Percent Cover or No./m^2				
	3/8/78	5/23-24/78	6/19/78	7/18/78	10/15/78
0.2 m					
(% Cover)					
Balanus cariosus	16.1	9.7	7.6	37.0	27.5
Balanus glandula	0.1	0.2	3.0	1.4	0.2
Chthamalus dalli	1.5	4.0	1.1	3.1	0.8
Mytilus edulis	11.5	16.0	25.0	32.5	51.7
Spirorbinae	P	2.8	0.9	1.7	0.4
(#/m^2)					
Acmaeidae	407.3	595.3	888.8	753.3	404.0
Anthopleura artemisia	0.7	0	0.8	3.3	1.3
Evasterias troschelii	0	0	0.8	3.3	22.0
Ischnochiton ?albus	93	0.7	0	0	0
Katharina tunicata	36.7	44.7	26.4	20.0	22.0
Leptasterias ?hexactis	15.3	20.7	15.2	8.0	6.7
Metridium senile	21.3	22.0	65.6	51.3	24.7
Mopalia ciliata	0.7	2.0	0.8	0	1.3
Nucella lamellosa	0	1.3	4.0	1.3	0.7
Onchidoris bilamellata	2.0	0.7	0	0	5.3
Schizoplax brandtii	10.7	20.0	17.6	9.3	4.0
Strongylocentrotus drobachiensis	34.7	35.3	16.0	7.3	6.0
Tealia crassicornis	2	2.0	1.6	0	0.7
Tonicella lineata	16.7	14.7	24.8	21.3	20.0
0.0 m					
(% Cover)					
Balanus cariosus	0	2.9	3.3	1.8	0
Hydrozoa(b)	P	4.8	3.3	5.6	2.0
Mytilus edulis	31.0	17.3	37.5	20.5	44.5
Serpulidae	P	0	2.0	0	0.3
Spirorbinae	P	P	1.0	7.0	6.8
(#/m^2)					
Acmaeidae	2.4	200.7	117.0	73.3	190.0
Cancer oregonensis	0	0	2.0	2.7	8.0
Crucigera zygophora	0	0	P	24.0	22.7
Easterias troschelii	2	42	14.0	64.7	39.3
Katharina tunicata	27.3	50	66.0	44.0	36.0
Leptasterias ?hexactis	18	7.7	8.0	2.6	1.3
Metridium spp.	168.7	308.7	0	392.7	278.7
Mopalia ciliata	6.7	0	11.0	14.7	12.0
Nemertea(b)	0	2.7	0	3.3	17.3
Nucella lamellosa	0	4.7	7.0	12.6	0
Ritterella ?pulchra	0	15.3	0	0	
Schizoplax brandtii	0	4.7	11.0	0	2.0
Strongylocentrotus drobachiensis	23.3	36.7	19.0	21.3	20.0
Tonicella lineata	33.3	44.7	60.0	84.0	56.0

+3.8 m, the "Fucus - Odonthalia" Zone

Algal sampling during 1977 and 1978 served to quantify the dominance of this level by the brown rockweed Fucus and the red Odonthalia floccosa,* at least during the period from fall through early spring (Figures 4-2 and 4-3**). During the period from late spring through the summer, however, standing crop of Halosaccion glandiforme increased to exceed that of Odonthalia in June of 1977 and all species in May through July of 1978. Peak cover and biomass of Halosaccion occurred in June in both years. Late summer decay of Halosaccion and continued health of Fucus caused Fucus to heavily dominate algal biomass in late summer of 1977. Peak biomass of Fucus (1,516 g/m^2) and of all algae at this level (1,720 g/m^2) occurred during August of 1977.

The acorn barnacle Balanus glandula was codominant in the use of the primary space (rock surface) at this level with mean coverage as high as 61.4 percent in October 1977 (Table 4-1). Lowest coverage (0.3 percent) in May 1978 (Table 4-2) was probably due in part to altered positioning of the transverse sampling line (at a lower contour) since there was a corresponding increase in coverage of the thatched barnacle B. cariosus. This latter species was typically subdominant to B. glandula at this level, preferring moist pockets and the shaded north side of the island. The bay mussel Mytilus edulis was the other major dominant in terms of occupation of primary space at +3.8 m with mean coverage ranging from a low of 19.7 percent (June 1977) to a high of 42.0 percent (October 1978).

Gastropod grazers (limpets, littorines, pulmonates) were the most abundant motile organisms at the +3.8-m level. The limpets (Notoacmaea, Collisella) were extremely abundant with densities of up to 300 per m^2 (all sizes included). The sharp jump in counts from May to June 1977 (Table 4-1) was due to inclusion in the latter and in subsequent counts of all sizes of limpets down to 1- to 2-mm juveniles. Recruitment of limpets apparently occurs in early summer (e.g. Table 4-2) with a gradual

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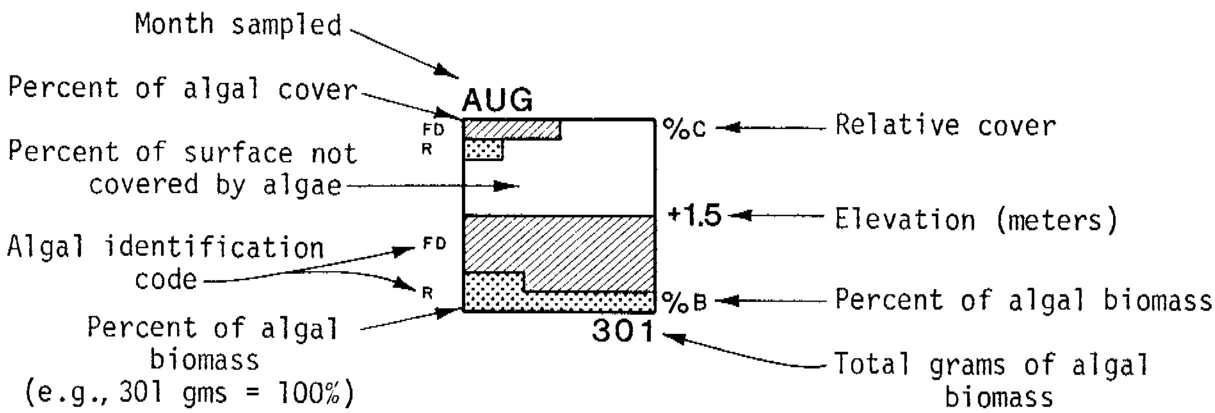
* Odonthalia at this level was inseparably mixed with varying amounts of Rhodomela larix and all numbers reported include both species.

** See Table 4-3 for key to abbreviations in Figures 4-2 and 4-3.

KEY TO FIGURES 4-2, 4-3, 4-4, AND 4-5



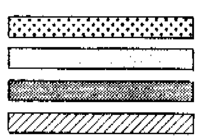
Each ☐ = 2 percent; each full column = 20 percent

In the example FD cover = 10 percent; biomass = 74 percent

R cover = 4 percent; biomass = 26 percent

In some instances, percent cover exceeded 100 because of species layering; this is indicated by expanding the boundaries of the percent cover box.

Major taxa indicated as follows:



= fleshy Rhodophyta
= coralline Rhodophyta
= Chlorophyta
= Phaeophyta

Note: On Figure 4-3 each ☐ = 1 percent cover and each full column = 10 percent; biomass was not measured.

TABLE 4-3

ALGAL IDENTIFICATION CODES

A	*Alaria crispa*
AC	*Agarum cribrosum*
AF	*Alaria fistulosa*
ART	Articulating corallines
AT	*Alaria taeniata*
CD	*Cladophora* spp.
CHL	Miscellaneous Chlorophyta
CO	Corallines (encrusting and articulating)
CR	*Codium ritteri*
CY	*Cymathere triplicata*
E	*Endocladia muricata*
EC	Encrusting corallines
F	*Fucus distichus*
G	*Gigartina* spp.
HG	*Halosaccion glandiforme*
HI	*Hildenbrandia* sp.
HS	*Hedophyllum sessile*
LJ	*Laminaria* spp. juveniles
LG	*Laminaria groenlandica*
M	*Monostroma* spp.
NL	*Nereocystis luetkeana*
OF	*Odonthalia floccosa*
OL	*Odonthalia lyalli*
O/R	*O. floccosa* and *Rhodomela larix*
PF	*Petalonia fascia*
PH	Miscellaneous Phaeophyta
POR	*Porphyra* spp.
PT	*Pterosiphonia* sp.
R	Miscellaneous Rhodophyta
RH	*Rhodymenia palmata*
RL	*Rhodymenia liniformis*
RP	*Ralfsia pacifica*
RX	*Rhodomela larix*
SC	*Scytosiphon lomentaria*
SCH	?*Schizymenia*
SO	*Soranthera ulvoidea*
SP	*Spongomorpha* spp.

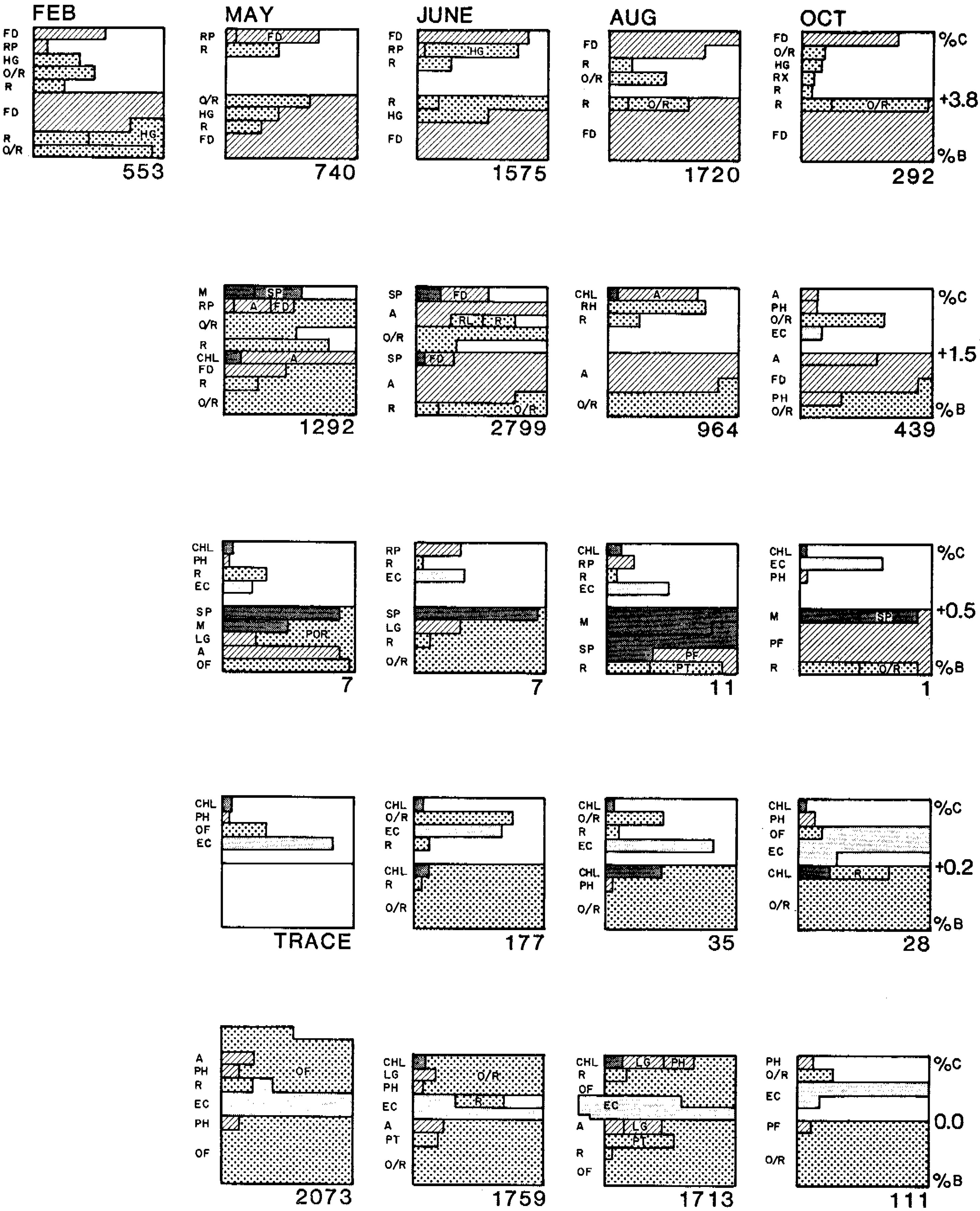


FIGURE 4-2

ZONATION, COVER AND BIOMASS OF ALGAE AT GULL ISLAND IN 1977

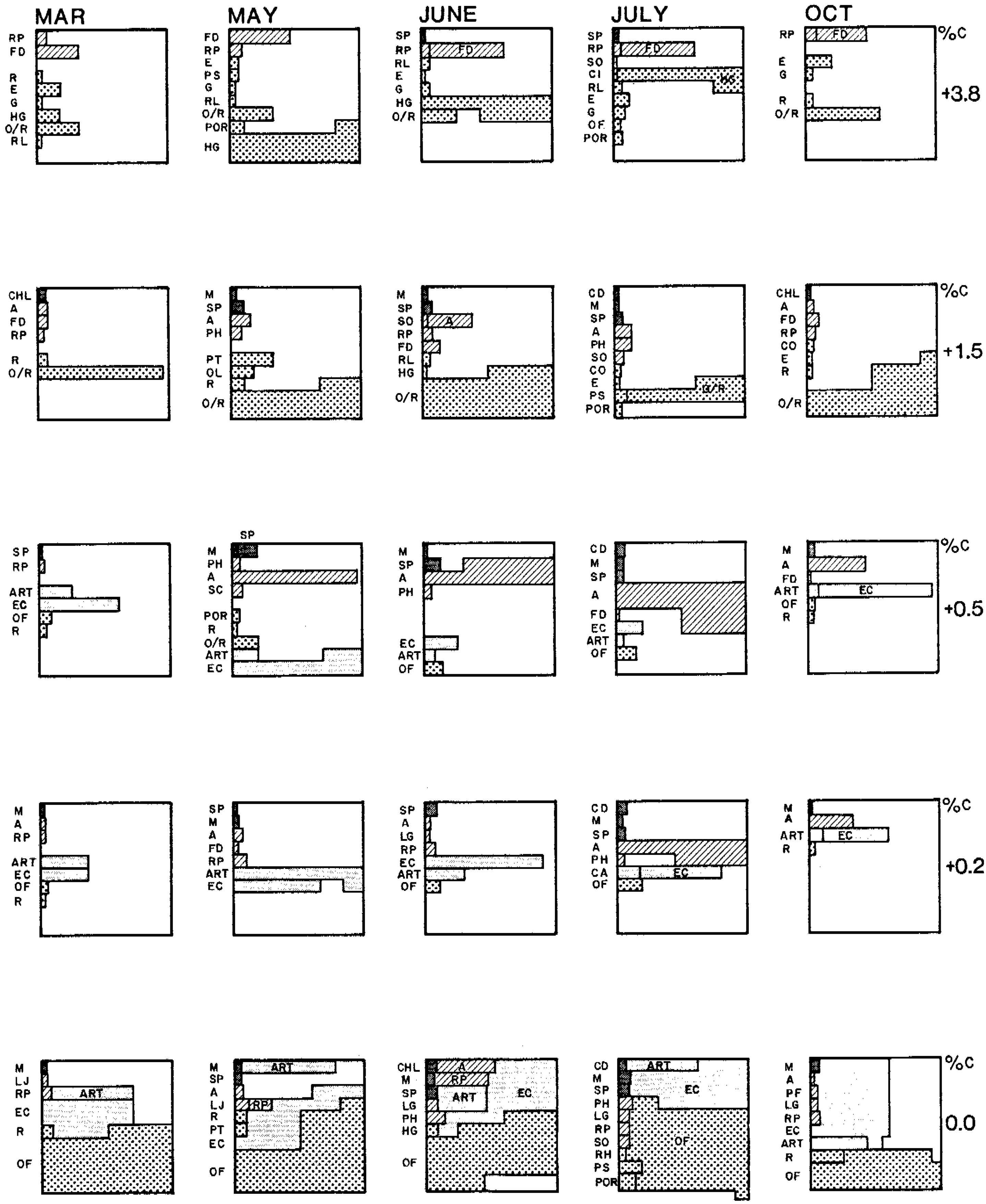


FIGURE 4-3

ZONATION AND COVER OF ALGAE AT GULL ISLAND IN 1978 decline in numbers by late summer continuing through the following spring. The periwinkle Littorina sitkana was also present in great number but was not counted. The pulmonate Siphonaria thersites was common (13.1 per m^2 in June 1978) in summer and fall, following June recruitment, but was absent during the winter and spring.

Predatory nemerteans, primarily Emplectonema ?gracile were the major representatives of higher trophic levels present. Their numbers tended to increase somewhat in late fall and winter, a period of apparent breeding activity.

+1.5 m, the "Alaria" Zone

This level, still on the sloping upper portion of "Gorilla Rock," lies within the broad "Alaria" zone described from the 1974 to 1976 studies (Dames & Moore 1976). Alaria crispa* did, in fact, grow rapidly from a few juveniles present in February 1977 to a position of dominance during June (25 percent cover; 1,951 g/m^2). However, by August Alaria cover had declined to 12.1 percent and biomass had dropped to 527.5 g/m^2. This decline in Alaria continued at this level with only a slight resurgence (to 3 percent cover) in early summer of 1978 (Figures 4-2, 4-3). In previous years, midsummer coverage of Alaria had ranged from 30 to 90 percent in this area (Dames & Moore 1976).

In 1978, as in previous years, the red algal turf of O. floccosa and Rhodomela larix was a dominant assemblage and better developed during the fall to spring period (Tables 4-4, 4-5). However, throughout 1978, these reds maintained a clear dominance over all other algae. Fucus was present in small amounts during most of 1977-1978 but achieved co-dominance with the reds only in fall of 1977, following the late summer decline in Alaria.

The thatched barnacle B. cariosus was more abundant at this level than at +3.8 m and ranked high in coverage among sessile fauna (14.6 to 52.5 percent, Tables 4-1, 4-2). During the winter months (e.g. February

* Called A. ?praelonga in Dames & Moore (1976).

TABLE 4-4

GULL ISLAND ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1977

	Level									
	3.8 m		1.5 m		0.5 m		0.2 m		0.0 m	
Month/Class	%	gm/m^2	%	gm/m^2	%	gm/m^2	%	gm/m^2	%	gm/m^2
February										
Chlorophyta	0	0	--		--		--		--	
Phaeophyta	13.7	206.4	--		--		--		--	
Rhodophyta										
encrusting	0	0	--		--		--		--	
other	21.2	346.0	--		--		--		--	
Total	34.9	552.4	--		--		--		--	
May										
Chlorophyta	0.3	2.9	11.5	32.8	1.6	1.8	1.1	0	0.4	0.1
Phaeophyta	14.4	537.4	10.2	229.2	1.1	1.7	1.4	0	8.5	65.3
Rhodophyta										
encrusting	0	--	0	--	3.1	--	14.8	--	25.0	--
other	8.0	199.8	66.9	1,029.8	3.4	3.7	9.7	--	99.1	2,012.0
Total	22.7	740.1	88.6	1,291.8	9.2	7.2	27.0	0	133.0	2,077.4
June										
Chlorophyta	0.3	1.2	3.8	37.7	0.5	1.4	1.3	4.3	1.8	13.3
Phaeophyta	18.0	1,048.7	32.8	2,087.0	7.3	0.5	15.7	0.1	7.7	83.4
Rhodophyta										
encrusting	0	--	0.5	--	5.9	--	9.8	--	21.0	--
other	21.1	525.2	36.5	674.4	2.5	5.5	6.2	172.9	63.3	1,662.3
Total	39.4	1,575.1	73.6	2,799.1	16.2	7.4	33.0	177.3	93.8	1,759.0
August										
Chlorophyta	0.3	3.4	1.3	1.9	2.0	7.3	1.3	3.0	3.0	14.0
Phaeophyta	34.4	1,516.3	13.6	527.6	4.7	1.8	9.6	0.5	10.8	161.5
Rhodophyta										
encrusting	0	--	0.2	--	7.4	--	11.2	--	32.0	--
other	12.1	200.5	18.8	434.5	3.8	1.8	6.8	31.8	61.7	1,537.8
Total	46.8	1,720.2	33.9	964.0	17.9	10.9	28.9	35.3	107.5	1,713.3
October										
Chlorophyta	0.1	--	0.4	--	0.8	0.2	0.7	1.4	0.5	0.6
Phaeophyta	14.6	237.1	4.5	255.2	0.8	0.7	2.5	0	2.6	2.3
Rhodophyta										
encrusting	0	--	2.7	--	9.8	--	31.0	--	18.0	--
other	10.3	57.8	13.4	183.5	3.1	0.2	16.3	26.5	11.8	107.8
Total	25.0	294.9	21.0	338.7	14.5	1.1	50.5	27.9	32.9	110.7

TABLE 4-5

GULL ISLAND ALGAL COVER (PERCENT) BY MAJOR TAXON, 1978

Month/Taxon	Tide Level +3.8 m	+1.5 m	+0.5 m	+0.2 m	0.0 m
March					
Chlorophyta	0	0.4	0.1	0.1	0.1
Rhodophyta					
encrusting	0	0	6.4	3.6	18.7
other	7.3	10.0	3.5	4.0	52.0
Phaeophyta	3.8	1.2	0.2	0.3	1.0
Total	11.1	11.6	9.9	7.9	71.8
May					
Chlorophyta	0	1.0	1.8	0.5	0.6
Rhodophyta					
encrusting	0	0.4	13.0	11.5	23.5
other	27.3	28.4	4.3	6.8	55.3
Phaeophyta	5.1	2.1	10.9	1.2	3.1
Total	32.4	31.9	30.0	20.0	82.5
June					
Chlorophyta	0.2	0.7	2.1	0.5	1.1
Rhodophyta					
encrusting	0	0	2.4	9.0	26.3
other	19.8	35.7	2.1	3.8	55.0
Phaeophyta	6.3	5.6	17.5	0.7	9.8
Total	26.3	42.0	24.1	14.0	92.2
July					
Chlorophyta	0.3	0.7	1.0	1.0	1.6
Rhodophyta					
encrusting	0	0.1	1.9	6.3	29.2
other	15.6	14.2	1.7	3.5	67.2
Phaeophyta	6.3	3.3	30.1	16.4	2.8
Total	22.2	18.3	34.7	26.2	100.8
October					
Chlorophyta	0	0.1	0.3	0.1	0.4
Rhodophyta					
encrusting	0	0.3	8.7	5.1	35.8
other	8.7	31.8	1.9	1.2	35.9
Phaeophyta	4.6	2.0	4.5	3.3	1.3
Total	13.3	34.3	15.4	9.7	73.4

1977, March 1978) however, coverage by the blue mussel Mytilus edulis was greater. Another barnacle Chthamalus dalli was a major subdominant (0 to 18.6 percent cover) along with B. glandula which increased from near 0 to about 9.6 percent cover during the last half of 1978.

As at the higher level, the gastropod grazers were especially important at this level, maintaining a strong numerical dominance among mobile fauna. Limpets were again the most abundant (to 429.3 per m^2) with density fluctuations paralleling those described at the +3.8-m level. The large chiton Katharina tunicata was also an important grazer with densities reaching 66.4 per m^2 in August 1977. A smaller chiton Schizoplax brandtii was also among the dominants with peak density of 48.8/m^2, also in August 1977. The final grazer of importance was the pulmonate Siphonaria thersites. This species, like the limpets, apparently recruits during early summer, reaching a peak density of 240.7 per m^2 in June 1978.

Several sea anemone species were also abundant at the +1.5-m level. Metridium senile reached a density of 108.3 per m^2 following successful recruitment in two successive summers while Tealia and Anthopleura artemisia were considerably less abundant. The starfish Leptasterias, a predator on small barnacles and mussels, was moderately abundant (to 21.6 per m^2) except during the winter surveys when its cryptic coloration and habits may have combined with poor lighting to bias counts.

+0.5 m and +0.2 m, the Rocky Bench

The two levels sampled on the rocky bench of "Gorilla Rock" lay in an area that, in the summers of 1974 through 1976, was virtually covered (25 to 100 percent) by a dense mat of Alaria crispa attached to B. cariosus shells (Dames & Moore 1976). Sometime prior to the sampling in February 1977, a major change occurred that affected the community structure throughout the remainder of the study. The coverage of barnacles on the bench (mostly B. cariosus) declined to near zero in the spring of 1977. At this time, there was almost a total absence of Alaria

(Table 4-1, Figures 4-2 and 4-3). New set of B. cariosus spat occurred during 1977 and, with rapid growth, accounted for 26 percent cover at +0.5 m by late August 1977. Balanus cariosus density continued to increase through 1978 (to 66 percent cover, Table 4-2) at the +0.5-m level. At the +0.2-m level starfish predation reduced coverage during early summer of 1978, but August cover was 37 percent (Table 4-2). A partial recovery of Alaria populations was associated with this recurrence of B. cariosus as coverage reached 30 percent at the +0.5-m level and 15.5 percent at the +0.2-m level in July.

Other algae were generally of little importance on the bench except for encrusting and articulating corallines which covered up to 30 percent of the rock surface in some areas (+0.2 m in October 1977, Table 4-4). The corallines occurred mainly in tidal channels, pools, and small pockets retaining water during emersion. Odonthalia floccosa was also common.

In addition to B. cariosus, the major sessile invertebrate on this bench was the mussel (M. edulis). Like the barnacles the mussels were virtually absent in the winter of 1976-77 but expanded their coverage later in 1977 (to 18.6 percent at +0.5 m) following a heavy set in early summer. During 1978 mussel coverage continued to increase on the bench (to 70 percent at +0.5 in July) despite heavy predation by starfish and snails.

Another sessile form, the sponge Halichondria panicea which, in association with B. cariosus, had been a notable member of the community under the Alaria canopy in earlier years, declined rapidly on the bench during the spring of 1977 and was virtually absent throughout the remainder of the study. This was probably a result of desiccation caused by lack of the protective shading by Alaria and loss of the protection from predation provided by the heavy stand of adult B. cariosus.

The species comprising the remainder of the community on the bench were similar to those in the "Alaria zone" at +1.5 m. Grazers were abundant; dominants included acmaeids (to 888/m^2) and the chitons

Katharina (to $66/m^2$), Tonicella lineata (to $62.8/m^2$), and Schizoplax brandtii (to $88/m^2$). The sea urchin Strongylocentrotus droebachiensis was also abundant in tidal channels and pools, especially at +0.2 m where peak densities of $26/m^2$ were reached in August 1977.

Density of the starfish Leptasterias increased significantly (all comparisons) between 1977 and 1978 (mean density at both levels: 3.4 in 1977; 25.7 in 1978), probably in response to increased availability of barnacle and mussel food items. The larger asteroid Evasterias troschelii was also present in much lower densities during sampling but probably moved on to the bench to feed during periods of inundation. Another predator on barnacles and mussels, the snail Nucella, was absent at both the 0.5- and 0.2-m levels in 1977, but became increasingly abundant (to $4/m^2$) at both levels in 1978. The increase in abundance of small Balanus and Mytilus, more suitable for predation, probably accounts to a large degree for the increased density of Leptasterias and Nucella at these levels. Anemones, primarily Tealia spp. and Metridium senile, were very common from the summer of 1977 on.

0.0 m, the "Odonthalia" Zone

The slopes of the relatively flat rock bench break steeply downward at about MLLW (Figure 2-2) marking a sharp break in biological assemblages. In the 1974-76 studies this break marked the lower edge of the Alaria zone. In 1977 and 1978, however, it was better characterized by the contrast between a thick growth of red algae and the relatively barren bench surface. Red algae, dominated by O. floccosa (to 75 percent), were by far the most abundant group of erect algae (Figures 4-2 and 4-3), while encrusting and articulating corallines covered much of the rock surface under the Odonthalia canopy. Smaller brown algae (juvenile Laminaria groenlandica, Petalonia fascia) were often common, but few adults of the larger species (L. groenlandica) survived at this level despite the relatively low degree of desiccation experienced.

Animals occupied a minor percentage of the primary substrate at this level. The hydroids Abietinaria turgida and the barnacle B. cariosus, combined for up to about 12 percent cover at times, while tunicates (e.g., Ritterella ?pulchra) and serpulid worms (e.g., Crucigera zygophora, Spirobinae) were less important (Tables 4-1 and 4-2). Mussels set heavily on the fronds of O. floccosa during the spring of 1977 and maintained from 17 to 44.5 percent cover subsequently. In terms of Mytilus biomass and relative cover, growth of individuals overrode the effects of mortalities due to predation and other causes. The anemones, including Metridium (to 392.7/m^2) and Tealia (to 9.5/m^2), were also abundant and occasionally occupied a significant amount of primary space.

Grazing pressure appeared intense. Four species of chitons, lead by K. tunicata (to 66/m^2) and T. lineata (to 84/m^2), limpets (to 200/m^2), and sea urchins (to 76/m^2) were the dominant grazers.

Two species of starfish (L. ?hexactis (to 18/m^2) and E. troschelii (to 64/m^2) were common at this level, probably exploiting primarily the recent set of mussels. Scavengers or omnivores occasionally seen at this level were the brachyurans, Cancer oregonensis (to 8.0/m^2) and Pugettia gracilis (to 8.0/m^2).

4.1.2 Seldovia Point

General ecological features of Seldovia Point intertidal and subtidal communities have been described by Dames & Moore (1976) based on the 1974 to 1976 studies. These characteristics are summarized here.

The uppermost edge of the macrophyte zone began at about +4 m or above depending on the exposure with patches of the rockweed Fucus distichus, and occasional tufts of Endocladia muricata. Vast numbers of the periwinkle Littorina sitkana were often present grazing on periphyton and Fucus. Acorn barnacles (Balanus glandula) were abundant along with a major predator on them, the snail Nucella sp.

At lower levels, Fucus was joined by increasing amounts of red algae including Halosaccion glandiforme, Rhodymenia spp.* and Gigartina papillata. Barnacles were joined by the mussel, Mytilus edulis, as a major occupant of primary space. The limpets, Collisella and Notoacmaea, were the most abundant grazers.

Below about +2.0 m the reds were clearly dominant to about the +1.5-m level or below. In this broad zone, seasonally dominated by the brown alga Alaria taeniata, occupied much of the boulder beach to near MLLW. The reds from the upper level were found as understory species in this area along with encrusting corallines in the wetter areas. Surge, or drainage, channels and permanently wetted areas had dense growths of the laminarian Hedophyllum sessile. The thatched barnacle B. cariosus was abundant throughout the Alaria zone and extended to below MLLW.

Several herbivores were conspicuous in this area. Limpets and the large chiton Katharina tunicata were found throughout, while the green urchin Strongylocentrotus droebachiensis occurred primarily in lower areas. A sharp reduction in algal cover and biomass occurred throughout this zone in fall and winter as the result of low light levels, damage from exposure during low tides, heavy seas, and possibly, intense herbivory. The six-ray starfish Leptasterias ?hexactis was an important predator on barnacles, mussels, and snails throughout the area. Under boulders in this area, typical assemblage included large numbers of a small sea cucumber, Cucumaria ?vegae, the isopods Gnorimosphaeroma oregonensis, Pentidothea wosnesenskii, gammarid amphipods, urchins, a predatory snail Volutharpa ampulacea, periwinkles, limpets, a sipunculid worm Golfingia margaritacea, and Leptasterias.

Near and below MLLW, A. taeniata gave way to A. fistulosa and Laminaria groenlandica, typically subtidal forms. The opportunistic green alga Monostroma covered substantial areas of the bench in the

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* Includes R. liniformis, called Callophyllis in Dames & Moore (1976), and R. palmata.

vicinity of MLLW and, along with Alaria, was a common food of the urchins. Large areas devoid of significant macroalgae attested to the efficiency of urchin herbivory. Other important herbivores included the limpets and chitons seen farther up the beach as well as the lined chiton, Tonicella lineata, a micro-grazer often found in association with crustose corallines.

From below MLLW to past the 18-m contour, lay an extensive multi-layered kelp bed. The floating canopy consisted of the bull kelp Nereocystis luetkeana and A. fistulosa. Under this were intermediate layers of L. groenlandica and the "sieve kelp" Agarum cribrosum, and a lower layer of foliose red algae such as Turnerella mertensiana,* Kallymenia and Callophyllis sp. On the substrate beneath these macroalgae were cushion-like patches of Codium ritteri and the encrusting corallines. This subtidal algal assemblage also experienced high seasonality with a major reduction in areal coverage in the fall and early winter. New growth began in early spring. Macroinvertebrates were common with echinoderms (urchins and starfish) among the most obvious forms.

Intertidal sampling was carried out four times (February 16, May 5 and 6, July 2 and 3, August 28 and 29) at four levels (+2.0, +1.5, +0.8, 0.0 m) on Seldovia Point during 1977 and five times (March 7, May 26, June 20, July 19, and October 19) at three levels (+2, +1.5, 0.0 m) during 1978. Subtidal sampling was conducted in five periods (February 10 and 12; May 10, 11, and 13; August 4 and 5; September 13; November 2 and 5) at three depths (6, 12, and 18 m) in 1977, and in three periods (June 1, 2, and 29; July 11 and 12, October 30 and 31; November 8) at three depths (-6, 9, and 12 m) in 1978. Sampling was in accordance with procedures described in Sections 3.1.1 and 3.1.2.

+2 m, the "Fucus" Zone

The upper level sampled during 1977-78 (+2.0 m) was in an area of large (0.3 to 2 m) boulders interspersed with areas of less stable

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* Includes forms called ?Schizymenia in Dames & Moore (1976).

cobbles and gravel. This variability in substrate was reflected in a high degree of patchiness in organism distributions. Moderate development of benthic species occurred on stable rock surfaces clear of gravel abrasion while few organisms were found in the finer materials unless the substrate was stabilized by proximity to larger boulders (e.g., under rock fauna).*

The dominant alga at the +2.0-m level was the rockweed F. distichus. This species showed a moderately strong seasonal pattern with a steady increase in coverage through the spring and early summer. Peak standing crop was reached in July in both 1977 (30.8 percent, 2,934 g/m^2) and 1978 (23.8 percent, 1,466 g/m^2) with a minimum value of 9 percent cover and 249 g/m^2 recorded in March 1978 (Figures 4-4 and 4-5, Appendix Tables 4-2-1 through 4-2-11). A variety of red algae, especially H. glandiforme, R. liniformis, and the opportunistic Porphyra sp. were also present, especially in the summer, but only exceeded 10 percent total coverage in June and July. Biomass contribution of red algae at this level was small to insignificant.

Sessile epifauna was very sparse at the +2.0-m level. Fairly dense barnacle cover (19.8 percent) was present in February 1977, but declined to less than 1 percent by late summer, remaining low throughout 1978 (Tables 4-6 and 4-7). Average cover of the mussel M. edulis was less than 2.6 percent throughout the study period. New set and growth of the small barnacle Chthamalus dalli covered up to 3.8 percent (July 1978) of the primary substrate.

Moreover, relatively few species of motile invertebrates were found at +2 m (Figure 4-6), and the only species present in large numbers were periwinkles (1,686/m^2, only counted in February 1977), the limpets (to 109/m^2), and the pulmonate Siphonaria thersites (to 61.2/m^2). All of these species are primarily grazers on the microflora coating rocks and

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* Sampling conventions adopted did not include counting of under-rock fauna or infauna unless they were visible without moving any substrate materials.

TABLE 4-6

SELDOVIA POINT INTERTIDAL INVERTEBRATE DOMINANTS, 1977

Level/Species	Date/Average Percent Cover or No./m²			
	2/16/77	5/5-6/77	7/2-3/77	8/28-29/77
+2 m				
(% Cover)				
Balanus glandula	19.8	2.3	1.2	0.5
Mytilus edulis	2.6	1.7	2.6	1.7
($\#/m^2$)				
Acmaeidae	10.0	99.6	81.5	66.8
Anthozoa[c]	<6	2.8	0.4	1.6
Leptasterias ?hexactis	0	0	6.7	1.6
Littorina sitkana	1,685.7	P	P	P
Nucella emarginata	2.4	4.0	0	0.4
Pagurus hirsutiusculus	0	0	4.4	2.0
Pentidothea wosnesenskii	2.4	P[a]	0	8.8[b]
Siphonaria thersites	0.4	0	2.2	16.8
1.5 m				
(% Cover)				
Balanus cariosus	0.6	0.1	2.9	2.4
Chthamalus dalli	2.6	0.5	2.4	1.8
Halichondria panicea	1.2	0.3	3.7	0.8
Rhynchozoon bispinosum	0	P	2.7	5.4
($\#/m^2$)				
Acmaeidae	7.2	58.0	43.2	54.7
Anthozoa[c]	0	0	1.6	4.4
Cucumaria vegae	1.6	P	6.4	P
Katharina tunicata	0	0.5	2.0	1.3
Leptasterias ?hexactis	0	0.	6.0	4.4
Metridium sp.	0	0	0.4	5.3
Pagurus hirsutiusculus	0	0	P	1.8
Schizoplax brandtii	0	0.5	3.2	0.4
Siphonaria thersites	P	5.7	22.0	17.8
0.8 m				
(% Cover)				
Balanus cariosus	14.0	17.4	13.1	21.2
Chthamalus dalli	3.0	0.1	1.4	7.1
Halichondria panicea	0	10.4	2.3	8.2
Rhynchozoon bispinosum	0.4	0.3	1.7	11.7
Schizobranchia insignis	0	0	2.8	0.7
($\#/m^2$)				
Acmaeidae	6.4	25.5	53.9	15.2
Anthozoa[d]	0.8	0.5	1.6	1.6
Cucumaria vegae	0	P	11.6	P
Katharina tunicata	23.2	17.0	20.0	32.8
Leptasterias ?hexactis	0	1.5	4.4	3.6
Pagurus beringanus	0	0	6.0	4.0
Pugettia gracilis	0	0	1.6	11.6
Schizoplax brandtii	0.8	4.0	0.4	0.4
Tealia spp.	4.0	1.0	0.4	0

(a) P = present.
(b) Identification in this period is uncertain.
(c) Includes all anthozoan species at this level except *Metridium* sp.
(d) Includes all anthozoan species at this level except *Tealia* spp.

TABLE 4-6

Level/Species	Date/Average Percent Cover or No./m^2 2/16/77	5/5-6/77	7/2-3/77	8/28-29/77
0.0 m.				
(% Cover)				
Balanus cariosus	17.1	15.2	11.8	27.5
Halichondria panicea	2.8	0	1.1	0.5
Schizobranchia insignis	6.8	0.8	0.1	0.6
(#/m^2)				
Acmaeidae	3.6	13.3	20.0	10.8
Katharina tunicata	7.5	12.9	6.0	3.2
Leptasterias ?hexactis	1.2	0.4	1.6	3.6
Metridium senile	0	0	0	7.6
Mopalia ciliata	0	3.1	7.2	15.2
Pagurus beringanus	0	0	5.6	0.4
Pugettia gracilis	0.4	1.8	0	10.0
Strongylocentrotus drobachiensis	0.4	13.3	37.2	10.0
Tonicella lineata	2.0	4.4	8.4	5.6

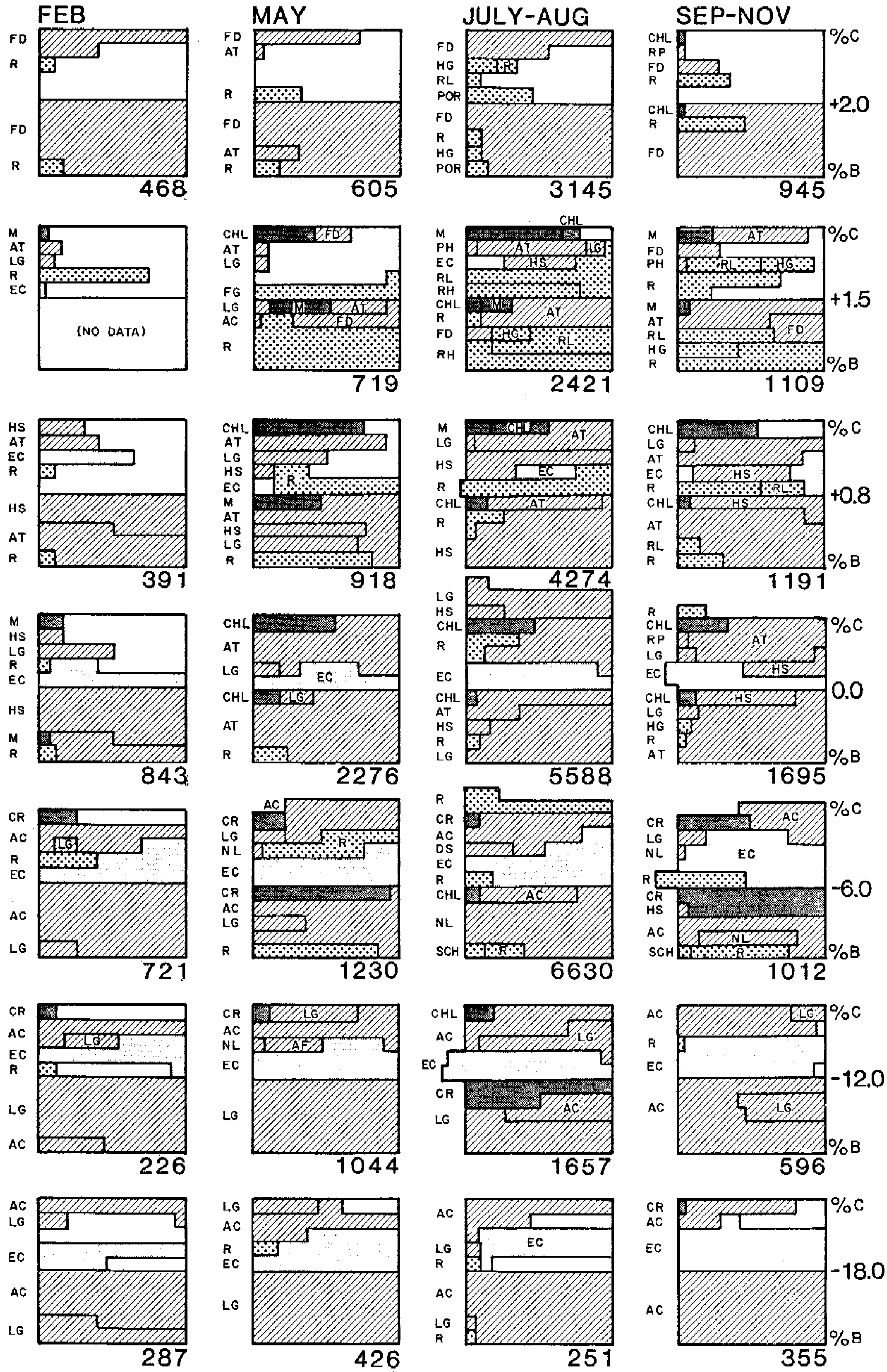
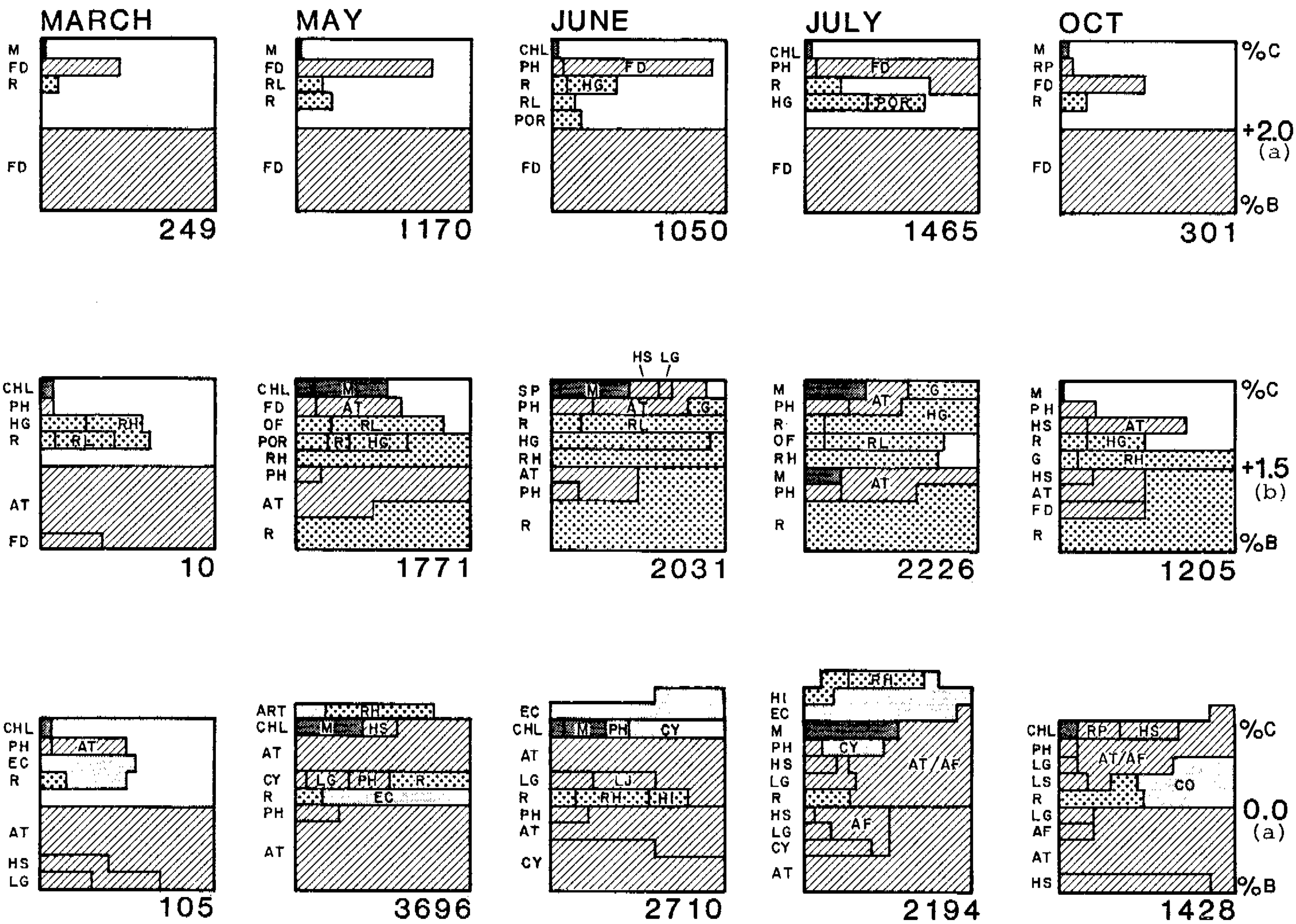


FIGURE 4-4

ZONATION, COVER AND BIOMASS OF ALGAE AT SELDOVIA POINT IN 1977



(a) Only phaeophytes were weighed at this level.

(b) Only phaeophytes were weighed at this level in March. Chlorophytes were only weighed in July.

FIGURE 4-5

ZONATION, COVER AND BIOMASS OF ALGAE AT SELDOVIA POINT IN 1978

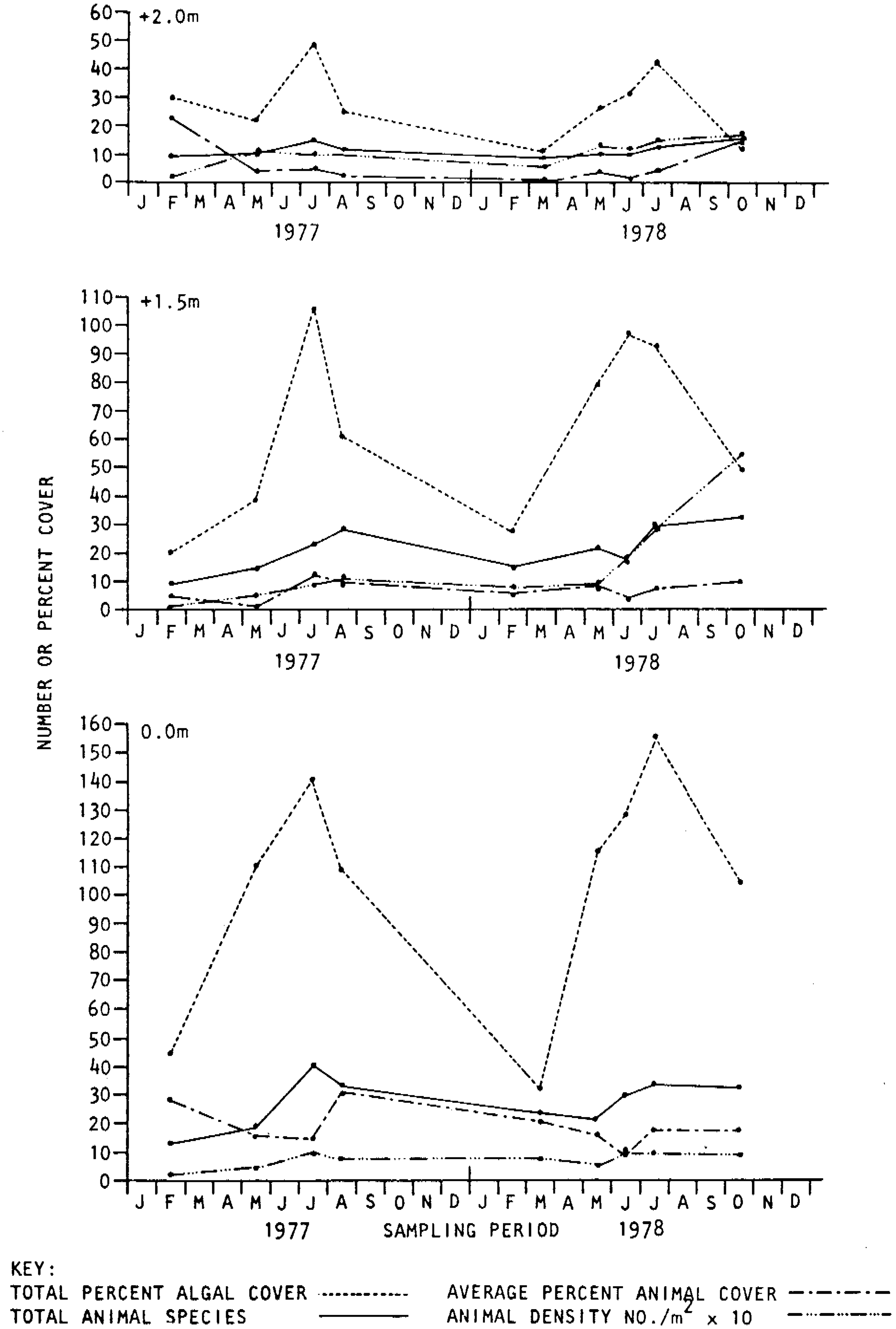


FIGURE 4-6

TRENDS IN COMMUNITY PARAMETERS AT SELDOVIA POINT IN 1977-1978 plants of this level. The starfish Leptasterias, a predator on these gastropods as well as on barnacles and mussels, was seen only occasionally (to 6.7/m^2 in July 1977) but more undoubtedly went unnoticed under larger boulders. Nucella emarginata, a predator on barnacles, was also not overly abundant (to 4.0/m^2 in July 1977) and was only seen in 4 of 9 sample periods, Tables 4-6 and 4-7).

A large disparity existed at this level between the density of the most abundant species (limpets and pulmonates) and that of the next most abundant forms (Tables 4-6 and 4-7).

+1.5 m, the "Rhodymenia" Zone

At the +1.5-m level the red algae R.palmata, R. liniformis, and H. glandiforme visually dominated a fairly narrow but distinct band of shoreline. At this level the substrate was predominantly boulders and cobbles containing more stable substrate than at higher levels. This, plus the greater immersion time, permitted development of a more diverse and productive community than that found at higher levels.

Total algal cover was near 100 percent in midsummer (June, July) with total standing crop exceeding 2,000 g/m^2 (Tables 4-8 and 4-9, Figures 4-4 and 4-5). Reduction in standing crop began by August and winter levels were very low, probably less than 100 g/m^2. The three dominant red algae were approximately equal in abundance during most of the year, but R. liniformis seemed to decline more quickly in the fall than the other species.

Some areas sampled at the +1.5-m level were transitional with the "Alaria" zone below and contained significant amounts of A. taeniata. Average standing crop of Alaria was only 9.3 g/m^2 with less than 1 percent cover in March 1978 but increased to 798 g/m^2 with 9.6 percent cover by May. Green algae, primarily Monostroma sp. contributed up to 15.6 percent cover (July 1977). However, standing crop did not exceed 100 g/m^2 except in July 1977 when it reached 161 g/m^2, still less than 7 percent of the total biomass.

TABLE 4-7

SELDOVIA POINT INTERTIDAL INVERTEBRATE DOMINANTS, 1978

Level/Species	Date/Average Percent Cover or No./m^2				
	3/7/78	5/26/78	6/20/78	7/19/78	10/19/78
+2 m					
(% Cover)					
Balanus cariosus	0.1	0.2	0	0	0.6
Balanus glandula	0.3	0.3	0.3	0.4	0.6
Chthamalus dalli	0.3	1.8	0.7	3.8	0.2
Mytilus edulis	0.2	1.5	0.3	0.6	0.2
(#/m^2)					
Acmaeidae[a]	44.4	100.8	66.8	108.8	99.6
Anthozoa	4	1.2	0.4	1.2	2.4
Cucumaria vegae	0	0	1.2	0	0
Nucella emarginata	0	0	0.0	3.2	0
Pagurus hirsutiusculus	0	0.8	4.0	0.4	0
Siphonaria thersites	13.2	22.8	54.8	40.0	61.2
1.5 m					
(% Cover)					
Balanus cariosus	0.5	0.6	1.5	0.5	1.7
Balanus glandula	0	0.1	0	0	6.0
Chthamalus dalli	4.9	0	0.8	0.4	1.3
Mytilus edulis	0.2	2.6	0.1	0.2	0.2
Rhynchozoon bispinosum	0.3	0	2.5	5.9	9.0
(#/m^2)					
Acmaeidae[b]	37.6	44.8	52.8	65.2	91.6
Anthozoa	3.2	0	0.4	0	8.0
Cucumaria vegae	0.8	P[c]	47.6	27.2	2.0
Katharina tunicata	1.6	0.4	2.4	2.0	3.6
Leptasterias ?hexactis	0	2.4	4.4	5.6	36
Metridium spp.	0.8	2.4	3.2	15.6	0
Nemertea[a]	0.4	2.8	1.6	0.4	3.6
Nucella sp.	4.0	0	1.2	0.8	0.4
Pagurus spp.[a]	0	2.8	2.4	4.8	9.6
Pentidotea wosnesenskii	0.4	4.8	P	0	P
Schizoplax brandti	0	2.4	9.2	2.4	0.4
Siphonaria thersites	28.4	16.4	35.6	157.6	395.6
0.0 m					
(% Cover)					
Balanus cariosus	18.3	12.7	6.8	12.4	5.0
Chthamalus dalli	0	0.1	0	0.3	10.4
Rhynchozoon bispinosum	0	0.3	0.4	1.4	0.6
Schizobranchia insignis	2.1	P	0.8	1.3	0.1
(#/m^2)					
Acmaeidae[b]	14.8	13.2	14	36.0	7.0
Anthozoa	4.4	1.2	0	2.0	1.0
Katharina tunicata	19.2	26.8	10.4	17.2	32
Leptasterias ?hexactis	2.4	2.0	0.4	4.4	0.5
Metridium spp.	0.4	2.0	1.6	5.2	0
Mopalia ciliata	1.6	3.2	2.8	0	6
Nemertea[a]	0	0.4	4	7.2	4.5
Pagurus beringanus	1.2	0	32	2.4	0
Pentidotea wosnesenskii	1.2	0.6	0	0	P
Strongylocentrotus drobachiensis	14.0	8.8	16.4	1.6	5.0
Tonicella lineata	1.6	3.6	9.2	7.6	2.5

(a) Includes all species.
(b) Unidentified spp., includes *Tealia crassicornis*.
(c) P = present.

TABLE 4-8

SELDOVIA POINT ALGAL COVER AND BIOMASS BY CLASS, 1977

	Level													
	+2 m		+1.5 m		+0.8 m		0.0 m		-6 m		-12 m		-18 m	
Month/Class	%	gm/m^2	%	gm/m^2	%	gm/m^2	%	gm/m^2	%	gm/m^2	%	gm/m	%	gm/m
February														
Chlorophyta	0.2	0.7	0.8	--	0.3	--	2.7	6.8	4.8	1.8	1.9	--	0	0
Rhodophyta														
encrusting	0	--	1.2	--	13.3	--	27.3	--	38.1	--	31.3	--	28.0	--
other	1.8	15.1	14.5	--	2.3	9.2	1.2	14.1	8.1	--	1.8	8.3	0.1	--
Phaeophyta	27.7	452.5	3.8	--	14.0	381.8	12.7	821.8	36.3	719.5	30.2	226.0	23.3	282.4
Total	29.7	468.3	20.3	--	29.9	391.0	43.9	842.7	87.3	731.3	65.2	234.3	51.4	282.4
May														
Chlorophyta	0.3	0.3	8.1	60.9	14.7	79.9	10.5	64.2	3.7	228.1	1.9	40.9	0	0
Rhodophyta														
encrusting	0	--	0	--	2.5	--	27.8	--	45.0	--	72.4	--	45.5	--
other	6.4	17.4	22.3	455.5	21.8	142.6	12.1	86.6	23.8	207.9	15.8	5.3	3.1	T[(a)]
Phaeophyta	15.7	587.3	8.4	202.8	31.2	677.2	58.6	2,123.2	42.2	713.2	49.9	1,009.7	39.4	425.8
Total	22.4	605.0	38.3	719.2	70.2	899.7	109.0	2,274.0	114.7	1,149.0	140.0	1,055.9	88.0	425.8
July-August														
Chlorophyta	1.8	1.5	15.6	160.8	10.9	102.3	9.3	47.8	1.7	116.4	3.4	490.9	0	0
Rhodophyta														
encrusting	0	--	4.8	--	8.1	--	38.1	--	49.3	--	46.8	--	41.4	--
other	15.3	205.6	64.3	1,395.6	25.4	269.7	9.2	86.8	28.7	409.5	T	3.9	2.1	41.4
Phaeophyta	31.1	2,937.6	19.5	884.7	56.7	3,901.8	83.9	5,453.3	46.4	6,103.8	56.5	1,162.1	26.8	248.7
Total	48.2	3,144.7	104.2	2,421.1	101.1	4,273.8	140.0	5,587.9	126.1	6,629.7	106.8	1,656.9	70.1	250.8
September-November														
Chlorophyta	0.5	0.6	4.6	19.8	10.9	37.8	6.7	35.4	9.3	787.9	0	0	0.6	--
Rhodophyta														
encrusting	0	--	0.1	--	2.0	--	32.0	--	62.0	--	58.8	--	63.3	--
other	6.6	83.1	37.0	574.9	17.2	193.5	3.8	39.4	12.6	242.9	0.8	0.02	2.8	0
Phaeophyta	19.2	861.6	20.0	514.2	51.1	1,760.1	66.1	1,620.1	31.1	986.0	38.6	596.2	22.0	355.2
Total	26.3	945.3	61.7	1,108.9	81.2	1,991.4	108.6	1,694.9	115.0	2,016.8	98.2	596.2	88.1	355.2

(a) T = Trace.

TABLE 4-9

SELDOVIA POINT ALGAL COVER AND BIOMASS BY CLASS, 1978

	Tide Level					
	+2 m		+1.5 m		+0.0 m	
Month/Taxon	%	gm/m2(a)	%	gm/m2	%	gm/m2(a)
March						
Chlorophyta	0.1	--	1.4	--	1.1	--
Rhodophyta						
encrusting	0	--	0.8	--	17.8	--
other	2.0	--	23.7	--	3.7	--
Phaeophyta	9.2	249.2	1.4	10.0	10.0	105.3
Total	11.3	249.2	27.3	10.0	32.6	105.3
May						
Chlorophyta	0.6	--	11.2	--	8.1	--
Rhodophyta						
encrusting	0	--	0.1	--	18.6	--
other	6.7	--	24.4	--	2.9	--
Phaeophyta	18.7	1,169.8	13.2	859.6	62.1	3,696.0
Total	26.0	1,169.8	79.2	859.6	115.2	3,696.0
June						
Chlorophyta	0.4	--	8.3	--	6.5	--
Rhodophyta						
encrusting	0	--	0.1	--	28.2	--
other	12.0	--	63.7	1,623.5	16.7	--
Phaeophyta	18.8	1,050.0	24.0	407.5	77.4	2,709.6
Total	31.2	1,050.0	96.1	2,031.0	128.8	2,709.6
July						
Chlorophyta	0.8	--	7.1	--	11.5	--
Rhodophyta						
encrusting	0	--	1.4	--	34.2	--
other	16.7	--	68.0	1,498.5	22.8	--
Phaeophyta	24.9	1,465.6	15.3	639.8	86.7	2,194.2
Total	41.6	1,465.6	91.8	2,225.8	155.2	2,194.2
October						
Chlorophyta	0.1	--	0.9	--	1.7	--
Rhodophyta						
encrusting	0	--	0.7	--	26.6	--
other	2.3	--	29.0	840.6	15.2	--
Phaeophyta	10.0	301.2	19.0	364.6	61.0	1,427.5
Total	12.4	301.2	49.6	1,205.2	104.5	1,427.5

(a) Only phaeophytes were weighed at +2 m and 0.0 m.

The very dense algal growth at +1.5 m was probably closely related to the limited occupation of primary space by sessile animals and the grazers. Three species of barnacles, B. glandula, B. cariosus, and C. dalli, contributed up to 9 percent coverage, often on boulder tops or under overhangs unsuitable for algal growth. The mussel M. edulis was not abundant in the area although some large boulders nearby supported nearly 100 percent cover. The starfish Leptasterias may have contributed somewhat to low numbers of barnacles and mussels. Increased coverage of barnacles in October 1978 was paralleled by increased density of Leptasterias to $36/m^2$, the maximum recorded at this level. The encrusting bryozoan Rhynchozoon bispinosum covered up to 9 percent of the surface (October 1978), mostly on overhanging surfaces.

The most abundant herbivores were the pulmonate S. thersites (to $396/m^2$) and the limpets (to $92/m^2$). Numbers of both appeared to increase markedly in late summer and fall due to recruitment of a new generation. Although usually considered to be microherbivores, these animals, especially Siphonaria, were clearly consuming material from the fronds of Rhodymenia and Halosaccion in October 1978. The large chiton Katharina tunicata, while not abundant (to $3.6/m^2$), was a significant grazer at this level. The isopod Pentidotea wosnesenskii was usually present and occasionally abundant (but not counted) attached to algae or under boulders and, along with the hermit crab Pagurus hirsutiusculus (to $9.6/m^2$), was an important scavenger at this level. Anemones, especially Metridium sp. (to $15.6/m^2$) were another scavenging group found here.

+0.8 m, the "Alaria" Zone

The +0.8-m level was only sampled in 1977. It lay approximately in the middle of the broad lower section of cobble bench that was characterized during the summer months by an abundance of the brown alga Alaria taeniata. Development of Alaria peaked in 1977, with 38 percent cover (July) and a biomass of 1,333 g/m^2 (August). The sampling area was laterally crossed by several surge or runoff channels where the laminarian Hedophyllum sessile was strongly dominant. The holdfast of this species was virtually always in a permanently wetted area while that of Alaria was typically on an emergent rock or B. cariosus shell. Coverage by H. sessile in individual quadrats occasionally reached 100 percent with biomass equivalent to 10 kg/m^2. Average coverage peaked at 36 percent in July with an average biomass of 3,185 g/m^2 (Tables 4-8 and 4-9).

At the +0.8-m level, coverage of the primary substrate by sessile animals was much greater than at +1.5-m level. This was attributable primarily to large B. cariosus (13.1 to 21.2 percent cover, Table 4-6), although the green sponge Halichondria panicea (to 10.4 percent) and the encrusting bryozoan R. bispinosum (to 11.7 percent) were also important. Acmaeids (to $53.9/m^2$) and Katharina (to $32.8/m^2$) lead the grazers in abundance; Siphonaria was completely absent. Scavengers and predators remained much as at the 1.5-m level except that Pagurus beringanus (to $6/m^2$) and Pugettia gracilis (to $11.6/m^2$) largely replaced Pagurus hirsutiusculus and Pentidotea.

0.0 m, the lower "Alaria" Zone*

Rock surfaces in the upper portion of this sampling area were typical of the broad "Alaria" band described at the +0.8-m level, but the lower portions of the irregular bench were transitional, supporting many more typically subtidal species (e.g., Alaria fistulosa, Cymathere triplicata, Nereocystis luetkeana, Strongylocentrotus, Henricia tumida, Trichotropis cancellata and unidentified tunicates).

Encrusting coralline algae accounted for a relatively constant percent coverage of the primary substrate (17.8 to 34.2 percent) over the 2-year study period (Tables 4-8, 4-9). Total coverage by non-encrusting algae varied more widely on a seasonal basis at this level than at any other level (e.g., from 14.8 percent in March to 121.1 percent in July 1978; Figure 4-6). Laminarians accounted for greater than 90 percent of

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* The fixed pin at this level was actually at about +0.3 m (+1 ft) on a rock ridge. However, most of the sampling occurrd at lower elevations (to about -0.3 m); hence, the approximate average level of 0.0 m was used.

algal biomass at this level with the remaining portion about equally split between reds and greens. Average algal biomass peaked at 5,588 g in July 1977 and 3,696 g (phaeophytes only) in May 1978 (Tables 4-8 and 4-9).

Alaria taeniata (to 54.9 percent cover, 3,501 g/m^2) was the dominant species throughout most of the study. Temporary dominance by H. sessile (February 1977), Laminaria groenlandica (July 1977) and Cymathere (June 1978) (Figures 4-5, 4-6) was probably due, in part, to differences in the precise orientation of the sample transverse between sampling periods.

The thatched barnacle B. cariosus was the dominant sessile animal at MLLW with coverage ranging from a low of 5 percent to a high of 27.5 percent. Sand tubes of the sabellid polychaete Schizobranchia insignis formed cushion-like aggregations covering 6.8 percent of the primary substrate in February 1977 and from 0.1 to 2.1 percent during the remainder of the study.

Major herbivores from higher levels (Acmaeidae to 36/m^2; K. tunicata to 32/m^2) were joined by the green sea urchin S. drobachiensis (to 37.2/m^2). As in previous years, these grazers were effective at reducing algal cover. Some areas, especially slightly below MLLW where high densities of urchins were found, were virtually devoid of macroalgae. In October 1978 many K. tunicata had "captured" fronds of A. taeniata between their mantle and the rock and were systematically eating through the midrib. Many plants in the vicinity had been truncated in this fashion, usually fairly close to the stipe. The chitons Mopalia ciliata (to 15.2/m^2) and Tonicella lineata (to 9.2/m^2) were important grazers on the microflora of this level. Predation by the grazers and the starfish Leptasterias ?hexactis (to 4.4/m^2) probably was a major factor in limiting recruitment of B. cariosus. Most B. cariosus at this level were adults that were several years old. The sea anemones Metridium senile, Tealia spp., and Cribrinopsis were common (to 7.2/m^2).

In general, the abundance of dominant animal species tended to fluctuate less widely at this level than at the higher levels sampled (Figure 4-6). Moreover, no one or two animals were vastly more abundant than all others as occurred with limpets and *Siphonaria* at higher levels.

4.2 ROCKY HABITATS - WEST SIDE

4.2.1 Scott Island

No previous detailed ecological surveys of Scott Island have been conducted. Based on aerial surveys, Dames & Moore (1977) reported that the islands off the entrance to Iniskin Bay supported "light to moderate algal cover." From field surveys, they also described in moderate detail the assemblages on "Rocky Point", which juts into Iniskin Bay about 1.8 km NNE of Scott Island, and the algal assemblage on the west and southwest side of Scott Island itself. The latter site is generally the same location described below. Upper intertidal levels had abundant cover by the rockweed *Fucus distichus* and barnacles. Intermediate levels had an abundance of several "pioneer" species, e.g., *Rhodymenia palmata*, *R. liniformis*,* *Halosaccion glandiforme*, *Odonthalia*, and *Porphyra*. Laminarians were uncommon since observations did not extend below MLLW.

Three levels on the Scott Island transect were sampled four times (April 23-24, June 23, July 21, September 16) during 1978.

The "*Fucus*" Zone

The upper level sampled on Scott Island was intentionally located on irregular bedrock at an elevation supporting maximum development of the "*Fucus*" zone. *Fucus* achieved its maximum coverage (54 percent) in April and remained at about 50 percent until September when it dropped to 37.1 percent. Maximum biomass (2,292 g) was recorded in July (Table 4-10). No other erect alga was very abundant on the sloping rocks of the true "*Fucus*" zone but the encrusting brown ?*Ralfsia pacifica* was common (to 38 percent cover). However, the sampling transverse at this level included a fairly broad (2 to 4 m) runoff channel where continuous wetting permitted development of a biota typical of considerably lower levels. Several red algae were sufficiently abundant in this area to

*Called *Callophyllis* in Dames & Moore (1977).

TABLE 4-10

SCOTT ISLAND ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

	Zone					
	"Fucus"		"Rhodymenia"		"Laminarian"	
Month Taxon	%	gm/m^2 (b)	%	gm/m^2	%	gm/m^2
April						
Chlorophyta						
encrusting	0.2	--	1.0	--	0.9	--
other	0.6	--	9.4	9.9	5.9	2.7
Encrusting reds & browns (a)	22.1	--	0.4	--	0.1	--
Phaeophyta	54.0	1,491.6	13.3	224.6	13.0	214.5
Rhodophyta						
encrusting corallines	1.3	--	0.1	--	0.7	--
other	21.2	137.2	58.1	1,587.1	21.8	268.2
Total	99.4	1,628.8	82.3	1,821.6	42.4	485.4
June						
Chlorophyta						
encrusting	0.7	--	7.0	--	0.8	--
other	1.0	--	10.9	75.3	12.2	106.4
Encrusting reds & browns	49.9	--	18.3	--	3.4	--
Phaeophyta	49.7	2,150.8	6.7	555.1	43.9	2,197.7
Rhodophyta						
encrusting corallines	0.6	--	5.8	--	8.1	--
other	19.2	--	124.0	4,635.0	67.9	1,726.6
Total	121.1	2,150.8 (b)	172.7	5,265.4	136.3	4,030.7
July						
Chlorophyta						
encrusting	0.7	--	5.3	--	1.3	--
other	2.5	--	1.4	--	7.6	--
Encrusting reds & browns	17.1	--	10.3	--	1.7	--
Phaeophyta	59.0	2,292.2	11.7	517.4	62.1	1,169.0
Rhodophyta						
encrusting corallines	4.4	--	0.5	--	10.6	--
other	29.7	--	125.2	4,368.1	71.1	3,473.7
Total	113.4	2,292.2 (b)	154.4	4,885.5	154.4	4,642.7
September						
Chlorophyta						
encrusting	0.2	--	10.2	--	1.3	--
other	1.7	--	1.6	--	3.2	15.7
Encrusting reds & browns	30.8	--	9.2	--	2.9	--
Phaeophyta	37.6	1,374.0	7.3	115.1	23.7	448.2
Rhodophyta						
encrusting corallines	4.9	--	0.3	--	14.4	--
other	22.9	--	88.7	1,404.1	55.2	1,345.0
Total	98.1	1,374.0	117.3	1,519.2	100.7	1,808.9

(a) Includes *Ralfsia pacifica* and other unidentified encrusting rhodophytes and phaeophytes.

(b) Only phaeophytes weighed at this level.

contribute a total coverage of about 55 percent when averaged over the entire sampling period. These include Rhodomela ?lycopodioides and Odonthalia floccosa (to 18.2 percent), and encrusting corallines (to 4.9 percent), but an unidentified red algal film contributed considerably.

The fauna was poorly developed in the "Fucus" zone. Although among the most important, the barnacles B. glandula and C. dalli contributed marginally to cover (Table 4-11). The important micrograzers included acmaeids (up to 24.4/m^2), Littorina sitkana, and pulmonate snail Siphonaria thersites (up to 11.2/m^2). Important predators and scavengers included the whelk N. emarginata (to 23.6/m^2) and the hermit crab P. hirsutiusculus (to 37/m^2). Invertebrate populations were generally dominated by juveniles; adults were fairly uncommon.

The "Rhodymenia" Zone

Below the "Fucus" zone, the bedrock dropped off slowly and then formed a conspicuous hogback parallel to the shoreline. At this level, the appearance of the biota was strongly dominated by the red algae R. pacifica (up to 64.3 percent) and R. liniformis (up to 74.2 percent). Maximum biomass for red algae was 4.6 kg/m^2 in June (Table 4-10). Other plants that contributed significantly to the vegetative assemblage at this level included Fucus (up to 10.9 percent and 516.3 g/m^2), the red algae Gigartina papillata (up to 17.1 percent), and Halosaccion glandiforme (14.8 percent). Several encrusting algae contributed slightly to cover.

The fauna at this level was quite impoverished. Only two sessile forms appeared commonly (Table 4-11); neither appeared to contribute appreciably. Motile forms were likewise sparse. None of the species exceeded a density of 7.5/m^2. Highest densities were observed in September.

TABLE 4-11

SCOTT ISLAND INTERTIDAL INVERTEBRATE DOMINANTS

Level/Species	Date/Average Percent Cover or No./m^2 4/24/78	6/23/78	7/21/78	9/16/78
	"Fucus" zone			
(% Cover)				
Balanus glandula	10.3	10.2	4.1	0.9
Chthamalus dalli	0	1.6	6.3	5.8
Halichondria panicea	0.3	1.0	3.8	4.6
(#/m^2)				
Acmaeidae	23.6	24.4	16.8	18.0
Cerithiopsis sp.	0	0	0	5.0
Littorina sitkana	P	P	P	P
Nucella emarginata	23.6	12.8	5.2	18.5
Pagurus beringanus	0	5.2	0.4	18.5
Pagurus hirsutiusculus	23.2	12.4	21.2	37.0
Pagurus unid. juv.	0	4.8	0	0
Schizoplax brandtii	2.0	0.8	0	9.0
Siphonaria thersites	3.6	11.2	9.6	7.0
Volutharpa sp.	4.0	0	0	0
	"Transition" zone			
(% Cover)				
Halichondria panicea	3.5	0.9	2.6	2.5
Rhynchozoon bispinosum	0	0.8	3.1	2.1
(#/m^2)				
Acmaeidae	1.2	2.9	1.3	4.7
Lacuna sp.	0	1.7	0	--
Pagurus beringanus	0	0	0	3.3
Pagurus hirsutiusculus	0	0	1.3	7.3
	"Rhodymenia" zone			
(% Cover)				
Halichondria panicea	0.05	1.0	0.3	0.5
Modiolus modiolus	0.3	1.6	0.7	4.8
(#/m^2)				
Acmaeidae	2.0	1.6	1.2	5.3
Leptasterias sp.	1.2	1.2	6.0	5.3
Pagurus beringanus	0.4	1.6	4.8	8.0
Telmessus cheiragonus	0	2.0	0.8	0
Tonicella lineata	0	3.2	0.4	7.3

The Laminarian Zone

Below the hogback at the outer edge of the "Rhodymenia" zone, a 30 m wide bedrock terrace strewn with small boulders and shallow tide pools supports a light crop of Laminaria and other seaweeds. Highest algal standing stocks were observed in July (4642.7 g/m^2), when red algae contributed 3473.7 g/m^2. The kelp Laminaria groenlandica was a dominant plant (up to 43.3 percent cover and 1873.4 g/m^2) but the red algae Rhodymenia pacifica (38 percent cover) and R. liniformis (up to 20 percent cover) were at least as important. Encrusting coralline algae covered an increasing proportion of bottom during the study (from 0.7 percent to 14.4 percent). The kelp Alaria taeniata became important by July but disappeared by September. Other important species included Fucus (up to 9.1 percent cover and 324 g/m^2), Monostroma (up to 7.2 percent), Gigartina papillata (up to 5.7 percent) and Spongomorpha (up to 5.2 percent).

The fauna at this level was rather impoverished but included some representatives of the subtidal fauna. The main suspension feeders were the sponge Halichondria panicea (up to one percent) and the horse mussel Modiolus modiolus (up to 4.8 percent). Micrograzers included limpets (up to 5.3/m^2) and the lined chiton Tonicella lineata (7.3/m^2). The only common predator/scavengers were the starfish Leptasterias ?hexactis, the hermit crab Pagurus beringanus and the helmet crab Telmessus cheiragonus (Table 4-11).

4.2.2 Knoll Head

No previous studies of this area are known. The area was selected because the predominantly rocky stretch of coastline is structurally complex and is intermediate in the degree of exposure between Scott Island and White Gull Island.

Three levels on the Knoll Head transect were sampled three times (June 21, July 20 and September 17) during 1978. Weather precluded sampling during the April survey.

The "*Fucus*" Zone

The upper level sampled was located on top of a rock logback in an area of maximum development of the "*Fucus*" zone. *Fucus* maintained coverage of about 45 percent in June and July but declined to 37 percent in September. Maximum biomass at this level (1896.3 g/m^2) was observed in July (Table 4-12). Other important algae at this level included an unidentified encrusting green alga (to 4.7 percent), the red algae *Rhodomela ?lycopodioides* (to 25.7 percent) and an unidentified red algal film (to 23.8 percent) and the brown encrusting alga ?*Ralfsia pacifica* (to 14.2 percent). *Rhodomela* and articulated corallines were abundant in the tide pools. Red algae contributed an average of about 39 percent over the entire sampling period, largely due to an unidentified red algal film.

The fauna at this level, generally typical of the "*Fucus*" zone elsewhere on the west side, was quite sparse. Dominant sessile forms were *B. glandula* and *C. dalli*. Motile organisms included the grazing snail *L. sitkana*, which was abundant and was observed laying eggs in June. Other grazers included a few limpets (Acmaeidae) and very few chitons. The predaceous gastropod *Nucella emarginata* was very common, particularly juveniles.

The "Transition" Zone

An expanse of rather smooth bedrock was located below the "*Fucus*" zone. The appearance of this zone was dominated by the red algae *Rhodymenia palmata* (up to 68 percent) and *R. liniformis* (up to 26.5 percent). Maximum biomass for red algae was observed in July (2658.1 g/m^2; Table 4-12). *Fucus* also contributed appreciably to cover and biomass (up to 31.8 percent and 992.2 g/m^2). Two opportunistic species, the red *Porphyra* sp. (3.6 percent) and the green *Monostroma fuscum* (11.0 percent) were common at this level in June, but declined during the remaining periods. Small plants of *Alaria taeniata* and *Laminaria groenlandica* were observed. The red *Gigartina papillata* were fairly common in all surveys (up to 18.1 percent).

TABLE 4-12

KNOLL HEAD ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

Month Taxon	Zone: "Fucus" %	"Fucus" gm/m^{2}[b]	"Transition" %	"Transition" gm/m^{2}	"Rhodymenia" %	"Rhodymenia" gm/m^{2}
June						
Chlorophyta						
encrusting	3.0	--	7.8	--	0.8	--
other	0.8	--	24.3	257.1	28.5	235.3
Encrusting reds & browns[a]	14.2	--	33.4	--	12.9	--
Phaeophyta	54.4	1,528.7	30.0	992.2	6.4	51.2
Rhodophyta						
encrusting corallines	0.8	--	1.7	--	6.3	--
other	11.9	--	89.2	2,393.1	119.9	3,724.7
Total	85.1	1,528.7	186.4	3,642.4	174.8	4,011.2
July						
Chlorophyta						
encrusting	0.4	--	4.3	--	2.8	--
other	0.1	--	5.1	26.2	4.5	20.5
Encrusting reds & browns	24.2	--	45.3	--	32.5	--
Phaeophyta	46.8	1,896.3	34.9	724.8	10.7	66.1
Rhodophyta						
encrusting corallines	1.0	--	3.3	--	15.4	--
other	39.2	--	94.7	2,658.1	120.9	3,397.9
Total	111.7	1,896.3	188.6	3,409.1	186.8	3,484.5
September						
Chlorophyta						
encrusting	4.7	--	12.0	--	3.1	--
other	0.3	--	1.1	--	1.6	--
Encrusting reds & browns	23.8	--	13.0	--	20.3	--
Phaeophyta	37.5	1,093.8	24.2	633.9	6.3	368.4
Rhodophyta						
encrusting corallines	1.0	--	0.4	--	3.8	--
other	16.9	--	94.4	2,238.4	99.6	2,176.8
Total	84.2	1,093.8	145.1	2,872.3	134.7	2,545.2

(a) Includes Ralfsia pacifica and other unidentified encrusting Rhodophyta and Phaeophyta.
(b) Only Phaeophyta weighed at this level.

Very few animals were found at this level (Table 4-13). The only taxa consistently observed were the sponge Halichondria (up to 4.3 percent cover), amphipods, the hermit crabs Pagurus beringanus (up to $3.2/m^2$) and P. hirsutiusculus (up to $4.8/m^2$), the snail Lacuna (up to $2.7/m^2$) and an encrusting bryozoan Rhynchozoon bispinosum (up to 7.6 percent cover). Most of these were most common in September, but densities were quite low for all invertebrates.

The "Rhodymenia" Zone

The substrate at a lower level is similar to that in the "Transition" zone. The biota at this level was much like that at the "Transition" zone except that R. palmata dominated more completely and Fucus was only found on the highest prominences. This level supported the lushest development of algae biomass (up to 4.01 kg/m^2 by June) (Table 4-12), mainly from the contribution of R. palmata.

The fauna was sparsely developed (Table 4-13). The only reliable components were the encrusting bryozoan R. bispinosum (up to 4.8 percent cover), the small starfish Leptasterias ?hexactis (up to $2/m^2$) and a small pink social ascidian Dendrodoa sp. (up to $3.3/m^2$). Most invertebrates were most common in September.

In the low surge channels surrounding this terrace, a fairly dense assemblage of laminarians (L. groenlandica, L. saccharina and Alaria sp.) and the red alga Constantinea simplex was observed. Large areas devoid of macroalgae were present although herbivores were scarce. The horse mussel Modiolus modiolus was present in the lowest channels although beds were not dense; shell debris indicated recent mortality. Large Tealia and Cribrinopsis were common in protected areas under boulders. Several starfish (Henricia leviusculus, Solaster stimpson; and Leptasterias ?hylodes were observed. Other species seen included the thatched barnacle B. cariosus, the lined chiton Tonicella lineata and a greenling (Hexagrammos sp.).

TABLE 4-13

KNOLL HEAD INTERTIDAL INVERTEBRATE DOMINANTS

Level/Species	Date/Average Percent Cover or No./m^2 6/21/78	7/20/78	9/17/78
"Fucus" zone			
(% Cover)			
Balanus glandula	15.8	10.5	6.5
Chthamalus dalli	2.3	7.1	8.4
Halichondria panicea	0	1.3	0.6
(#/m^2)			
Acmaeidae	13.0	46.7	30.0
Lacuna sp.	0.2	0	P
Nucella emarginata	26.0	18.7	28.8
Pagurus hirsutiusculus	0	9.3	16.0
"Transition" zone			
(% Cover)			
Halichondria panicea	4.3	1.3	0.2
Rhynchozoon bispinosum	0.4	2.0	7.6
(#/m^2)			
Acmaeidae	2.7	2.7	0
Lacuna sp.	2.7	2.7	P
Leptasterias ?hexactis	2.0	0	1.6
Pagurus hirsutiusculus	0.7	0.7	4.8
"Rhodymenia" zone			
(% Cover)			
Rhynchozoon bispinosum	0.5	1.0	4.8
(#/m^2)			
Acmaeidae	2.0	0	3.2
?*Dendrodoa* sp.	0.2	3.3	0
Leptasterias ?hexactis	0.7	1.3	2.0
Oregonia gracilis	0	0	3.3
Pagurus beringanus	0	0	3.3

General

Several fairly strong seasonal and spatial patterns were apparent. At the levels dominated by Rhodymenia, biomass was highest in June and declined substantially thereafter. Fucus attained maximal development in July. Plant biomass generally was highest in areas dominated by Rhodymenia, especially at the lowest level sampled. Phaeophyta, mainly represented by Fucus, became increasingly less important at lower levels (Table 4-12).

4.2.3 White Gull Island

There are no known prior studies of the intertidal or subtidal benthic communities of White Gull Island.

The "Fucus" Zone

The upper level sampled on White Gull Island was on an irregular rock bench in the midst of the "Fucus" zone (Section 2.7). Coverage by the rockweed Fucus distichus increased from 13 to 28 percent from June to September 1978 with maximum biomass (993.8 g/m^2) in July. Several red algae including Rhodomela ?lycopodioides (to 4.6 percent), identified polysiphonous forms (Rhodomelaceae; to 1.4 percent) and encrusting corallines (to 1.8 percent) were also common, primarily in small tide pools and moist crevices (Table 4-14).

The fauna at this level, typical of the "Fucus" zone elsewhere on the west side, was somewhat sparse. Balanus glandula (to 36.0 percent cover in July; Table 4-15) and Chthamalus dalli (to 3.9 percent cover in July) were the only significant sessile forms. Nucella emarginata were numerous (to 63.6, mostly juveniles, in August) and preying on the barnacles. The most common grazers were the limpets (Acmaeidae, to 27.2/m^2) and the periwinkle, Littorina sitkana. Periwinkles were laying eggs at this level during the June survey. The hermit crab Pagurus hirsutiusculus increased in abundance through the study period from 4.8/m^2 in June to 18.8/m^2 in September.

TABLE 4-14

WHITE GULL ISLAND ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

Month Taxon	Zone: "Fucus" %	"Fucus" gm/m^2 [(b)]	"Transition" %	"Transition" gm/m^2
June				
Chlorophyta				
encrusting	0.7	--	11.7	--
other	0.1	--	26.2	--
Encrusting reds & browns[(a)]	23.2	--	28.4	--
Phaeophyta	13.1	546.9	60.6	979.1
Rhodophyta				
encrusting corallines	1.2	--	2.8	--
other	8.0	--	33.9	548.0
Total	46.3	546.9	163.6	1,527.1
July				
Chlorophyta				
encrusting	0.9	--	1.1	--
other	--	--	5.2	28.6
Encrusting reds & browns	14.1	--	10.0	--
Phaeophyta	23.8	993.8	73.1	2,682.7
Rhodophyta				
encrusting corallines	1.0	--	10.3	--
other	7.0	--	44.4	784.2
Total	46.8	993.8	144.1	3,495.5
September				
Chlorophyta				
encrusting	0.2	--	0.9	--
other	--	--	0.4	--
Encrusting reds & browns	6.7	--	3.2	--
Phaeophyta	28.2	869.0	41.5	1,104.8
Rhodophyta				
encrusting corallines	1.8	--	4.5	--
other	4.8	--	19.4	293.1
Total	41.7	869.0	69.9	1,379.9

(a) Includes *Ralfsia pacifica* and other unidentified Rhodophyta and Phaeophyta.
(b) Only Phaeophyta weighed at this level.

TABLE 4-15

WHITE GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS

Level/Species	Date/Average Percent Cover or No./m^2 6/22/78	7/22/78	9/16/78
	"Fucus" zone		
(% Cover)			
Balanus cariosus	0.1	0.1	0.6
Balanus glandula	20.5	36.0	27.9
Chthamalus dalli	1.4	3.9	2.0
Halichondria panicea	0.4	0.5	0.3
(#/m^2)			
Acmaeidae	16.0	27.2	27.2
Littorina sitkana	A	--	P
Nucella emarginata	10.4	7.6	63.6
Pagurus hirsutiusculus	4.8	14.4	18.8
	"Transition" zone		
(% Cover)			
Balanus cariosus	3.1	1.4	0.9
Balanus glandula	0.6	0.5	5.2
Chthamalus dalli	2.9	18.6	18.1
Halichondria panicea	16.7	12.9	12.9
Rhynchozoon bispinosum	2.1	4.6	3.3
(#/m^2)			
Acmaeidae	18.2	10.4	39.6
Cucumaria ?vegae	7.1	9.2	0.9
Leptasterias ?hexactis	3.1	8.4	12.4
Metridium senile	0.9	0.8	5.8
Nucella emarginata	2.2	16.4	27.6
Pagurus beringanus	2.7	0.4	3.6
Pagurus hirsutiusculus	5.8	11.2	17.3
Schizoplax brandtii	11.1	4.4	3.6

The "Transition" Zone

Below the upper rock bench of the "*Fucus*" zone, the beach at the White Gull transect dropped to a lower bench with numerous boulders, tide pools, and channels. On the shoreward part of this bench, no quantitative sampling was done, but exposed upper rock surfaces were dominated by *Fucus* and obvious green layers of *Spongomorpha* and *Monostroma*. In shaded areas the green sponge *Halichondria panicea* formed thick mats, occasionally covering barnacles and generally reinforcing the green appearance of the area. In the channels, *Alaria taeniata* and *Laminaria groenlandica* were abundant along with the reds *Rhodymenia palmata* and encrusting corallines. The most obvious animals present were hermit crabs, *Pagurus* spp., encrusting bryozoans, probably *Rhynchozoon bispinosum*, and hydroids.

The transverse sampled on the seaward edge of this bench was in an area containing a great diversity of microhabitats from deep pools to exposed ridges. Biota in this area was highly dependent on the exposure of the substrate to waves, sunlight, and water drainage. Density and coverage figures given are averaged over all microhabitats sampled, and high standard deviations reflect the patchiness of this environment.

Upper rock surfaces elevated from the bench 0.5 to 1.0 m and with convex or sloped surfaces retaining little moisture, had a biota dominated by *Fucus* (to 18.8 percent), the opportunistic *Porphyra* (to 9.2 percent in June), *B. glandula* (to 5.5 percent with new set in September), and *C. dalli* (to 18.1 percent). *Littorina*, small chitons (e.g., *Schizoplax brandtii*, to 11.1/m^2), and limpets (to 39.6/m^2) were the most abundant grazers. At lower levels, sides of rock channels with some protection from desiccation had dense growth of *R. palmata* (to 21.2 percent) and *A. taeniata* (to 40.2 percent), often in fairly narrow bands. *Rhodymenia liniformis* (to 11.1 percent) and *Gigartina papillata* (to 2.4 percent) were also common in these areas. In the tide pools, *L. groenlandica* was the dominant brown alga (to 13.6 percent). Several typical tide pool species of red algae (corallines, to 11.3 percent; *Ahnfeltia plicata*, to

0.1 percent) were present. The fauna was richer in and near the pools than on the upper rock surfaces.

The green sponge H. panicea (to 16.7 percent), Balanus cariosus (to 3.1 percent), and the encrusting bryozoan R. bispinosum (to 4.6 percent) were the most important sessile animals. Hermit crabs (especially P. hirsutiusculus, to $17.3/m^2$) were abundant in the pools along with the anemone Metridium senile, which jumped in density from $0.8/m^2$ in June to $5.8/m^2$ with a new set in late summer. The small sea cucumber Cucumaria ?vegae was abundant (to $9.2/m^2$) in silty crevices and among the larger barnacles.

Predatory snails (N. emarginata, to $27.6/m^2$) and starfish (Leptasterias ?hexactis, to $12.4/m^2$) ranged throughout this sampling level, probably in response to barnacle density, but generally sought moister areas during low tide periods.

Below MLLW the bench dropped sharply to nearly vertical. This face was heavily covered with corallines and other encrusting forms. Rhodymenia palmata was fairly common to at least -1.2 m but did not form the dense cover seen along the margins of pools and channels on the bench.

4.3 GROWTH RATES AND PRIMARY PRODUCTION OF SOME DOMINANT LAMINARIAN KELPS

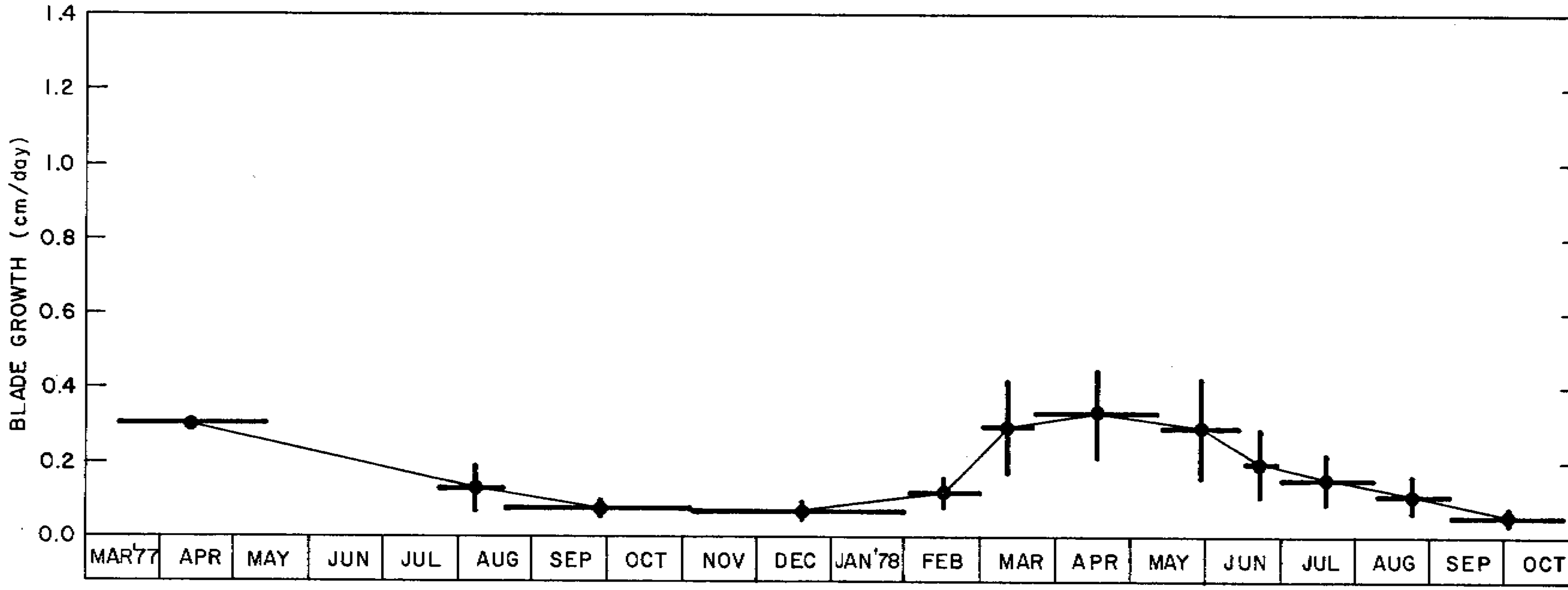
Growth rates for three species of laminarian algae were examined in order to assist in calculation of primary production rates. The species studied, namely, Agarum cribrosum, Alaria fistulosa and Laminaria groenlandica, are among the dominant species in the floral assemblages in Kachemak Bay and along the outer Kenai Peninsula. Other dominants in Kachemak Bay include, in the intertidal zone, Fucus distichus, Alaria taeniata, A. crispa and Hedophyllum sessile, and, subtidally, Nereocystis luetkeana.

Growth rates were successfully measured almost continuously for individual plants of Agarum cribrosum, Alaria fistulosa and Laminaria groenlandica from March 1977 through October 1978. Alaria fistulosa is a large species that forms heavy surface canopies; adult plants attain a length of at least 20 meters. Densities seldom exceed one plant/m^2, but biomass may approach 5 kg/m^2. Agarum and L. groenlandica are smaller plants that form a dense understory; adult plants attain a length of one and two meters, respectively. Densities of adult plants frequently exceed 20 plants/m^2, and biomass can approach 5 kg/m^2 in Kachemak Bay.

4.3.1 Average Growth Rates for Agarum cribrosum

Thirty-eight plants of Agarum cribrosum were labelled during this program. At least one growth observation was obtained from 33 of them. Records extending for over a year were obtained for four plants and for at least eight months for 15 plants.

Growth rates for Agarum cribrosum (Figure 4-7) are lowest in fall and early winter (September through January) and highest in spring (April). Average rates ranged from 0.05 cm/day in September and October 1978 to 0.33 cm/day in April 1978. Growth rates generally exceeded 0.2 cm/day in March, April, May and part of June, but fell below 0.12 cm/day (into the lower quartile) from August through mid-February, slightly



MEAN BLADE GROWTH (cm)	0.300	(~0.21)	0.128	0.072	0.068	0.118	0.291	0.327	0.291	0.194	0.149	0.106	0.052
s*			0.066	0.025	0.030	0.045	0.130	0.118	0.138	0.094	0.067	0.052	0.024
SE			0.022	0.010	0.013	0.011	0.033	0.026	0.032	0.023	0.015	0.013	0.007
n	2		9	6	5	16	16	20	19	17	19	16	12
DAYS	61	(69)	37	77	88	30	21	51	35	13	40	32	47
GROWTH INCREMENT (cm)	18.3	(14.5)	4.7	5.5	6.0	3.5	6.1	16.7	10.2	2.5	6.0	3.4	2.4

*S = STANDARD DEVIATION; SE = STANDARD ERROR; n = NUMBER OF PLANTS MEASURED

FIGURE 4-7

SEASONAL PATTERNS IN GROWTH FOR AGARUM CRIBROSUM AT JAKOLOF BAY over half of the year. During the periods of slowest growth, nearly all tagged plants grew at a slow rate rather than ceasing growth completely (Appendix 4.3.1).

Individual growth rates appeared to vary more during periods of peak growth than during slow growth (Figure 4-7). However, despite the high variability, growth rates differed significantly between periods of slow growth and fast growth. For example, the hypothesis that growth rates in the September-October 1978 period were slower than growth rates observed in the March through May 1978 period was tested using an approximate "t" test for independent means (Sokal and Rohlf, 1969). The difference was highly significant ($P < 0.001$; one-tailed test).

In contrast, a comparison of average growth rates in the same season of consecutive years indicates strong uniformity. For instance, comparisons of growth rates for the July-August periods in 1977 and 1978, or the September-October periods of the same years, indicate no significant difference between those periods (Student's t-test, $P > 0.10$ in both cases).

The hypothesis that growth rate is correlated with plant size was tested for three observation periods, namely, 22 July to 18 August 1977, 30 January to 1 March 1978 and 24 March to 12 May 1978 (Appendix 4.3.1). For this analysis, stipe length was used as an index of plant size. The data and regression equations for the last two periods are shown in Figure 4-8. The correlations were not significant for any of the periods ($P \gg 0.1$ in all three cases).

Average blade growth increments were calculated for each observation period by multiplying its average daily growth rate by the number of days in the period (Figure 4-7). These increments were summed over a year to compute an annual mean rate of blade elongation. From March 1977 through February 1978, the estimate of average blade growth was 58.6 cm and from November 1977 through October 1978, it was 56.8 cm.

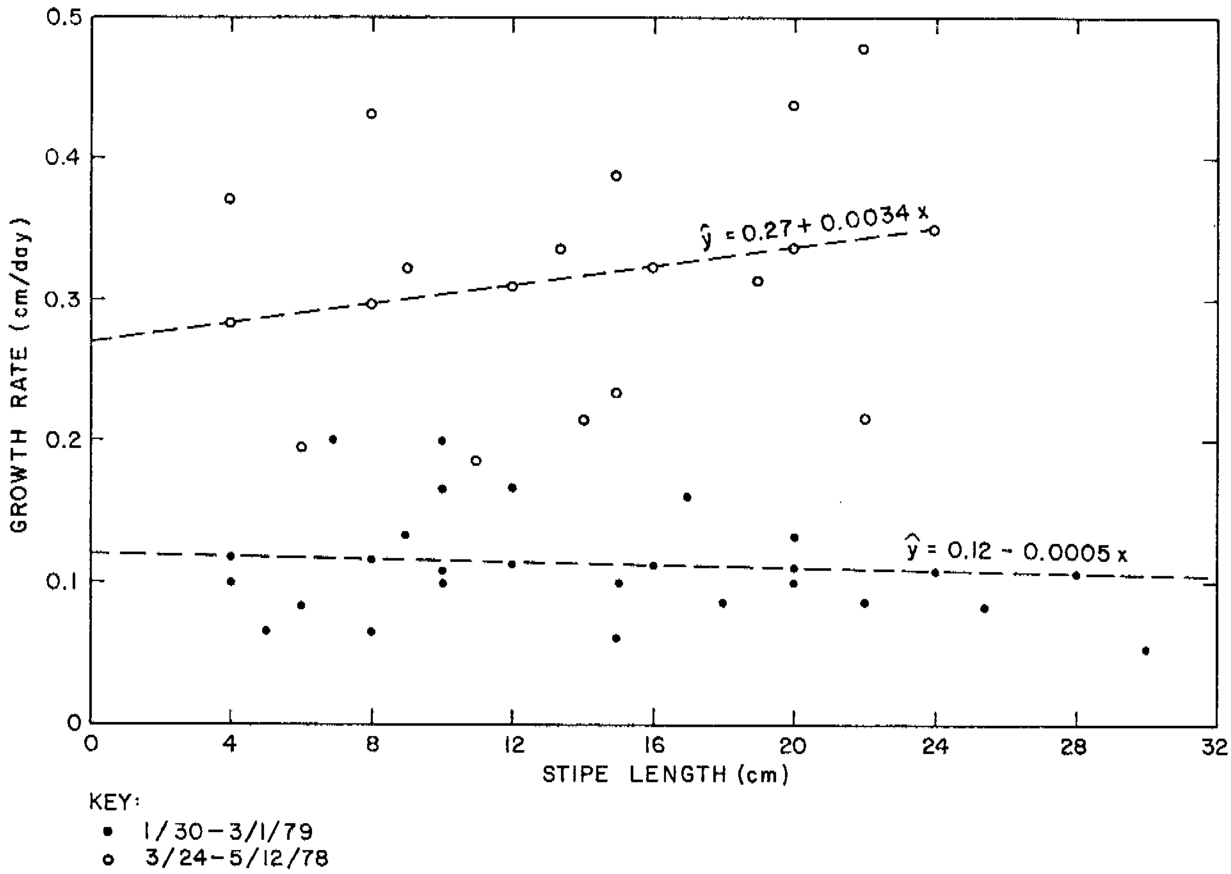


FIGURE 4-8

RELATIONSHIP BETWEEN STIPE LENGTH AND GROWTH RATE
FOR AGARUM CRIBROSUM
DURING TWO OBSERVATION PERIODS

The tagged plants of *Agarum* were generally distributed among five locations. The physical characteristics of these sites differed in several respects, e.g. light levels, exposure to tidal currents and turbulence, and silt deposition. The hypothesis that average growth rates were the same at each location was tested using the non-parametric Friedman two-way analysis of variance. A summary of the available data (Table 4-16) suggests that the plants at the shallowest site (Rocky Finger, 10 feet deep) grew more slowly than at the deepest site (Lower Transect, 25 feet deep). Two combinations of the data were tested, namely, 1) sites 1, 2 and 3 for the periods extending from 2/1/78 to 10/26/78, and 2) sites 1, 2, 3 and 4 for the periods extending from 3/22/78 to 10/26/78. In both tests, the probability that the site was unimportant to growth rates was low (for combination 1, $P = 0.085$; for combination 2, $P < 0.05$). Generally, plants grew faster at site 1, but the other sites exhibited no strong patterns.

Stipe lengths were recorded on several occasions to permit an evaluation of the efficacy of using that parameter for determining age structure and to examine growth rates of the stipe. These data, summarized in Table 4-17, evoke a degree of puzzlement because they do not provide clear indication of stipe growth. For plants with records covering between six and nine months, the mean change in stipe length was an increase of 0.77 ± 2.31 cm ($n = 13$). In this group of plants, stipe length increased in six, decreased in three, and did not change in four. For the entire group of plants with at least two measurements, nine increased in length, eight decreased and six did not change (Table 4-17). The maximum increase in length was six cm and the maximum decrease was four cm. Certainly, we recognized that measuring the length of the contorted stipes of *Agarum* presented problems, but the data seems fairly convincing that stipe growth is slow and irregular.

Knowledge of the annual turnover rate (i.e. the rate at which blade tissue is replaced) is useful in the calculation of primary productivity. It can be calculated for either blade length or weight. In terms of length, it is estimated as the ratio of the annual blade growth increment to the average blade length. Average blade length for tagged *Agarum* on

TABLE 4-16

AVERAGE RATES OF BLADE GROWTH (CM/DAY) FOR *AGARUM CRIBROSUM* FOR SPECIFIC SITES AND PERIODS AT JAKOLOF BAY

Site Number	Site Name		1977			1978						
			7/25-8/18	8/18-11/3	11/3 2/1/78	2/1-3/1	3/1-3/22	3/22-5/12	5/12-6/16	6/16-8/8	8/8-9/9	9/9-10/26
1	Lower Transect, 25 m Rock (-25 feet; high current velocity on both ebb and flow)	$\bar{x}$	0.188	0.091	0.091	0.119	0.301	0.444	0.360	0.272	0.143	0.072
		s	--	--	--	0.059	0.080	0.089	0.185	--	0.067	--
2	East of N-S Finger Transect (-15 feet; high current velocity on flow)	$\bar{x}$	--	--	--	0.104	0.326	0.389	0.320	0.180	0.078	0.053
		x	--	--	--	0.021	0.069	0.084	0.087	0.052	0.016	--
3	E-W Finger Transect, 30 m Boulder (-15 feet; moderate current veolcity on flow)	$\bar{x}$	--	--	--	0.139	0.234	0.297	0.296	0.131	0.097	0.043
		s	--	--	--	0.049	0.106	0.104	0.186	0.049	0.046	0.020
4	West of N. End of N-S Finger Transect (-20 feet; low current velocity)	$\bar{x}$	--	--	--	--	--	0.206	0.275	0.167	0.141	0.032
		s	--	--	--	--	--	0.017	0.090	--	--	0.011
5	Rocky Finger (-10 feet; moderate current velocity on flow)	$\bar{x}$	0.117	0.059	0.054	0.083	--	--	--	0.165	--	0.069
		s	0.068	0.031	--	0.027	--	--	--	--	--	--

TABLE 4-17

CHANGES IN STIPE LENGTH FOR INDIVIDUAL PLANTS OF AGARUM CRIBROSUM AT JAKOLOF BAY
STIPE LENGTH (CM) AT DATE OF OBSERVATION

Plant Designation	3/12	5/12	7/22	8/18	10/31	11/3	1/30	3/22	5/12	8/8	9/9	10/26	Overall Change
AG4			6				4						-2
AG14							4	4					0
AG19							6				7		+1
AG38							5	6		7	8	8	+3
AG41							9	7	7.5	8	10.5	9	0
AG17			10				10						0
AG10							7				12.5	13	+6
AG37							10	9		9	12.5	12	+2
AG39							12	10		12	13.5	10	-2
AG40							10	8		11	12	13	+3
AG42											12	11	-1
AG1			12				12						0
AG2	13	13											0
AG45											15	13.5	-1.5
AG35							15	13.5					-1.5
AG43							17	15			16	15	-2
AG12					15		10	11					-4
AG44							15	15		14	16		+1
AG36							20	19				20	0
AG16							20	22					+2
AG11						22	22	20					-2
AG31											23	24	+1
			31	32	35								+4

30 January was 28.9 ± 8.8 cm (n = 18). That date was selected because it is near the beginning of the growth period and average plant size is near its minimum. Using an average annual growth increment of 57.7 cm, the turnover rate in terms of length is two for the average plant. Since growth rates do not appear to vary with plant size, at least for mature plants, turnover rates apparently range from 1.2 for larger plants to over six for plants with blades less than six cm long.

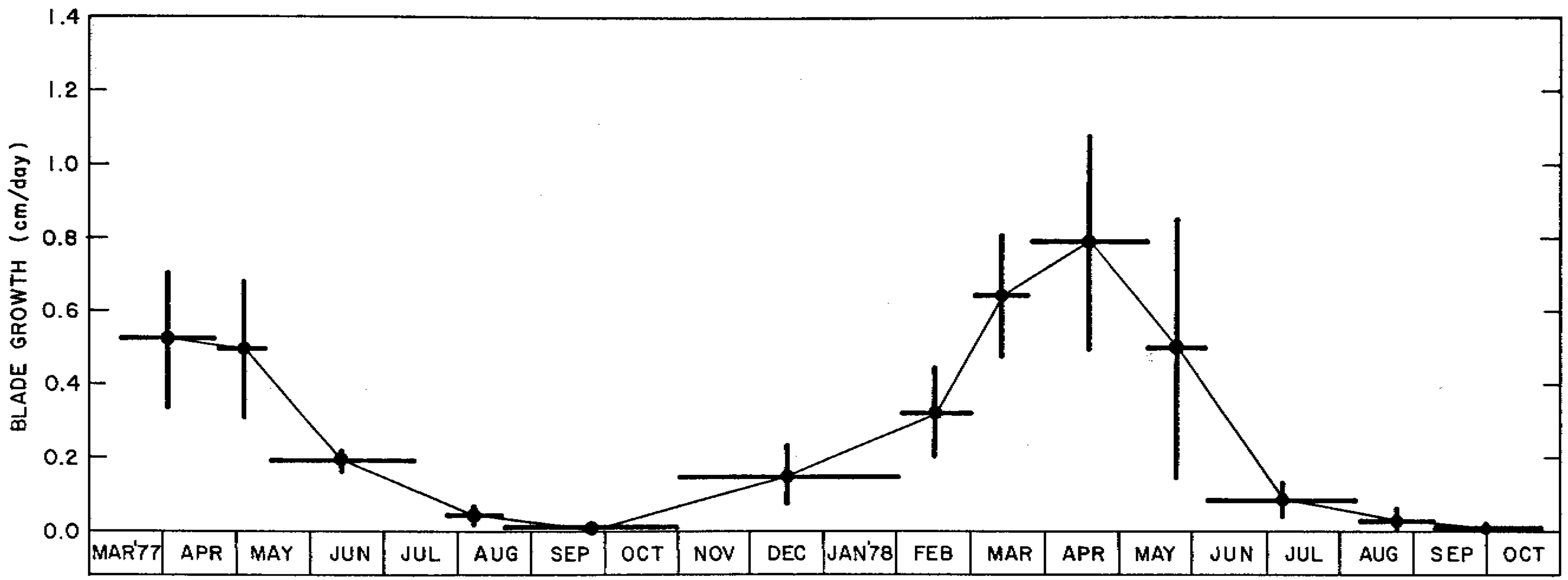
These ratios do not pertain to the turnover rate in terms of weight. Because both width and thickness of the blade increase with greater length, weight increases at an exponential rate for a given linear increase in blade length.

4.3.2 Average Growth Rates for *Laminaria groenlandica*

Forty-three plants of *Laminaria groenlandica* were labelled during this program. At least one growth observation was obtained from 42 of them. Records extending for over a year were obtained for only one plant, but thirteen produced records for at least eight months and 23 for over six months.

Growth rates for *L. groenlandica* are lowest in late summer and fall (August, September and October) and highest in spring (March and April) (Figure 4-9). Average rates ranged from 0.005 cm/day in August through October 1977 to 0.79 cm/day in April 1978. Growth rates exceeded 0.4 cm/day from March through late May, and fell below 0.2 cm/day (the lower quartile) from June through early January, i.e., more than seven months. During the periods of slowest growth, 18 of the tagged plants apparently ceased growth for one to three months (Appendix 4.3.2).

Individual growth rates appeared to vary more during periods of peak growth than during slow growth (Figure 4-9). However, despite the high variability during periods of rapid growth, growth rates differed significantly between periods of slow and rapid growth. For example, the hypothesis that growth rates were slower in the August through October 1978 period than in the March through May 1978 period was tested



MEAN BLADE GROWTH (cm)	0.525	0.497	0.195	(0.125)	0.054	0.005	0.151	0.328	0.645	0.789	0.499	0.083	0.031	0.010
s*	0.188	0.192	0.027		0.028	0.007	0.081	0.125	0.171	0.296	0.357	0.051	0.039	0.017
SE	0.050	0.051	0.009		0.009	0.003	0.041	0.024	0.036	0.063	0.078	0.012	0.009	0.005
n	14	14	10		10	6	4	28	22	22	21	18	18	12
DAYS	41	20	61	(13)	24	74	91	30	21	51	25	63	32	47
GROWTH INCREMENT (cm)	21.5	9.9	11.9	1.6	1.3	0.4	13.7	9.8	13.5	40.2	12.5	5.2	1.0	0.5

*S = STANDARD DEVIATION; SE = STANDARD ERROR; n = NUMBER OF PLANTS MEASURED

FIGURE 4-9

SEASONAL PATTERNS IN GROWTH FOR LAMINARIA GROENLANDICA AT JAKOLOF BAY using an approximate "t" test for independent means (Sokal and Rohlf, 1969). The difference was highly significant ($P < 0.0005$; one-tailed test).

A comparison of average growth rates in the minimum growth period of consecutive years indicates strong uniformity. For instance, comparison of growth rates for the September through October periods in 1977 and 1978 indicates no significant difference ($P > 0.25$). However, comparison of the maximum growth periods indicates that, although the growth patterns are similar, maximum growth rates can differ significantly between years ($P < 0.025$, two-tailed t-test).

Average blade growth increments were computed for each observation period by multiplying its average daily growth rate by the number of days in the period (Figure 4-9). These increments were summed over a year to compute an annual mean rate of blade elongation. From March 1977 through February 1978, the estimate of average blade growth was 83.6 cm, and from November 1977 through October 1978, it was 96.4 cm.

The hypothesis that growth rate is correlated with plant size was tested for two observation periods, namely, January through March 1978 and September through October 1978 (Appendix 4.3.2). The data and regression equations are shown in Figure 4-10. The correlations were not significant for either period ($P > 0.1$ in both cases).

The tagged plants were generally distributed among four locations. The physical characteristics of these sites differed mainly in the degree of exposure to tidal currents and the extent to which they extended above the surrounding rock substrate into the water column. All locations were at approximately the same depth and not exposed to siltation. A summary of the data (Table 4-18) suggests that plants on the 10 meter boulder grew more rapidly than the other sites, but the hypothesis is not supported statistically. The data used comprised a block covering from 1/30/78 to 10/26/78 for the 0 meter, 10 meter and 25 meter boulder areas. The hypothesis that average growth rates varied with respect to

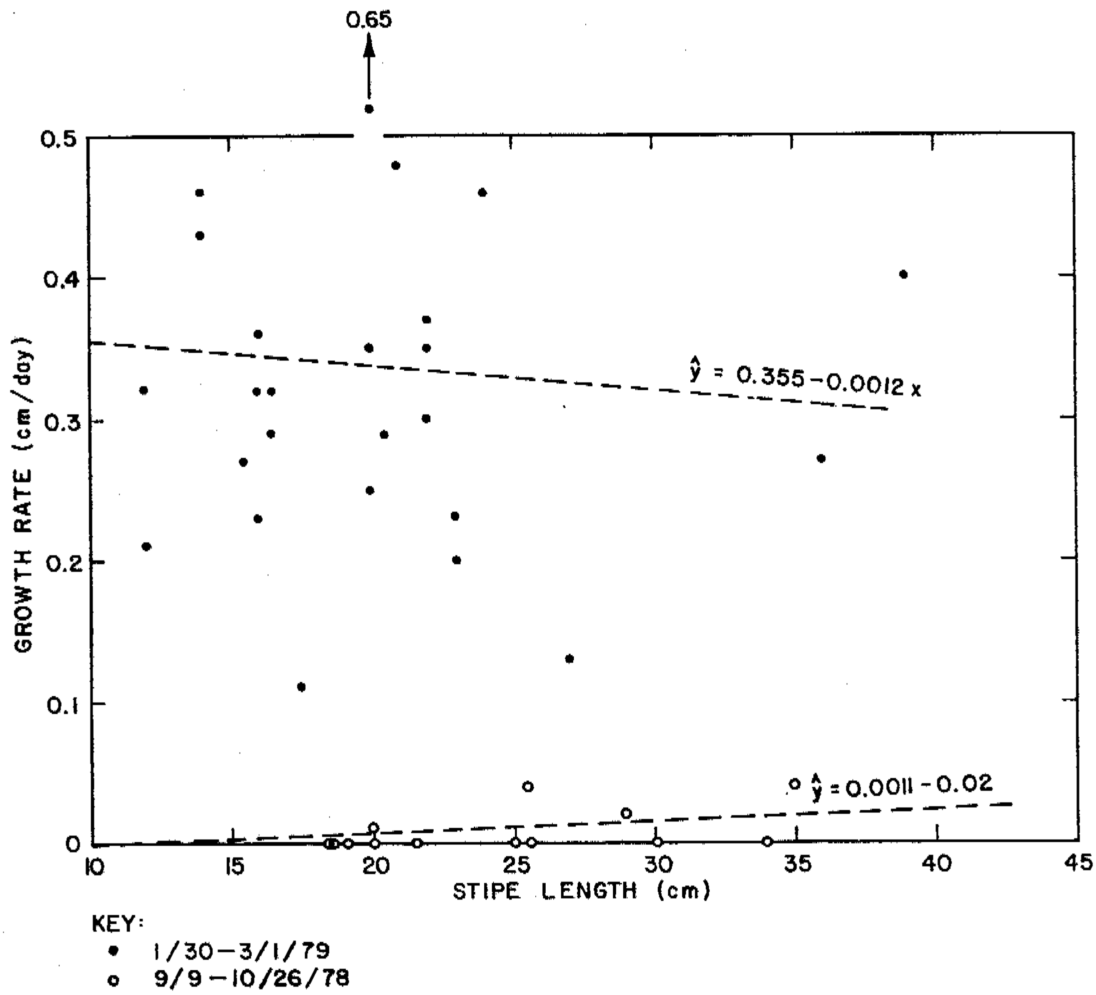


FIGURE 4-10

RELATIONSHIP BETWEEN STIPE LENGTH AND GROWTH RATE FOR LAMINARIA GROENLANDICA DURING TWO OBSERVATION PERIODS

TABLE 4-18

AVERAGE RATES OF BLADE GROWTH (CM/DAY) FOR LAMINARIA GROENLANDICA
FOR SPECIFIC SITES AND PERIODS AT JAKOLOF BAY

	1977					1978							
	4/22	5/12	7/12	8/18	11/3	1/30	3/1	3/22	5/12	6/6	8/8	9/9	10/26
N. of Metridium Rock (Low; laminar flow, high velocity)	--	0.663	0.213	--	--	0.151	0.253	--	0.556	--	--	--	--
0 Meter Boulder (Moderate, turbulent flow, high velocity)	--	0.603	0.156	0.042	0.007	--	0.328	0.631	0.524	0.712	0.085	0.022	0.009
10 Meter Boulder (High, laminar flow, moderate velocity)	--	--	--	--	--	--	0.446	0.691	1.075	0.552	0.084	0.042	0.022
25 Meter Boulder (Moderate, laminar flow, moderate velocity)	0.514	0.450	0.200	0.067	0.000	--	0.299	0.644	0.588	0.320	0.095	0.025	0.000

location was not statistically significant (P = 0.237, non-parametric Friedman two-way analysis of variance).

Stipe lengths were recorded on several occasions to permit evaluation of that parameter in determining age structure and to examine growth rates of the stipe. These data, summarized in Table 4-19, indicate the occurrence of seasonal patterns in stipe growth. Positive growth of the stipe appears to occur during the period when rates of blade growth are high (2/1 through 8/8), whereas it appears that negative growth (shrinkage) occurs during the period of minimal growth (8/8 through 1/30). The hypothesis that rate of stipe growth was greater during the period 1/30 through 3/22/78 than in 9/9 through 10/26/78 was tested with a t-test, and found to be highly significant ($P < 0.005$). Figure 4-11).

Twenty-two plants had stipe length measured on both 1/30 or 2/1 and 9/9 (Table 4-19). Initial stipe length ranged from 12 cm to 39 cm, and the change in length over that period ranged from -0.5 cm to +25 cm and averaged 7.85 cm. The hypothesis that stipe length and its rate of growth are related was tested with a correlation coefficient. The negative correlation observed between the initial stipe length (x) and its subsequent growth ($\hat{Y} = 16.145 - 0.416x$; (Table 4-11) was not significant ($r = -0.303$, $P > 0.1$).

The relationship between the simultaneous increase in length of stipe and blade (Figure 4-12) was tested with a correlation coefficient. The hypothesis that growth of the two structures was directly related was significant ($r = 0.87$, $P < 0.0005$). The regression equation suggests that they grow about three times as fast as stipes. Furthermore, the data suggest that growth of both structures is influenced by plant location; plants on the 10 meter rock appeared to grow faster than elsewhere. This boulder extends about 1.5 meters above the surrounding seafloor and all plants tagged were on top of it. Because of its small size, however, few plants were tagged.

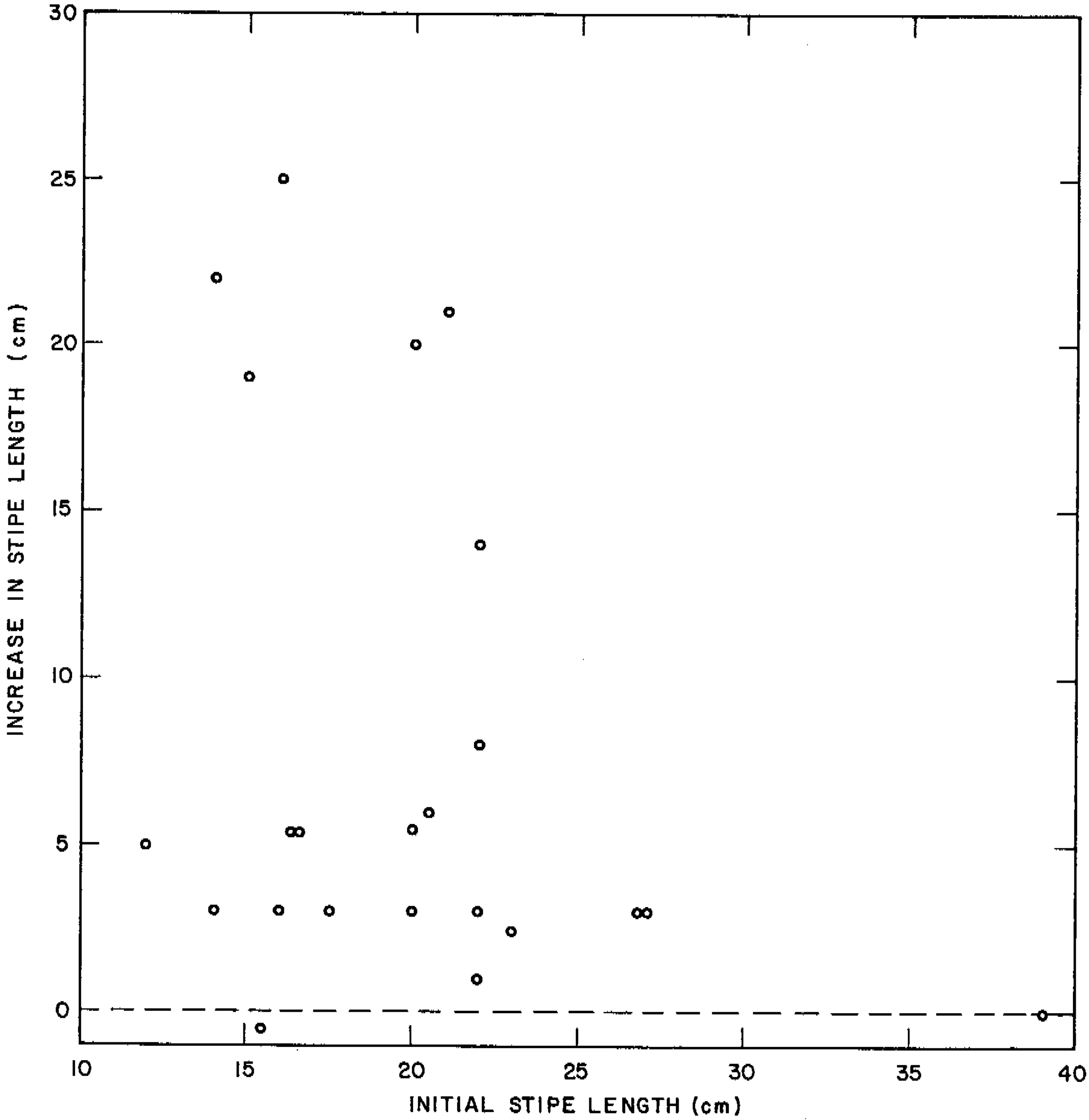


FIGURE 4-11

RELATIONSHIP BETWEEN INITIAL STIPE LENGTH AND SUBSEQUENT STIPE GROWTH FOR <u>LAMINARIA GROENLANDICA</u> FROM 1/30/78 TO 9/9/78

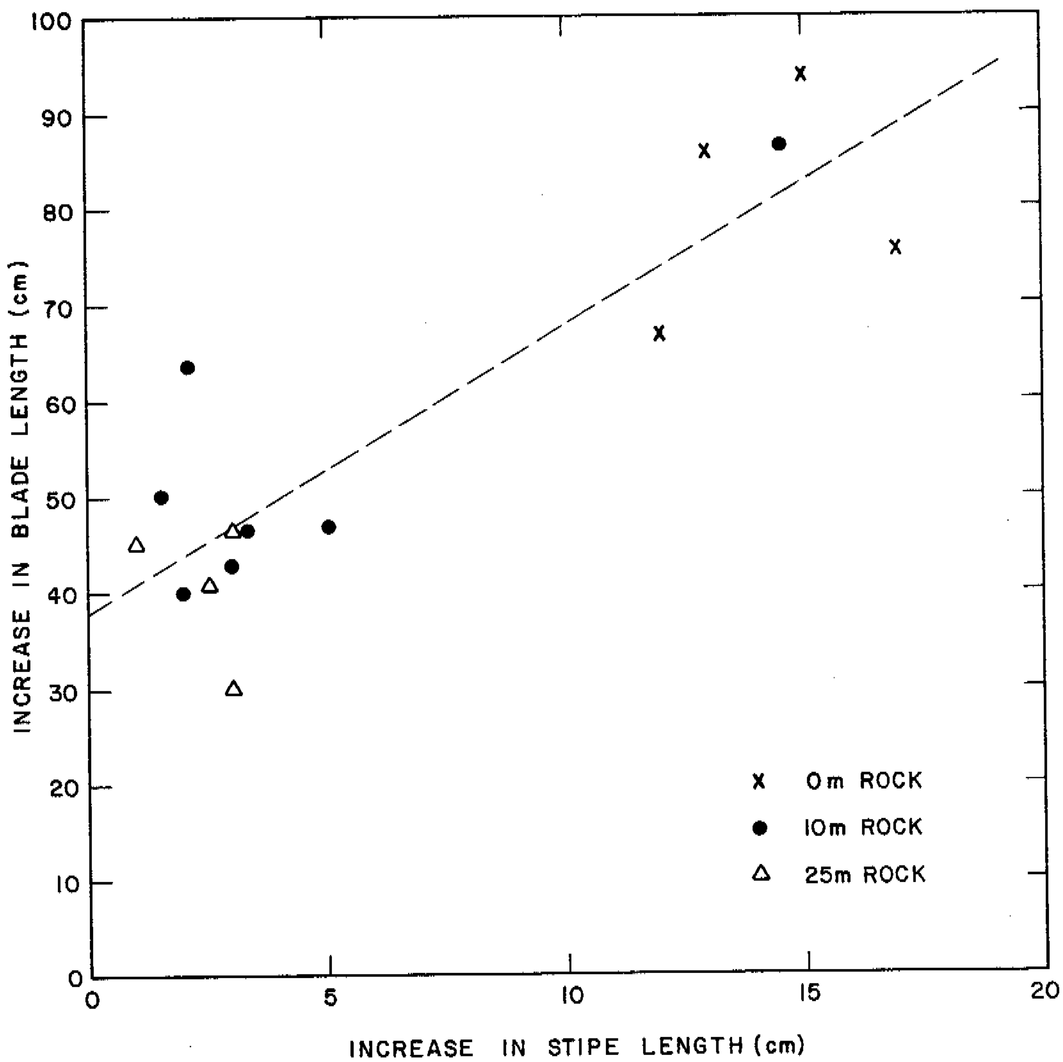


FIGURE 4-12

RELATIONSHIP BETWEEN INCREASE IN LENGTH OF STIPE AND BLADE FOR LAMINARIA GROENLANDICA FROM 3/22/78 TO 9/9/78

TABLE 4-19

CHANGES IN STIPE LENGTH FOR INDIVIDUAL PLANTS OF
LAMINARIA GROENLANDICA AT JAKOLOF BAY

Plant Designation	10/31	1/30	2/1	3/22	6/9	8/8	9/9	10/26	Overall Change
NO4	35	36							+ 1
NO6		15.5					15		- 0.5
NO7	23	22					23		0
NO8	37	39					39		+ 2
NO9			14	20	29		35	36	+22
L17	31	27					30		- 1
L19	22	20							- 2
L34		16		17	17	18	19	18	+ 2
L38		22		27	33		36		+14
L40		20		25.5	34		40		+20
L41		22		23	26		28	28	+ 6
L42		21		30	36		42		+21
L43		20					23	23	+ 3
L44		22		23		25	25	24	+ 2
L45			16	24	38.5	45	41		+25
L46		27		27			30	30	+ 3
L47		20		22.5	23		25.5	25	+ 5
L48		23		24	26		25.5	24	+ 1
L49			15	21	28		34	33	+18
L51			16.5	18		21	22		+ 5.5
L52			17.5	18		20	20.5	20	+ 2.5
L53			20.5	23.5		27	26.5	31	+10.5
L54			16.5	19		20		22	+ 5.5
L55			24	27					+ 3
L56			12	14			17	15	+ 3
L57			16	16					0
L58			14	13			17	17	+ 3
L420			12	18	31				+19
$\bar{X}$	-0.8		3.0	6.3	2.8	-0.3	-0.2		6.9
s	2.4		2.8	4.8	--	1.9	1.6		8.2
Rate/day	-0.009		0.061	0.079	0.047	-0.010	-0.001		

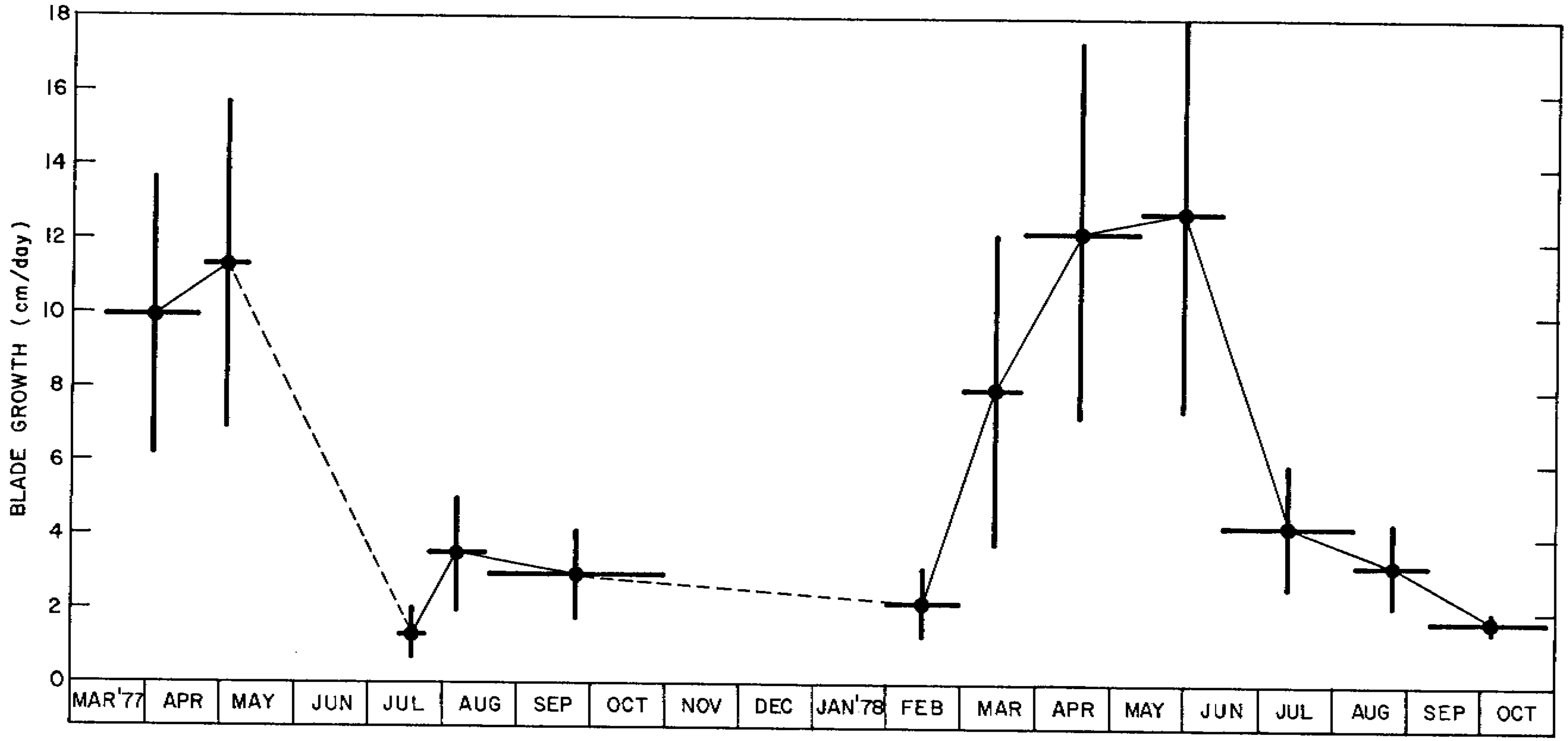
4.3.3 Alaria fistulosa

4.3.3.1 Average Growth Rates

Fifty-six plants of Alaria fistulosa were labelled during this program. At least one growth observation was obtained from 42 of them. The longest records were obtained for two plants extending from 02/01/78 to 10/26/78. Seven additional plants were followed for over seven months. The average length of observation was for 105 days. This is a reflection of the high mortality rates of this genus in Alaska which, although generally considered to be perennial, is virtually annual. In addition to high natural mortality, handling activities associated with tagging and measurements seemed to increase mortality rates. This resulted mainly from weakening the attachment by the holdfast. Blade damage resulted in some loss of growth markers. However, since growth occurs mainly in the meristem (between the blade and stipe), and that structure was not handled, we have no reason to suspect that tagging affected growth rates. Additionally, plant loss was greater during 1977 because the front of sea urchins grazed through the tagging area and extirpated virtually all the Alaria.

Growth rates for A. fistulosa were lowest during fall and midwinter, but increased rapidly to a peak in spring (April-May) (Figure 4-13). Average rates ranged from 1.36 cm/day in July 1977 to 12.79 cm/day in May-June 1978. Growth rates generally exceeded 6.4 cm/day (half the maximum rate) in March through June, but fell below 4.24 cm/day (into the lower quartile) during the remaining months, i.e. two-thirds of the year. The slowest rate of growth observed for an individual plant was 0.84 cm/day for the month of February and the most rapid was 18.77 cm/day from late May to early June (Appendix 4.3.3).

Individual growth rates appeared to vary more during periods of peak growth than during slow growth (Figure 4-13). However, despite high variability, growth rates differed significantly between periods of slow and rapid growth. For example, the hypothesis that growth rates in



MEAN BLADE GROWTH (cm)	9.93	11.31	(6.34)	1.36	3.48	>2.94	(2.58)	2.21	7.98	12.35	12.79	4.28	3.28	1.70
S*	3.37	4.44		0.67	1.57	1.22		0.95	4.21	4.99	5.15	1.65	1.17	0.29
SE	1.42	1.81		0.24	0.50	0.70		0.25	1.12	1.21	1.33	0.52	0.39	0.15
n	7	6		8	10	3		14	14	17	15	10	9	5
DAYS	40	20	61	13	24	74	93	28	23	49	35	53	32	47
GROWTH INCREMENT (cm)	397.2	226.2	(326.7)	17.7	83.5	217.6	239.9	61.9	183.5	605.2	447.7	226.8	105.0	79.9

* S = STANDARD DEVIATION; SE = STANDARD ERROR; n = NUMBER OF PLANTS MEASURED

FIGURE 4-13

SEASONAL PATTERNS IN GROWTH FOR ALARIA FISTULOSA AT JAKOLOF BAY the September-October 1978 period were slower than those observed in the May-June 1978 period was tested using an approximate "t" test for independent means (Sokal and Rohlf 1969). The difference was highly significant ($p < 0.005$; one-tailed test).

In contrast, a comparison of average growth rates in the same season of consecutive years indicates strong uniformity. For instance, comparison of the growth rates for the April-May 1977 and March-May 1978 periods, and the July-August 1977 and June-August 1978 periods indicate no significant differences in growth rates between these respective periods (Student's t-test, $P > 0.10$ in both cases).

The hypothesis that growth rate is correlated with plant size was tested for six observation periods, namely, 12 March to 22 April, 1977, 22 April to 12 April 1977, 12-22 April, 1977, 30 January to 1 March 1978, 16 June to 8 August 1978, and 8 August to 9 September, 1978 (Appendix 4.3.3). For this analysis, stipe length was used as an index of plant size. The data and regression equations for two periods are shown in Figure 4-14. The correlations was significant only for the 16 June to 8 August period ($p < 0.05$; $P > 0.10$ for the other periods).

Average blade growth increments were calculated for each observation period by multiplying its average daily growth rate by the number of days in the period (Figure 4-13). These increments were summed over a year to compute an annual mean rate of blade elongation. From March 1977 through February 1978, the estimate of average blade growth was 1630.7 cm, and from November 1977 through October 1978 it was 1950 cm.

The tagged plants of Alaria were generally distributed among three locations. These locations differed mainly in depth, but somewhat in water quality. Sufficient data for comparison were only obtained at "Upper Boulders, Finger Reef" and at "5 m on E-W Finger Line". At the former, depth was about -2 m below MLLW, tidal currents strong and water possibility warmer and more turbid during low slack tide. At the latter site, depth was about -5 below MLLW. The hypothesis that average

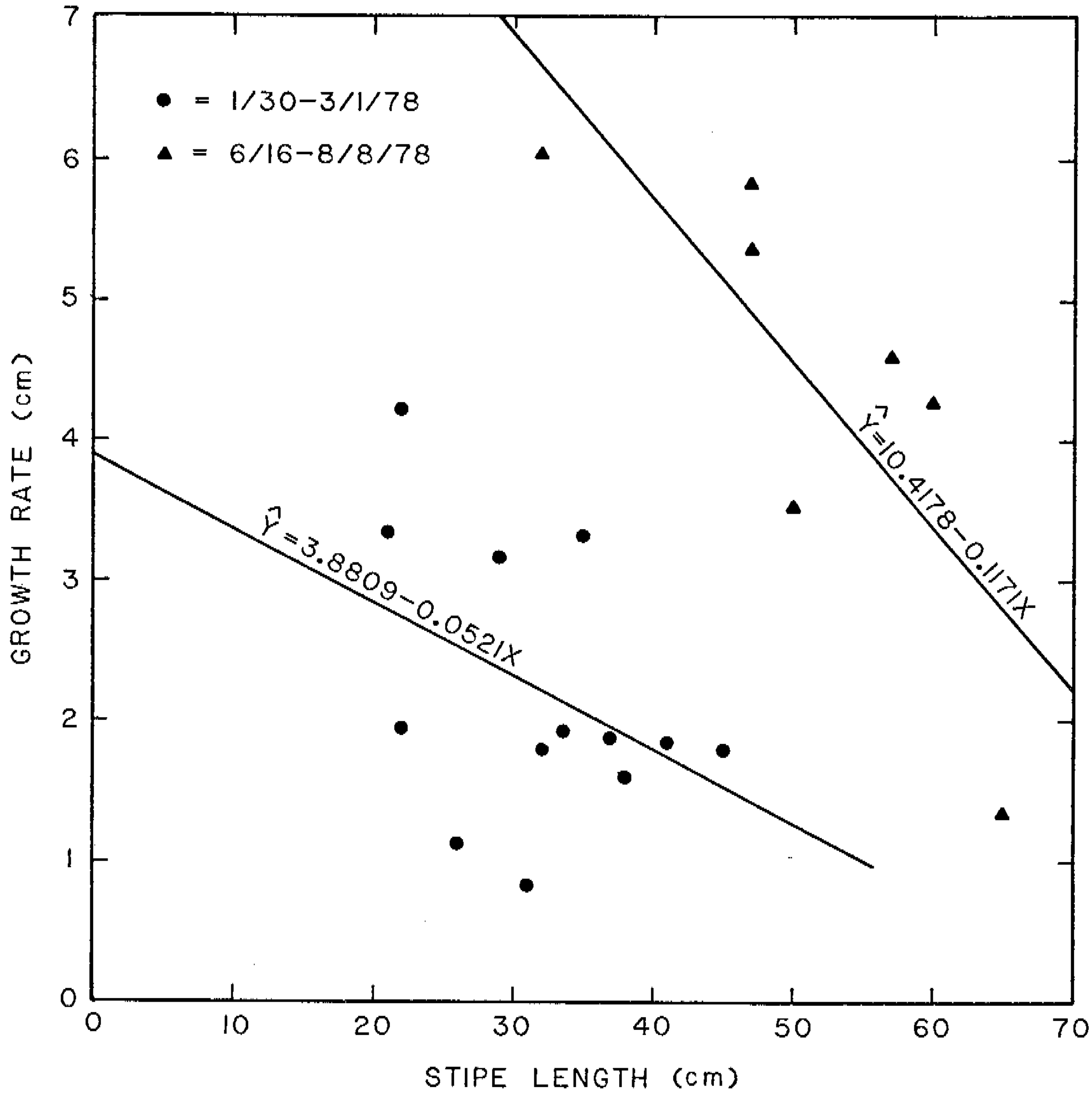


FIGURE 4-14

RELATIONSHIP BETWEEN STIPE LENGTH AND GROWTH RATE FOR <u>ALARIA FISTULOSA</u> AT JAKOLOF BAY growth rates were the same at each location was tested using the Mann-Whitney U Test. A summary of the available data (Table 4-20) supports that hypothesis but the data are weak. Comparisons between these locations for two periods (2/1 - 3/1/78 and 3/1 - 3/24/78) indicated that growth rates were not significantly different.

Stipe lengths were recorded on several occasions to permit an evaluation of the efficiency of using that parameter for determining age structure, and to examine growth rates of the stipe. These data, summarized in Table 4-21, are rather ambiguous. All plants examined for over three months showed increases in stipe length. However, several plants examined for shorter periods exhibited substantial decreases in stipe length. The explanation of this is unclear; problems in measurement should not be ruled out.

4.3.3.2 Primary Production

The equations used to calculate annual primary production (AP) for the large kelp *Alaria fistulosa* incorporates data for growth, density and length-weight data were used to construct a horizontal life table. The growth data are based on patterns described above; rates used from October to January are probably somewhat conservative.

The two density levels used are based on estimates from (1) a fixed transect in a shallow area with fairly high density of both adult and juvenile plants (Dames & Moore 1976), and (2) on a lower, more general average from quadrats and band transects spread throughout the area (Table 4-22). Generally, densities of juveniles were scarce to absent during fall and mid-winter, increased rapidly during April to a peak in May, and then decreased rapidly through the summer. Adults were present all year, but densities were lowest in March-May and highest in July and August.

These data suggest the general shape of the survivorship curve and were used as a basis for Figure 4-15. The generality of the curves

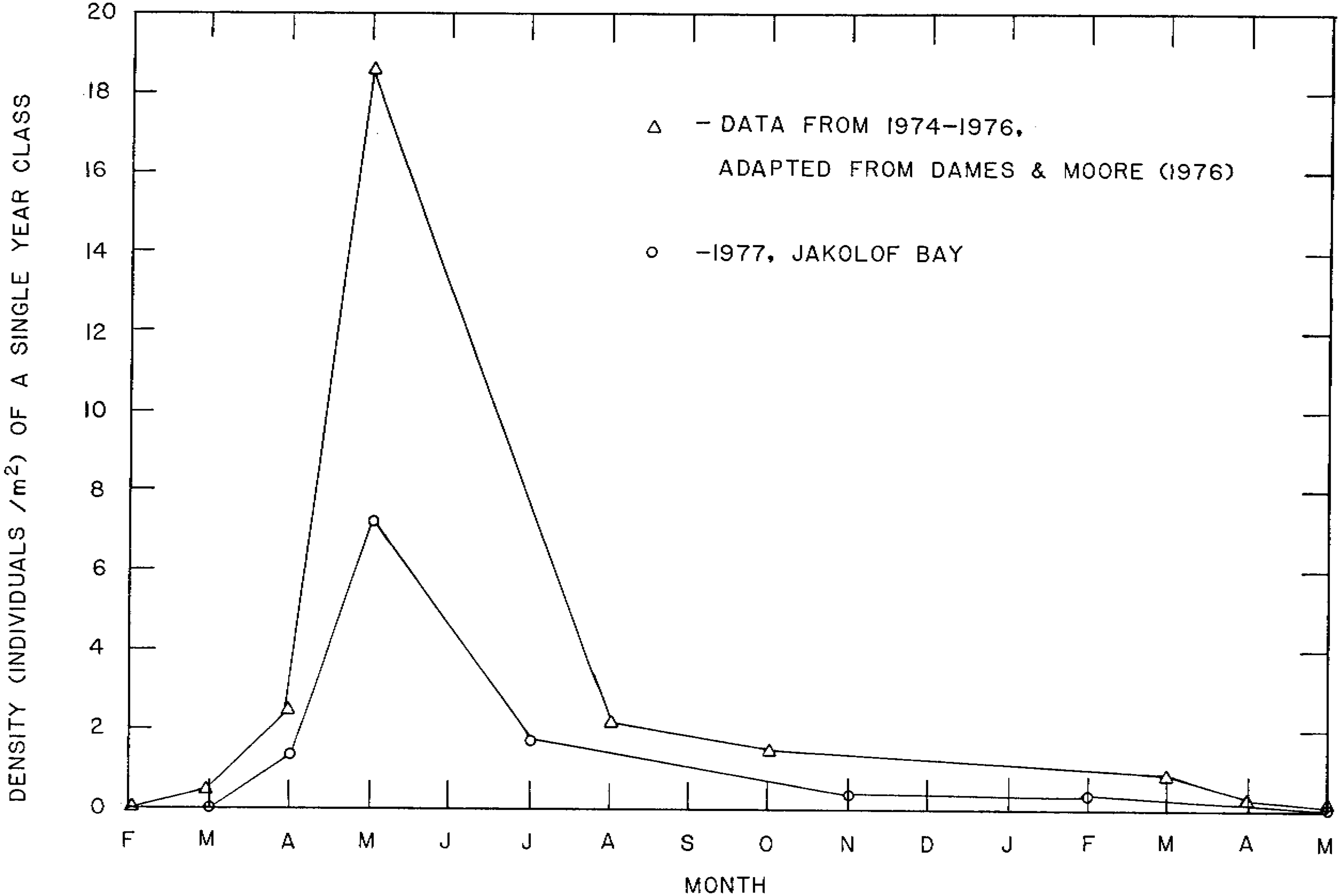


FIGURE 4-15

GENERALIZED SURVIVORSHIP CURVES FOR ALARIA FISTULOSA AT JAKOLOF BAY

TABLE 4-20

AVERAGE RATES OF BLADE GROWTH (CM/DAY) FOR
Alaria fistulosa FOR SPECIFIC SITES AND PERIODS IN JAKOLOF BAY

		02/02 - 03/01	03/01 - 03/24	03/24 - 06/16	06/16 - 08/08	08/08 - 09/09	09/09 - 10/26
5 m on E-W Finger Line (5 m deep)	$\bar{x}$	2.23	6.84	9.95	5.96	3.49	1.45
	s	1.15	4.30	6.18	4.90	1.59	--
Upper Boulder Finger Reef (2 m deep)	$\bar{x}$	2.18	8.94	13.23	4.17	2.38	2.19
	s	0.79	4.45	--	--	--	--
E. of E-W Finger Line (5 m deep)	$\bar{x}$	--	--	15.94	5.23	4.32	1.28
	s	--	--	1.41	--	--	0.56

TABLE 4-21

CHANGES IN STIPE LENGTH FOR INDIVIDUAL PLANTS OF *Alaria fistulosa* AT JAKOLOK BAY

Plant Designation	Stipe Length (cm) at Date of Observation											Overall Change
	03/13	04/22	05/12	07/15	08/18	10/31	02/01	03/22	08/08	09/09	10/26	
AL68										15	22	+ 7
AL26				17	19							+ 2
AL24				17		28						+11
AL22				18	10							- 8
AL15				20	11	37						+17
AL25				21	36							+15
AL21				21		41						+20
AL32							21			50	52	+31
AL30							22		47	45		+23
AL18		27	29	35								+ 8
AL23							28			33		+ 5
AL19		29	30									+ 1
AL 4							29				53	+24
AL27							30	29				- 1
AL38							31	30				- 1
AL 6									32	26	25	- 7
NO 9	32.5	31	33									+0.5
NO 6	34	39	43									+ 9
NO 3	35	35	36									+ 1
NO 4	37.5	34										-3.5
AL50									38	29		- 9
AL31							38		60	62		+23
NO 8	39	35	40									+ 1
NO 2	39	38	40									+ 1
AL58										39	40	+ 1
AL36							41		65			+24
AL33							45	43				- 2
AL 7									47	33		-14
NO 5	48	47	51									+ 3
AL51									52	53		+ 1
AL63									65	74		+ 9
$\bar{x}$	0.29		2.63	--	0.00	--	--	1.3	--	2.25		
s	3.08		1.51		11.17			0.6		3.40		

TABLE 4-22

DENSITY DATA (INDIVIDUALS/m^2) FOR *Alaria fistulosa* AT JAKOLOK BAY, 1974-1977

Data from fixed transect, 1974-1976, adapted from Dames & Moore (1976):

	08/74	10/74	03/75	05/75	08/75	10/75	04/76	07/76
Juveniles	--	--	0.24	18.72	0.96	0.12	2.48	4.52
Adults	2.40	1.64	0.96	0.12	2.24	1.60	0.24	1.96

Data from random areas at Jakolof Bay study site:

	02/77	03/77	04/77	05/77	07/77	11/77
Juveniles	0	0	1.33	7.19	0.32	0
Adults	0.69	0.027	0.025	0.12	1.81	0.33

appears acceptable based on our impressions of growth and survivorship for *Alaria* in Kachemak Bay. However, density levels, while representative of a well-developed kelp bed, are undoubtedly rather high for Kachemak Bay as a whole, as *A. fistulosa* has been observed mainly in high current areas between 1.5 m and 12 m depths (personal observation).

The length-weight relationship (Figure 4-16) is based on plants collected from the study site. The correlation is highly significant for plants up to 10 m in length ($r = 0.96$, $P \ll 0.001$). The regression equation, exponential because increased length is accompanied by increased blade width and thickness, was used to calculate fresh weights of a hypothetical, uneroded plant at various lengths up to 12 m. The linear increase in the plant weight: plant length ratio associated with increasing length (Figure 4-17) is probably mainly due to increasing width. Although we observed that larger plants had wider blades, in the absence of data showing this relationship at lengths greater than 10 m, we felt it was inappropriate to assume that the ratio continued increasing. This choice also precluded using the regression equation for plant lengths appreciably larger than 11 m. Therefore, plant weights for plants longer than 12.0 m were calculated by multiplying their length by 2.2 g/cm, the length-weight ratio for 11 m long plants.

Alaria spp. are virtually annuals in Alaska (personal observation for three species). This feature permitted treating the population as a cohort simplifying the production computations. Therefore, we assumed that the plants recruited on 1 May ($m = o$) at a length of 30 cm ($L_o = 30$ cm). (This was a statistical assumption; Table 4-22 indicates the occurrence of juveniles in numerous months before and after May, but definitely, juvenile density was highest then.) Based on these assumptions, the hypothetical, uneroded length of a plant at the end of a specific month was taken as:

$$L_m = t_m \bar{G}_m + L_{m-1},$$

where t_m is the number of days in the month and G_m is the observed

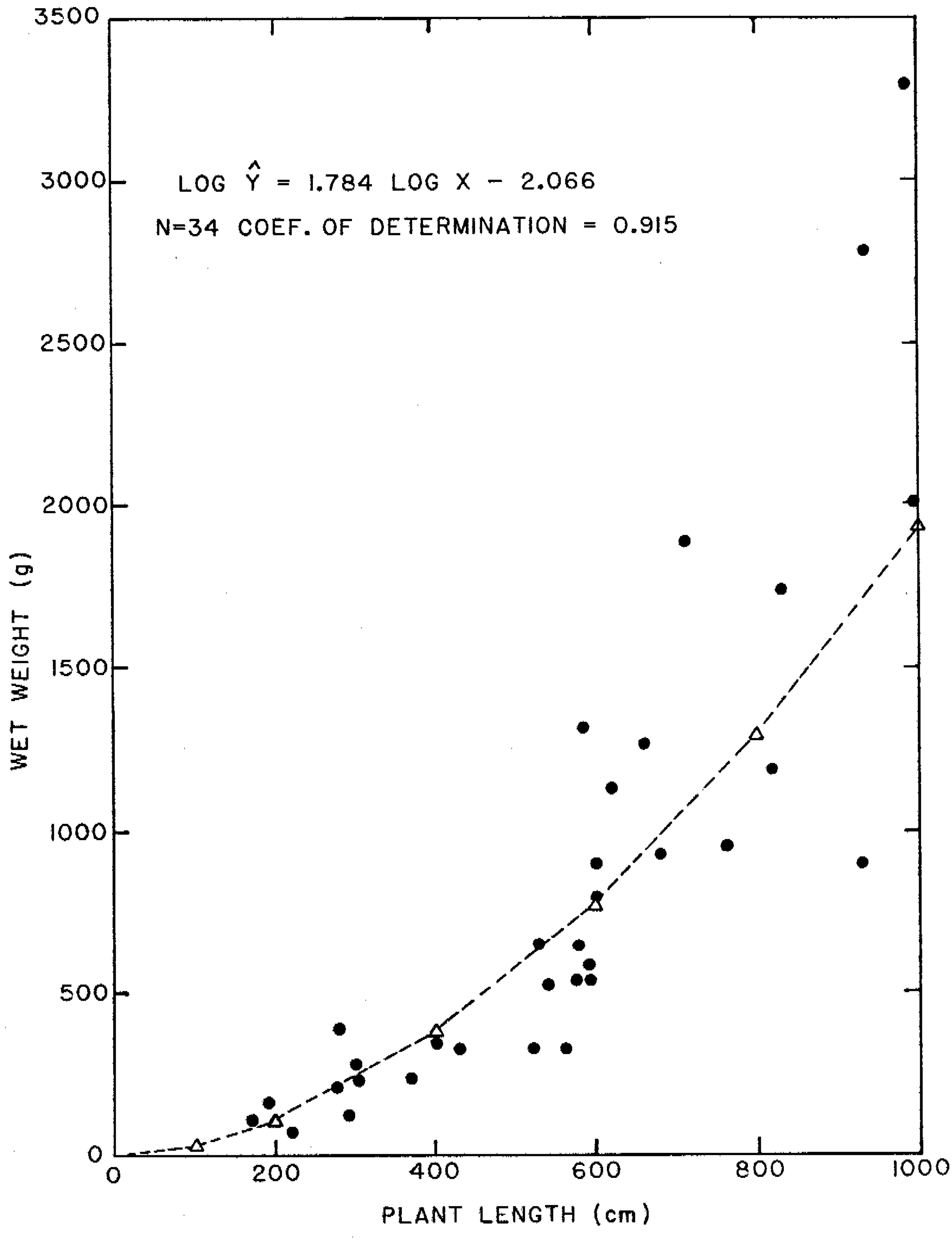


FIGURE 4-16

LENGTH-WET WEIGHT RELATIONSHIP
FOR *ALARIA FISTULOSA* AT JAKOLOF BAY
FOR PLANTS COLLECTED ON 12, 15 AND 25 JULY, 1977

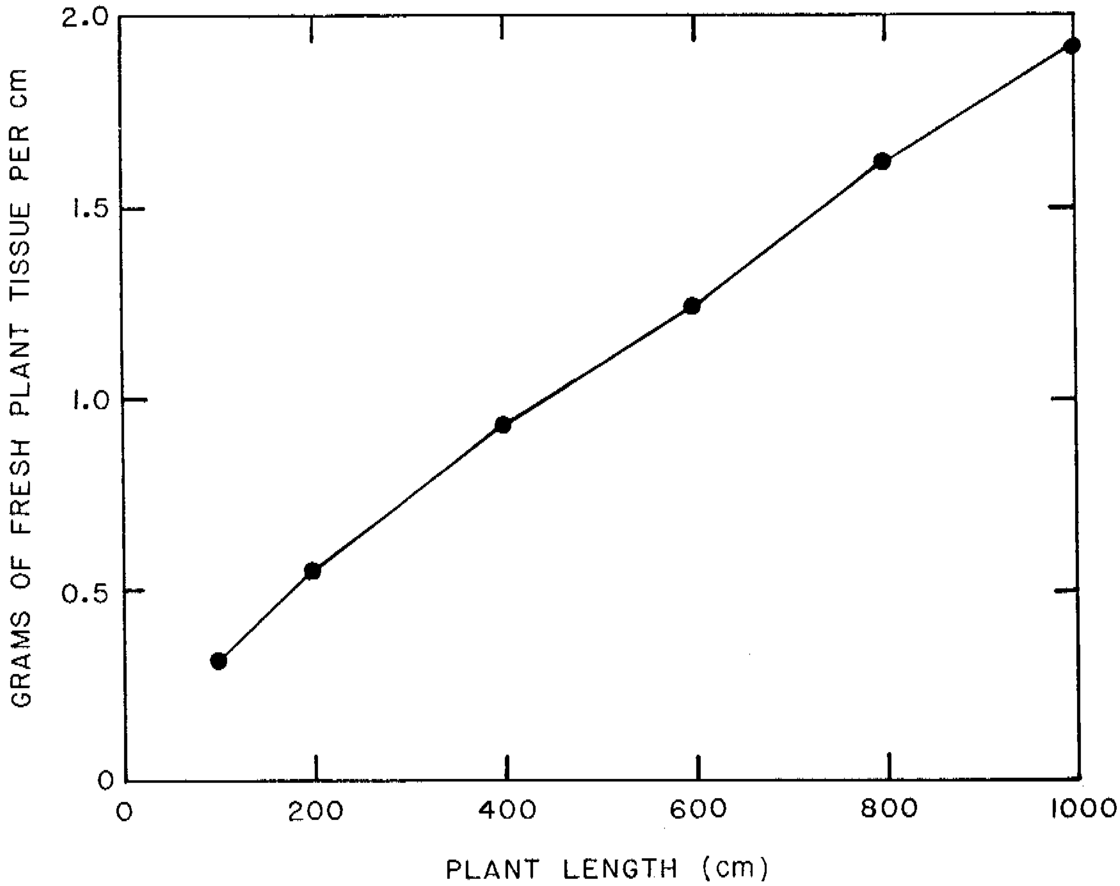


FIGURE 4-17

RELATIONSHIP BETWEEN PLANT LENGTH AND LENGTH:
WET WEIGHT RATIO FOR
ALARIA FISTULOSA FROM JAKOLOF BAY

average daily growth rate for that month. Calculations of L_m must be accomplished consecutively.

The monthly increment in fresh tissue weight (T_m) for an average individual was taken as the difference between individual plant weight in consecutive months, i.e., $W_m - W_{m-1}$, where

$$W_m = 10^{1.784 \log L_m - 2.066}.$$

For the total population, monthly tissue production (MP_m) involves a simple relationship between T_m, plant density (D_m) and the shape of the survivorship curve during that month ($D_m - D_{m-1}$):

$$MP_m = T_m ((D_m + D_{m-1})/2) = T_m \bar{D}_m.$$

Data for May in Table 4-23 are used as an example. Given an average plant length and weight of 30 cm and 3.7 g on 30 April and an average observed growth rate of 12.5 cm/day for May, the average plant will have grown about 388 cm to an uneroded length of 418 cm by the end of May. The length-weight regression equation predicts a plant that long would weigh 408 g. Since the initial size of the average plant was about 4 g, the tissue increment per plant is 404 g. Multiplying this increment by average plant density for May

$$(D_1 + D_o)/2 = (5.6 + 7.19)/2 = 6.395 \text{ plants/m}^2$$

gives an estimate of 2577 g tissue produced/m^2 in May.

The calculations of primary production for A. fistulosa are summarized in Table 4-23. These indicate that over 80 percent of the plant tissue produced by this species is produced during May, June, and July, when estimates of carbon fixation range up to 13.77 gC/day in the densely populated areas. Annual averages range from 1.17 gC/m^2/day in the study area to 3.05 gC/m^2/day in the high density area.

TABLE 4-23

ESTIMATES OF PRIMARY PRODUCTION FOR THE KELP *ALARIA FISTULOSA* FOR THE JAKOLOF BAY STUDY SITE

	A	M	J	J	A	S	O	N	D	J	F	M	A	Annual Production By Cohort
Average Growth Rate (cm/day) - G_m	--	12.5	10.0	6.0	3.8	2.5	2.0	2.0	2.0	2.0	2.0	5.5	10.0	
Indiv. Length (cm) at end of month - L_m	30	418	718	904	1022	1097	1159	1219	1281	1343	1399	1570	1870	
Indiv. Weight (g) at end of month - W_m	3.7	408	1070	1614	2008	2279	2514	2682	2818	2955	3078	3454	4114	
Monthly Increment in Fresh Tissue Weight (g) - T_m		404	662	544	394	271	235	168	136	137	123	376	660	
CONSERVATIVE ESTIMATE OF PRODUCTION														
Density at end of month (plants/m²) - D_m	7.19	5.60	1.81	1.40	1.05	0.75	0.45	0.40	0.35	0.33	0.30	0.19	0	
Production (g/m²/month) by														
Plants remaining		2262	1198	762	414	203	106	67	48	45	37	71	0	
Plants lost to area		321	1254	112	69	41	35	4	3	1	2	21	63	
Monthly Fresh Tissue Production (g/m²/month) - MP_m		2583	2452	874	483	244	141	71	51	46	39	92	63	7,139
											Dry weight/m²			1,428[1]
											g C/m²			428[2]
HIGH DENSITY AREA ESTIMATE OF PRODUCTION														
Density at end of month (plants/m²) - D_m	18.72	13.00	7.80	2.24	1.80	1.50	1.40	1.25	1.10	1.00	0.90	0.30	0	
Production (g/m²/month) by														
Plants remaining		5252	5164	1219	709	407	329	210	150	137	111	113	0	
Plants lost to area		1155	1721	1512	87	41	12	13	10	7.	6	113	99	
Monthly Fresh Tissue Production (g/m²/month) - MP_m		6407	6885	2731	796	448	341	223	160	144	117	226	99	18,577
											Dry weight/m²			3,715[1]
											g C/m²			1,115[2]

1 Assuming a dry tissue weight/wet weight ratio of 0.2 (Mann, 1972).
2 Assuming a g C/dry weight ratio of 0.3 (Mann, 1972).

These estimates probably indicate the correct order of magnitude of tissue production for Alaria stands around Kachemak Bay, but several factors could alter them substantially. The model is quite sensitive to changes in life history features in May and June such as:

- initial density
- the temporal relationship between peak density and growth rates
- the shape of the survivorship curves
- growth rates

Environmental factors or disturbances altering any of these features in March or April (period of maximal germination) through June could probably have significant influence on the annual production of this species.

4.4 RESULTS - SOFT SUBSTRATES

At the two sand beaches and the mud flat studied the respective faunas were distinctly different. Sampling efforts were essentially equal in each survey. Twenty-two species were identified from the sand beach at Deep Creek (Table 4-24), where the fauna was dominated by the gammarid amphipod *Eohaustorius eous*. Thirty species were identified from the sand beach at Homer Spit (Table 4-24), where the fauna was dominated by the polychaete *Scolelepis* sp. A. Forty species were identified from the mud flat at Chinitna Bay (Table 4-25), where the fauna was dominated by the clams *Maxoma balthica*, *Mya arenaria*, *M. truncata* and *Mya priapus*. *Mya* spp. are possibly present at commercially harvestable densities. Although unmeasured, the mud flat also supported appreciable standing crops of benthic diatoms and filamentous brown and green algae in the summer.

4.4.1 Biological Assemblage of the Sand Beach at Deep Creek

The infaunal assemblage at the Deep Creek site was sampled three times during the period covered by this report, namely on 4 February,

TABLE 4.24. FREQUENCY OF OCCURRENCE OF TAXA FROM SANDY INTERTIDAL SITES ON THE EAST SIDE OF LOWER COOK INLET IN 1977

Taxa	Deep Creek	Homer Spit
PLATYHELMINTHES		
Turbellaria, unid.	0	1
ANNELIDA - Polychaeta		
Abarenicola sp.	1	0
Capitella capitata	3	1
Chaetozone setosa	1	0
Eteone nr. *longa*	3	2
Magelona pitelkae	0	1
Nephtys ?*ciliata*	2	3
Nephtys sp. (juv.)	0	1
Paraonella platybranchia	3	3
Sabellidae, unid.	0	1
Scolelepis p. A	3	3
Scoloplos armiger	3	1
Spionidae, unid.	0	1
Spiophanes ?*bombyx*	0	1
Typosyllis sp.	0	1
ARTHROPODA - Crustacea		
Anisogammarus cf. *confervicolus*	2	0
Archaeomysis grebnitzkii	2	1

Taxa	Deep Creek	Homer Spit
Atylidae, sp.A	1	0
Crangon ?alaskensis elongatus	0	1
Eohaustorius eous	3	3
Gammaridae sp.A	1	0
Gammaridea, red striped	0	1
Lamprops carinata	0	1
Lamprops quadriplicata	1	1
Lamprops sp.	0	1
Lysianassidae, unid.	1	2
Oedocerotidae, unid.	1	0
Paraphoxus milleri	1	2
Paraphoxus sp.	2	1
Synchelidium sp.	1	0
MOLLUSCA - Gastropoda		
Littorina sitkana	0	1
MOLLUSCA - Pelecypoda		
Mytilus edulis	0	1
Protothaca staminea	0	1
Spisula polynyma	0	3
CHORDATA - Pisces		
Ammodytes hexapterus	0	3
Total Number of Species	22	30

TABLE 4.25. PERIOD OF OCCURRENCE OF TAXA FROM MUD FLAT SITE AT GLACIER SPIT, CHINITNA BAY IN 1977

TAXON		TAXON	
NEMERTEA, unid.	7[a]	ARTHROPODA	
		Acarina, unid.	7
ANNELIDA		Cyclopoida, unid.	7
Abarenicola pacifica	4	*Crangon* sp	7
Ampharete acutifrons	4,7	Harpacticoida, unid.	7
Aphroditoidea, unid	4	Insecta (larva)	7
Axiothella rubricincta	7	Ischyrocerodidae, unid.	7
Capitella capitata	4,7	*Pontoporeia femorata*	7
Eteone nr. *longa*	4,7	*Saduria entomon*	4
E. nr. *pacifica*	7	*Tritella ?pilimana*	4,7
Glycinde polygnatha	4		
Harmothoe imbricata	4,7	MOLLUSCA	
Malacoceros sp	4,7	*Aglaja diomedea*	7
Maldanidae, unid.	7	*Clinocardium nuttallii*	4,7
Nephtys sp	4,7	*Cylichna* sp	7
Nephtys sp (juvenile)	4,7	*Macoma balthica*	4,7
Oligochaeta, unid.	7	*Macoma* sp	4
Paraonella platybranchia	7	*Mya arenaria*	4,7
Paraonidae, unid.	4	*M. priapus*	4,7
Phyllodoce groenlandica	4,7	*M. truncata*	4,7
Polydora caulleryi	4,7	*Mya* spp. (juveniles)	4,7
Polygordius sp	7	*Pseudopythina* sp	4,7
Potamilla sp	4,7		
Scoloplos armiger	4,7		
Spio ?filicornis	7		
?*Spio* sp	4		
Spionidae, unid.	7		
ECHIURA			
Echiurus echiurus alaskensis	4,7		

[a] Number refers to month of sampling period; 4 = April, 7 = July

7 April and 29 July 1977. A total of 17 taxa, including eight polychaete and nine crustacean taxa, was identified during the sampling period (Table 4-24).

Quantitatively, the infauna was dominated heavily by gammarid amphipods, especially the haustoriid *Eohaustorius eous* (Table 4-26). Relative abundance was remarkably uniform seasonally. An unidentified member of the amphipod family Gammaridae (Gammaridae sp. A) was quite abundant in the July survey. The remaining species were only of marginal numerical importance. Most notable among these were the polychaetes *Eteone* nr. *longa* and *Scolelepis* sp. A, and the gammarid *Paraphoxus milleri*. The raw data for these samples, by core, level and survey, are presented in Appendix 4.4.1 through 4.4.3 and species summaries in Appendix 4.4.4 through 4.4.6.

4.4.1.1 Zonation

To examine zonation, the species at each level were assigned, by survey, to "importance" categories according to their density and frequency of occurrence (see METHODS section). Species composition was then compared among the sampling levels. According to these criteria, the upper level was dominated by *Eteone* and *Eohaustorius*, the middle two levels by *Eohaustorius* and the lower level by *Scolelepis* and *Eohaustorius* (Table 4-27). Only the latter species was important at all levels.

The relationship between elevation and density was examined, but only the increase of *Eohaustorius* at lower elevations departed significantly from random ($P < 0.02$). In contrast, *Eteone* was more abundant at the upper levels than below, but the pattern was not statistically significant. In addition, densities in July appeared to be quite variable for several species. It appears that the middle level is near the upper limit for *Scolelepis* and *Paraphoxus* at this beach. The paucity of statistically significant elevation-related density differences among the species observed is probably mostly a consequence of too few samples, or a high degree of patchiness, as well as the changes in the beach shape and the corresponding movement of the animal populations in relation to the sampling levels.

TABLE 4-26. OVERALL DENSITY (NO./M^2) OF COMMON SPECIES AT DEEP CREEK SITE

Taxa	2/77 Density	%	4/77 Density	%	7/77 Density	%
Polychaeta		(17.6)[a]		(12.9)		(13.4)
Capitella ?capitata	9.6	1.8	-	-	9.6	0.8
Eteone nr. *longa*[b]	44.6	8.6	9.6	1.6	9.6	0.8
Nephtys ?ciliata[b]	-	-	9.6	1.6	9.6	0.8
Paraonella platybranchia	15.9	3.0	9.6	1.6	12.7	1.0
Scolelepis sp. A[b]	15.9	3.0	35.0	5.4	92.3	7.4
Scoloplos armiger[b]	6.4	1.2	15.9	2.7	31.8	2.6
Gammaridea		(81.3)		(84.7)		(84.6)
Anisogammarus cf. *confervicolus*	6.4	1.2	6.4	1.0	-	-
Eohaustorius eous	404.2	78.3	461.5	78.8	648.4	51.9
Gammaridae, sp. A	-	-	-	-	388.3	31.2
Paraphoxus milleri[b]	9.6	1.8	28.6	4.9	19.1	1.5
Mysidacea						
Archaeomysis grebnitzkii	3.2	0.6	-	-	3.2	0.2

[a] Parenthetic number are total percentages in major taxa

[b] Also common in sandy infaunal samples collected at 200 ft. depths in the middle of Lower Cook Inlet and at Homer Spit

[c] Also found at Homer Spit

TABLE 4-27. IMPORTANT SPECIES AT EACH LEVEL AT DEEP CREEK

Species	Sampling Level 1	2	3	4
Polychaetes				
Capitella capitata		Frequent		
Eteone nr *longa*	Dominant	Frequent		
Paraonella platybranchia		Frequent	Sub-dominant	Frequent
Scolelepis sp. A		Seasonal	Sub-dominant	Dominant
Scoloplos armiger			Sub-dominant	Frequent
Crustaceans				
Anisogammarus cf *confervicolus*	Frequent			Frequent
Eohaustorius eous	Dominant	Dominant	Dominant	Dominant
Gammaridae sp. A		Seasonal	Seasonal	Seasonal
Paraphoxus milleri		Frequent	Sub-dominant	Sub-dominant

Field observations indicate patterns of vertical distribution in the sediment for some of the species. All of the gammarid amphipods appear to live within 5 cm of the water-sand interface. On the other hand, the polychaetes Scolelepis and Nephtys are generally encountered at least 15 cm below the interface during low tides.

4.4.1.2 Seasonal Patterns

Several seasonal patterns were apparent. Overall density increased from February to July (Table 4-26). Within this general pattern, two trends were discerned. Gammaridae sp. A increased strongly in abundance during the summer. Several other species, i.e., Eohaustorius and the polychaetes Scolelepis and Scoloplos, increased during the survey, but not significantly (respectively, $P > 0.65$, >0.05 and >0.20, based on a Friedman X_r^2 analysis of variance computed with pooled data for each level and tested among surveys). In contrast, Eteone nr. longa decreased in abundance but not significantly ($P > 0.05$). These trends appear strong and the lack of significance appears to be mainly a consequence of too few samples.

4.4.1.3 Biomass

In terms of biomass, the fauna at Deep Creek was generally dominated by polychaetes in April but by gammarid amphipods in July (Table 4-28). Specifically, in order of importance, the dominant polychaetes were Scoloplos, Eteone, Nephtys and Scolelepis in April, and Scoloplos, Scolelepis, Nephtys and Abarenicola in July. Dominant gammarids were Eohaustorius in April, and in July, Gammaridae sp. A and Eohaustorius. Overall, Eohaustorius dominated in terms of biomass in April and Gammaridae sp. A in July; Eohaustorius was next most important in July.

Generally, biomass levels were relatively low and consequently strongly affected by large, uncommon species such as Nephtys, or spatially and temporally patchy species such as Gammaridae sp. A. However, two general trends appeared real. During both surveys, there was a tendency for biomass to be greater at lower levels, mainly reflecting the patterns

TABLE 4.28. DISTRIBUTION OF WHOLE WET AND ESTIMATED DRY WEIGHTS IN SAMPLE SETS AT DEEP CREEK IN 1977 (WEIGHTS IN GRAMS)

Level	April 1	April 2	April 3	April 4	April Survey Total Wet Weight	April Survey Total Dry Weight[a]	July 1	July 2	July 3	July 4	July Survey Total Wet Weight	July Survey Total Dry Weight
Polychaeta	(0.360)[b]	(0.010)	(0.120)	(0.444)	(0.934)	(0.155)	(0.064)	(0.641)	(0.324)	(0.388)	(1.417)	(0.221)
Abarenicola pacifica	0	0	0	0	0	–	0	0.127	0	0	0.127	0.027
Capitella capitata	0	0	0	0	0	–	0	0.027	0	0.005	0.032	0.006
Cirratulidae, unid.	0	0	0	0	0	–	0	0	0.008	0	0.008	0.001
Eteone nr *longa*	0.260	0	0	0	0.260	0.051	0.020	0.008	0	0	0.028	0.006
Nephtys caeca	0	T	0	0.183	0.183	0.035	0	0	0.070	0.080	0.150	0.029
Paraonella platybranchia	0	T	T	0	T	T	0.001	–	–	0.001	0.002	T
Polychaeta, unid.	0	T	0	0	T	T	–	–	–	–	–	–
Scolelepis sp A	0	0	0.010	0.163	0.173	0.025	0.043	0.032[c]	0.01	0.140	0.226	0.032
Scoloplos armiger	0.100	0	0.110	0.098	0.308	0.044	0	0.447	0.235	0.162	0.844	0.120
Gammaridea[d]	(0.106)	(0.095)	(0.125)	(0.324)	(0.650)	(0.128)	(0.246)	(3.094)	(0.725)	(0.659)	(4.724)	(0.922)
Eohaustorius eous	0.033	0.095	0.125	0.291	0.544	0.107	0.126	0.234	0.315	0.239	0.914	0.179
Paraphoxus milleri	0.033	T	0	0.013	0.046	0.009	0	0.010	0.020	0.030	0.060	0.012
misc. gammarids	0.040	0	0	0.020	0.060	0.012	0.120	2.850	0.390	0.390	3.750	0.731
Total	0.466	0.105	0.245	0.768	1.584	0.283	0.310	3.825	1.049	1.047	6.231	1.143
Biomass (g/m^2)	5.93	1.34	3.12	9.78			3.95	48.70	13.36	13.33		
Average biomass (g/m^2)					5.04	0.901					19.84	3.638

[a] Based on conversion factors indicated in Thorson (1957)

[b] Parenthetic values are total wet whole weight for major taxa

[c] Only data for 9 cores

[d] Gammarid weights for July are estimates based on July abundance and wet weight/number ratio in April; samples were lost in the mails before weighing

of the dominant species. Furthermore, there was a strong increase in biomass between April and July. This reflected an increase in biomass in the dominant species, particularly Eohaustorius and Scoloplos, as well as the appearance of several additional species during this period (Table 4-28).

4.4.1.4 Size Structures

Observations on size structure were attempted for the gammarid Eohaustorius eous and the polychaete Scolelepis to provide insight into growth rates, life cycle and eventually permit estimation of secondary production.

It was possible to examine the size structure of Eohaustorius by measuring its length (from the tip of the rostrum to the base of the telson) with an ocular micrometer (Appendix 4.4.7). The length-frequency histograms represent pooled samples for all four levels (Figure 4-18). Based on these data, it appears that at least two age classes occurred in the population. The younger class appeared less abundant than the older one, but this may be an artifact of the mesh size of the sieve used to screen the samples. However, reproductive potential of haustoriids is reported to be fairly low (Sameoto 1969a and b).

A comparison of the April and July modes for the young age class suggests that growth was rather slow. The modal size of the older age class appears to have decreased during the same period, perhaps due to size specific predation or post spawning mortality of larger individuals. The difference in size structure is highly significant ($P < 0.005$, Kolmogorov-Smirnov two-sample test).

Size data were collected for two other gammarid amphipods but are unsatisfactory for one of several reasons. Average lengths for Paraphoxus milleri were 4.4 ± 1.7 mm in April ($n = 8$) and 7.7 ± 3.6 mm in July ($n = 6$) but the sample sizes were very small. Gammaridae sp A, very common in July, had an average length of 2.5 ± 0.7 mm (Appendix 4.4.8), but no comparative data were available from April.

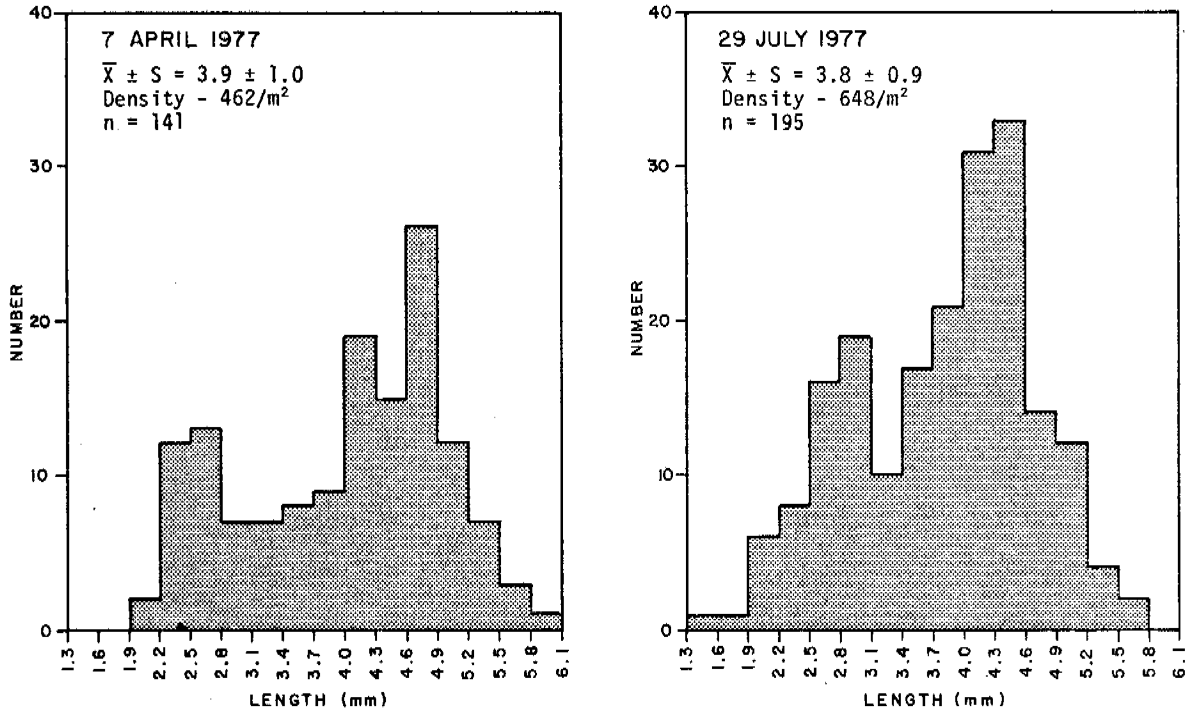


FIGURE 4-18

LENGTH FREQUENCY HISTOGRAMS
FOR <u>EOHAUSTORIUS EOUS</u> FROM DEEP CREEK, 1977

Generally, useful measurements were not obtainable for Scolelepis because of its fragility and absence of hard parts useful in size measurements. To date, we have been unable to obtain a single whole worm. However, it is our impression based on visual examination of the samples that, on the average, worms were small in winter or spring, and large in the summer.

4.4.1.5 Numerical Parameters

Patterns in the numerical parameters were rather straight forward and consistent during the study. Generally, abundance, species richness and species diversity increased during the period of the survey (Table 4-29). Also, the first two parameters were generally higher at the lower elevations.

The significance of the observed increase in abundance from February to July was tested separately for each level on unpooled data (Appendix 4.4.1 through 4.4.3) by means of the Kruskal-Wallis one-way analysis of variance. The differences were found to be highly significant ($P < 0.01$) at levels 1, 2 and 3, but did not depart from random at level 4 ($P > 0.3$).

When abundance was tested in the same manner for differences among levels, highly significant differences ($P < 0.01$) were found for all sample sets. In February and April, abundances were higher at lower elevations. In contrast, the two intermediate elevations (levels 2 and 3) had the higher densities in July.

The other abundance parameters presented (total number of organisms collected per level and number per m^2) are both derived directly from the raw data. Thus, the patterns are identical, i.e., exhibiting general increases with season and, during each survey, with lower elevation.

Species richness was evaluated statistically by comparing the number of species in each core (unpooled data) among levels and surveys; again the Kruskal-Wallis one-way analysis of variance was used. The differences observed among surveys at a given level were significant at

TABLE 4.29. SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT DEEP CREEK

Elevation (ft)	Abundance: Total per Level	Abundance: $\bar{x} \pm s$ per Core	Abundance: per m^2	Species Richness: Total per Level	Species Richness: $\bar{x} \pm s$ per Core	Species Diversity: H	Evenness: N/S	Evenness: E	Grams Wet Weight per m^2
4 February 1977									
0	18	1.8 ± 1.9	229.2	4	1.3 ± 0.7	1.32	4.5	0.62	-
-1	21	2.1 ± 1.6	267.4	3	1.2 ± 0.4	0.70	7.0	0.54	-
-2	39	3.9 ± 1.7	496.6	6	1.7 ± 0.8	1.05	6.5	0.35	-
-3	84	8.4 ± 4.3	1069.5	7	2.0 ± 0.7	0.69	12.0	0.23	-
Overall	162			9			18.0		
$\bar{x} \pm s$		4.1	515.7		1.6	0.9 ± 0.30		0.44 ± 0.18	-
7 April 1977									
0	10	1.0 ± 0.9	127.3	5	0.8 ± 0.6	1.50	2.0	0.57	5.93
-1	31	3.1 ± 3.2	394.7	5	1.2 ± 0.8	0.64	6.2	0.31	1.34
-2	35	3.5 ± 2.8	445.6	6	1.3 ± 0.9	0.96	5.8	0.32	3.12
-3	108	10.8 ± 4.8	1375.1	7	2.6 ± 1.3	0.95	15.4	0.28	9.78
Overall	184			10			18.4		
$\bar{x} \pm s$		4.6	585.7		1.5	1.01 ± 0.36		0.37 ± 0.13	5.04
29 July 1977									
0	39	3.9 ± 2.3	496.6	5	2.0 ± 0.9	1.15	7.8	0.44	3.95*
-1	173	17.3 ± 16.3	2202.7	12	3.9 ± 1.4	1.72	14.4	0.27	48.70
-2	101	10.1 ± 4.9	1286.0	11	3.4 ± 1.3	1.56	9.2	0.27	13.36
-3	84	8.4 ± 6.2	1069.5	9	2.7 ± 1.3	1.61	9.3	0.34	13.33
Overall	391			16			24.4		19.84
$\bar{x} \pm s$		9.9	1263.7		3.0	1.51 ± 0.25		0.33 ± 0.08	

* Biomass for gammarids in July based on average weight/specimen in April; animals lost in mails.

level 1, highly significant at levels 2 and 3, but not significant ($P > 0.5$) at level 4. At levels 1 and 3, fewest species per core were encountered in April, but at all levels, greatest species richness occurred in July. The total number of species encountered in each survey also increased during the study (Table 4-29). In February and April, there was a fairly well-defined increase in species richness at the lower sampling levels, but this pattern was not apparent in July.

Species diversity (H) generally increased from February to July, but was quite variable among the levels within each period. However, neither the patterns of variation with season nor with elevation were significant.

Evenness parameters generally indicated that species were less equitably distributed at lower elevations and in the later surveys. This is mainly a reflection of large increases in the density of populations of a rather limited number of species at lower elevations and through time. However, in all surveys, over 50 percent of the species were represented by three or fewer specimens. None of the patterns was statistically significant.

Species-area curves were constructed for each level and survey to provide insight into rates of species acquisition in the samples and the suitability of the sampling program. In most cases, the curves for specific levels show signs of becoming asymptotic (Figure 4-19). Only at levels 2, 3 and 4 in July does it appear that a substantial number of additional species might have been obtained by further sampling. Such patterns emphasize the low species richness and high N/S ratios reported above.

Composite species-area curves were constructed for each survey by tabulating, by level, the cumulative number of species identified. In all cases, the rate of "accrual" was fairly slow and uniform. This is probably a reflection of the intensity of the physical gradients. It is not surprising, however, that July, the mildest period sampled, initially

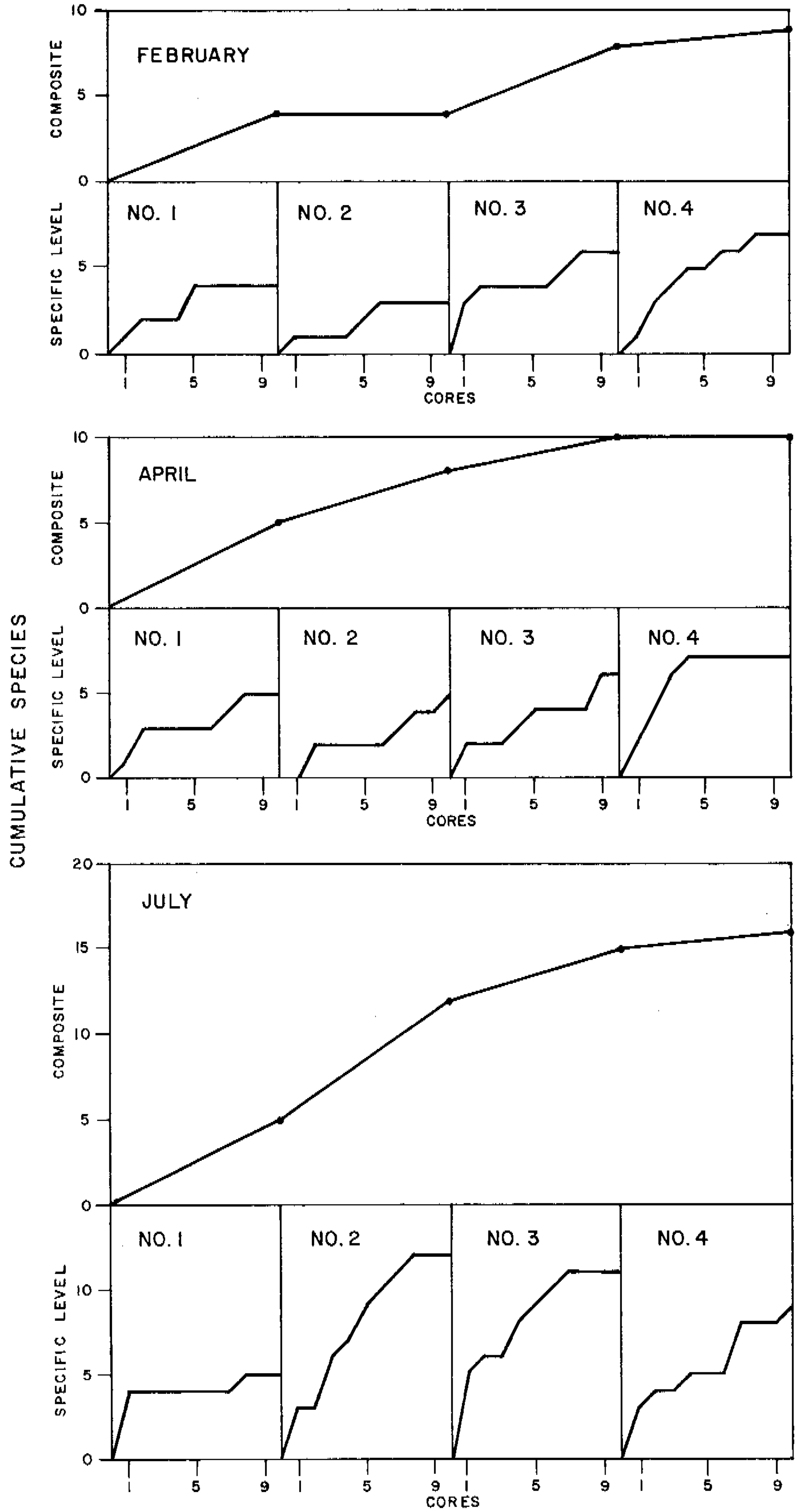


FIGURE 4-19 - SPECIES/AREA CURVES FOR DEEP CREEK produced the most rapid rate of "accrual" (the steepest slope). During that period, many less tolerant species were able to expand their local distribution to shallower levels.

4.4.2 Biological Assemblage of the Sand Beach at Homer Spit

The infaunal assemblage at the Homer Spit station was sampled three times during the period covered by this report, namely on 17 February, 7 March and 28 July 1977. A total of 25 taxa, including 11 polychaete, 8 crustacean, and two molluscan (Table 4-24), was identified from the core samples.

Quantitatively, the infauna was dominated heavily by polychaetes, especially *Paraonella platybranchia* and *Scolelepis* sp. A (Table 4-30). Relative abundance of all groups was fairly uniform. Gammarid amphipods were substantially less important, with *Eohaustorius* and *Paraphoxus* the most abundant. The redneck clam (*Spisula*) and a fish (sand lance, *Ammodytes*) were encountered in low numbers in each survey. The raw data for these samples, by core, level and survey, are presented in Appendix 4.4.9 through 4.4.11 and species summaries in Appendix 4.4.12 through 4.4.14.

4.4.2.1 Zonation

To examine zonation, the species at each level were assigned, by survey, to "importance" categories according to their density and frequency of occurrence (see METHODS section). Species composition was then compared among the sampling levels. According to these criteria, the upper two levels were dominated by *Scolelepis*, level 3 by *Scolelepis*, *Paraonella* and *Paraphoxus* and the lower level by *Scolelepis* (Table 4-31). *Paraonella* and *Scolelepis* were important at all levels, and the latter dominated throughout.

The relationship between elevation and density was examined, with the Kruskal-Wallis analysis of variance. *Scolelepis* was significantly more dense at lower elevations ($P < 0.001$). The density pattern of *Paraonella*, high toward the middle of the beach and lower at the upper

TABLE 4.30. OVERALL DENSITY (NO./M^2) OF COMMON SPECIES AT HOMER SPIT SITE

Taxa	2/77 Density	%	3/77 Density	%	7/77 Density	%
Polychaeta		(75.8)[a]		(84.8)		(78.1)
Eteone nr. *longa*[b,c]	6.4	1.0	0	0	3.2	0.3
Nephtys ?ciliata	6.4	1.0	9.5	1.0	3.2	0.3
Paraonella platybranchia	146.4	24.2	38.2	7.3	213.3	20.4
Scolelepis Sp. A[b,c]	273.7	45.2	385.2	73.3	547.5	52.3
Gammaridea		(16.8)		(12.7)		(5.8)
Eohaustorius eous	19.1	3.1	12.7	2.4	28.7	2.7
Paraphoxus milleri[b,c]	44.6	7.3	50.9	9.7	19.1	1.8
Pelecypoda						
Spisula polynyma[b]	12.7	2.1	3.2	0.6	6.4	0.6
Pisces						
Ammodytes hexapterus[b]	12.7	2.1	6.4	1.2	3.2	0.3

[a] Parenthetic values are percent of the overall total individuals within the major taxon indicated

[b] These species were also common in sandy infaunal samples collected at 200' depths in the middle of Lower Cook Inlet

[c] Also found at Deep Creek

TABLE 4.31. IMPORTANT SPECIES AT EACH LEVEL AT HOMER SPIT

Species	Sampling Level (m) 30	75	100	135
Polychaetes				
Nephtys ?*ciliata*		Frequent		
Paraonella platybranchia	Frequent	Frequent	Dominant	Frequent
Scolelepis Sp. A	Dominant	Dominant	Dominant	Dominant
Crustaceans				
Eohaustorius eous		Sub-dominant	Sub-dominant	Frequent
Lamprops carinata				Seasonal
L. quadriplicata	Seasonal			
Paraphoxus milleri	Frequent		dominant	Sub-dominant
Pelecypods				
Spisula polynyma (juv.)				Sub-dominant
Fishes				
Ammodytes hexapterus			Frequent	

and lower levels, was also highly significant (P <0.01).

4.4.2.2 Seasonal Patterns

The seasonal patterns apparent in Table 10 are not statistically significant even though the differences are large in some cases. The density of the polychaete Scolelepis, for example, increased two-fold from February to July. The cumaceans Lamprops spp. became abundant in July.

Samples were collected in March immediately following a large storm to attempt to examine the effects of that disturbance. Generally, it appeared that the storm had little effect. However, a comparison of density of species between the February and March surveys provides some insight on vertical distribution within the sediment. Density reductions were noted for several species (e.g., Eteone, Eohaustorius, Spisula and Ammodytes) but only Paraonella was reduced significantly (P <0.05; Table 4-30) and only at the 100 m level. That reduction following storm surf suggests that these species live near the surface of the sediment. In contrast, the density of Scolelepis, which usually lives at least 15 cm below the surface, increased from February to March.

4.4.2.3 Biomass

In terms of biomass, the fauna at Homer Spit was strongly dominated by polychaetes in both March and July (Table 4-32). Scolelepis was by far the most important species at every level and in both surveys. Paraphoxus was the most important gammarid.

Biomass was relatively low but appeared only slightly affected by large, uncommon species. Two trends were fairly clear. Spatially, biomass increased markedly at lower elevation. Temporally, biomass increased sharply from April to July. Both patterns are mainly reflections of increases in Scolelepis. Gammarids showed little change by location or between periods.

TABLE 4.32. DISTRIBUTION OF WHOLE WET AND ESTIMATED DRY WEIGHTS IN SAMPLE SETS AT HOMER SPIT IN 1977 (WEIGHTS IN GRAMS)

	March				Survey Total		July				Survey Total	
Sampling Level:	30m	75m	100m	135m	Wet Weight	Dry Weight[a]	30m	75m	100m	135m	Wet Weight	Dry Weight
Polychaeta	(0.080)[b]	(0.810)	(2.571)	(2.350)	(5.811)	(0.831)	(0.247)	(1.529)	(1.657)	(6.224)	(9.657)	(1.448)
Abarenicola pacifica	0	0	0	0	0	-	0	0.015	0	0	0.015	0.003
Capitella capitata	0	0	0	0	0	-	0	0	0.010	0.060	0.070	0.013
Magelona pitelkai	0	0	0	0.030	0.030	0.006	0	0	0	0	0	-
Nephtys sp.	0	0.020	0.005	0	0.025	0.005	0.184	1.140	-	0	1.324	0.255
Paraonella platybranchia	0	-	0.005	0	0.005	0.001	0.012	0.010	0.023	0.015	0.060	0.011
Sabellidae, unid.	0	0	0.005	0	0.005	0.001	0	0	0	0	0	-
Scolelepis sp A	0.080	0.790	2.556	2.240	5.666	0.807	0.048	0.364	1.624	6.149	8.185	1.166
Spio sp	0	0	0	0.080	0.080	0.011	0	0	0	0	0	-
Spiophanes bombyx	0	0	0	0	0	-	0.003	0	0	0	0.003	T
Gammaridea	(0.010)	(0.085)	(0.039)	(0.075)	(0.209)	(0.041)	(0.029)	(0.035)	(0.098)	(0.029)	(0.191)	(0.038)
Eohaustorius eous	0	0.005	0.009	0.005	0.019	0.004	0.009	0.005	0.018	0.009	0.041	0.008
Paraphoxus milleri	0.010	0.050	0.030	0.070	0.160	0.031	0.020	0	0.020	0.020	0.060	0.012
misc. gammarids	0	0.030	0	0	0.030	0.006	T	0.030	0.060	0	0.090	0.018
Total	0.090	0.895	2.610	2.425	6.020	0.872	0.276	1.564	1.755	6.253	9.848	1.486
Biomass (g/m^2)	1.15	11.40	33.23	30.88			3.51	19.91	22.35	79.62		
Average biomass (g/m^2)					19.17	2.78					31.35	4.73

[a] Based on conversion factors indicated in Thorson 1957

[b] Parenthetic values are total wet whole weight for large taxa

4.4.2.4 Size Structures

Size data were collected for the gammarid amphipods *Paraphoxus milleri* and *Eohaustorius eous*, but the sample sizes were too small to provide satisfactory comparisons. The average size of *Paraphoxus* was 6.2 ± 1.1 mm in March (n = 7) and 6.1 ± 1.5 mm in July (n = 5). Data are not available for *Eohaustorius* in March, but average length was 3.8 ± 0.5 mm in July (n = 5).

4.4.2.5 Numerical Parameters

Patterns in the numerical parameters were fairly straight-forward and consistent during the survey. Basically, abundance, species richness and species diversity increased during the survey and, except for species diversity, at lower elevations (Table 4-33). Among the evenness parameters, N/S also increased during the study and at lower elevations, whereas E declined during the study and at lower elevations.

The significance of the observed increases from February to July was tested separately for each level on unpooled data (Appendix 4.4.9 through 4.4.11) using the Kruskal-Wallis analysis of variance. The seasonal increases in abundance were significant ($P < 0.05$) at the 30 m, 75 m and 135 m levels, but did not depart from random at the 100 m level. Similar analysis of abundance patterns among levels during a survey indicated that the increase in density at lower elevations observed in each survey were highly significant ($P < 0.01$).

Species richness was examined similarly by comparing the number of species per core among levels and surveys with the Kruskal-Wallis test. The seasonal changes observed at specific levels were significant at the 30 m ($P < 0.01$), 75 m and 135 m levels (for both, $P < 0.05$). Generally, there was a decline from February to March, and an increase by July at each level. Only in March were the observed differences among levels significantly different from random ($P < 0.01$). In both February and March, the average number of species per core was highest at the 100 m level. These patterns were fairly well reflected by the total number of

TABLE 4.33. SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT HOMER SPIT

	Abundance			Species Richness		Species Diversity	Evenness		
Sampling Level (m)	Total per Level	$\bar{x} \pm s$ per Core	per m^2	Total per Level	$\bar{x} \pm s$ per Core	H	N/S	E	Grams Wet Weight per m^2
				17 February 1977					
~30	12	2.4 ± 1.7	305.6	4	2.0 ± 1.2	1.25	3.0	0.60	
~75	8	1.6 ± 1.5	203.7	5	1.4 ± 1.5	1.52	1.6	0.57	
100	33	6.6 ± 2.1	840.4	7	3.8 ± 1.3	1.89	4.7	0.53	
135	42	8.4 ± 3.2	1069.6	7	3.0 ± 1.6	1.77	6.0	0.49	
Overall	95			14			6.79		
$\bar{x} \pm s$		4.8	604.8		2.6	1.61 ± 0.28		0.55 ± 0.05	
				7 March 1977					
30	9	0.9 ± 1.1	114.6	3	0.6 ± 0.7	0.71	3.0	0.55	
75	25	2.5 ± 1.6	318.3	6	1.7 ± 0.8	1.60	4.2	0.51	
100	48	4.8 ± 3.0	611.2	8	2.3 ± 1.2	1.58	6.0	0.37	
135	83	8.3 ± 6.3	1056.9	6	2.0 ± 0.8	0.75	13.8	0.28	
Overall	165			12			13.8		
$\bar{x} \pm s$		4.1	525.3		1.7	1.16 ± 0.50		0.43 ± 0.13	
				28 July 1977					
30	64	6.4 ± 5.1	814.9	12	3.3 ± 2.2	2.25	5.8	0.43	
75	47	4.7 ± 2.2	585.7	9	2.9 ± 1.2	2.16	5.1	0.50	
100	75	7.5 ± 2.9	955.0	9	3.0 ± 0.7	1.69	8.3	0.36	
135	144	14.4 ± 5.2	1833.6	10	3.3 ± 1.4	1.26	16.0	0.27	
Overall	330			16			20.6		
$\bar{x} \pm s$		8.3	1047.3		3.1	1.84 ± 0.46		0.39 ± 0.10	

species per level and the overall number of species per survey (Table 4-33). However, the pattern for species richness was rather confused in July.

Species diversity was, on the average, highest at each level, and overall, in July. However, the relationships among levels in a specific survey were confused.

Evenness patterns generally indicated that the species were less equitably distributed at the lower levels and in the later surveys. The decrease in evenness with lower elevation is a reflection of the relatively moderate increase in species richness in comparison with the increase in density. The average decrease in evenness during the study is a reflection of substantial density increases among a fairly stable suite of species.

Species-area curves were constructed for each level and survey to provide insight into rates of species acquisition in the samples and the suitability of the sampling program. Generally, the curves for specific levels showed signs of becoming asymptotic (Figure 4-20). However, it appears that a substantial number of species could have been added by additional sampling at the 30 m and 135 m levels in July. This pattern accentuates the finding of low species diversity and high N/S ratios.

Composite species-area curves were constructed for each survey by tabulating by level the cumulative number of species identified. In February and March, the rate of "accrual" was fairly slow and uniform at each level. This seems to indicate a strong gradient for physical factors. This interpretation is amplified by the composite curve for July, when conditions were comparatively very mild. In this case, the rate of "accrual" is initially rapid, i.e., most of the species observed were identified at the upper level, and the subsequent rate is quite slow. Although this suggests that the mild conditions have allowed a number of species previously restricted to lower levels to expand into higher elevations, examination of the species lists from the intertidal levels does not support this hypothesis.

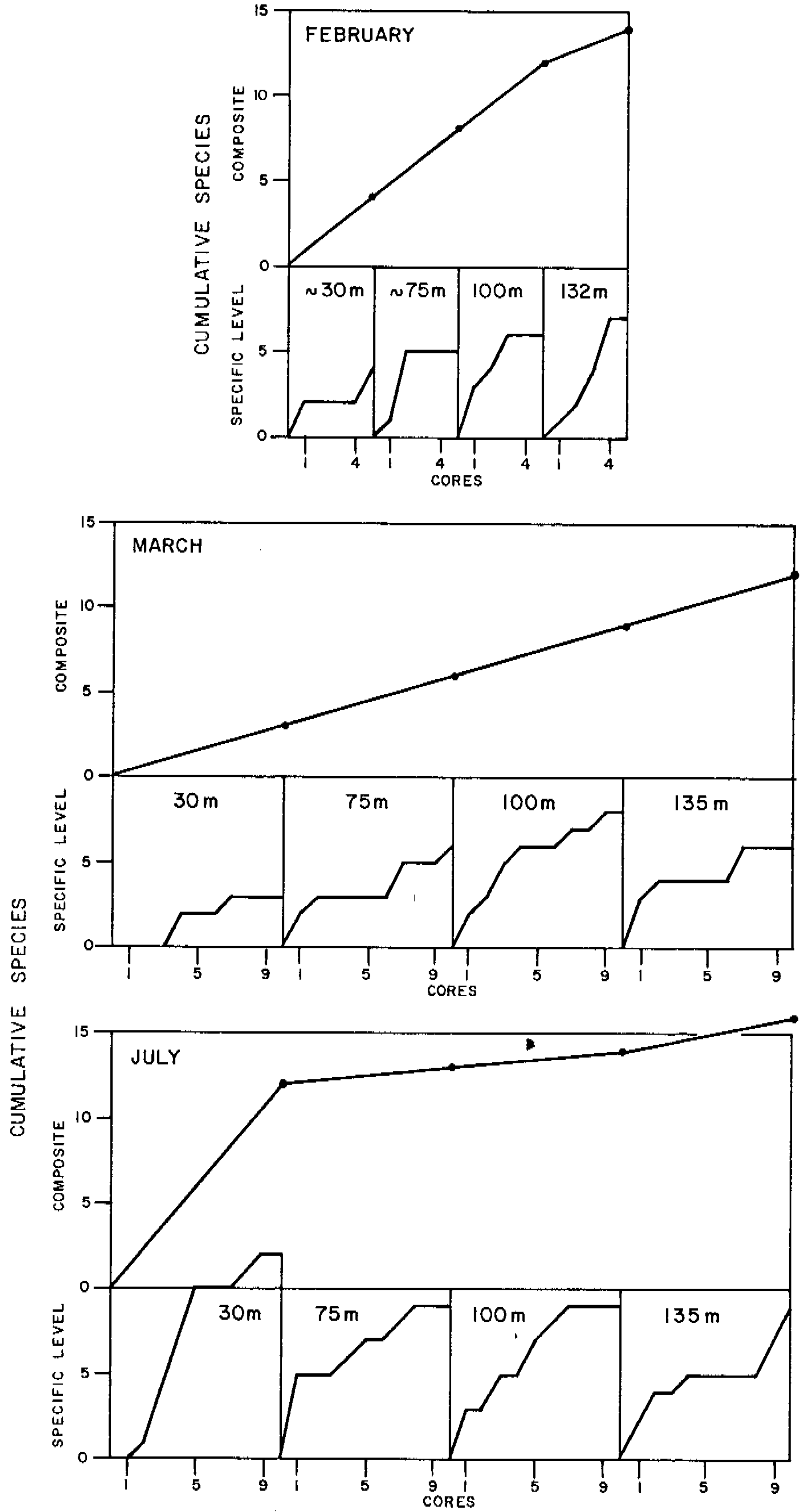


FIGURE 4-20 - SPECIES/AREA CURVES FOR HOMER SPIT

4.4.3 Biological Assemblage of the Mud Flats at Glacier Spit, Chinitna Bay

The infaunal assemblage at Glacier Spit, Chinitna Bay, (Figure 2-5) was sampled twice during the period covered by this report, namely on 6 April, and 30 July, 1977. A total of 45 taxa, including 22 annelids, nine arthropods, and nine molluscs, was identified in the core samples (Table 4-25). Twenty of these taxa, including 67 percent of the molluscs and 50 percent of the annelids, were observed in both sample sets. Only one arthropod taxon occurred in both surveys; in fact, that species, a caprellid amphipod, Tritella pilimana, was the only crustacean of any importance.

In terms of abundance and biomass, the fauna was dominated heavily by pelecypods, especially Macoma balthica and Mya spp., (Table 4-34). Relative abundance was uniform between surveys. Furthermore, these clam species comprised at least 90 percent of the whole wet weight in the samples, while the remaining taxa contributed little. Several other species, especially the polychaete worms Nephtys, Potamilla, and Spio, and the clams Clinocardium and Pseudopythina, contributed at least marginally to density. Raw abundance data by core are presented in Appendix 4.4.15 and 4.4.16, and biomass data by core in Appendix 4.4.17 and 4.4.18. These types of data are summarized, by species, in Appendices 4.4.19, 4.4.20, and 4.4.21. Size and weight data for several species are in Appendix 4.4.22 through 4.4.30.

4.4.3.1 Seasonal Patterns

Several seasonal patterns are apparent in the Chinitna Bay samples. The average number of specimens per core, and thus the other abundance parameters, decreased from April to July (Table 4-35; $P \ll 0.001$, with Student's t-test). However, within this general pattern, two strong trends were discerned. Density of polychaetes and the caprellid increased dramatically between surveys ($P \ll 0.005$, Wilcoxin matched-pairs signed ranks t-test). In contrast, most of the clams became substantially less abundant ($P > 0.05$) during the same period.

TABLE 4.34. OVERALL DENSITY (NO./M^2) AND BIOMASS[a] OF COMMON TAXA AT THE GLACIER SPIT, CHINITNA BAY SITE

	4/6/77				7/30/77			
	Density (no./m^2)	%	Biomass (g/m^2)	%	Density	%	Biomass	%
Echiurida								
Echiurus echiurus	38.2	0.6	22.82	1.0	41.4	0.8	31.80	0.8
Polychaeta		(9.5)[b]		(1.6)		(31.0)		(2.0)
Ampharete acutifrons	12.8	0.2	0.05	T	28.7	0.6	-	-
Capitella capitata	15.9	0.2	0.07	T	111.4	2.2	-	-
Eteone nr *longa*	38.2	0.6	0.55	T	121.0	2.4	0.73	T
Harmothoe imbricata	9.5	0.1	0.77	T	63.7	1.3	8.13	0.2
Malacoceros sp	15.9	0.2	0.04	T	38.2	0.8	0.05	T
Nephtys sp (adults & (juvenile)	331.0	5.0	27.92	1.2	324.7	6.5	59.94	1.5
Phyllodoce groenlandica	15.9	0.2	1.58	0.1	28.7	0.6	4.07	0.1
Polydora caulleryi	15.9	0.2	0.03	T	54.1	1.1	0.05	T
Potamilla sp	117.8	1.8	2.13	0.1	245.1	4.9	4.86	0.1
Scoloplos armiger	3.2	T	0.01	T	38.2	0.8	0.04	T
Spio filicornis	0	0	0	0	448.8	9.0	0.98	T
Crustacea		(0.1)		(T)		(4.9)		(T)
Tritella ?pilimana	3.2	T	T	T	187.8	3.8	T	T
Pelecypoda		(88.8)		(97.6)		(62.8)		(97.3)
Clinocardium nuttallii (juv. & adults)	213.3	3.2	1.53	0.1	105.0	2.1	201.8	5.0
Macoma balthica	4672.8	71.0	502.93	21.7	2654.7	53.4	461.55	11.4
Mya sp	804.8	12.2	1755.53	75.7	213.3	4.3	3257.53	80.7
Pseudopythina sp	144.7	2.2	1.94	0.1	140.1	2.8	6.6	0.2

[a] Based on whole preserved weights
[b] Parenthetic numbers are total percentages in major taxa

TABLE 4.35. SUMMARY OF NUMERICAL PARAMETERS FOR THE MUDDY INTERTIDAL ASSEMBLAGE AT GLACIER SPIT, CHINITNA BAY

	Abundance			Species Richness		Species Diversity	Evenness		
Elevation (ft)	Total per Level	$\bar{x} \pm s$ per Core	per m^2	Total per Level	$\bar{x} \pm s$ per Core	H	N/S	E	Grams Wet Weight per m^2
				6 April 1977					
+3.6	428	42.8 ± 16.7	5450	16	4.7 ± 2.6	0.85	26.8	0.16	4163.66
+2.5	435	43.5 ± 8.4	5539	16	6.6 ± 1.6	1.12	27.2	0.22	2975.03
+0.9	642	64.2 ± 18.7	8175	15	7.0 ± 1.3	1.41	42.8	0.22	1144.08
-1.2	563	56.3 ± 17.3	7156	20	6.7 ± 2.0	1.40	28.2	0.22	996.46
Overall	2068			25			82.7		
$\bar{x} \pm s$		51.7	6580		6.3	1.20 ± 0.27		0.21 ± 0.03	2319.81
				30 July 1977					
+3.6	250	25.0 ± 6.2	3183	20	6.4 ± 2.4	1.81	12.5	0.17	3743.89
+2.5	395	39.5 ± 13.7	5030	24	9.8 ± 2.5	2.82	16.5	0.27	3974.22
+0.9	441	44.1 ± 14.9	5615	25	10.1 ± 3.1	2.88	17.6	0.28	4858.09
-1.2	475	47.5 ± 13.9	6048	25	10.2 ± 3.3	2.54	19.0	0.22	3576.88
Overall	1561			36			43.4		
$\bar{x} \pm s$		39.0	4969		9.1	2.51 ± 0.49		0.24 ± 0.05	4038.27

4.4.3.2 Zonation

To examine zonation, the species at each level were assigned, by survey, to "importance" categories according to their density and frequency of occurrence (see METHODS section). Species composition was then compared among the sampling levels. According to these criteria, all levels were numerically dominated by a small pink clam Macoma balthica, and a polychaete Nephtys was subdominant at each (Table 4-36). Additionally, the polychaete Eteone occurred frequently at all levels. Other species that were important at all levels sampled were a tubicolous polychaete Potamilla and the clams Clinocardium, Mya spp. (unidentified juvenile specimens) and a commensal clam Pseudopythina. The eastern soft shell clam, Mya arenaria, was only important at the two upper levels and M. priapus at the lower two levels. Several other species became more important at lower levels, including the worm Spio, the caprellid Tritella, and the clams Clinocardium and Mya spp. (juveniles).

Consistent patterns of vertical distribution in the sediment were evident from field observations for several species (Figure 4-21). The caprellid lives on filamentous algae at the water-mud interface, (Benedict, personal communication), whereas most of the other species live in the sediments. Most of the polychaetes live near the sediment surface. However, Potamilla constructs tubes extending well into the sediment, and Nephtys adults live in burrows with at least two openings that extend to a depth of at least 15 cm into the sediment. Echiurus (Figures 4-21 and 4-22) constructs U-shaped burrows that may extend down into the sediment at least 30 cm. Pseudopythina appears to live in these burrows as a commensal, sometimes occurring attached to the spoonworm by byssus threads. The scaleworm Harmothoe is a commensal and appears in burrows with Nephtys, Echiurus and Mya. Juveniles of Macoma, Mya and Clinocardium live in the surface sediments. Adult Clinocardium live with the anterior margin of the shell right at the water-mud interface. Macoma and Mya burrow deeper as they grow larger, a trait which provides considerable protection from predators, physical stress and disruption. Adult Macoma balthica (Figures 4-21 and 4-22) generally live within 5 cm of the sediment surface. Adults of Mya spp. burrow

TABLE 4.36. IMPORTANT SPECIES AT EACH LEVEL AT GLACIER SPIT, CHINITNA BAY

	Elevation (ft)			
Species	+3.6	+2.5	+0.9	-1.2
Echiurus echiurus		Frequent	Frequent	
Polychaetes				
Capitella capitata		Frequent	Frequent	Frequent
Eteone nr *longa*	Frequent	Frequent	Frequent	Frequent
Harmothoe imbricata			Frequent	
Nephtys sp	Sub-dominant	Sub-dominant	Sub-dominant	Sub-dominant
Phyllodoce groenlandica				Frequent
Polydora caulleryi		Frequent		
Potamilla sp	Frequent	Frequent	Sub-dominant	Frequent
Spio ?*filicornis*		Seasonal	Seasonal	Frequent
Caprellidea				
Tritella ?		Seasonal	Seasonal	Frequent
Pelecypods				
Clinocardium nuttallii	Frequent	Frequent	Sub-dominant	Sub-dominant
Macoma balthica	Dominant	Dominant	Dominant	Dominant
Mya arenaria	Frequent	Frequent		
M. priapus			Frequent	Frequent
Mya spp (juv)	Frequent	Frequent	Sub-dominant	Dominant
Pseudopythina sp	Frequent	Frequent	Sub-dominant	Frequent

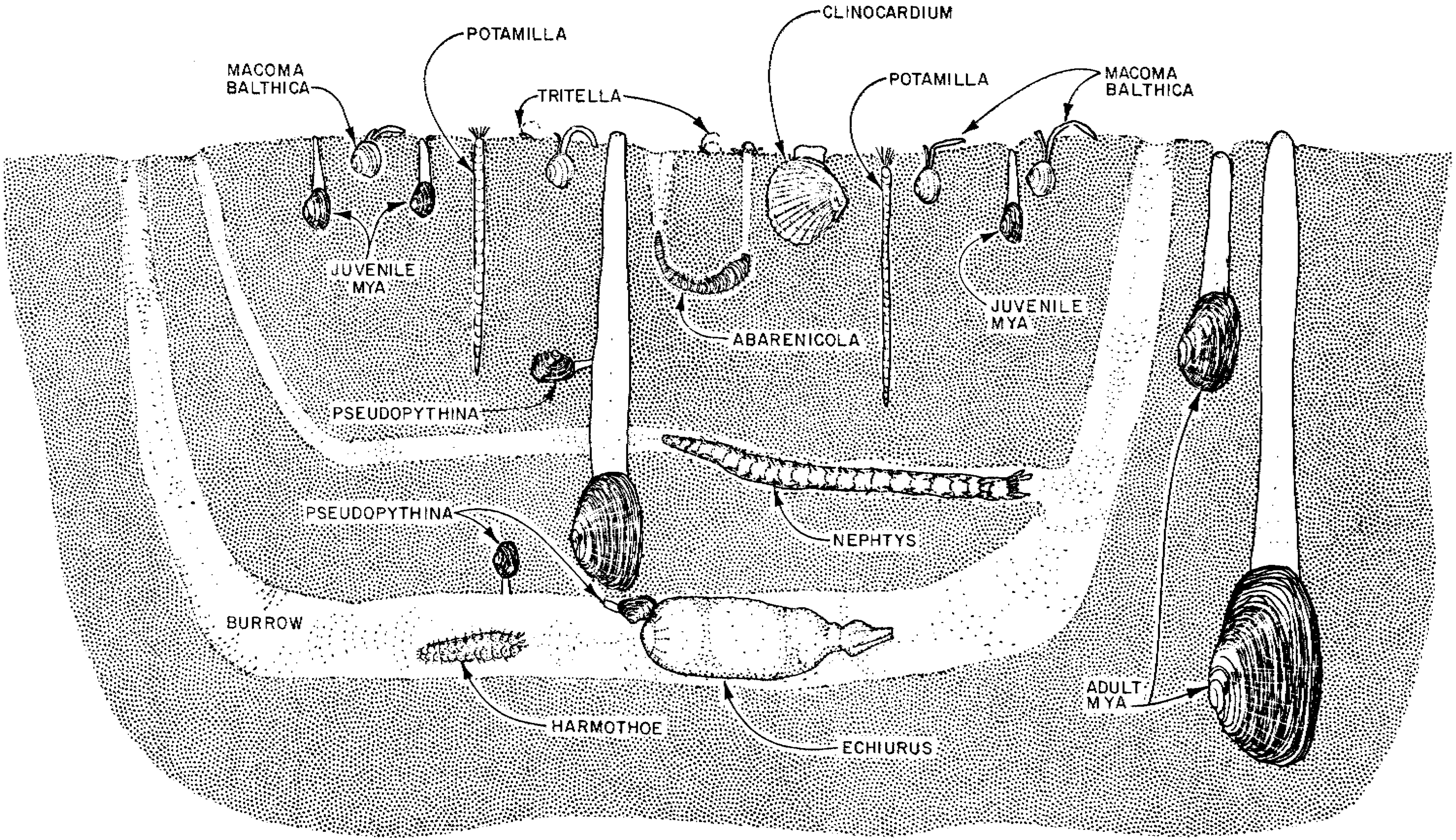


FIGURE 4-21 - DISTRIBUTION OF MAJOR ORGANISMS IN THE FAUNAL ASSEMBLAGE ON THE MUD FLAT AT GLACIER SPIT, CHINITNA BAY

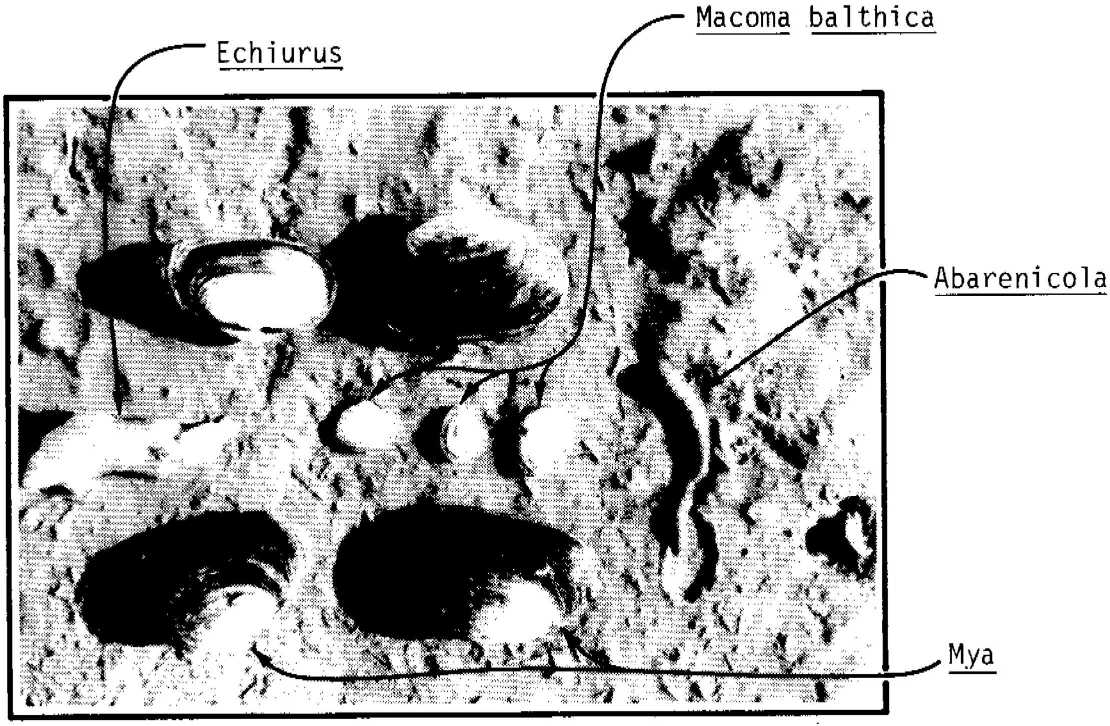


FIGURE 4-22

SEVERAL DOMINANT SPECIES IN THE MUD FLAT ASSEMBLAGE AT GLACIER SPIT, CHINITNA BAY down to at least 30 cm into the sediment and form semi-permanent burrows communicating vertically with the surface (Figures 4-21 and 4-22).

These patterns result in a substantial vertical distribution of the biomass in the upper 30 cm of the sediment. Furthermore, the burrowing habit of Mya spp. and Echiurus results in a fair degree of porosity in the upper 30 cm of the mud flats (Figures 4-21, 4-22 and 4-23). In Figure 4-23, the large holes were formed by adult Mya spp., and the smaller holes by Macoma balthica, polychaetes and Echiurus.

4.4.3.3 Biomass

During the survey, biomass (compared in Tables 4-35 and 4-37), generally increased significantly on the average and for most species examined (P = 0.005; Wilcoxin T-test). Among the major species, only Macoma exhibited a decline in biomass. Clam species contributed over 90 percent to both the wet and dry weight estimates for the mud flat examined. Data in Appendix 4.4.17 and 4.4.18 indicate that adult Mya arenaria and M. priapus are particularly important. Echiurus and polychaetes contribute less than two percent each to standing stocks. Among the polychaetes, Nephtys contributes most. Clinocardium displayed the highest rate of increase in biomass, and the magnitude of change was probably due mainly to growth.

4.4.3.4 Biology Of Macoma balthica

Observations on size structure were made for all of the clams collected to provide insight into growth rates and life cycles as well as to assist in estimation of secondary production (Appendix 4.4.22 through 4.4.30). The most useful data were for Macoma balthica and Mya spp. In all cases, the measurement used was shell length.

Length-frequency histograms for Macoma balthica from a 1976 collection and for both 1977 sampling periods covered by this report are included in Figure 4-24. These histograms also indicate the mean size

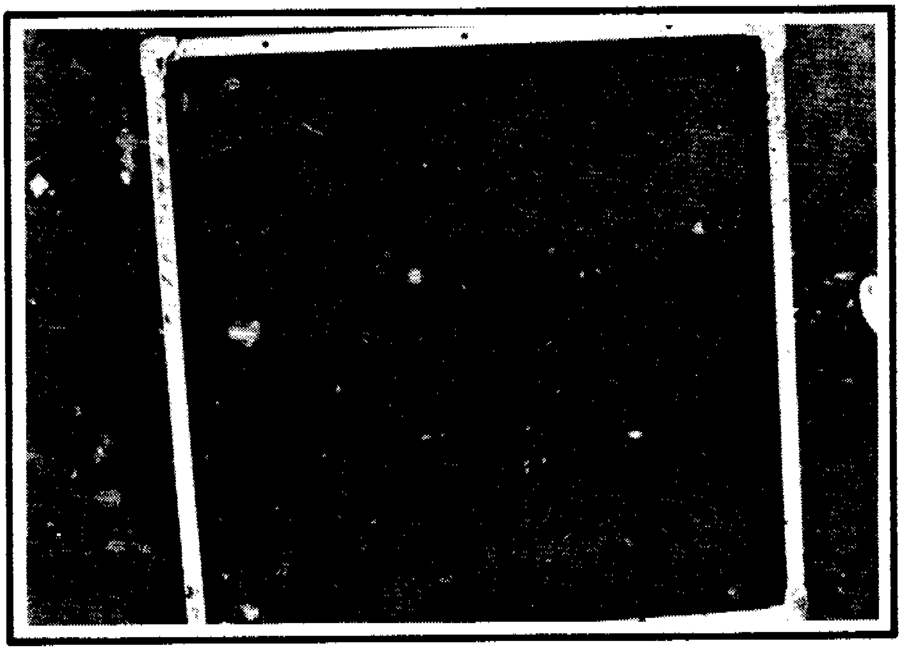


FIGURE 4-23

SURFACE OF THE MUD FLAT AT BRUIN BAY IN KAMISHAK BAY, LOWER COOK INLET, SHOWING THE POROSITY AS A CONSEQUENCE OF BIOLOGICAL ACTIVITY

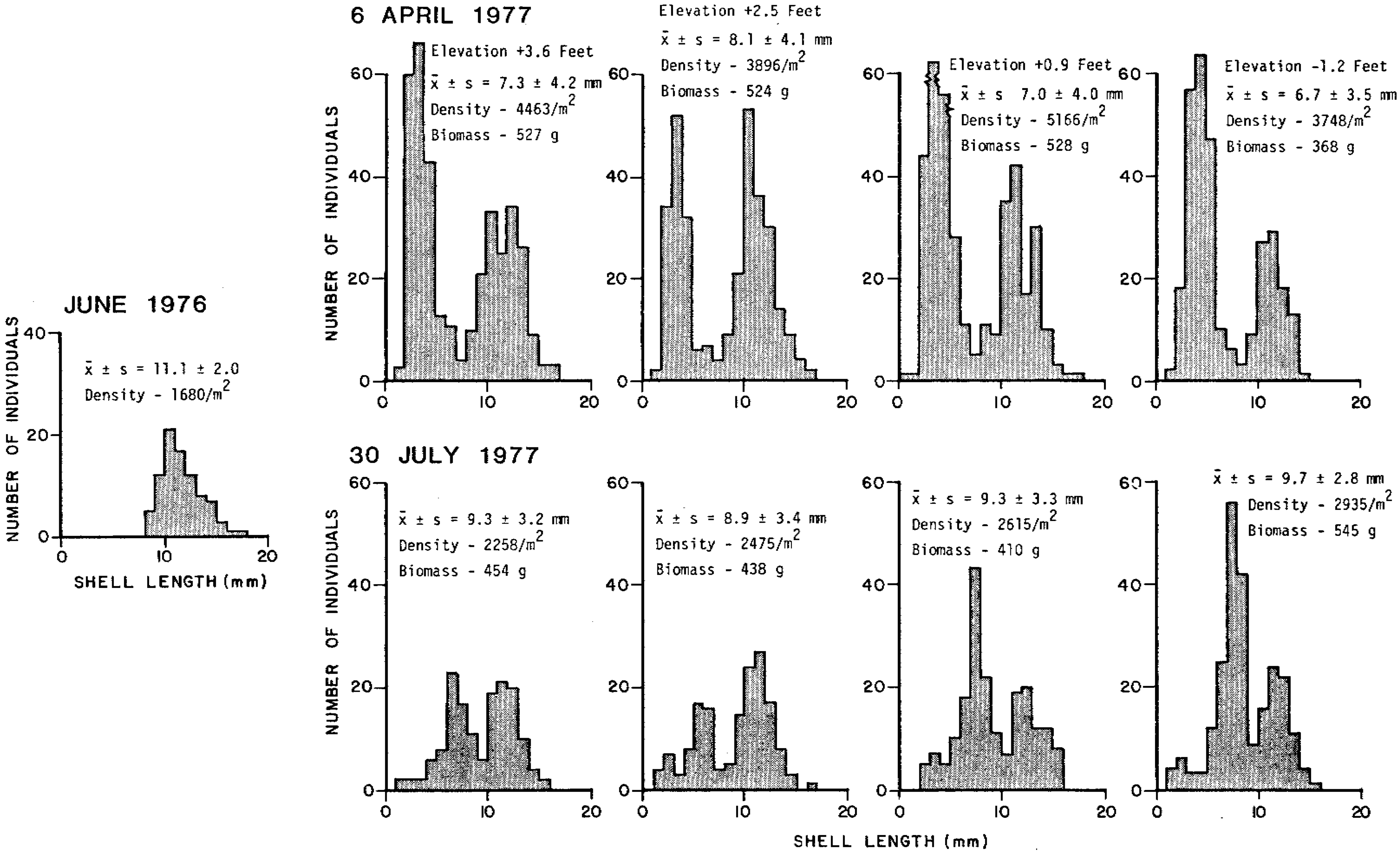


FIGURE 4-24

PATTERNS IN SIZE, ABUNDANCE AND BIOMASS FOR MACOMA BALTHICA

CHINITNA BAY

TABLE 4.37. SUMMARY OF BIOMASS DATA FOR THE MUDFLAT ASSEMBLAGE, GLACIER SPIT, CHINITNA BAY IN 1977

	Average Whole Wet Weight (g/m^2)		Conversion Factor	Estimated Dry Tissue Weight (g/m^2)	
	April	July		April	July
Echiurus	22.82	31.80	14%[a]	3.19	4.45
Polychaetes	35.06	78.99	14%[b]	4.91	11.06
Clams					
Clinocardium	1.53	201.8	5%[a]	0.08	10.09
Macoma balthica	502.93	461.55	5.75%[b]	28.92	26.54
Mya spp	1755.53	3257.53	6.6%[b]	115.86	215.00
Pseudopythina	1.94	6.6	5.4%[c]	0.10	0.36
Total	2319.81	4038.27		153.06	267.5

a Estimates based on examination of Thorson (1957)

b Based on conversions published in Thorson

c Average for pelecypods in Thorson

of the distribution, its standard deviation, and estimates for density and whole wet weight per m^2, where available. This comparison reveals several important features about the population structure of Macoma. Generally, all levels exhibited similar size structures during the same sampling period. In April 1977, members of the 0-year class were considerably more numerous than those in the older mode. By July, the difference was substantially reduced, particularly at the +3.6 foot and +2.5 foot levels, where the two modes were nearly equal in abundance. The 0-year class remained more numerous at the two lower levels in July. Except at the lowest level, the older mode was also reduced substantially between April and July. The decline of both modes resulted in the large reduction in overall density observed at all levels by July. These density reductions ranged from 22 percent at the -1.2 foot level to 49 percent at the +3.6 and +0.9 foot levels and averaged 39 percent. All reductions were significant ($P < 0.01$ in all cases; Kruskal-Wallis analysis of variance).

Growth was apparent in both modes (Figure 4-24). The 0-year class increased from between 3 and 4 mm in April to between 6 and 7 mm in July. The larger mode probably includes several year classes, so changes in the modal mean do not accurately reflect age-specific growth rates.

Above MLLW, biomass (wet whole weight) decreased between April and July. However, a substantial increase was observed at the -1.2 foot level. This was apparently a consequence of growth, combined with a relatively limited reduction in density.

The comparison of these histograms to the one for 1976 is quite revealing. The conspicuous absence of a 0-year class in 1976 is very probably a consequence of the relative harshness of the previous winter. Notable also was the substantially lower density in early summer.

4.4.3.5 Biology Of *Mya* spp.

Size structures for *Mya* spp. are not clearly definable because of the relatively low density of the adults and the confusion caused by the

0-year classes (juveniles) of three species. Specimens smaller than about 20 mm are very difficult to assign to species and have therefore been tabulated separately (Appendix 4.4.24). As a consequence, the number of specimens in the 0-year class for each species is unknown. However, the juvenile/adult ratio for *Mya* spp. averaged 28.7 and ranged from 1.4 to 88.0 in April, in contrast to July, when it averaged 0.7 and ranged from 0.1 to 1.3 (Table 4-38). Basically, the reduction in this ratio is a result of a considerable decrease in the abundance of juvenile *Mya*. Most of the loss appears to be a consequence of mortality; the slight increase in density of adults clearly doesn't account for the total reduction in juveniles. It appears, however, that growth of the juveniles was fairly rapid between April and July. Average shell length for the juvenile mode increased from 4.2 ± 1.0 mm in April to 11.9 ± 6.5 mm in July (Appendix 4.4.24). Contrasting the virtual absence of specimens larger than 6.5 mm in April to the fact that 78 percent of the juveniles in July were larger than 6.5 mm (Figure 4-25) supports a hypothesis that the increase in size was due to growth and not solely differential mortality, at least initially.

Average shell length of adult *Mya arenaria* and *M. priapus* increased between April and July, but the sample sizes were small (Appendix 4.4.25 and 4.4.26). Using Students' t-test, the increase from 67.0 mm to 73.7 mm for *M. arenaria* was not significant ($P > 0.10$), but for *M. priapus*, the increase from 26.9 mm to 46.5 mm was significant ($P < 0.05$). It seems imprudent to assume, without more direct evidence, that the latter increase is due solely to growth.

Additional information on the distribution and density of adult *Mya* spp. was obtained by counting siphon holes in a series of haphazard 1/16 m^2 quadrats at each sampling level (Table 4-39). Generally, this method produced more conservative density estimates than the core method, probably because the clams become distinguishable to species somewhat before they are large enough to produce a readily distinctive siphon hole. In fact, the quadrat data are probably more reliable than the core data for large clams because of the larger sampling area involved (0.0625 m^2 vs. 0.0078 m^2), the larger number of samples collected (25

TABLE 4.38. DISTRIBUTION OF ADULT AND JUVENILE *MYA* SPP. IN THE INTERTIDAL ZONE AT GLACIER SPIT, CHINITNA BAY IN 1977

	Average Number per Core							
	April				July			
Tidal Elevation (ft)	+3.6	+2.5	+0.9	-1.2	+3.6	+2.5	+0.9	-1.2
Adults								
Mya arenaria	0.7	0.5	0	0.3	0.5	0.5	0.4	0.1
M. priapus	0	0.2	0.1	0.1	0.2	0.1	0.6	0.5
M. truncata	0	0	0	0.1	0	0	0.3	0.2
Total adults	0.7	0.7	0.1	0.5	0.7	0.6	1.3	0.8
Juvenile *Mya* spp	1.2	1.0	8.8	11.9	0.1	0.4	0.6	1.0
Juvenile/adult ratio	1.7	1.4	88.0	23.8	0.1	0.7	0.5	1.3

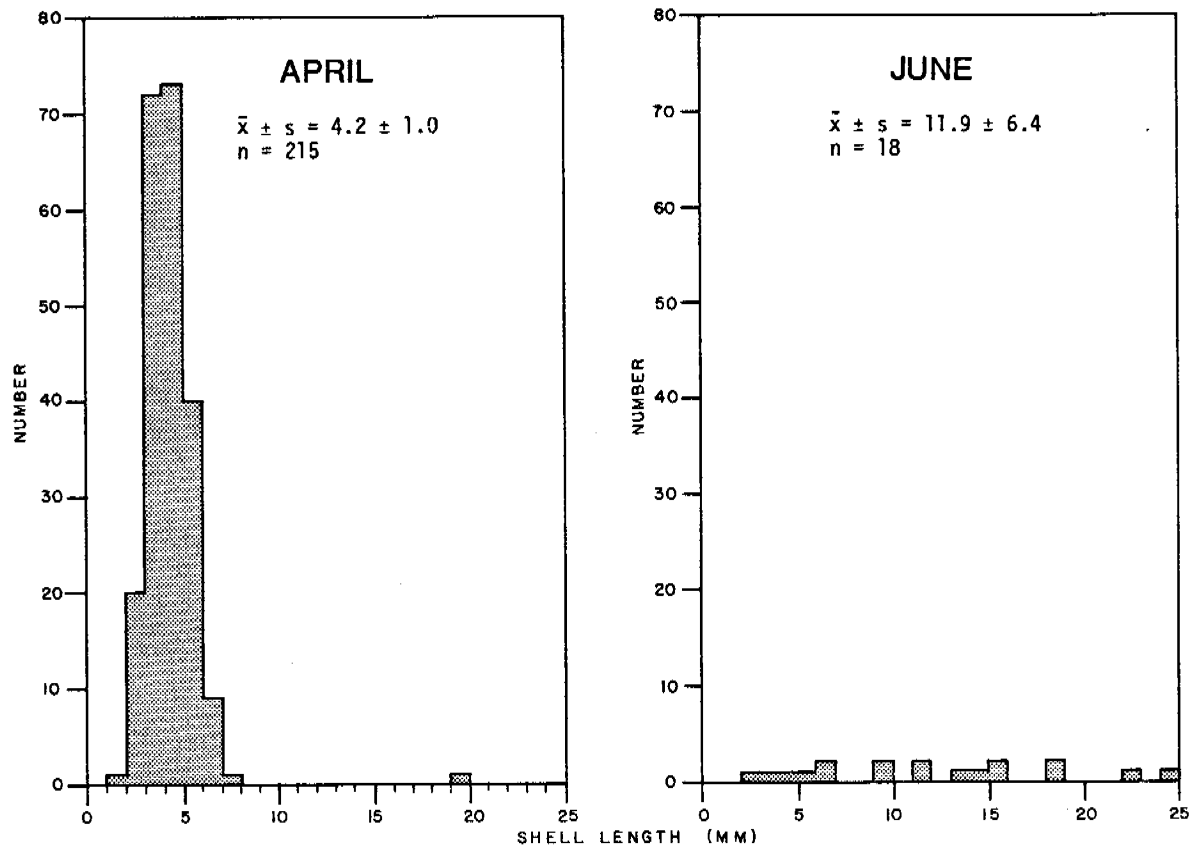


FIGURE 4-25

SHELL LENGTH FREQUENCY HISTOGRAMS
FOR JUVENILES OF MYA SPP.
FROM GLACIER SPIT, CHINITNA BAY IN 1977

TABLE 4.39. DISTRIBUTION AND DENSITY OF ADULT *MYA* SPP. BASED ON HAPHAZARD CASTS OF A 1/16m² QUADRAT

	Elevation (ft)							
	6 April 77				30 July 77			
Number per 1/16m² quadrat	+3.6	+2.5	+0.9	-1.2	+3.6	+2.5	+0.9	-1.2
0	1	1	0	3	0	0	0	2
1	2	2	0	4	2	4	2	4
2	6	3	3	5	2	2	4	1
3	5	6	3	3	3	1	3	5
4	8	5	4	4	4	2	6	6
5	1	2	3	3	4	6	1	0
6	1	1	3	2	1	3	2	5
7	0	2	3	1	2	1	2	1
8	0	1	1	0	2	2	2	1
9	0	0	1	0	1	2	2	0
10	0	1	0	0	3	1	0	0
11	0	0	2	0	1	0	1	0
12	1	1	0	0	0	1	0	0
13	0	0	2	0	0	0	0	0
$\bar{x}$	3.4	4.2	6.0	2.9	5.5	5.2	4.8	3.6
s	2.3	2.8	3.3	2.0	3.0	3.0	2.7	2.2
No./m²	53.8	67.8	96.0	46.7	87.7	83.2	76.2	57.6
Overall mean			66.0/m²					76.4/m²
Estimated number of adults/m², based on core data	101.8	101.8	38.2	63.6	114.8	127.4	216.4	114.7
Overall mean			76.4/m²					143.3/m²

4.4.3.6 Other Size And Density Data

Size data for the basket cockle (Appendix 4.4.28) indicate that average size increased markedly from April to July ($P < 0.001$; Kolmogorov-Smirnov two sample test). As in the case of *Mya*, a sharp reduction in density occurred over the same period (Table 4-40). It appears that the intertidal population is dominated by young specimens.

TABLE 4-40

DENSITY OF THE BASKET COCKLE *CLINOCARDIUM NUTTALLII* IN THE INTERTIDAL ZONE AT GLACIER SPIT, CHINITNA BAY

Elevation (ft.)	April	July
+3.6	63.7	38.2
+2.5	50.9	76.4
+0.9	432.9	165.5
-1.2	345.8	178.2
$\bar{x} \pm s$	223.3 ± 195.0	114.6 ± 68.1

Similarly, size data for the small commensal clam *Pseudopythina* sp. (Appendix 4.4.30) indicate a weak increase in average size ($P < 0.10$) from 3.2 mm to 5.0 mm. Average density was remarkably constant during this period (Table 4-41). This is probably a consequence of its apparent commensalism with burrowing species such as *Echiurus*, a behavior pattern that affords it considerable protection from severe predation pressures at the water-sediment interface. Highest densities appeared to occur at about MLLW.

TABLE 4-41

DENSITY OF THE COMMENSAL CLAM *PSEUDOPYTHINA* SP. IN THE INTERTIDAL ZONE AT GLACIER SPIT, CHINITNA BAY

Elevation (ft.)	April	July
+3.6	89.1	89.1
+2.5	203.7	114.6
+0.9	229.2	216.5
-1.2	56.6	140.1
$\bar{x} \pm s$	144.7 ± 84.6	140.1 ± 55.0

4.4.3.7 Numerical Parameters

Numerical parameters used to describe the assemblage exhibited few strongly consistent patterns. Abundance, species richness and species diversity generally increased from upper to lower elevations in each survey (Table 4-35). However, abundance decreased at all levels between April and July ($P \ll 0.001$). Species richness and species diversity all increased markedly during the same period. These patterns in abundance and species richness corresponded in a reduction in the average number of specimens per species (N/S). In spite of a seasonal decline in abundance, biomass increased substantially at all but the highest level. The seasonal change in biomass progressed from a 10 percent reduction at the +3.6 foot level, through a 34 percent increase at +2.5 feet, to 325 percent and 259 percent increases at the +0.8 foot and -1.2 foot levels.

Species-area curves were constructed for each level and survey to provide insight into rates of species acquisition in the samples and the suitability of the sampling program. Generally, the curves for specific levels appeared to be leveling off, but none was asymptotic after 10 samples (Figure 4-26). This pattern was more apparent in July. However, it seems obvious that additional sampling effort only would have added a number of uncommon species to the lists compiled at each level during the respective sampling periods. This pattern accentuates the finding of high N/S ratios and low species diversity.

The composite species-area curves also generally tended to level off, but definitely were not asymptotic. This is to be expected because the sampling levels extend across an elevation gradient and new species are expected to be encountered at the lower levels. In fact, the number of new species appearing below the upper level was greater in July, but seems rather modest for both sampling periods. This suggests a relative homogeneity in composition of the mud flat assemblage in the area examined.

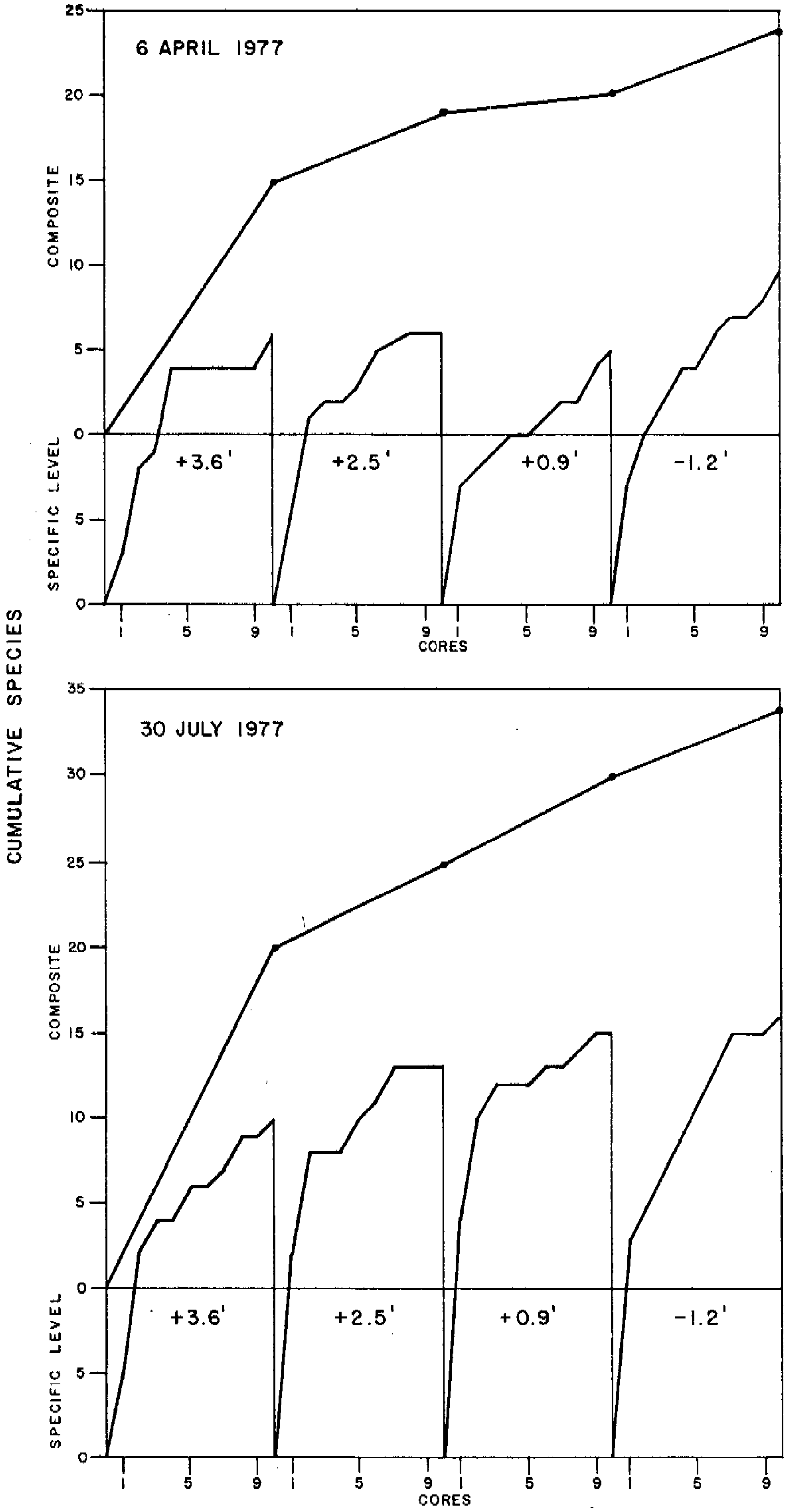


FIGURE 4-26 - SPECIES/AREA CURVES FOR GLACIER SPIT, CHINITNA BAY

5.0 DISCUSSION

This discussion is preliminary; major habitats have not been accorded equal effort at this time.

5.1 ECOLOGICAL STRUCTURE AND FUNCTION AT GULL ISLAND

Patterns in zonation at Gull Island are primarily related to differences in slope and elevation. The bedrock substrate was quite uniform. The main additional microhabitat resulting from physical conditions was provided by the small tidepools, particularly on the lower bench (0.5- to 0.0-m levels). The various biological assemblages found at the different levels studied acted strongly to modify physical conditions. Heavy cover of the primary substrate by mussels, barnacles, or algae resulted in reduced desiccation rates and higher species diversity ensued. This phenomenon was particularly notable in areas dominated by *Alaria crispa*, *Balanus cariosus* and *Odonthalia* spp.

Our observations suggest a strong dependence by *A. crispa* on *B. cariosus* (Figure 4-1). This became most obvious between summer of 1976 and spring of 1977 at the 0.5- and 0.2-m levels on the lower bench. This area was heavily covered by *A. Crispa* in the spring and summer of 1974, 1975, and 1976 (Dames & Moore 1976). During this period, quantitative data on relative cover were only collected for undisturbed quadrats, so information on the organisms under the *Alaria* canopy is lacking. However, data collected in winter when the *Alaria* canopy was absent indicate that adult *B. cariosus* covered a substantial proportion of the primary substrate during that season. Since this barnacle requires several years to reach maturity, it is reasonable to surmise that the same population of mature individuals existed under the *Alaria* canopy in the summers of 1974 through 1976. However, in the winter and spring surveys of 1977, *B. cariosus* cover was considerably reduced at these levels, and *A. crispa* failed to develop a canopy in the summer of 1977 and 1978. This was accompanied by a reduction in relative cover of the sponge *Halichondria panicea*, a frequent associate of *B. cariosus*.

Algal assemblages at all levels exhibited strong seasonal patterns in development, primarily in response to environmental conditions. Germination was most prevalent in the spring, and was accompanied by rapid growth in both new and overwintering plants. Highest development (greatest relative cover, biomass, and species diversity) of the algal assemblages was observed during the summer. Deterioration of the assemblages appeared to accompany fall storms. Poorest development of the algal assemblages was observed in the winter. Important environmental parameters appeared to be sunlight, nutrient availability, length and time of emersion, and wave action.

Invertebrate grazers, mainly chitons and limpets, also appeared to exert an important influence on the development of the algal assemblage. This influence is probably exercised mainly on microscopic gametophytes and juvenile sporophytes, rather than on adult sporophytes.

The main suspension feeders (Balanus spp. and Mytilus) were found mainly in the upper portions of the intertidal zone. This is probably a response to limitations on the upward distribution of invertebrate predators imposed by tidal emersion and the accompanying desiccation.

5.2 ECOLOGICAL STRUCTURE AND FUNCTION AT SELDOVIA POINT

The heterogeneous nature of the beach at Seldovia Point provided several microhabitats for benthic flora and fauna. Sampling during 1977 and 1978 focused on the most prevalent and obvious of these: the exposed upper and lateral surfaces of the rock bench, cobbles, and boulders. These surfaces supported an algae-herbivore dominated assemblage described in Section 4.1.2. Primary productivity was high, as indicated by the strong annual cycle in macrophyte standing crop and the high abundance of microherbivores (limpets, chitons, and pulmonate snails). A major fraction of the macrophyte production is exported to other communities in the form of frayed or broken fronds, dissolved or fine-particulate exudates, and metabolites or fecal pellets of macroherbivores (e.g., urchins) within the intertidal community. Plants that are fed upon by macroherbivores are usually weakened to the point where a major portion of the plant is carried away by wave action, leaving only some of the stipe, holdfast, or lower frond (e.g., Katharina grazing on Alaria in October 1978). These broken portions thus provide organic detritus to other primarily subtidal communities.

As is typical of most rocky littoral situations, there was strong competition for primary substrate among plants and sessile filter or suspension feeders. Micrograzers (limpets and small chitons) and macro-gazers (urchins, Katharina) appear to exert some control over algal standing crop. Sessile animals and the micrograzers themselves are preyed upon by a variety of starfish, prosobranch snails, and nudibranchs. Sea ducks, gulls, and sea otters may take a variety of these larger forms including barnacles, mussels, snails, and urchins.

Import of plant material from the subtidal community appeared to contribute somewhat to the energy base of detritivores in the mid and upper intertidal areas although no quantitative measurements were made. Portions of Agarum, Codium, Desmarestia, and other typically subtidal plants were frequently seen being eaten by urchins, Pentidotea, littorines, etc.

The undersides of rocks where water circulated freely were usually well covered by sessile filter feeding animals such as barnacles, bryo-zoans, hydroids, and serpulid worms (Spirorbinae). Primary productivity was very low because of low light levels, but predators such as Leptasterias, Nucella, and the nudibranch Onchidoris bilamellata foraged activity on the sessile fauna. Limpets often moved to shaded undersides of boulders seeking refuge from desiccation during periods of emersion.

Areas directly under and between boulders, where water movement was reduced sufficiently to allow accumulation of gravel, sand, and organic debris, had a completely different fauna from that on the rocks or boulders. This microhabitat supported an assemblage of detritivores living mostly off algal and other organic material trapped in the area. These included a small burrowing sea cucumber, Cucumaria vegae, the polychaete Cirratulus cirratus, and perhaps urchins. Hermit crab (Pagurus and Elassochirus), gammarid amphipod, and isopod scavengers were also present, taking advantage of the natural food trap afforded by these kinds of areas.

5.3 ECOLOGICAL STRUCTURE AND FUNCTION AT ROCKY INTERTIDAL SITES IN KAMISHAK BAY

The rocky intertidal sites examined in Kamishak Bay were all composed mainly of bedrock, with little boulder cover. Algal assemblages were dominated by *Fucus* at the upper levels and by red algae (*Rhodymenia pacifica* and *R. liniformis*) at the lower levels. Laminarian kelps were only important in tidal channels and pools, and subtidally, to a depth of about 3 m. Standing stocks of red algae and *Fucus* were moderately high in mid-summer.

Intertidal invertebrate assemblages were poorly developed. Generally, densities of typical intertidal dominants were low and populations comprised mainly juvenile specimens. This condition is attributed primarily to winter ice conditions.

Subtidal invertebrate assemblages are fairly well developed, but of dramatically different species composition than in Kachemak Bay. Encrusting forms with Arctic and Bering Sea affinities predominate, covering high proportions of the available rock surface. Dominant taxa include bryozoans, tunicates, sponges and barnacles, all of which are suspension feeders. Grazers are not common. Major predators are snails and starfish. Demersal fish are much less abundant than the substrate type would permit.

5.4 PRIMARY PRODUCTION BY MACROPHYTES

This subject will be discussed in the final report, now in preparation.

5.5 SAND BEACH ASSEMBLAGES

The biological assemblages observed on the sand beaches exhibited many fundamental similarities in composition and structure. Many of the species were important at both sites, including the polychaetes Eteone nr. longa, Nephtys ?ciliata, Paraonella platybranchia and Scolelepis sp. A, and the gammarid amphipods Eohaustorius eous and Paraphoxus milleri (Table 4-24). Age structure data are not available for any for these species, but most appear to live for two years or less. Reporting on five species of haustoriids, Sameoto (1969a, 1969b) indicates ranges in longevity of 12 to 17 months; most were annuals. Hedgpeth (1957) reported that most sand beach organisms are annuals.

Many of the families, genera, and in some cases, the species, are characteristic components of unconsolidated intertidal assemblages in the Pacific and Atlantic Oceans (e.g., Withers 1977).

Many of the seasonal and elevational patterns observed for numerical parameters were similar for the two beaches (Tables 4-29 and 4-33). Levels of density, average number of species, species diversity, evenness and biomass were uniformly rather low at both locations. Sand beaches are generally characterized by low values for these parameters (Dexter 1969, 1972). At both beaches abundance, species diversity and biomass parameters generally increased from winter to summer, agreeing with the pattern described by Hedgpeth (1957), and from higher to lower elevations as reported by Johnson (1970). In addition, the average number of specimens per species increased from winter to summer, which was accurately reflected by decreases in the evenness index (E) over the same period. Keith and Hulings (1965) found similar patterns on sand beaches on the Texas Gulf Coast.

In spite of the basic similarities, some faunal dissimilarities imply important differences between the areas. Specifically, the fauna at Deep Creek was dominated numerically by gammarid amphipods, viz. Eohaustorius, Gammaridae sp. A and Paraphoxus (Table 4-16). In contrast, the fauna at Homer Spit was dominated by polychaetes such as Scolelepis, and gammarids were only of marginal importance (Table 4-30). In terms of biomass, the fauna at Deep Creek was again dominated by Eohaustorius in both surveys whereas at Homer Spit, it was dominated by Scolelepis.

Furthermore, the fauna at Homer Spit was somewhat richer than that examined at Deep Creek, biomass was appreciably greater, and the range of organisms, including a clam and a fish, was broader. Withers (1977) reported that the polychaete fauna on Welsh beaches was better developed in sheltered areas. Furthermore, he noted that; on exposed beaches, "only a very reduced fauna of crustaceans and small polychaetes was found." These facts lead to the impression that the fauna at Deep Creek was responding to a more rigorous environment and was more typical of exposed intertidal beaches. This impression was amplified by the strong dominance at Deep Creek by a haustoriid amphipod, a family often characteristic of exposed sandy beaches (Barnard 1969), the importance of another amphipod, *Anisogammarus*, and a mysid *Archaeomysis*, both typically intertidal species (Kozloff 1973). In contrast, the fauna at Homer Spit was characterized by increased importance of polychaetes, and the consistent appearance of characteristically subtidal forms such as the redneck clam (*Spisula*) and the sand lance (*Ammodytes*).

Pronounced annual variations in the abundance of organisms are characteristic of sand beaches (Hedgpeth 1957). The increases in abundance, species richness, species diversity and biomass observed in this study in spring and summer are a consequence of a combination of reduced environmental stress, growth, and recruitment. Higher species richness indicates that several species are attempting to colonize the intertidal zone during this relatively mild period. Size structures, when available, indicated that many juvenile specimens were present, and growth was also apparent for at least one species (*Eohaustorius*).

It is probable that several factors are responsible for lower levels of abundance, species richness and biomass in the winter. Increased wave action undoubtedly raises mortality rates for species living near the water-sand interface. March samples from Homer Spit taken immediately after a storm suggested that density of some polychaetes was reduced. However, densities of *Eohaustorius* and *Paraphoxus* were not appreciably affected, and *Scolelepis*, which lives buried deeply in the sand, increased substantially during this period. Keith and Hulings (1965) reported that sand faunas on the Texas Gulf Coast were not appreciably affected by the waves of Hurricane Cindy in 1963. Low winter temperatures undoubtedly reduce metabolic rates and feeding activities, thus slowing growth and reproductive activities. Woodin (1974) states that many polychaetes die after spawning and this may account in part for the seasonal variations in density observed at both beaches. Increased sediment instability associated with storms is likely to reduce success rate in recruitment, but this may be of little importance in winter.

The precise role of predation in the sand beach assemblages is, at present, still unclear. Predation presence appears low, but has not been assessed in detail. The only infaunal predator recognized so far is the polychaete Nephtys (Kozloff 1973, Green 1968), which probably feeds on Scholelepis. Pressure from shorebirds appears minimal, even during the peaks of migration. Several species are known to feed on amphipods on sandy beaches (Sameto 1969a; Dave Erikson, personal communication). Species observed on local sandy beaches include Semi-palmated Plovers (Calidris pusilla), Rock Sandpipers (C. ptilacnemis), Dunlin (C. alpina), Western Sandpipers (C. mauri), and Sanderlings (C. alba). However, most prefer other habitats. Glaucous-winged Gulls (Larus glaucescens) and Mew Gulls (L. canus) are commonly observed foraging on the exposed low-tide terrace; they appear to capture the large polychaete Nephtys, amphipods, the helmet crab Telmessus, the sand lance Ammodytes, and also occasionally larger clams. When the low-tide terrace is underwater, several species of diving ducks (e.g., Greater Scaup (Aythya marila), Oldsquaw (Clangula hyemalis), White-winged Scoter (Melanitta deglandi), Surf Scoters (M. perspicillata), and Black Scoters (M. nigra) move in to feed. Apparently spring is the period of greatest utilization by sea ducks, but even then usage is minor. Predation pressure from birds is somewhat reduced in the winter.

Several demersal fishes and epifaunal invertebrates, all potential predators, have been collected on the low-tide terrace during periods of submergence. The fish included Pacific staghorn sculpin (Leptoccottus armatus), brown Irish lord (Hemilepidotus spinosus), starry flounder (Platichthys stellatus), butter (Isopsetta isolepis) and English sole

(Parophyrys vetulus), Dolly Varden trout (Salvelinus malma), steelhead trout (Salmo gairdneri), sand lance and sandfish (Trichodon trichodon) (personal observation). The epifaunal invertebrates were mainly crustaceans, such as Dungeness, tanner, and helmet crabs and gray shrimp (Crangon sp.). Our subtidal observations indicate most of the fish and infaunal invertebrates move into deeper water during the winter months. Virnstein (1977) has shown that crabs and fish can exert strong control on infaunal population of polychaetes and clams on soft substrates. He further points out that the importance of predation cannot be determined without experimental manipulation.

The importance of competition as a factor influencing composition of the sand beach faunas and the distribution and abundance of their component species is difficult to assess based on the existing data. Sand beaches are strongly influenced by various physical stresses and thus are typical of physically controlled habitats as defined by Sanders (1968), wherein biological interactions such as competition and predation are thought to be relatively unimportant. Slow moving or juvenile organisms that live near the water-sand interface may be strongly influenced by storm surf or temperature extremes during low tides. The large decrease in the density of Paraonella noted after a winter storm may be evidence of this. Furthermore, Hedgpeth (1957) suggests that food supplies are not limiting on sand beaches. Combining these possibilities with observed low species richness and densities, it therefore seems plausible to consider interspecific competition inconsequential.

However, both Virnstein (1977) and Woodin (1974) point out the danger of ignoring biological interactions in physically controlled habitats. Interspecific competition in protected intertidal soft substrates has been shown for several species (e.g., Woodin 1974, Fenchel 1975, and Ronan 1975), but not on exposed sand beaches. The dominance of environmental stress in these habitats must be examined from the viewpoint of juveniles as well as adults of each species, as most adults live in more protected circumstances on soft substrates. For instance, recruiting juveniles of the polychaete Scolelepis face a much more rigorous environment near the water-sand interface than the deeply buried adults. It appears that the adults migrate vertically in the sand, moving upward to richer food concentrations during calm weather and downward in response to physical stresses and disturbances. Under such circumstances, it is possible that intraspecific competition for food and space could occur at the deeper, more protected levels, especially during the winter. However, as Scolelepis appears to be the only deep burrowing deposit feeder found on exposed sand beaches, interspecific competition seems unlikely.

The trophic structure of the sand beaches is not well understood, but a tentative food web is indicated in Figure 5-1. The main source of energy for the assemblage appears to be detritus, which the primary consumers ingest mainly for the adhering bacteria. The two major categories of detritivores recognized in the sand beach assemblages are suspension feeders and deposit feeders. The former, including a mysid Archaeomysis and the clams Spisula, Siliqua, and Tellina lutea, feed on organic particles in suspension or at the water-sand interface. However, a greater proportion of the energy appears to pass through polychaetes and gammarid amphipods. The gammarid amphipods Eohaustorius and Paraphoxus are probably selective deposit feeders, burrowing to feed on sand grains and organic particles of specific sizes. The polychaete Scolelepis, which ingests large quantities of sand, is probably a nonselective deposit feeder.

The primary consumer groups appear to contribute to both marine and terrestrial systems by serving as forage items for birds and fish. The most important linkages seem to go to fish and shorebirds. Based on the low standing stocks, low levels of observed bird predation (even during spring migration), and the relative inaccessibility of a major biomass component (the deep burrowing polychaete Scolelepis) to the major shorebirds (which feed chiefly at or near the sediment surface), it appears that the sand beach habitat contributes only minimally to bird productivity of Lower Cook Inlet. Its importance to the subtidal forms (fish, crabs, and shrimp) is unclear at present. However, productivity appears to be low in comparison with mud beaches.

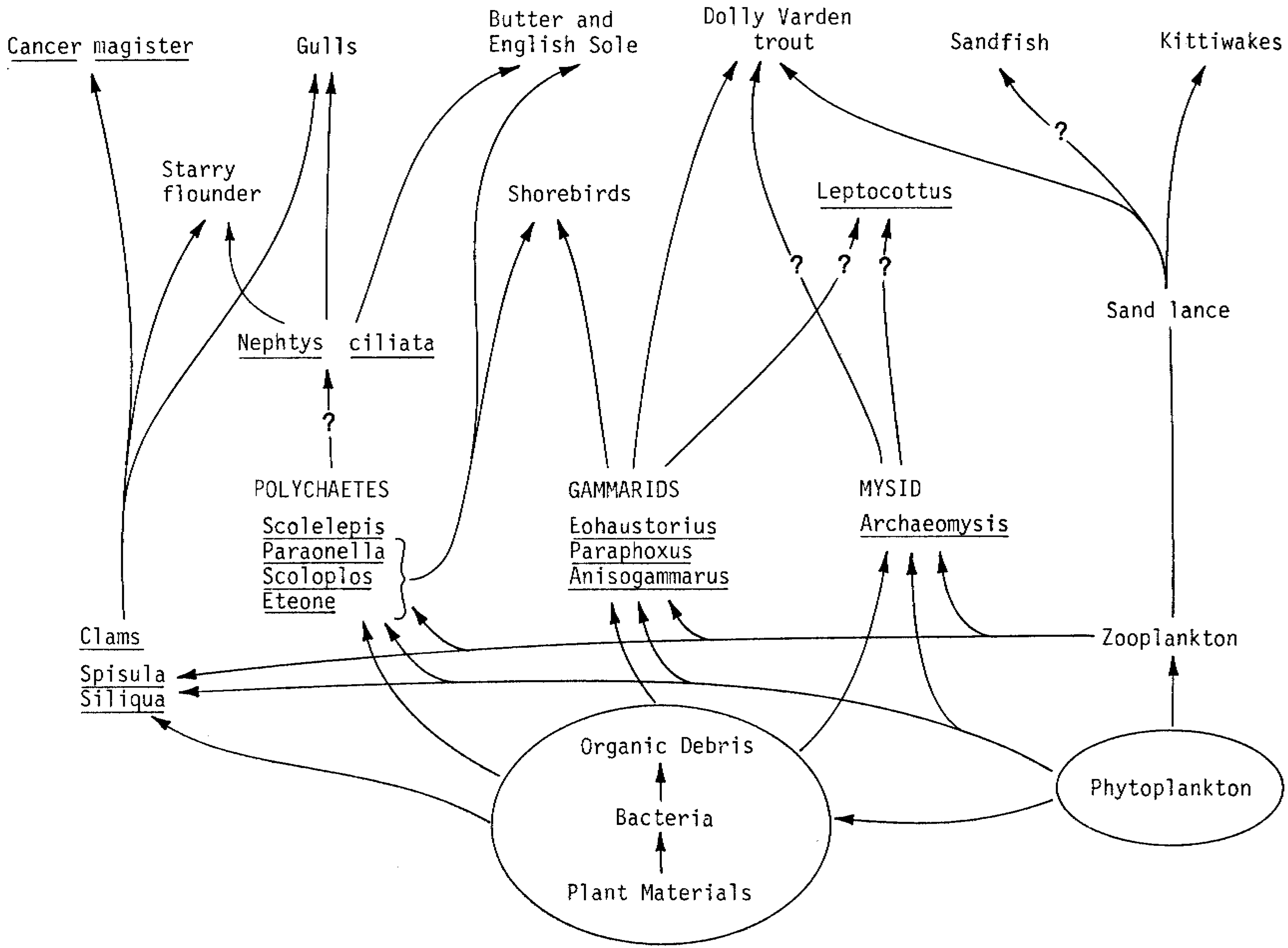


FIGURE 5-1 - GENERALIZED FOOD WEB FOR SAND BEACHES AT HOMER SPIT AND DEEP CREEK

A comparison of infaunal data from several sand beaches on the east side of Lower Cook Inlet suggests that the sand beach assemblages are quite variable spatially and possibly temporally (Table 5-1). Only 17 percent of the species were found at more than three of the stations. Only *Eohaustorius* and *Paraphoxus* were found on all occasions. Temporal patchiness cannot be examined because of differences in sampling areas and methods at Homer Spit and Deep Creek. Samples for 1976 were collected with a much smaller, shorter core tube than in 1977, and fewer samples were collected in 1976, so deep burrowing forms such as *Scolelepis*, and uncommon or patchy species were not sampled adequately in that survey.

Two patterns seem rather well-defined. Overall, polychaetes decrease and crustaceans increase in importance on the beaches moving from Homer to Deep Creek. As noted above, this seems to reflect a gradient in physical energy, with Deep Creek being subjected to stronger, more consistent current action, as well as higher turbidity, colder temperatures, lower salinities and more ice.

Further insight into this physical stress gradient is provided by comparing the species composition of Homer Spit and Deep Creek with that of a subtidal sand habitat at the A.R.Co. C.O.S.T. well site in the middle of Lower Cook Inlet (∿60 m deep). There is a surprising but definite resemblance between the intertidal sand assemblages and that described for unstable subtidal sand substrates (Table 5-2; Dames & Moore 1978). Forty-five percent of the species considered important at Deep Creek and eighty percent of those at Homer Spit were also common at the C.O.S.T. well site. The polychaete *Scolelepis* and a gammarid amphipod *Paraphoxus* were frequently considered dominants at all locations. Other species that were common at all locations include the polychaetes *Eteone* nr. *longa*, *Nephtys* ?*ciliata*, and *Scoloplos armiger*. It is tempting to speculate, in view of the physical gradient, that the faunal differences observed between the various sites represent sequences in the successional development of a sandy substrate, as suggested by Johnson (1970). This could not be shown without experimental manipulation, however.

TABLE 5-1. SPECIES COMPOSITION AND DENSITY (NO./M^2) AT SAND BEACHES ON THE EAST SIDE OF LOWER COOK INLET. BEACHES ARE ARRANGED FROM SOUTH TO NORTH.

TAXA	Homer Spit 1977	Homer Spit 1976	Bishops Beach 1976	Whiskey Gulch 1976	Deep Creek 1977	Deep Creek 1976	Clam Gulch 1976
Polychaeta	(78%)	(29%)	(38%)	(16%)	(13%)	(16%)	(10%)
Abarenicola sp	0	0	0	0	6.4	0	0
Capitella capitata	25.5	0	0	0	9.6	0	0
Chaetozone setosa	0	0	0	0	6.4	0	0
Eteone nr *longa*	3.2	0	0	0	9.6	37.8	0
Magelona ?sacculata	0	0	113.6	0	0	0	0
Nephtys ?ciliata	22.3	37.9	37.9	21.6	9.6	0	0
Paraonella platybranchia	213.3	0	0	0	12.7	75.8	75.8
Scolelepis sp A	547.5	0	0	32.5	92.3	0	12.6
Scoloplos armiger	0	75.8	0	0	31.8	75.8	0
Spio filicornis	0	0	0	0	0	75.8	25.3
Spiophanes bombyx	3.2	75.8	75.8	0	0	0	0
Crustacea	(6%)	(59%)	(63%)	(84%)	(85%)	(84%)	(90%)
Anisogammarus confervicolus	0	0	0	10.8	0	0	0
Anonyx sp	0	0	0	10.8	0	0	0
Archaeomysis grebnitzkii	0	0	0	0	3.2	0	0
Atylidae, unid.	0	0	0	0	3.2	0	0
Crangon alaskensis elongata	12.7	0	0	0	0	0	0
Cumacea, unid.	0	151.5	0	10.8	0	0	0
Eohaustorius eous	28.7	37.9	75.8	151.5	648.4	1363.6	947.0
Gammariidae, unid.	0	0	0	0	388.3	0	12.6
Hippomedon sp	0	151.5	227.3	0	0	0	0
Lamprops carinata	60.5	0	0	0	0	0	0

TAXA	Homer Spit 1977	Homer Spit 1976	Bishops Beach 1976	Whiskey Gulch 1976	Deep Creek 1977	Deep Creek 1976	Clam Gulch 1976
Crustacea, cont.							
Lamprops quadriplicata	79.6	0	0	0	19.1	0	0
Lamprops sp	3.2	0	0	0	0	0	0
Paraphoxus milleri	19.1	37.9	75.8	108.2	19.1	37.8	25.3
Synchelidium sp	12.7	0	0	0	6.4	0	0
Pelecypoda	(0.6%)	(18%)					
?Macoma sp	0	37.9	0	0	0	0	0
?psephidia lordii	0	37.9	0	0	0	0	0
Spisula polynyma	6.4	0	0	0	0	0	0
Pisces	(0.3%)						
Ammodytes hexapterus	3.2	0	0	0	0	0	0

TABLE 5-2. COMPARISON OF DENSITIES ($NUMBER/M^2$) FOR IMPORTANT SPECIES AT VARIOUS SITES ON UNSTABLE SAND HABITATS IN LOWER COOK INLET

	Deep Creek	Homer Spit	ARCO site Ocean Ranger	ARCO site Control
Polychaetes				
Capitella capitata	6.4	0	0	0
Chaetozone setosa	0	0	5.0	5.4
Eteone nr *longa*	21.3	3.2	0.6	92.9
Nephtys ?ciliata	6.4	6.4	12.2	35.7
Ophelia limacina	0	0	45.0	125.0
Paraonella platybranchia	12.7	132.6	0	0
Polygordius sp	0	0	7.8	407.1
Scolelepis sp A	47.7	402.1	423.9	160.7
Scoloplos armiger	18.0	2.1	61.7	33.9
Sphaerosyllis pirifera	0	0	0	25.0
Spiophanes bombyx	0	1.1	185.6	2410.7
Streptosyllis nr *latipalpa*	0	0	7.2	12.5
Crustaceans				
Anisogammarus confervicolus	4.3	0	0	0
Archaeomysis grebnitzkii	1.1	0	0	0
Eohaustorius eous	504.7	20.2	0	0
Gammaridae sp A	129.4	0	-	-
Orchomene cf *pacifica*	0	0	3.9	17.9
Paraphoxus milleri	19.1	38.2	56.1	14.3
Clams				
Astarte sp	0	0	0.6	25.0
Glycymeris subobsoleta	0	0	2.2	50.0
Liocyma fluctuosa	0	0	31.7	58.9
Spisula polynyma	0	7.4	0.6	3.6
Tellina nuculoides	0	0	19.4	44.6
Gastropods				
Propebela spp	0	0	16.1	7.1
Sand dollars				
Echinarachnius parma	0	0	22.2	17.9
Fish				
Ammodytes hexapterus	0	7.4	C	C
Overall Average Density	788	726	1017	3852

5.6 MUD FLAT ASSEMBLAGES

Our studies so far have indicated that, in contrast to sand beaches, the mud flat off Glacier Spit, Chinitna Bay, supports a large standing crop of suspension and deposit feeders, has higher species richness, and appears to be highly productive. However, spatial, seasonal and annual variability were considerable, being influenced strongly by weather conditions and predation. Species richness, species diversity and biomass were greatest in the summer, whereas abundance was lowest in summer (Table 4-35). This apparent paradox is attributable to the large reduction in the abundance of juveniles of the clams *Macoma balthica* and *Mya* spp. between April and July; most other species increased in abundance during the same period (Table 4-34).

The fauna was dominated heavily by the clams *Mya* spp. and *Macoma balthica*, which comprised more than 50 percent of the individuals and 90 percent of the wet biomass and dry tissue weight in both surveys (Tables 4-34 and 4-37). *Macoma* was by far the most abundant, but contributed only 10 to 15 percent of the biomass. Three other visually conspicuous species of marginal importance were an echiurid *Echiurus echiurus alaskanus*, a large polychaete *Nephtys* sp., and the basket cockle *Clinocardium nuttallii*, all of which also contributed marginally to biomass.

Ten species exhibited densities exceeding 100 individuals/m^2 in at least one survey. These included, in order of importance, *Macoma*, *Mya* spp., *Nephtys*, *Spio*, *Potamilla*, *Clinocardium*, *Pseudopythina*, *Tritella*, *Eteone*, and *Capitella* (Table 4-34). All of the worms except *Nephtys* increased in abundance substantially from April to July, whereas that worm and all of the clams became less abundant. All of the species exhibiting increased abundance are thought to be annuals, at least in this habitat. In contrast, all of the species that declined, including *Nephtys*, appear to be perennials (Thorson 1957).

The species that appear to represent the mature stage, or highest level of development, of this mud flat assemblage are the clams *Mya*, *Macoma*, *Pseudopythina*, the polychaete *Nephtys* and the echiurid *Echiurus*.

The present rarity of adult Clinocardium in the intertidal zone suggests that it does not survive harsh winters at these elevations in this location. However, long-time resident Wayne Byers indicated that adult cockles were abundant on these flats prior to the uplift resulting from the 1964 earthquake (personal communication). Mya spp. and Echiurus construct semi-permanent burrows which impart a characteristic appearance to the mud flats on the west side of Lower Cook Inlet (Figure 4-23).

The richness of this mud flat assemblage is indicated by the density and biomass of its constituent species, particularly the dominants. For instance, in April, when the population was dominated by the 0-year class, Macoma densities ranged from $4250/m^2$ to $5350/m^2$ (Appendix 4.4.15) and whole wet weight ranged from 340 g/m^2 to 550 g/m^2 (Appendix 4.4.17). Such densities are among the highest recorded for Macoma (Green 1968, Tunnicliffe and Risk 1977), and this is particularly notable in view of the high percentage of animals at least one year old during the summer (Figure 4-24).

The contrasting seasonal patterns of abundance for the major clams and the polychaetes seem to indicate differences in reproductive cycles. Density of the three main clam taxa decreased markedly from April to July. Moreover, the 0-year class strongly dominated the age structures for Macoma, Mya spp. and Clinocardium in the April samples but was strongly reduced in all cases by July. The implication is that recruitment occurs in late summer, fall or winter. This hypothesis is partially supported for Macoma by data from the Irish Sea for reproductive condition from Chambers and Milne (1975), and for Mya truncata by Thorson (1957). Surprisingly, however, Chambers and Milne (1975) observed heavy recruitment in July, four months after the local adult population was spawned out.

Myren and Pella (1977) found no seasonal changes in density for larger specimens of M. balthica at Valdez. The data for large specimens of Macoma and Mya spp. from Glacier Spit generally support that finding, and suggested that the adult size classes are much more stable than the 0-year class.

Density of the polychaete populations increased considerably from April to July. The July samples were strongly dominated by newly settled specimens, as was the case on the sand beaches. This pattern suggests late spring or early summer spawning.

It seems probable that both physical and biological factors are important in determining the density of the organisms living in the mud flats at Glacier Spit. Physical conditions are severe, especially near the water-sediment interface where temperature and salinity fluctuate widely and ice scouring and crushing can be substantial. In addition, predation pressures and intra- and interspecific competition for food and space are probably intense, especially in the spring, when maximum densities of young clams are concentrated in the upper few centimeters of sediment and high numbers of migratory birds exploit the mud flats. In addition, predation by adult clams on larval, metamorphosing and settling juvenile clams is probably intense during major periods of recruitment.

Predation seems to exert a strong influence on the density of several species, such as Macoma balthica, Mya spp. and Echiurus. A broad variety of predators exploit the mud flats (Figure 5-2). Diving ducks (scoters, scaup and Oldsquaw), gulls and shorebirds appear to be major predators on clams and polychaetes. Diving ducks and shorebirds are most abundant during spring migration and seem to concentrate on Macoma and Mya. Judging from the reductions of nearly 50 percent and 70 percent in the densities of Macoma and Mya, respectively, these predators are fairly effective. The changes in size structure indicate that juveniles, located near the sediment surface, are most frequently utilized. Gulls were observed foraging on the mud flats during both day and night low tides, and their egesta and shell debris indicate that they feed mainly on barnacles, Clinocardium, and crabs; large worms such as Nephtys are probably also taken frequently.

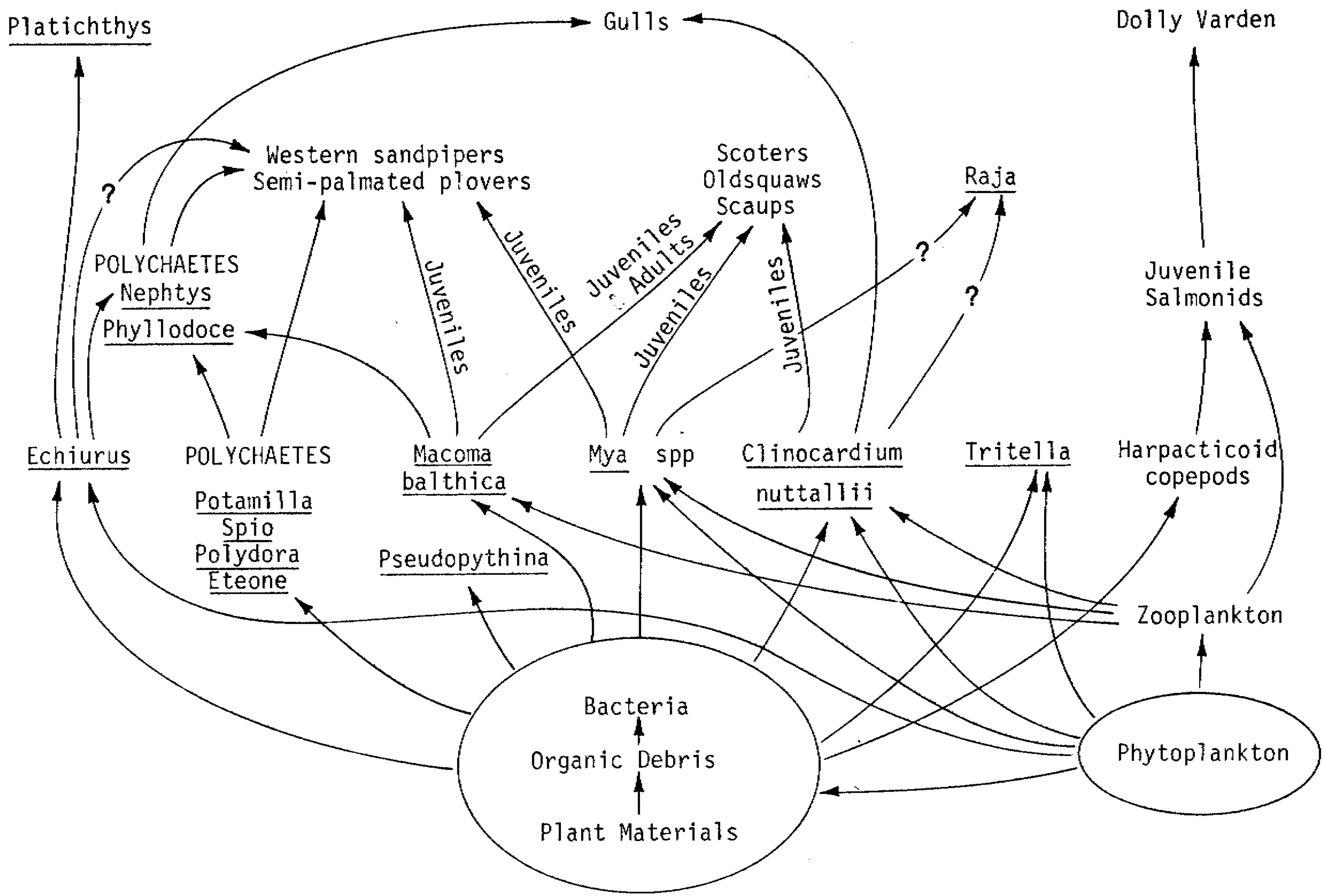


FIGURE 5-2 - GENERALIZED FOOD WEB FOR MUD FLAT AT GLACIER SPIT

The only resident predator of any importance observed in the study area was the polychaete Nephtys sp. The population of this perennial included specimens up to 10 cm in length, but was strongly dominated by the small, younger animals. The importance of this species is poorly understood. The few feeding observations made were for adults, and most had empty alimentary canals. The small number of feeders had all fed on adult Echiurus; one specimen contained two prey. Based on available prey and habits, it seems probable that juvenile Nephtys feeds on juvenile Echiurus and small polychaetes.

Gastropod predators, particularly small opisthobranchs, are frequently common locally on mud substrates and on more temperate mud flats. However, they were very uncommon during this survey.

Data are presently not available to describe the function of several predators, but some speculation is permissible based on other studies or observations. Excavations and shell remains observed while diving in Cottonwood Bay suggest that skates (Raja) may move into shallow bays and feed on Clinocardium. Starry flounder are reported to feed on Echiurus in the Bering Sea (Feder, personal communication). Other potential predators important to macrofaunal forms include Dungeness (Cancer magister) and tanner crab, rock sole (Lepidopsetta bilineata), and Pacific staghorn sculpin.

As indicated above, competition for food and space may be important in determining densities and growth rates of several species, particularly the clams Macoma and Mya spp. The feeding activities of dense adult clams may strongly reduce success of recruits attempting to settle, so that suitable space is limiting for larvae. Furthermore, food and space are somewhat synonymous for Mya and Macoma and, at high densities, available food may become limiting.

Several types of mud flats have been observed in southcentral Alaska; all are dominated by clams and generally they differ sharply from those described or observed in Washington (Kozloff 1973) or California (Ricketts and Calvin 1962). Species richness is rather lower, reflecting the absence or paucity of a number of higher taxa. Southcentral Alaskan mud flats generally lack burrowing shrimp (e.g., Callianassa and Upogebia), gammarid amphipods and isopods, deposit feeding or predatory gastropods (e.g., Hydrobia or Aglaja) and commensal fish (e.g., Clevelandia).

Southcentral Alaskan mud flats appear to have greater affinity to similar habitats on the Atlantic Ocean, which also support high densities of Macoma balthica and/or Mya spp. These species dominate on many mud flats in Lower Cook Inlet, and the burrow building Echiurus is frequently an important structural component. On some mud flats, such as the Dayville flats in Valdez (Feder, personal communication) and Mud Bay in Homer (personal observation), Mya and Echiurus are uncommon, reducing the permeability of the sediments.

A number of mud flats support beds of eelgrass (Zostera marina), but intertidal stands are frequently limited by winter ice.

The generalized trophic structure proposed for the mud flat (Figure 5-2) appears to be based on detrital material from marine and terrestrial systems. It is considerably more diverse than that for sand beaches. Griffiths (personal communications) indicates that the bacterial flora observed in the water column on the west side of the inlet suggests that terrestrial plants may be a major source of organic debris. The detritus, associated inorganic particles, bacteria and protozoans are ingested by suspension and deposit feeders (Jørgenson, 1966), but mainly the bacteria and protozoans are digested and assimilated (Johannes and Satomi 1966). Nearly all of the infaunal animals collected at Glacier Spit were detritivores; both suspension and deposit feeders were common but suspension feeders seem to dominate. Non-selective deposit feeders such as Abarenicola were uncommon.

Nearly all the predators observed were transients representing other systems, and were mainly effective only in spring and summer. However, several overwintering duck species are heavily dependent on mud flats. The fish, crabs and ducks move onto the intertidal flats during high tides, and the shorebirds move in during low tides. Commercially, the most important of these interactions appears to be that of juvenile salmon and harpacticoid copepods (Sibert et al. 1977, Kaczynski et al. 1973). The consequence of this concept is that a very large proportion of the tissue produced on the flats is exploited by predators from other systems. This is a particularly important concept on the west side of the Inlet because of 1) the richness of the mud flats, 2) the large proportion of mud flat habitat in the intertidal zone and, 3) the potential susceptibility of this assemblage to oil pollution.

A preliminary assessment of secondary production can be made using data for density, growth and biomass data and the predation hypotheses. Nearly all species exhibited sizeable changes in density between April and July. With the notable exception of Macoma, most species exhibited relatively large increases in standing crops. For Macoma, density decreased nearly 50 percent concurrent with a small decrease in standing crop. Average size of all the populations appeared to increase during this period. During this same period, it is probable that predation pressures were intense. Despite predation, whole wet weight increased during this four month period from 2.3 kg/m^2 to 4.0 kg/m^2. The 74 percent increase in biomass during a period of intense predation indicated moderately high net production.

5.7 FAUNAL COMPOSITION OF GRAVEL UPPER BEACHES AND SCOURED BOULDER FIELDS

Gravel/cobble upper beaches and scoured boulder fields were frequently associated with the soft substrates and so were examined qualitatively to develop a general idea of their faunal composition and structure. These areas were quite impoverished, a condition which Kozloff (1973) reports is normal. However, particularly during summer, the lower levels of gravel and cobble substrate characteristic of upper beach areas throughout much of Lower Cook Inlet appear to support moderate densities of two scavengers, namely, the gammarid amphipod *Anisogammarus confervicolus* and the isopod *Gnorimosphaeroma oregonensis*. These organisms are most abundant in areas where ground water from the upper beach seeps onto the beach. There, they aggregate mainly under large cobbles that rest in a manner allowing water to stand or pass gently under them. Generally, these species should be considered as cryptic rather than infaunal as they do not appear to live interstitially in the gravel. Nematodes appear to be the common infaunal form.

These species are also characteristic of the scoured boulder/cobble fields occurring at about MLLW. However, these areas are not subject to the continuous grinding that occurs in the gravel beach, and therefore are capable of supporting young populations of pioneer species such as barnacles (*Balanus* spp.) and mussels (*Mytilus edulis*). Generally, these populations do not survive a harsh winter, but annual replacement appears to be fairly reliable. The last two winters have been quite mild, however, so many such areas in Lower Cook Inlet support two year classes of barnacles and mussels.

These species appear to occupy positions low in the food web, and are probably mainly dependent upon phytoplankton (barnacles and mussels), or plant and animal debris (isopods and amphipods). However, casual observations suggest that a number of invertebrate, bird and fish species heavily utilize these resources for food. The nudibranch *Onchidoris bilamellata* and the snail *Nucella emarginata* compete for the barnacle and mussel resources. *Onchidoris* appears to be more successful in the less stable areas.

Shorebirds, mainly sandpipers, turnstones and plovers, put considerable predation pressure on these habitats, particularly during spring migration, when utilization is intense. The Rock Sandpiper, a winter resident, appears to be particularly important. Our observations during the winter suggest that this species is using these resources during both day and night low tides. The occurrence of night feeding by shorebirds in winter does not appear well known. However, the energetics argument appears strong, considering the combination of short day length, available low (feeding) tides, the possibility of reduced prey density and higher metabolic rates for resident birds during winter months.

Several invertebrate and fish species have been collected in beach seine hauls just below these habitats and it can be assumed that many of these probably feed there. The main invertebrates are adult and juvenile Dungeness crabs (Cancer magister), adult helmet crabs (Telmessus cheiragonus) and gray shrimp (Crangon alaskensis). Juvenile Dungeness crabs are fairly common in the boulder/cobble field during the summer. The main fish species observed include the sand lance (Ammodytes hexapterus), Pacific staghorn sculpin (Leptocottus armatus), starry flounder (Platichthys stellatus), and flathead sole (Hippoglossoides elassodon). Specific food habits have not been investigated in this area.

5.8 PRELIMINARY DISCUSSION OF THE POTENTIAL EFFECTS OF OIL POLLUTION

The two major potential types of oil pollution of concern in Lower Cook Inlet are catastrophic spills of crude oil and chronic pollution by refined petroleum or refinery effluents. Chronic pollution is a concern chiefly on the eastern shore of the Inlet since most onshore facilities are planned for that side (Warren, 1978). This would result from increased boat traffic to supply and support facilities and, in the event of development and production, from the operation of various onshore facilities related to treatment and transfer of oil and gas. During the exploration phase, chronic pollution from boat activities should be minimal, but during development and production, it could become significant. General sites being considered for construction of onshore facilities include the western tip of the southern Kenai Peninsula, between Port Graham and Port Chatham, and Anchor Point, just north of Kachemak Bay. Facilities could include crude oil terminals, production treatment facilities, and liquification and terminal facilities for natural gas. Suitable sites on the southern Kenai are located on or near very productive embayments and estuaries. The Anchor Point site would include an important river mouth and wetland.

A regional assessment of coastal morphology has been used to predict behavior of oil spills in Lower Cook Inlet and to develop a classification of the susceptibility of local coastal environments to oil spills (Hayes, Brown and Michel, 1977). This classification is based primarily on geological features and sediment characteristics as they relate to interactions with crude oil. It provides a useful starting point in assessing potential impacts from oil pollution, but it is necessary to temper the assessments with the idea that the major incentive for investigating potential effects of oil pollution is protection of biological assemblages. A point sometimes overlooked is that a ranking of biological assemblages by either importance or susceptibility to oil pollution does not always agree closely with the classification based on geological characteristics proposed by Hayes et al. (1977).

For the purposes of their assessment, Hayes et al. (1977) divided the 1216 km of examined shoreline into erosional, neutral and depositional categories (45, 38 and 17 percent, respectively). Because of the complex structure of the beaches, it is difficult to subdivide these categories into bedrock, boulder fields, gravel, sand or mud. The upper beach face in Lower Cook Inlet (Figures 2-4 and 2-6) is most commonly composed of gravel, or a mixture of gravel, sand, cobbles, and boulders. However, adjacent low-tide terraces are usually mud, sand, boulders or bedrock. The distinct difference in substrate between upper beach face and low-tide terrace on most beaches in Lower Cook Inlet makes it somewhat difficult to apply the Hayes assessment of environmental susceptibility locally. For instance, most flat fine-grained sandy beaches [given a susceptibility ranking of 3 on a scale of 1 (low) to 10 (high)], are bordered by a beach front of gravel or mixed sand and gravel (susceptibility rankings of 7 and 6, respectively). This problem is further complicated by assessment of biological susceptibility. Gravel or mixed sand and gravel beaches generally support only impoverished assemblages of small crustaceans and are therefore probably of lower importance than sand beaches which often support important populations of razor clams. Furthermore, it is important to consider the levels of tolerance or susceptibility to contamination of the organisms in an assemblage, and the importance of the assemblage to other assemblages or systems. Clearly then, several factors must be integrated to develop a satisfactory assessment of susceptibility.

5.8.1 Sand Beaches

Beaches with sandy low-tide terraces border about 50 percent of Lower Cook Inlet. They are concentrated on exposed portions of the Inlet, especially in its northeastern quadrant. Hayes et al. (1977) indicated that since these beaches are generally flat and hard-packed, they are relatively impenetrable to oil and thus have a fairly low susceptibility ranking. However, oil stranding during a falling tide may penetrate into the sediment (especially the water-soluble, toxic fractions) and come into contact with the infaunal forms (Anon. 1975). Furthermore, extensive burial of stranded oil can occur, increasing the residence time on polluted beaches. Such burial can induce anaerobic conditions, delaying microbial degradation.

The biological assemblages most commonly observed on sand beaches in Lower Cook Inlet are dominated by burrowing polychaetes, small crustaceans (gammarid amphipods and mysids) and razor clams. All are known to be somewhat sensitive to crude and petroleum products. Generally, standing stocks are low and the contribution of sand beaches to other systems appears low. However, beaches supporting dense clam populations are important to sport and commercial clamming enterprises. Recovery of the worm and crustacean populations would be rapid following contamination, but for clam populations, recovery would be very slow, possibly requiring decades.

5.8.2 Gravel And Sand Upper Beaches

As pointed out above, gravel or mixed sand and gravel upper beaches border a large proportion of the shoreline in Lower Cook Inlet. Hayes et al. (1977) indicate that oil arriving on such beaches can penetrate to considerable depths, especially on gravel, or can be buried, and thus residence periods can be great. Clean-up would be difficult without large-scale removal of sediments. Such beaches are therefore highly susceptible (ranking of 7 and 6, respectively) to oil pollution. In the Straits of Magellan, oil from the Metula spill formed thick asphalt pavement on low-tide terraces of mixed sand and gravel (Hayes et al. 1977); this formation was highly resistant to degradation.

The biological assemblage most frequently observed is impoverished, mainly including nematodes, one gammarid amphipod and one isopod species. The sensitivity of these species to crude oil is unknown, but, as they are all short lived, they probably could recovery fairly rapidly. However, widespread contamination could lead to a lengthy recovery period since both the gammarid and the isopod are brooders, having no pelagic larvae. Recolonization would depend upon migration rates. Our observations so far suggest that this assemblage supports limited secondary production and contributes little to other systems.

5.8.3 Scoured Boulder Fields

The extent of scoured boulder fields on the low-tide terrace is unclear, but they may be located primarily on spits and below eroding scarps. Hayes et al. (1977) do not specifically rank this type of habitat, and the basic sediment is often mixed sand and gravel. Therefore, many of the same considerations apply.

These boulder fields support a more diverse biotic assemblage, however, because of the high proportion of solid substate. Nevertheless, most of the animals are pioneer species and the populations are largely dominated by young organisms. These conditions are a consequence of scouring and abrasion. Juvenile barnacles and mussels are often dominant species and although production may be moderate, biomass is low. The contribution of this assemblage is not great, although overwintering Rock Sandpipers appear to feed in such areas. Because of their small size, many of the animals in this habitat would be susceptible to smothering by crude oil. However, natural scouring could be expected to facilitate clean-up and recovery would probably be rapid (perhaps within two years).

5.8.4 Mud Flats

Mud flats, variously referred to by Hayes et al. (1977), as muddy tidal flats, protected estuarine tidal flats and rias, border about 35 percent of the total shoreline of Lower Cook Inlet and nearly half of its western shoreline. The two types of mud flats described are 1) exposed muddy tidal flats, such as are observed in association with the wavecut sandstone platforms in southern Kamishak Bay, and 2) protected estuarine flats, which are "primarily drowned glaciated river valleys (rias)" such as Chinitna Bay (Hayes et al. 1977). Because of the difference in exposure and probable residence time, exposed flats were considered to be moderately susceptible to oil pollution (rank of 5) and protected flats to be highly susceptible (rank of 9; Hayes et al. 1977). These investigators described the flats as impermeable to oil. In fact, we believe that permeability may vary considerably, depending on the faunal components. Where the flats are dominated by *Macoma balthica*, but *Mya* spp. and *Echiurus* are absent, the flats indeed appear impermeable. Mud Bay, at Homer, and Dayville Flats, at Valdez, are examples of this type of flat. Shaw et al. (1977), in fact, reported low uptake and rapid loss of crude oil on Dayville Flats. Griffiths (personal communication) suggests that Shaw's findings may have been influenced by low densities of bacteria and organic debris, which have a direct relationship to uptake rates. However, where *Mya* and *Echiurus* are common their burrows, with densities of up to $100/m^2$ and extending up to 45 cm into the sediment, may increase the rate of oil penetration into the sediment, and allow oil to be stored at deep, anoxic levels. All mud flats observed to date on the west side of Cook Inlet are of this type.

Because of anoxic conditions near the sediment surface, and the low energy regime of the protected estuaries, residence time could extend up to 10 years in some of these areas (Hayes et al. 1977).

The fauna, dominated by longevous clam and polychaete species, includes several species that have been shown to be sensitive to oil contamination. For instance, Shaw et al. (1976) reported significant mortality in *Macoma balthica* in response to low dosages of Prudhoe Bay crude oil in elegant field experiments on Dayville Flats. Hampson and Sanders (1969) reported considerable mortality of *M. arenaria* and many polychaete species in West Falmouth, Mass., after exposure to high doses of fuel oil. Feder et al. (1976) observed anomalous increases in the density of harpacticoid copepods on Dayville Flats, but the causes and ramifications are not clear.

Because it appears that most of the tissue produced on the mud flats is utilized by transient predators from other systems, the condition of the mud flats is of considerable concern and importance. Animals particularly reliant on continued high productivity of the mud flats include 1) smolts of at least two species of salmon in spring (Sibert et al. 1977), 2) Western Sandpipers on spring migration, and 3) ducks, especially scoters, scaup and Oldsquaw, all year long. Only ducks and gulls appear to depend on adult or long-lived animals.

Recovery rates following contamination are subject to several conditions. Obviously, local conditions (orientation of estuary, time of year, tidal phase, porosity of the flat) are of importance. If appreciable quantities of oil penetrate deeply into the sediment, however, it is probable that full recovery will require at least 10 years. The dominant clam species all live at least 6-10 years (Chambers and Milne 1975, Feder and Paul 1974). Ducks appear to feed mainly on adult *Macoma*. Shorebirds, in contrast, feed mainly on young-of-year *Macoma*, *Mya*, annual polychaetes and harpacticoid copepods, which could recover fairly quickly if the sediments were uncontaminated. Based on the predictions of Hayes et al. (1977), it is probable that the exposed flats would recover in several years, but that the estuaries could require at least a decade.

6.0 CONCLUSIONS

The conclusions given herein are preliminary and abbreviated. More complete conclusions will be presented in the final report in preparation in which all the data will be presented and discussed.

6.1 ROCKY HABITATS

- Seaweed assemblages on the east side of the Inlet are strongly dominated by brown algae, mainly Fucus in the mid-intertidal zone and other kelps from the lower intertidal down to at least 70 foot depths. In contrast, on the west side of the Inlet, seaweed assemblages are mainly dominated by red algae (esp. Rhodymenia spp.) except at the upper level (mid-intertidal zone dominated by Fucus); kelps dominate from the lowest intertidal level down to a depth of about 10 feet, where significant algae growth closes.

- Intertidal invertebrate assemblages are diverse and well-developed on the east side of the Inlet, and include numerous mature specimens of long-lived species. In contrast, intertidal invertebrate assemblages on the west side of the Inlet are improverished and mainly composed of juvenile specimens of pioneer species.

- Subtidal invertebrate assemblages are well-developed, diverse and composed of long-lived forms on both sides of the Inlet, but are strongly dissimilar in composition and appearance. The fauna on the east side, dominated by sea urchins, snails, and starfish, show close affinities to southeast Alaska, British Columbia and Washington. In contrast, the fauna on the west side of the Inlet, dominated by bryozoans, tunicates, sponges and barnacles, shows close affinities with the Bering and Beaufort Seas.

- Rocky intertidal biotas exhibit strong seasonal changes on both sides of the Inlet, greatest development is in mid-summer and poorest in late winter. Ice is an important factor on the west side of the Inlet.

- Rocky subtidal biotas on the east side of the Inlet also exhibit significant seasonal changes, but such patterns are undescribed for the west side.

- Patterns of vertical zonation are clearly defined on rocky substrates on both sides of the Inlet.

- Primary production by macrophytes appears to be quite high in the southeastern quadrant of Lower Cook Inlet, and substantially lower on the west side of the Inlet. Most of the plant material is exported to other assemblages.

6.2 SAND BEACHES

- Faunas on sand beaches are dominated by polychaete worms (e.g., *Scolelepis* sp.) and gammarid (e.g., *Eothaustorius eous*). Proportions vary with exposure to wave action.

- Biomass is low and secondary production appears low.

- Patterns in vertical zonation are vague.

- Seasonal patterns in species composition and abundance are well defined; both parameters peak in mid-summer.

6.3 MUD BEACHES

- Faunas on mud beaches are dominated by clams (e.g., *Macoma balthica* and *Mya* spp.) Composition and proportions appear to vary with degree of consolidation of the sediment surface.

- Biomass is high and secondary production appears to be high.

- Patterns of vertical zonation are vague.

- Seasonal patterns in species composition and abundance are well-defined; both parameters peak in mid-summer.

- Mud flat faunas appear to be an important food resource for several species of shorebirds, diving ducks, and gulls, as well as some important fish (e.g., salmonid fry). A large proportion of the tissue produced in the mud flat assemblage is utilized by transient predators from other widespread assemblages (e.g., migratory shorebirds or ducks, or wide-ranging fish and crabs).

6.4 NEEDS FOR FURTHER STUDY

Needs for further study will be addressed in the final report.

6.5 SUMMARY OF JANUARY THROUGH MARCH QUARTER

Work during this quarter has all been related to preparation of the annual and final report, verificacion of digital data and processing the remaining digital data.

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A P P E N D I C E S

APPENDIX 4.3.1 DATA FOR STIPE LENGTH/GROWTH RATE (CM/DAY) RELATIONSHIPS FOR *AGARUM CRIBROSAM* AT JAKOLOF BAY

Stipe	Growth Period Ending											
Length (cm)	4/22	5/12	7/12	8/18	10/31	1/30	3/1	3/22	5/12	6/16	8/8	9/9	10/26
4				0.185									
4							0.100	0.286	0.373	0.250	0.150	0.063	
5				0.148	0.041		0.089						
5							0.067						
6								0.143	0.196				
6						0.068	0.083	0.486		0.120			
7											0.211		
7											0.092		
7						0.114	0.200	0.569		0.080	0.333		
7							0.133	0.214					
8							0.067						
8											0.133		
8												0.078	0.032
8									0.262	0.124			0.053
8													
9				0.185									
9							0.167	0.262	0.324	0.179	0.167		
9							0.200	0.439	0.431	0.571			
10							0.167	0.214				0.094	0.064
10							0.100	0.190				0.141	0.085
10													
10				0.037	0.095	0.054	0.107						
11	0.361			0.037	0.041	0.032	0.054		0.184				
11											0.208		
12.5												0.141	
12												0.172	
12											0.083	0.156	0.021
12												0.047	0.053
13	0.238												
14									0.216	0.179	0.250	0.125	0.043
14							0.061	0.273	0.337	0.280			
15							0.161	0.391	0.388	0.600		0.078	0.074
15							0.100	0.143	0.235	0.250	0.100		
16												0.094	0.021
20							0.133	0.286	0.314	0.292	0.050	0.094	0.053
20							0.100						
22								0.405	0.480	0.417	0.125	0.078	
22						0.071	0.089	0.239	0.439	0.320			
23				0.111									
23												0.0	0.032
25.5							0.083						

APPENDIX 4.3.2 DATA FOR STIPE LENGTH/GROWTH RATE (CM/DAY) RELATIONSHIPS FOR <u>LAMINARIA GROENLANDICA</u> AT JAKOLOF BAY

Stipe Length (cm)	Growth Period Ending 3/12	4/22	5/12	7/12	8/18	10/31	1/30	3/1	3/22	5/12	6/16	8/8	9/9	10/26
12								0.32						
12								0.21						
14										0.31				
14								0.46						
14								0.43	0.78	0.47				
15								0.61						
15.5								0.27						
16								0.29	0.57					
16								0.32						
16								0.36						
16								0.23						
16.5								0.29						
16.5								0.32						
17											0.49	0.05		0
17													0.05	0
17.5								0.11						
18										0.57			0	0
18										0.11				
19									0.67					
20								0.35		1.28				0.01
20								0.65					0.02	0
20								0.25						
20.5								0.29						
21								0.48		1.00			0.03	
22						0.12		0.30						
22								0.35						
22								0.37						
22.5										0.67				
23						0.19		0.23		1.02		0.08		0.0
23								0.20		0.67				
23.5										0.61				
24								0.46		1.10	0.59			
25													0	0
25.5											1.08			0
25.5														0.04
26												0.08		
27				0.20				0.13		0.78	1.51		0	
27										0.69				
28												0.19		0.02
29													0.12	
30											0.88			0
31											0.64			
33													0.04	
34													0.04	0
35														0.043
36								0.27					0	
38.5												0.06		
39								0.40						
41													0.11	

APPENDIX 4.3.3 DATA FOR STIPE LENGTH/GROWTH RATE (CM/DAY) RELATIONSHIPS FOR *ALARIA FISTULOSA* AT JAKOLOF BAY

Stipe Length (cm)	Growth Period Ending 3/12	4/22	5/12	7/12	7/22	8/18	10/31	1/30	3/1	3/22	5/12	6/16	8/8	9/9	10/26
15					0.86										
15					2.86										
15															1.67
17					1.29										
17					1.29										
18					1.71										
19						2.89									
20					0.86	3.59									
21									3.36						
21					0.86										
21					1.14										
22									1.96						
22									4.21						
26									1.14						
27			14.6												
28							4.31								
28								1.95							
29				0.98											
29									3.18						
31									0.84	2.17					
32									1.80						
32													6.05	3.97	1.45
33		14.78												1.82	
33.5									1.93						
34		3.58													
35		10.25	6.60						3.34						
37.5		11.45													
37									1.89						
38									1.61						
39		12.90	14.5											4.13	1.64
39		6.75	5.0												
40			11.95				2.54								
41							1.97		1.86						
45									1.80	4.46					
47													5.83	2.63	
47		9.80	15.20										5.37	1.72	
50													3.53		
53															2.19
57													4.60	4.50	
60													4.27		
62														4.78	
65													1.35		1.53

APPENDIX 4.4.1. ABUNDANCE DATA FOR CORE SAMPLES FROM DEEP CREEK BEACH; 4 FEBRUARY 1977.

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
					Level 1 (Upper)							
ANNELIDA - Polychaeta												
Capitella capitata	0	0	0	0	1	0	1	0	0	0	0.2 ± 0.4	2
Eteone nr. longa	1	0	1	2	0	0	0	1	2	2	0.9 ± 0.9	9
ARTHROPODA - Gammaridae												
Anisogammarus cf confervicolus	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
Eohaustorius eous	0	2	1	0	2	1	0	0	0	0	0.6 ± 0.8	6
S	1	1	2	1	3	1	1	1	1	1		
N	1	2	2	2	4	1	1	1	2	2		

Extralimital Species: Halichondria panicea on Sabellid tube, Mytilus edulis on boulder

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
					Level 2							
ANNELIDA - Polychaeta												
Capitella capitata	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	1
Eteone nr. longa	0	0	0	0	1	0	1	1	0	0	0.3 ± 0.5	3
ARTHROPODA - Gammaridea												
Eohaustorius eous	3	1	2	1	0	0	1	2	6	1	1.7 ± 1.8	17
S	1	1	1	1	1	1	2	2	1	1		
N	3	1	2	1	1	1	2	3	6	1		

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x}$ ± s		Total
					Level 3								
ANNELIDA - Polychaeta													
Eteone nr. longa	0	1	0	0	0	0	0	0	0	0	0.1	0.3	1
Paraonella platybranchia	0	0	0	0	0	0	1	1	2	0	0.4	0.7	4
Scolelepis Sp. A	0	0	0	0	0	0	0	1	0	0	0.1	0.3	1
Scoloplos armiger	1	0	0	0	0	0	0	0	0	1	0.2	0.4	2
ARTHROPODA - Gammaridae													
Eohaustorius eous	1	4	2	5	5	1	6	2	1	3	3.0	1.9	30
Paraphoxus milleri	1	0	0	0	0	0	0	0	0	0	0.1	0.3	1
S	3	2	1	1	1	1	1	3	2	2			
N	3	5	2	5	5	2	7	4	3	4			
					Level 4 (lower)								
ANNELIDA - Polychaeta													
Eteone nr. longa	0	0	1	0	0	0	0	0	0	0	0.1	0.3	1
Paraonella platybranchia	0	0	0	0	0	1	0	0	0	0	0.1	0.3	1
Scolelepis Sp. A	0	1	0	0	1	0	1	0	1	0	0.4	0.5	4
ARTHROPODA - Gammaridea													
Anisogammarus cf confervicolus	0	0	0	0	0	0	0	1	0	0	0.1	0.3	1
Eohaustorius eous	4	5	10	16	11	6	9	1	6	6	7.4	4.2	74
Paraphoxus milleri	0	1	0	0	0	0	0	0	1	0	0.2	0.4	2
ARTHORPODA - mysidacea													
Archaeomysis grebnitzkii	0	0	0	1	0	0	0	0	0	0	0.1	0.3	1
S	1	3	2	2	2	2	2	2	3	1			
N	4	7	11	17	12	6	10	3	8	6			

APPENDIX 4.4.2. ABUNDANCE DATA FOR CORE SAMPLES FROM DEEP CREEK BEACH; 7 APRIL 1977.

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
					Level 1 (Upper)							
ANNELIDA - Polychaeta												
Eteone nr. *longa*	1	0	1	0	0	0	0	0	1	0	0.3 ± 0.5	3
Scoloplos armiger	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	1
ARTHROPODA - Gammaridea												
Anisogammarus cf *confervicolus*	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Eohaustorius eous	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	0	2	0	0	2	0	0	0	0	0	0.4 ± 0.8	4
S	1	2	1	0	1	0	1	1	1	0		
N	1	3	1	0	2	0	1	1	1	0		
					Level 2							
ANNELIDA - Polychaeta												
Capitella capitata	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Nephtys ?ciliata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Paraonella platybranchia	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	1
ARTHROPODA - Gammaridea												
Eohaustorius eous	0	1	2	0	1	4	10	4	4	1	2.7 ± 3.0	27
Paraphoxus milleri	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	1
S	0	2	1	0	1	1	2	2	1	2		
N	0	2	2	0	1	4	11	5	4	2		

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
					Level 3							
ANNELIDA - Polychaeta												
Paraonella platybranchia	0	0	0	1	0	0	0	1	0	0	0.2 ± 0.4	2
Scoloplos armiger	0	0	0	0	0	0	0	0	2	0	0.2 ± 0.6	2
Scolelepis Sp. A	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	1
ARTHROPODA - Gammaridea												
Eohaustorius eous	3	7	2	3	0	0	0	3	2	8	2.8 ± 2.8	28
?Ischvroceridae, unid.	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
S	2	1	1	2	1	0	0	2	3	1		
N	4	7	2	4	1	0	0	4	5	8		
					Level 4 (Lower)							
ANNELIDA - Polychaeta												
Nephtys ?ciliata	0	0	2	0	0	0	0	0	0	0	0.2 ± 0.6	2
Scoloplos armiger	0	1	1	0	0	0	0	0	0	0	0.2 ± 0.4	2
Scolelepis Sp. A	1	1	1	1	0	0	0	2	2	1	0.9 ± 0.7	9
ARTHROPODA - Gammaridea												
Anisogammarus cf. *confervicolus*	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	1
Eohaustorius eous	15	7	3	8	13	4	3	16	13	7	8.9 ± 5.0	89
Gammaridea, unid.	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	1
Lysianassidae, unid.	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	0	1	0	1	0	0	0	0	0	1	0.3 ± 0.5	3
S	2	4	5	4	1	2	1	2	2	3		
N	16	10	8	11	13	5	3	18	15	9		

APPENDIX 4.4.3. ABUNDANCE DATA FOR CORE SAMPLES FROM DEEP CREEK BEACH; 29 JULY 1977.

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
						Level 1 (Upper)						
ANNELIDA - Polychaeta												
Eteone nr. *longa*	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	1
Paraonella platybranchia	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	1	1	0	1	0	1	0	0	0	1	0.5 ± 0.5	5
ARTHROPODA - Gammaridea												
Eohaustorius eous	2	7	0	4	1	3	1	4	2	4	2.8 ± 2.0	28
Gammaridae, Sp. A	1	0	1	1	1	0	0	0	0	0	0.4 ± 0.5	4
S	4	2	1	3	2	2	1	2	1	2	2.0 ± 0.9	
N	5	8	1	6	2	4	1	5	2	5	3.9 ± 2.3	
						Level 2						
ANNELIDA - Polychaeta												
Abarenicola Sp.	0	0	1	0	0	0	1	0	0	0	0.2 ± 0.4	2
Capitella capitata	0	0	0	0	0	0	0	1	0	1	0.2 ± 0.4	2
Eteone nr. *longa*	0	0	0	2	0	0	0	0	0	0	0.2 ± 0.6	2
Paraonella platybranchia	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	1	0	1	1	2	1	1	2	1	1	1.1 ± 0.6	11
Scoloplos armiger	0	0	1*	1*	1	1	0	0	0	0	0.4 ± 0.5	4
ARTHROPODA - Gammaridea												
Eohaustorius eous	4	8	6	2	11	6	9	3	2	1	5.2 ± 3.4	52
Gammaridae Sp. A	46	0	0	0	1	0	30	14	0	3	9.4 ± 16.1	94

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
					Level 2 Cont.							
Lamprops quadriplicata	0	0	0	0	0	0	1	0	1	0	0.2 ± 0.4	2
Oedocerotidae Sp.	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	1
Synchelidium Sp.	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
ARTHROPODA - Mysidacea												
Archaeomysis grebnitzkii	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
S	3	1	5	4	6	4	5	4	3	4	3.9 ± 1.4	
N	51	8	10	6	17	9	42	20	4	6	17.3 ± 16.3	
					Level 3							
ANNELIDA - Polychaeta												
Chaetozone setosa	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	1
Nephtys ?ciliata	0	0	0	0	0	0	1*	0	0	0	0.1 ± 0.3	1
Paraonella platybranchia	0	1*	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	0	0	0	1	0	1	0	2	0	0	0.4 ± 0.7	4
Scoloplos armiger	1	1*	0	0	0	0	1*	1	1*	0	0.5 ± 0.5	5
ARTHROPODA - Gammaridea												
Atylidae Sp. A	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	1
Eohaustorius eous	12	9	2	6	15	6	5	7	4	4	7.0 ± 4.0	70
Gammaridae Sp. A	3	0	1	2	0	2	3	0	0	0	1.1 ± 1.3	11
Lamprops quadriplicata	1	0	0	1	1	0	0	0	1	0	0.4 ± 0.5	4
Paraphoxus milleri	1	0	0	0	0	0	0	1	0	0	0.2 ± 0.4	2
Synchelidium Sp.	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	
S	5	3	2	5	3	4	4	4	3	1	3.4 ± 1.3	
N	18	11	3	11	17	10	10	11	6	4	10.1 ± 4.9	

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
					Level 4 (Lower)							
ANNELIDA - Polychaeta												
Capitella capitata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Nephtys ?ciliata	0	1*	0	0	1	0	0	0	0	0	0.2 ± 0.4	2
Paraonella platybranchia	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	1
Scolelepis Sp. A	0	0	0	1	2	2	2	0	0	2	0.9 ± 1.0	9
Scoloplos armiger	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
ARTHROPODA - Gammaridea												
Eohaustorius eous	3	7	9	6	1	0	19	2	2	4	5.3 ± 5.6	53
Gammaridae Sp. A	1	0	0	0	2	3	0	2	0	5	1.3 ± 1.7	13
Paraphoxus milleri	1	0	0	2	0	0	0	0	0	0	0.3 ± 0.7	3
S	3	2	1	3	4	2	4	2	1	4	3.3 ± 2.4	
N	5	8	9	9	6	5	23	4	2	12	7.8 ± 6.4	

* Fragment

APPENDIX 4.4.4. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT DEEP CREEK, 4 FEBRUARY 1977

TAXA Station No.:	Density (No./m^2) 1	2	3	4*
ANNELIDA - Polychaeta				
Capitella capitata	25.5	12.7	0	0
Eteone nr. *longa*	114.6	38.2	12.7	12.7
Paraonella platybranchia	0	0	50.9	12.7
Scolelepis Sp. A	0	0	12.7	50.9
Scoloplos armiger	0	0	25.5	0
ARTHROPODA - Gammaridea				
Anisogammarus cf. *confervicolus*	12.7	0	0	12.7
Eohaustorius eous	76.4	216.4	381.9	942.2
Paraphoxus milleri	0	0	12.7	25.5
ARTHROPODA - Mysidacea				
Archaeomysis grebnitzkii	0	0	0	12.7
Total Number of Specimens:	18	21	39	84

* Lowest level on beach

APPENDIX 4.4.5. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT DEEP CREEK, 7 APRIL 1977

	Density (No./m^2)			
TAXA Station No.:	1	2	3	4*
ANNELIDA - Polychaeta				
Capitella capitata	0	12.7	0	0
Eteone nr. *longa*	38.2	0	0	0
Nephtys ?*ciliata*	0	12.7	0	25.5
Paraonella platybranchia	0	12.7	25.5	0
?*Scolelepis* Sp. A	0	0	12.7	114.6
Scoloplos armiger	12.7	0	25.5	25.5
ARTHROPODA - Gammaridea				
Anisogammarus cf. *confervicolus*	12.7	0	0	12.7
Eohaustorius Sp.	12.7	343.7	356.4	1133.0
Gammaridea, unid.	0	0	12.7	25.5
Paraphoxus Sp.	50.9	12.7	12.7	38.2
Total Number of Specimens:	10	31	35	108

* Lowest level on beach

APPENDIX 4.4.6. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT DEEP CREEK, 29 JULY 1977

	Density ($No./m^2$)			
TAXA Station No.:	1	2	3	4*
ANNELIDA - Polychaeta				
Abarenicola Sp.	0	25.5	0	0
Capitella capitata	0	25.5	0	12.7
Chaetozone setosa	0	0	12.7	0
Eteone nr. longa	12.7	25.5	0	0
Nephtys ?ciliata	0	0	12.7	25.5
Paraonella platybranchia	12.7	12.7	12.7	12.7
Scolelepis Sp. A	63.7	140.1	50.9	114.6
Scoloplos armiger	0	50.9	63.7	12.7
ARTHROPODA - Gammaridea				
Atylidae Sp. A	0	0	12.7	0
Eohaustorius eous	356.6	662.1	891.3	674.8
Gammaridae Sp. A	50.9	1196.8	140.1	165.5
Lamprops quadriplicata	0	25.5	50.9	0
Paraphoxus milleri	0	12.7	25.5	38.2
Synchelidium Sp.	0	12.7	12.7	0
ARTHROPODA - Mysidacea				
Archaeomysis grebnitzkii	0	12.7	0	0
Total Number of Specimens:	39	173	101	83

* Lowest level on beach

APPENDIX 4.4.7. POOLED SIZE DATA FOR *EOHAUSTORIUS EOUS* AT DEEP CREEK IN 1977

Size Class (mm)	4/7/77	7/29/77
1.3 - 1.5		1
1.6 - 1.8		1
1.9 - 2.1	2	6
2.2 - 2.4	12	8
2.5 - 2.7	13	16
2.8 - 3.0	7	19
3.1 - 3.3	7	10
3.4 - 3.6	8	17
3.7 - 3.9	9	21
4.0 - 4.2	19	31
4.3 - 4.5	15	33
4.6 - 4.8	26	14
4.9 - 5.1	12	12
5.2 - 5.4	7	4
5.5 - 5.7	3	2
5.8 - 6.0	1	
Mean length (mm)	3.9	3.8
s	1.0	0.9

APPENDIX 4.4.8. LENGTH DATA FOR UNID. GAMMARIDAE WITH DARK EYE AND COARSE ANTENNAE, DEEP CREEK, 29 JULY 77

	1	2	3	4	Total
1.5		3			3
1.6		2			2
1.7		1	1	1	3
1.8		2			2
1.9	1	3			4
2.0	1	3		3	7
2.1		3			3
2.2		9	3	2	14
2.3		8	1	1	10
2.4		1	1	2	4
2.5	1	8	2	1	12
2.6		2	1		3
2.7		5		1	6
2.8		7			7
2.9		4			4
3.0		1		1	2
3.1		1			1
3.2		3		1	4
3.3		3			3
3.4		3			3
3.5		1	1		2
3.6		1			1
3.7		2			2
7.0		1			1

$n = 103$

$\bar{x} = 2.52$

$s = 0.69$

APPENDIX 4.4.9. SAMPLE DATA FOR HOMER SPIT BEACH; 17 February 1977.

TAXA	1	2	3	4	5	$\bar{x} \pm s$	Total
			Cores* near 30m level				
ANNELIDA - Polychaeta							
Eteone nr. *longa*	0	0	0	0	1	0.2 ± 0.4	1
Paraonella platybranchia	2	1	0	0	1	0.8 ± 0.8	4
Scolelepis Sp. A	1	1	1	1	2	1.2 ± 0.4	6
ARTHROPODA - Mysidacea							
Archaeomysis grebnitzkii	0	0	0	0	1	0.2 ± 0.4	1
Total	3	2	1	1	5		
			Cores* near 75m level				
ANNELIDA - Polychaeta							
Nephtys ?*ciliata*	0	1	0	0	0	0.2 ± 0.4	1
Scolelepis Sp. A	1	0	0	2	0	0.6 ± 0.9	3
Spionidae, unid.	0	1	0	0	0	0.2 ± 0.4	1
Typosyllis Sp.	0	1	0	0	0	0.2 ± 0.4	1
ARTHROPODA - Gammaridea							
Eohaustorius eous	0	1	0	0	1	0.4 ± 0.5	2
Total	1	4	0	2	1		

TAXA	1	2	3	4	5	x ± s	Total
	Cores* from 100m level						
ANNELIDA - Polychaeta							
Magelona pitelkai	0	1	0	0	0	0.2 ± 0.4	1
Paraonella platybranchia	1	4	3	0	4	2.4 ± 1.8	12
Scolelepis Sp. A	1	2	1	5	2	2.2 ± 1.6	11
ARTHROPODA - Gammaridea							
Eohaustorius eous	0	0	1	0	0	0.2 ± 0.4	1
Gammaridae, unid. (red-striped)	0	0	1	0	1	0.4 ± 0.5	2
Paraphoxus milleri	1	0	1	1	1	0.8 ± 0.4	4
PISCES							
Ammodytes hexapterus	0	0	1	1	0	0.4 ± 0.5	2
Total	3	7	8	7	8		
	Cores* from 132m level						
ANNELIDA - Polychaeta							
Magelona pitelkai	0	0	0	1	0	0.2 ± 0.4	1
Paraonella platybranchia	0	0	2	2	3	1.4 ± 1.3	7
Scolelepis Sp. A	8	2	5	6	2	4.6 ± 2.6	23
ARTHROPODA - Gammaridea							
Gammaridae, unid. (red-striped)	0	2	2	0	0	0.8 ± 1.1	4
Paraphoxus milleri	0	0	0	1	2	0.6 ± 0.9	3
MOLLUSCA - Gastropoda							
Littorina sitkana	0	0	2	0	0	0.4 ± 0.9	2
MOLLUSCA - Pelecypoda							
Spisula polynyma	0	0	0	2	0	0.4 ± 0.9	2
Total	8	4	11	12	7		

APPENDIX 4.4.10. SAMPLE DATA FOR HOMER SPIT BEACH; 7 MARCH 1977

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
						Cores* from 30m level						
ANNELIDA - Polychaeta												
Nephtys ?ciliata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	0	0	0	1	2	0	0	3	1	0	0.7 ± 1.1	7
ARTHROPODA - Gammaridea												
Paraphoxus milleri	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	1
Total	0	0	0	2	2	0	1	3	1	0		
						Cores* from 75m level						
ANNELIDA - Polychaeta												
Nephtys ?ciliata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Paraonella platybranchia	0	0	0	0	0	0	1	1	0	2	0.4 ± 0.7	4
Scolelepis Sp. A	0	1	1	0	1	4	1	3	2	0	1.3 ± 1.3	13
ARTHROPODA - Gammaridea												
Anonyx Sp.	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	1
Eohaustorius eous	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	1	0	0	0	1	1	0	0	2	0	0.5 ± 0.7	5
Total	2	1	1	0	2	5	3	4	4	3		

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
					Cores* from 100m level							
ANNELIDA - Polychaeta												
Nephtys ?ciliata	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	1
Paraonella platybranchia	0	1	0	2	1	1	2	0	1	0	0.8 ± 0.8	8
Sabellidae, unid.	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	2	1	1	4	4	1	5	0	7	5	3.0 ± 2.3	30
Scoloplos armiger	0	0	0	0	0	0	2	0	0	0	0.2 ± 0.6	2
ARTHROPODA - Gammaridea												
Eohaustorius eous	0	0	0	1	1	0	0	0	0	0	0.2 ± 0.4	2
Paraphoxus milleri	1	0	2	0	0	0	0	0	0	0	0.3 ± 0.7	3
MOLLUSCA - Pelecypoda												
Mytilus edulis (juv.)	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Total	3	2	5	7	6	2	9	0	9	5		
					Cores* from 135m level							
ANNELIDA - Polychaeta												
Magelona pitelkai	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Scolelepis Sp. A	19	1	6	16	4	12	3	5	1	4	7.1 ± 6.3	71
ARTHROPODA - Gammaridea												
Eohaustorius eous	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	1	0	1	0	1	0	0	1	0	3	0.7 ± 0.9	7
MOLLUSCA - Pelecypoda												
Spisula polynyma (juv.)	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
CHORDATA - Pisces												
Ammodytes hexapterus	0	0	0	0	0	0	1	1	0	0	0.2 0.4	2
Total	21	2	7	16	5	12	5	7	1	7		

APPENDIX 4.4.11. SAMPLE DATA FOR HOMER SPIT BEACH; 28 July 1977

TAXA	1	2	3	4	5	6	7	8	9	10	$\bar{x} \pm s$	Total
					Cores* from 30m level							
PLATYHELMINTHES												
Turbellaria, unid.	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	1
ANNELIDA - Polychaeta												
Nephtys Sp. (juv.)	0	0	0	1	1	1	0	1	0	0	0.4 ± 0.5	4
Paraonella platybranchia	0	0	0	3	3	4	5	0	0	0	1.5 ± 2.0	15
Scolelepis Sp. A	0	0	2	0	2	4	1	1	4	1	1.5 ± 1.5	15
Spiophanes ?bombyx	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
ARTHROPODA - Crustacea												
Crangon ?alaskensis elongata (juv.)	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	1
Lamprops carinata	0	0	0	0	1	1	0	2	1	0	0.5 ± 0.7	5
L. quadriplicata	0	0	0	0	6	2	2	5	1	0	1.6 ± 2.2	16
Eohaustorius eous	0	0	1	0	1	0	0	0	0	0	0.2 ± 0.4	2
Gammaridae, unid.	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	0	1	0	0	0	0	0	0	1	0	0.2 ± 0.4	2
MOLLUSCA - Pelecypoda												
Protothaca staminea	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	1
Total	0	1	4	5	15	12	8	10	8	1		

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
					Cores* from 75m level							
ANNELIDA - polychaeta												
Capitella capitata	0	0	0	0	0	0	1	4	0	0	0.5 ± 1.3	5
Nephtys ?ciliata	1	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	1
Nephtys Sp. (juv.)	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraonella platybranchia	2	4	2	1	3	1	0	0	0	0	1.3 ± 1.4	13
Scolelepis Sp. A	1	4	1	2	0	3	1	0	1	2	1.5 ± 1.3	15
ARTHROPODA - Crustacea												
Crangon ?alaskensis elongata (juv.)	0	0	0	0	1	0	0	0	1	0	0.2 ± 0.4	2
Eohaustorius eous	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	1
Lamprops carinata	1	0	0	1	0	0	0	0	0	0	0.2 ± 0.4	2
L. quadriplicata	0	0	0	0	2	1	1	0	0	0	0.4 ± 0.7	4
Lamprops Sp.	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	1
Synchelidium Sp.	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	1
Total	6	9	3	5	6	6	3	5	2	2		
					Cores* from 100m level							
ANNELIDA - Polychaeta												
Capitella capitata	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Nephtys Sp. (juv.)	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	1
Paraonella platybranchia	3	4	3	4	0	4	3	1	1	6	2.9 ± 1.8	29
Scolelepis Sp. A	6	2	2	3	3	2	3	1	5	7	3.4 ± 2.0	34

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Total
					Cores* from 100m level Cont.							
ARTHROPODA - Crustacea												
Eohaustorius eous	1	0	0	1	0	0	1	1	0	0	0.4 ± 0.5	4
Lamprops carinata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	1
Paraphoxus milleri	0	0	0	0	0	1	0	0	0	1	0.2 ± 0.4	2
Synchelidium Sp.	0	0	0	0	2	0	0	0	0	0	0.2 ± 0.6	2
PISCES												
Ammodytes hexapterus	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	1
Total	10	6	7	8	6	7	8	3	6	14		
					Cores* from 135m level							
ANNELIDA - Polychaeta												
Capitella capitata	0	2	0	0	0	0	0	0	0	0	0.2 ± 0.6	2
Eteone nr. longa	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	1
Paraonella platybranchia	0	1	0	2	2	0	4	1	0	0	1.0 ± 1.3	10
Scolelepis Sp. A	14	3	8	9	12	7	11	16	8	20	10.8 ± 4.9	108
ARTHROPODA - Crustacea												
Crangon ?alaskensis elongata	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	1
Eohaustorius eous	0	0	0	0	0	0	0	0	1	1	0.2 ± 0.4	2
Lamprops carinata	1	1	0	0	0	1	2	0	4	2	1.1 ± 1.3	11
L. quadriplicata	0	2	0	0	0	0	1	1	1	0	0.5 ± 0.7	5
Paraphoxus milleri	0	0	0	1	0	1	0	0	0	0	0.2 ± 0.4	2
MOLLUSCA - Pelecypoda												
Spisula polynyma	0	0	0	0	0	0	0	0	2	0	0.2 ± 0.6	2
Total	15	9	8	12	14	9	18	18	16	25		

APPENDIX 4.4.12. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT HOMER SPIT BEACH; 17 FEBRUARY 1977

TAXA	Density (No./m^2) 30m	75m	100m	132m*
ANNELIDA - Polychaeta				
Eteone nr. *longa*	25.5	0	0	0
Magelona pitelkai	0	0	25.5	25.5
Nephtys ?*ciliata*	0	25.5	0	0
Paraonella platybranchia	101.9	0	305.6	178.3
Scolelepis Sp. A	152.8	76.4	280.1	585.7
Spionidae, unid.	0	25.5	0	0
Typosyllis Sp.	0	25.5	0	0
ARTHROPODA - Gammaridae				
Eohaustorius eous	0	50.9	25.5	0
Gammaridae, unid. (red-striped)	0	0	50.9	101.8
Paraphoxus milleri	0	0	101.8	76.4
ARTHROPODA - Mysidacea				
Archaeomysis grebnitzkii	25.5	0	0	0
MOLLUSCA - Gastropoda				
Littorina sitkana	0	0	0	50.9
MOLLUSCA - Pelecypoda				
Spisula polynyma	0	0	0	50.9
PISCES				
Ammodytes hexapterus	0	0	50.9	0

* lowest level on beach

APPENDIX 4.4.13. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT HOMER SPIT BEACH; 7 MARCH 1977

	Density (No.m^2)			
TAXA	30m	75m	100m	135m*
ANNELIDA - Polychaeta				
Magelona pitelkai	0	0	0	12.7
Nephtys ?ciliata	12.7	12.7	12.7	0
Paraonella platybranchia	0	50.9	101.9	0
?Sabellidae, unid.	0	0	12.7	0
Scolelepis Sp. A	89.1	165.5	382.0	904.0
Scoloplos armiger	0	0	25.5	0
ARTHROPODA - Gammaridea				
Anonyx Sp.	0	12.7	0	0
Eohaustorius eous	0	12.7	25.5	12.7
Paraphoxus milleri	12.7	63.7	38.2	89.1
MOLLUSCA - Pelecypoda				
Mytilus edulis (juv.)	0	0	12.7	0
Spisula polynyma	0	0	0	12.7
PISCES				
Ammodytes hexapterus	0	0	0	25.5

* lowest level on beach

APPENDIX 4.4.14. DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT HOMER SPIT BEACH; 28 JULY 1977

TAXA	Density (No./m^2)			
	30m	75m	100m	135m*
PLATYHELMINTHES				
Turbellaria, unid.	12.7	0	0	0
ANNELIDA - Polychaeta				
Capitella capitata	0	63.7	12.7	25.5
Eteone nr. *longa*	0	0	0	12.7
Nephtys ?ciliata	0	12.7	0	0
Nephtys Sp. (juv.)	50.9	12.7	12.7	0
Paraonella platybranchia	191.0	165.5	369.2	127.3
Scolelepis Sp. A	191.0	191.0	432.9	1375.1
Spiophanes ?bombyx	12.7	0	0	0
ARTHROPODA - Crustacea				
Crangon ?alaskensis elongata	12.7	25.5	0	12.7
Eohaustorius eous	25.5	12.7	50.9	25.5
Lamprops carinata	63.7	25.5	12.7	140.1
L. quadriplicata	203.7	50.9	0	63.7
Lamprops Sp.	0	12.7	0	0
Paraphoxus milleri	25.5	0	25.5	25.5
Synchelidium Sp.	12.7	12.7	25.5	0

TAXA	Density (No./m^2) 30m	75m	100m	135m*
MOLLUSCA - Pelecypoda				
Protothaca staminea	12.7	0	0	0
Spisula polynyma	0	0	0	25.5
PISCES				
Ammodytes hexapterus	0	0	12.7	0

* lowest level on beach

APPENDIX 4.4.15. ABUNDANCE DATA FOR CORE SAMPLES FROM THE +3.6 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 6 APRIL 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m^2
ECHIURIDAE												
Echiurus echiurus	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
ANNELIDA - Polychaeta												
Abarenicola pacifica	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Capitella capitata	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	12.7
Eteone nr *longa*	0	0	1	0	0	0	0	0	2	0	0.3 ± 0.7	38.2
Glycinde polygnatha	0	0	0	0	1	0	0	0	0	1	0.2 ± 0.4	25.5
Harmothoe imbricata	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Malacoceros sp	0	0	0	0	2	0	0	0	0	0	0.2 ± 0.6	25.5
Nephtys sp	1	0	2	0	0	0	1	1	0	0	0.5 ± 0.7	63.7
Nephtys sp (juv.)	0	1	1	0	3	1	1	0	0	0	0.7 ± 0.9	89.1
Paraonidae, unid.	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Phyllodoce groenlandica	0	0	0	0	2	0	0	0	0	0	0.2 ± 0.6	25.5
Potamilla sp	0	1	4	0	0	0	0	0	0	0	0.5 ± 1.3	63.7
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0	1	0	1	2	0	0	0	0	1	0.5 ± 0.7	63.7
Macoma balthica	25	31	26	46	45	32	41	22	32	65	36.5 ± 13.0	4647.3
Mya arenaria	0	0	0	0	2	1	1	2	0	1	0.7 ± 0.8	89.1
Mya sp	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	12.7
Mya spp (juv.)	0	0	0	1	8	0	2	0	0	1	1.2 ± 2.5	152.8
Pseudopythina sp	0	1	1	0	1	0	0	0	0	4	0.7 ± 1.3	89.1
No. of Individuals	27	36	35	48	67	34	47	25	34	75		
No. of Species	3	6	5	3	10	3	4	3	2	8		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE +2.5 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 6 APRIL 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
ECHIURIDAE												
Echiurus echiurus	1	0	1	1	0	1	1	1	2	0	0.8 ± 0.6	101.9
ANNELIDA - Polychaeta												
Aphroditoididae	1	0	0	0	0	0	1	0	0	1	0.3 ± 0.5	38.2
Capitella capitata	0	2	0	0	0	0	0	0	0	0	0.2 ± 0.4	25.5
Eteone nr longa	0	1	0	0	1	1	0	1	0	0	0.4 ± 0.5	50.9
Glycinde polygnatha	0	0	1	1	0	0	0	1	0	0	0.3 ± 0.5	38.2
Harmothoe imbricata	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	12.7
Nephtys sp	2	1	1	0	0	1	0	0	1	1	0.7 ± 0.7	89.1
Nephtys sp (juv.)	2	2	2	0	0	0	2	1	1	1	1.1 ± 0.9	140.1
Polydora caulleryi	0	0	0	0	1	0	0	0	1	0	0.2 ± 0.4	25.5
Potamilla sp	0	2	1	1	0	0	1	0	0	1	0.6 ± 0.7	76.4
ARTHROPODA - Isopoda												
Saduria entomon	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	12.7
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0	1	1	0	0	0	1	0	1	0	0.4 ± 0.5	50.9
Macoma balthica	40	33	29	32	35	35	32	53	22	38	34.9 ± 8.1	4443.6
Mya arenaria	0	1	0	1	0	0	0	1	1	1	0.5 ± 0.5	63.6
M. priapus	0	0	0	0	0	1	0	0	1	0	0.2 ± 0.4	25.5
Mya sp fragment	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Mya spp (juv.)	1	3	0	0	3	0	0	2	0	1	1.0 ± 1.2	127.3
Pseudopythina sp	0	6	4	2	0	0	0	1	3	0	1.6 ± 2.1	203.7
No. of Individuals	47	52	40	38	40	40	38	62	33	45		
No. of Species	5	9	7	6	4	6	6	9	8	6		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE +0.9 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 6 APRIL 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m^2
ECHIURIDAE												
Echiurus echiurus	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	12.7
ANNELIDA - Polychaeta												
Ampharete acutifrons	1	0	0	0	0	0	0	0	0	1	0.2 ± 0.4	25.5
Capitella capitata	1	0	1	0	0	0	0	0	0	0	0.2 ± 0.4	25.5
Eteone nr *longa*	0	0	0	1	0	1	0	0	1	0	0.3 ± 0.5	38.2
Harmothoe imbricata	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	12.7
Malococeros sp	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Nephtys sp	1	0	1	1	2	2	3	1	1	1	1.3 ± 0.8	165.5
Nephtys sp (juv.)	2	3	3	6	0	2	2	3	3	5	2.9 ± 1.7	211.7
Phyllodoce groenlandica	0	0	1	0	0	0	0	0	0	1	0.2 ± 0.4	25.5
Polydora caulleryi	0	0	0	0	0	0	2	0	0	0	0.2 ± 0.6	25.5
Potamilla sp	1	2	2	6	2	1	6	2	2	1	2.5 ± 1.9	318.3
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	1	3	3	3	8	3	4	3	4	2	3.4 ± 1.8	432.9
Macoma balthica	37	37	38	37	50	38	57	29	64	33	42.0 ± 11.2	5347.6
Mya priapus	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	12.7
Mya sp	1	0	1	0	0	0	0	0	0	0	0.2 ± 0.4	25.5
Mya spp (juv.)	1	1	4	9	13	7	13	6	13	21	8.8 ± 6.3	1120.5
Pseudopythina sp	0	1	0	0	0	0	6	1	4	6	1.8 ± 2.5	229.2
No. of Individuals	46	47	54	63	75	54	93	45	94	72		
No. of Species	8	6	7	6	5	7	7	6	9	9		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE -1.2 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 6 APRIL 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
ECHIURIDAE												
Echiurus echiurus	1	0	0	0	0	0	0	0	1	0	0.2 ± 0.4	25.5
ANNELIDA - Polychaeta												
Ampharete acutifrons	0	0	1	0	0	0	0	0	0	1	0.2 ± 0.4	25.5
Capitella capitata	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Eteone nr longa	0	1	0	0	0	1	0	0	0	0	0.2 ± 0.4	25.5
Glycinde polygnatha	0	0	0	0	0	1	1	0	1	0	0.3 ± 0.5	38.2
Malacoceros sp	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Nephtys sp	3	1	1	1	1	0	2	0	0	0	1.0 ± 1.0	127.3
Nephtys sp (juv.)	5	1	0	0	5	4	3	0	0	1	2.1 ± 2.1	267.4
Phyllodoce groenlandica	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Polydora caulleryi	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Potamilla sp	0	0	0	1	0	1	0	0	0	0	0.2 ± 0.4	38.2
Scoloplos armiger	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	12.7
?Spio sp	0	0	1	0	0	0	0	0	0	1	0.2 ± 0.4	38.2
ARTHROPODA - Amphipoda												
Tritella pilimana	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	12.7
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	1	2	8	4	0	3	4	4	5	1	2.7 ± 1.7	343.8
Macoma balthica	31	32	52	33	28	44	39	40	23	31	33.4 ± 6.5	4252.6
Macoma sp	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Mya arenaria	1	0	0	0	0	1	1	0	0	0	0.3 ± 0.5	38.2
Mya priapus	0	0	0	1	0	0	0	0	0	0	0.1 ± 0.3	12.7
Mya truncata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	12.7
Mya spp (juv.)	13	12	13	6	5	35	9	17	2	8	11.9 ± 9.8	1515.2
Pseudopythina sp	0	1	0	0	0	0	1	1	1	1	0.5 ± 0.5	63.6
No. of Individuals	57	51	76	46	39	91	61	62	34	46		
No. of Species	8	7	6	6	3	9	8	4	7	9		

APPENDIX 4.4.16. ABUNDANCE DATA FOR CORE SAMPLES FROM THE +3.6 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 30 JULY 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
ECHIURIDAE												
Echiurus echiurus	0	1	1	0	0	0	0	0	0	0	0.2 ± 0.4	25.5
ANNELIDA - Polychaeta												
Ampharete acutifrons	0	0	1	1	0	0	0	0	1	0	0.4 ± 0.5	51.0
Capitella capitata	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Eteone nr longa	1	1	1	0	1	0	1	0	0	0	0.5 ± 0.5	63.8
Eteone nr pacifica	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Harmothoe imbricata	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Malococeros sp	0	0	0	0	0	0	1	0	0	1	0.2 ± 0.4	25.5
Nephtys sp	0	2	0	1	3	1	0	1	2	1	1.1 ± 1.0	140.1
Nephtys sp (juv)	1	0	2	1	0	0	1	1	1	1	0.8 ± 0.6	102.0
Polydora caulleryi	0	0	1	0	0	0	0	0	1	0	0.2 ± 0.4	25.5
Potamilla sp	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	12.7
Scoloplos armiger	0	1	0	0	0	0	0	0	0	1	0.2 ± 0.4	25.5
Spio filicornis	1	3	1	1	0	0	1	3	0	0	1.0 ± 1.2	127.6
ANNELIDA - Oligochaeta	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
ARTHROPODA - Crustacea												
Crangon sp	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Tritella ?pilimana	0	0	0	0	1	0	0	0	1	0	0.2 ± 0.4	25.5
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (adult)	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	12.7
(juv)	0	0	0	0	0	0	0	1	1	0	0.2 ± 0.4	25.5
Macoma balthica	14	20	22	14	21	18	15	21	17	15	17.7 ± 3.1	2253.6
Mya arenaria	1	0	0	0	2	0	0	1	1	0	0.5 ± 0.7	63.8
M. priapus	0	0	0	0	1	0	1	0	0	0	0.2 ± 0.4	25.5
Mya sp (frag & juv.)	0	0	1	0	1	0	1	0	0	0	0.3 ± 0.5	38.2
Pseudopythina sp	0	2	3	0	0	0	1	1	0	0	0.7 ± 1.1	89.1
No. of Individuals	18	33	33	18	30	19	22	31	25	21		
No. of Species	5	10	9	4	6	2	7	8	7	6		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE +2.5 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 30 JULY 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m^2
ECHIURIDAE												
Echiurus echiurus	1	0	0	0	2	0	1	1	0	0	0.5 ± 0.7	63.8
ANNELIDA - Polychaeta												
Capitella capitata	1	8	0	0	6	0	0	0	0	0	1.5 ± 3.0	191.3
Eteone nr longa	1	4	3	2	3	0	0	1	0	0	1.4 ± 1.5	178.6
Eteone nr pacifica	2	0	0	0	0	0	0	0	0	0	0.2 ± 0.6	25.5
Harmothoe imbricata	1	0	1	0	1	0	0	1	0	0	0.4 ± 0.5	50.9
Malococeros sp	0	3	0	0	0	0	0	0	0	0	0.3 ± 0.9	38.3
Maldanidae (juv.)	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Nephtys sp (adults)	4	0	0	0	2	1	0	0	3	1	1.1 ± 1.4	140.3
(juv.)	1	8	2	4	0	1	0	1	1	2	2.0 ± 2.4	255.1
Phyllodoce groenlandica	0	0	0	0	0	0	2	0	0	0	0.2 ± 0.6	25.5
Polydora caulleryi	3	0	1	1	0	1	0	3	0	1	1.0 ± 1.2	127.5
Potamilla sp	4	1	0	4	0	1	2	0	0	0	1.2 ± 1.6	153.1
Scoloplos armiger	0	0	0	0	0	1	0	1	0	0	0.2 ± 0.4	25.5
Spio filicornis	6	4	4	5	3	1	1	9	3	2	3.8 ± 2.4	484.7
Spionidae, unid.	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	12.7
ARTHROPODA - Crustacea												
Crangon sp	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	12.7
Cyclopoida	0	0	0	0	0	0	0	1	0	1	0.2 ± 0.4	25.5
Harpacticoida	0	4	0	0	0	0	0	0	0	0	0.4 ± 1.3	50.9
Ischyroceridae	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	12.7
Tritella ?pilimana	0	6	0	3	0	2	0	0	3	7	2.1 ± 2.6	267.9
Insecta (larvae)	0	1	0	0	1	0	0	0	0	1	0.3 ± 0.5	38.3

+2.5 Foot Level Cont.

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (adult)	0	0	0	1	0	0	1	1	0	1	0.4 ± 0.7	50.9
(juv.)	0	1	0	0	0	0	0	1	0	0	0.2 ± 0.4	25.5
Macoma balthica	10	28	29	20	22	17	18	21	15	14	19.4 ± 6.0	2470.1
Mya arenaria	1	1	0	1	0	0	1	1	0	0	0.5 ± 0.5	63.8
M. priapus	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Mya spp (frag. & juv.)	1	0	0	1	0	2	0	0	1	1	0.6 ± 0.7	76.5
Pseudopythina sp	3	1	3	0	0	0	0	2	0	0	0.9 ± 1.2	114.6
No. of Individuals	39	72	43	42	42	27	27	46	26	31		
No. of Species	12	15	7	9	10	8	8	12	5	9		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE +0.9 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 30 JULY 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
ECHIURIDAE												
Echiurus echiurus	0	1	1	0	0	1	0	0	2	0	0.5 ± 0.7	63.8
ANNELIDA												
Ampharete acutifrons	1	0	1	1	0	0	0	0	0	0	0.3 ± 0.5	38.3
Capitella capitata	1	0	1	0	0	11	0	0	0	0	1.3 ± 3.4	165.8
Eteone nr longa	0	2	1	1	0	4	0	0	2	0	1.0 ± 1.3	127.6
Harmothoe imbricata	2	1	0	2	0	1	1	2	1	0	1.0 ± 0.8	127.6
Malacoceros sp	1	2	0	0	0	0	0	0	0	0	0.3 ± 0.7	38.3
Nephtys sp (adult)	2	1	1	1	0	2	2	2	1	4	1.2 ± 0.8	153.1
(juv.)	2	1	0	0	0	1	1	1	0	0	0.6 ± 0.7	76.5
Oligochaeta, unid.	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Phyllodoce groenlandica	0	0	0	0	0	0	0	0	1	1	0.2 ± 0.4	25.5
Polydora caulleryi	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Polygordius sp	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Potamilla sp	6	2	6	8	4	2	5	2	0	1	3.6 ± 2.6	459.2
Scoloplos armiger	2	0	0	0	0	0	0	0	0	0	0.2 ± 0.6	25.5
Spio filicornis	14	2	6	2	1	5	12	0	1	1	4.4 ± 4.9	560.2
ARTHROPODA												
Acarina	0	0	0	0	0	1	0	0	0	0	0.1 ± 0.3	12.7
Cyclopoida	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Pontoporeia femorata	0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3	12.7
Tritella ?pilimana	10	0	0	0	0	4	3	0	9	0	2.6 ± 3.9	331.6

+0.9 Foot Level Cont.

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
MOLLUSCA												
Clinocardium nuttallii (adult)	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	12.7
(juv.)	1	0	2	5	0	0	3	0	1	0	1.2 ± 1.7	152.8
Cylichna sp	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Macoma balthica	31	22	15	14	23	22	19	24	9	26	20.5 ± 6.4	2610.3
Mya arenaria	0	1	0	1	1	0	1	0	0	0	0.4 ± 0.5	50.9
M. priapus	0	2	1	0	0	0	2	1	0	0	0.6 ± 0.8	76.4
M. truncata	0	0	2	1	0	0	0	0	0	0	0.3 ± 0.7	38.2
Mya spp (frag. & juv.)	1	0	1	2	1	1	2	1	0	1	1.0 ± 0.7	127.6
Pseudopythina sp	0	1	2	2	0	7	1	2	2	0	1.7 ± 2.0	216.5
No. of Individuals	76	40	41	40	31	62	52	36	29	34		
No. of Species	14	13	13	11	5	12	10	7	10	6		

ABUNDANCE DATA FOR CORE SAMPLES FROM THE -1.2 FOOT LEVEL AT GLACIER SPIT, CHINITNA BAY INTERTIDAL AREA; 30 JULY 1977

TAXA	Number Per Core Sample										x ± s	Estimated no./m²
ECHIURIDAE												
Echiurus echiurus	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
ANNELIDA - Polychaeta												
Ampharete acutifrons	0	0	0	0	0	1	0	0	1	0	0.2 ± 0.4	25.5
Axiothella rubrocincta	0	1	0	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Capitella capitata	1	0	1	0	0	0	3	0	0	1	0.6 ± 1.0	76.5
Eteone nr *longa*	2	0	0	1	1	0	3	1	0	1	0.9 ± 1.0	114.8
Harmothoe imbricata	1	0	1	0	0	0	1	1	0	1	0.5 ± 0.5	63.8
Malacoceros sp	0	0	0	0	0	1	2	0	0	1	0.4 ± 0.7	51.0
Nephtys sp	0	1	0	2	0	2	1	2	2	1	1.1 ± 1.1	140.3
Nephtys sp (juv.)	2	6	2	3	0	6	3	0	2	1	2.5 ± 2.1	318.9
Paraonella platybranchia	0	0	0	0	0	0	2	0	0	0	0.2 ± 0.6	25.5
Phyllodoce groenlandica	0	2	0	1	0	0	0	0	1	1	0.5 ± 0.7	63.8
Polydora caulleryi	1	1	0	0	0	1	1	0	0	0	0.4 ± 0.5	50.9
Potamilla sp	3	5	4	3	0	1	2	5	3	4	3.0 ± 1.6	382.0
Scoloplos armiger	1	0	0	0	0	1	0	0	0	0	0.2 ± 0.4	25.5
Spio filicornis	4	13	10	3	0	5	4	3	6	3	5.1 ± 3.8	650.5
NEMERTEA, unid.	0	0	0	1	0	0	0	1	0	0	0.2 ± 0.4	25.5
ARTHROPODA												
Acarina	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
Pontoporeia femorata	0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3	12.7
Tritella ?pilimana	7	1	0	0	0	0	1	0	0	1	1.0 ± 2.2	127.6

-1.2 Foot Level Cont.

TAXA	Number Per Core Sample										x ± s	Estimated no./m^2
MOLLUSCA												
Aglaja diomadea	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	12.7
Clinocardium nuttallii (adult)	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	12.7
(juv.)	2	2	1	0	1	3	2	1	0	1	1.3 ± 0.9	165.5
Macoma balthica	50	19	30	21	28	27	23	20	18	22	25.8 ± 9.4	3285.0
Mya arenaria	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	12.7
M. priapus	0	0	0	2	0	2	0	0	0	1	0.5 ± 0.8	63.8
M. truncata	0	0	0	0	1	1	0	0	0	0	0.2 ± 0.4	25.5
Mya spp (frag. & juv.)	2	1	1	0	1	2	3	0	0	1	1.1 ± 0.1	140.1
Pseudopythina sp	0	0	1	0	0	2	4	2	0	2	1.1 ± 1.3	140.1
No. of Individuals	77	52	53	37	33	55	56	36	33	43		
No. of Species	13	10	10	8	5	12	15	9	6	14		

APPENDIX 4.4.17. BIOMASS DATA (GRAMS WHOLE WET WEIGHT) FOR CORE SAMPLES FROM GLACIER SPIT, CHINITNA BAY, 6 APRIL 1977

TAXA	1	2	3	4	5	6	7	8	9	10	x̄ ± s	Biomass/m
					+3.6 Level							
ECHIURA												
Echiurus echiurus	0	0.377	0	0	0	0	0	0	0	0	0.038 ± 0.119	4.838
ANNELIDA - Polychaeta												
Abarenicola pacifica	0	0	0	0	0	0	0	0	0	0.024	0.002 ± 0.008	0.255
Capitella capitata	0	0	0	0	0.007	0	0	0	0	0	0.001 ± 0.002	0.127
Eteone nr longa	0	0	T	0	0	0	0	0	0.090	0	0.009 ± 0.028	1.146
Glycinde sp	0	0	0	0	0.001	0	0	0	0	0.047	0.005 ± 0.015	0.637
Harmothoe imbricata	0	0	0	0	0	0	0	0	0	0.007	0.001 ± 0.002	0.127
Malacocerus sp	0	0	0	0	0.001	0	0	0	0	0	T	T
Nephtys sp	0.005	0	0	0.14	0.726	0.054	0.139	0.10	0.005	0	0.017 ± 0.222	2.165
Nephtys sp (juv.)	0	0	T	0	T	T	T	0	0	0	T	0.026
Paraonidae, unid.	T	0	0	0	0	0	0	0	0	0	T	T
Phyllodoce groenlandica	0	0	0	0	0.017	0	0	0	0	0	0.002 ± 0.005	0.255
Potamilla sp	0	0.001	0	0	0.063	0	0	0	0	–	0.006 ± 0.020	0.764
ARTHROPODA - Crustacea												
Arthropod frag.	0	0	0	0.002	0	0	0	0	0	0	T	0.025

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					+3.6' Level Cont.							
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0	0.005	0	0.005	0.02	0	0	0	0	0.005	0.004 ± 0.006	0.509
Macoma balthica	4.32	4.69	2.31	4.59	4.00	3.48	3.33	2.55	5.50	7.88	4.3 ± 1.6	547.5
Mya arenaria	0	0	0	0	24.11	71.07	62.84	107.77	0	14.22	28.0 ± 38.8	3565.1
Mya spp (juv.)	0	0	0	0.005	0.05	0	0.01	0	0	0.01	0.008 ± 0.016	1.02
Mya sp (frag.)	0	0	0	0	0	0	3.03	0	0	0	0.3 ± 1.0	38.2
Pseudopythina sp	0	0.006	0.005	0	0.03	0	0	0	0	0.02	0.006 ± 0.011	0.76
Total	4.33	5.08	2.32	4.74	29.03	74.60	69.35	110.42	5.60	22.21	32.75 ± 38.35	4169.5
					+2.5' Level							
ECHIURA												
Echiurus echiurus	0.135	0	0.690	1.24	0	0.90	0.025	0.360	0.291	0	0.364 ± 0.439	46.35
ANNELIDA - Polychaeta												
Aphroditoidae, unid.	0.002	0	0	0	0	0.126	0	0	0.095	0	0.022 ± 0.047	2.801
Capitella capitata	0	0.001	0	0	0	0	0	0	0	0	T	T
Eteone nr longa	0	0.022	0	0	0.012	0.010	0	0.004	0	0	0.005 ± 0.008	0.637
Glycinde sp	0	0	0.075	0.006	0	0	0	0.030	0	0	0.011 ± 0.024	1.401
Harmothoe imbricata	0	0	0	0	0	0.029	0	0	0	0	0.003 ± 0.009	0.382

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					+2.5' Level Cont.							
Nephtys caeca	0.42	0.890	0.146	0	0.322	0.494	0	0	0.177	0.09	0.254 ± 0.285	32.34
Nephtys sp (juv.)	0.038	0.007	0.0 0	0	0	0	0.002	0.005	0.003	0.005	0.007 ± 0.011	0.891
Polydora caulleryi	0	0	0	0	0.003	0	0	0	0.002	0	T	0.06
Potamilla sp	0	0.017	0.040	0.008	0.022	0	0.003	0	0	0.034	0.012 ± 0.015	1.528
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0	0.005	0.01	0	0	0	0.01	0	0.01	0	0.004 ± 0.005	0.509
Macoma balthica	5.12	4.91	3.28	2.49	6.45	3.93	3.67	4.20	3.55	4.90	4.2 ± 1.1	534.7
Mya arenaria	0	51.61	0	7.17	0	0	0	62.62	39.20	9.86	17.0 ± 24.4	2164.5
M. priapus	0	0	0	0	0	7.05	0	0	6.10	0	1.3 ± 2.8	165.5
Mya sp (frag.)	0	0	0	0	0	0	0	0	0	0.84	0.08 ± 0.27	10.19
Mya spp (juv.)	0.01	0.02	0	0	0.02	0	0	0.005	0	0.6	0.07 ± 0.19	8.91
Pseudopythina sp	0	0.07	0.02	0.22	0	0	0	0.01	0.02	0	0.034 ± 0.07	4.33
Total	5.73	57.55	4.27	11.13	6.83	12.54	3.71	67.23	49.45	16.33	23.48 ± 24.55	2989.33

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
						+0.9' Level						
ECHIURA												
Echiurus echiurus	0	0	0	0	0	0	0	0	1.099	0	0.110 ± 0.348	14.006
ANNELIDA - Polychaeta												
Ampharete acutifrons	0.010	0	0	0	0	0	0	0	0	0.001	0.001 ± 0.003	0.127
Capitella capitata	0.001	0	0	0	0	0	0	0	T	0	0.0001 ± 0.0003	0.013
Eteone nr longa	0	0	0	0.004	0	0.003	0	0	0.001	0	0.001 ± 0.001	0.127
Glycinde sp	0.020	0.005	0	0	0	0	0	0	0.050	0.070	0.015 ± 0.025	1.910
Harmothoe imbricata	0	0	0	0	0	0	0	0	0.195	0	0.020 ± 0.062	2.546
Malacocerus sp	0	0	0	0	0	0	0	0	0	0.001	0.0001 ± 0.0003	0.013
Nephtys sp	0.040	0	0.575	0.450	0.35	0.238	-	-	0.245	0.093	0.288 ± 0.189	29.03
Nephtys sp (juv.)	0.001	0.006	0.006	0.012	0	0.004	0.239	0.051	0.040	0.020	0.009 ± 0.013	1.146
Phyllodoce groenlandica	0	0.409	0.007	0	0	0	0	0.011	0	0.035	0.046 ± 0.128	5.857
Polydora caulleryi	0	0	0	0	0	0	0.004	0	0	0	0.0004 ± 0.001	0.051
Potamilla sp	0.046	0.012	0.020	0.182	0.030	0.005	0.032	0.011	0.061	0.012	0.041 ± 0.053	5.220
Spionidae, unid.	0	0	0	0	0	0	0	0	0	0.002	T	0.025
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0.1	0.01	-	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02 ± 0.03	2.55
Macoma balthica	3.58	4.89	4.16	5.19	3.82	3.94	6.64	1.70	5.01	3.92	4.3 ± 1.3	547.5

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					+0.9' Level Cont.							
Mya priapus	0	0	0	0	0	2.37	0	0	0	0	0.2 ± 0.7	25.5
Mya sp (frag.)	4.29	0	33.83	0.96	0	0	0	0	0	0	3.91 ± 10.6	497.8
Mya spp (juv.)	0.005	0.01	0.03	0.07	0.14	0.075	0.10	0.06	0.10	0.17	0.07 ± 0.06	8.9
Pseudopythina sp	0	0.01	0	0	0	0	0.03	0.02	0.02	0.06	0.014 ± 0.02	1.78
Total	8.09	5.35	38.63	6.89	4.36	6.65	7.06	1.86	6.83	4.39	9.01 ± 10.56	1147.37
					-1.2' Level							
ECHIURA												
Echiurus Echiurus	0.001	0	0	0	0	0	0	0	2.05	0	0.205 ± 0.648	26.101
ANNELIDA - Polychaeta												
Ampharete acutifrons	0	0	0.002	0	0	0	0	0	0	0.003	0.0005 ± 0.001	0.064
Capitella capitata	0	0	0	0	0	0	T	0	0	0	T	T
Eteone nr longa	0	0.001	0	0	0	0.006	0	0.009	0	0	0.002 ± 0.003	0.255
Glycinde sp	0.001	0	0	0	0	0.004	0.055	0	0.005	0	0.007 ± 0.017	0.891
Malacocerus sp	0	0	0	0	0	0	0	0	0	T	T	T
Nephtys caeca	0.419	-	0.506	0.682	0.178	0	0.496	0.270	0.095	0	0.356 ± 0.302	45.327
Nephtys sp (juv.)	0.012	0.910	0	0	0.005	0.011	0.006	0	0	0.001	0.004 ± 0.005	0.509
Phyllodoce groenlandica	0.015	0	0	0	0	0	0	0	0	0	0.002 ± 0.005	0.191

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					-1.2 Level Cont.							
Polydora caulleryi	0	0.001	0	0	0	0	0	0	0	0	0.0001 ± 0.0003	0.013
Potamilla sp	0	0	0	0.028	0.001	0.012	0.043	0	0	0	0.008 ± 0.015	1.019
Scoloplos armiger	0	0	0	0	0	0	0	0	0.004	0	0.0004 ± 0.001	0.051
?Spio sp	0	0	0.004	0	0	0	0	0	0	0	0.0004 ± 0.001	0.051
ARTHROPODA - Crustacea												
Tritella pilimana	0	0	0	0	0	0.005	0	0	0	0	0.0005 ± 0.002	0.064
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (juv.)	0.005	0.01	0	0.01	0	0.1	0.01	0.02	0.02	0.05	0.02 ± 0.03	2.55
Macoma balthica	2.55	3.54	0	4.48	1.19	2.30	3.67	5.21	1.40	2.54	2.7 ± 1.6	342.3
Mya arenaria	0.99	0	0	0	0	11.15	0.68	0	0	0	1.3 ± 3.5	163.2
M. priapus	0	0	0	0.03	0	0	0	0	0	0	0.003 ± 0.01	0.382
M. truncata	0	0	0	0	0	0	24.34	0	0	0	2.4 ± 7.7	309.9
Mya spp (juv.)	0.13	0.14	0	0.13	0.07	0.32	0.05	0.13	0.02	0.07	0.11 ± 0.09	13.5
Pseudopythina sp	0	0	0	0	0	0	0.02	0.01	0.01	0.02	0.006 ± 0.009	0.76
Total	4.12	4.60	0.51	5.36	1.44	13.91	29.37	5.65	3.60	2.68	7.12 ± 8.63	906.9

APPENDIX 4.4.18. BIOMASS DATA (GRAMS WHOLE WET WEIGHT) FOR CORE SAMPLES FROM GLACIER SPIT, CHINITNA BAY, 30 JULY 1977

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					+3.6' Level							
ECHIURA												
Echiurus echiurus	0	1.52	0.65	0.01	0	0	0	0	0	0	0.22 ± 0.05	27.76
ANNELIDA												
Ampharete acutifrons	0.01	0	T	T	0	0	0	0	0.01	0	T	T
Capitella capitata	0	T	0	0	0	0	0	0	0	0	T	T
Eteone nr longa	0.014	0.007	T	0	T	0	T	0	0	0	0.002 ± 0.005	0.267
Eteone nr pacifica	0	0.008	0	0	0	0	0	0	0	0	0.001 ± 0.003	0.102
Harmothoe imbricata	0	0.17	0	0	0	0	0	0	0	0	0.017 ± 0.054	2.165
Hirudinea, unid.	0	0.015	0	0	0	0	0	0	0	0	0.002 ± 0.005	0.19
?Malacocerus sp	0	0	0	0	0	0	T	0	0	T	T	T
Nephtys sp	0	0.49	0	0.20	0.52	0.35	0	0.31	0.65	1.39	0.39 ± 0.42	49.78
Nephtys sp (juv.)	T	0	0.005	T	0	0	0.265	T	-	0.003	0.027 ± 0.084	3.48
Oligochaeta, unid.	0	0	0	0	0	0	0	0	0	T	T	T
Polydora caulleryi	0	0	T	0	0	0	0	0	T	0	T	T
Potamilla sp	0	0	0	0	0.0	0	0	T	0.002	0	0.001 ± 0.003	0.153
Scoloplos armiger	0	T	0	0	0	0	0	0	0	0.005	0.001 ± 0.002	0.064
Spio filicornis	0.004	T	T	T	0	0	T	T	0	0	0.001 ± 0.002	0.122

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					+3.6' Level Cont.							
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii	0	0	0	0	0	0	0	3.70	0	0	0.37 ± 1.17	47.1
C. nuttallii (juv.)	0	0	0	0	0	0	0	0.18	0.01	0	0.02 ± 0.05	2.4
Macoma balthica	2.90	4.65	3.45	4.64	3.25	3.80	2.70	4.34	2.98	2.97	3.6 ± 0.70	454.6
Mya arenaria	67.95	0	0	0	78.77	0	0	54.77	9.00	0	21.0 ± 32.4	2680.2
M. priapus	0	0	0	0	7.27	0	1.94	0	0	0	0.9 ± 2.3	117.3
Mya spp (juv.)	0	0	0.19	0	0	0	0	0	0	0	0.02 ± 0.06	2.4
Mya sp (frag.)	0	0	0	0	8.11	0	2.03	0	0	0	1.0 ± 2.6	127.3
Pseudopythina sp	0	0.39	0.02	0	0	0	0.005	0.005	0	0	0.0 ± 0.12	5.3
Total	70.88	7.25	4.32	4.85	97.93	4.15	6.94	63.31	12.65	4.37	27.67 ± 35.45	3522.6
					+2.5' Level							
ECHIURA												
Echiurus echiurus	1.27	0	0.38	0	1.60	0	0.1	0.795	0	0	0.415 ± 0.600	52.776
ANNELIDA												
Capitella capitata	T	0.007	0	0	0.005	0	0	0	0	0	0.001 ± 0.003	0.166
Eteone nr *longa*	0.007	0.014	0.05	T	0.02	0	0	0.01	0	0	0.010 ± 0.016	1.30
Eteone nr *pacifica*	T	0	0	0	0	0	0	0	0	0	T	T

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
+2.5' Level Cont.												
Harmothoe imbricata	0.24	0	0.34	0	0.326	0	0	0.08	0	0	0.099 ± 0.145	12.55
?Maldanidae (juv.)	0	T	0	0	T	0	0	0	0	0	T	T
Malococerus sp	0	T	0	0	0	0	0	0	0	0	T	T
Nephtys sp	0.404	0	0	0	0.394	0.84	0	0	0.84	0.14	0.26 ± 0.34	33.33
Nephtys sp (juv.)	-	0.012	0.02	0.02	T	0.02	0	T	0.014	-	0.009 ± 0.009	1.12
Phyllodoce groenlandica	0	0	0	0	0	0	0.384	0	0	0.08	0.046 ± 0.121	5.908
Polydora caulleryi	T	0	T	T	0	T	0	T	0	T	T	T
Potamilla sp	0.055	0.026	0	0.11	0	T	0.02	0	0	0	0.021 ± 0.036	2.687
Scoloplos armiger	0	0	0	0	0	T	0	T	0	0	T	T
Spio filicornis	0.018	T	0.01	0.01	0.016	T	T	0.03	0.007	T	0.009 ± 0.010	1.21
?Spionidae, unid.	0	0	0	0	T	0	0	0	0	0	T	T
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (adult)	0	0	0	7.79	0	0	3.32	9.83	0	7.01	2.8 ± 3.9	355.9
C. nuttallii (juv.)	0	0.005	0	0	0	0	0	0.34	0	0	0.04 ± 0.11	4.4
Macoma balthica	1.85	5.15	4.76	3.93	4.28	1.95	2.89	2.86	2.27	4.46	3.4 ± 1.2	438.0
Mya arenaria	81.07	19.35	0	68.66	0	0	8.05	13.06	0	0	19.0 ± 30.3	2421.7
M. priapus	0	9.39	0	0	0	0	0	0	0	0	0.9 ± 3.0	119.6
Mya spp. (juv.)	T	0	0	0	0	0.14	0	0	0.36	0	0.05 ± 0.12	6.4

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
+2.5' Level Cont.												
Mya sp (frag.)	0	0	0	4.50	0	0	0	5.75	0	49.21	5.9 ± 15.3	757.1
Pseudopythina sp	0.27	0.02	0.06	0	0	0	0	0.24	0	0	0.06 ± 0.11	7.5
Total	85.18	33.97	5.62	85.02	6.64	2.95	14.76	33.00	3.49	60.90	33.16 ± 32.93	4221.7
+0.9' Level												
ECHIURA												
Echiurus echiurus	0	1.09	0.23	0	0	0.950	0	0	1.65	0	0.314 ± 0.590	40.036
ANNELIDA												
Ampharete acutifrons	T	0	T	T	0	0	0	0	0	0	T	T
Capitella capitata	0.015	0	T	0	0	0.015	0	0	0	0	0.003 ± 0.006	0.382
Eteone nr *longa*	0	0.007	T	0.005	0	0.033	0	0	0.023	0	0.007 ± 0.012	0.866
Harmothoe imbricata	0.030	0.285	0	0.03	0	0.05	0.022	0.40	0.03	0	0.083 ± 0.141	10.530
Malacocerus sp	T	0.002	0	0	0	0	0	0	0	0	T	0.032
Nephtys sp	0.986	0.383	0.065	0.930	0	1.614	0.844	0.36	1.75	0.35	0.728 ± 0.607	92.717
Nephtys sp (juv.)	0.006	–	0	0	0	–	–	–	0	0	0.001 ± 0.002	0.076
Oligochaeta, unid.	0	0.07	0	0	0	0	0	0	0	0	0.007 ± 0.022	0.891
Phyllodoce groenlandica	0	0	0	0	0	0	0	0	0.645	T	0.072 ± 0.215	9.125
Polydora caulleryi	0	0	0.007	0	0	0	0	0	0	0	0.001 ± 0.002	0.089

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
+0.9' Level Cont.												
Polygordius sp	T	0	0	0	0	0	0	0	0	0	T	T
Potamilla sp	0.155	0.07	0.10	0.21	0.105	0.018	0.06	0.09	0	0.002	0.081 ± 0.067	10.313
Scoloplos armiger	T	0	0	0	0	0	0	0	0	0	T	T
Spio filicornis	0.037	0.008	0.009	0.01	T	0.010	0.017	0	0.004	0.014	0.011 ± 0.011	1.389
Spionidae, unid.	0	0.008	0	0	0	0	0	0	0	0	0.001 ± 0.003	0.102
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (adult)	0	0	0	0	25.50	0	0	0	0	0	2.6 ± 8.1	324.6
C. nuttallii (juv.)	0.15	0	0.007	4.00	0	0	0.01	0	0.005	0	0.02 ± 0.05	3.1
Macoma balthica	4.79	4.35	1.57	2.23	3.68	2.81	4.38	4.50	0.28	3.59	3.2 ± 1.5	409.6
Mya arenaria	0	39.16	0	23.00	20.80	0	11.29	0	0	0	9.4 ± 13.9	1199.8
M. priapus	0	41.22	17.78	0	0	0	5.35	19.89	0	0	8.4 ± 10.0	1072.5
M. truncata	0	0	24.54	14.75	0	0	0	0	0	0	3.9 ± 8.6	501.1
Mya spp (juv.)	0	0	0.04	0.14	0	0.54	0	0	0	0	0.2 ± 0.3	30.8
Mya sp (frag.)	28.34	0.79	0	40.97	0.65	0	10.87	9.67	0	0	9.1 ± 14.4	1162.4
Pseudopythina sp	0	0.005	0.03	0.005	0	0.17	0.005	0.59	0.01	0	0.08 ± 0.19	10.4
Total	34.51	87.38	44.38	86.28	50.74	6.21	32.83	35.50	4.40	3.96	38.62 ± 30.39	4917.36

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
						-1.2' Level						
ECHIURA												
Echiurus echiurus	0.520	0	0	0	0	0	0	0	0	0	0.052 ± 0.164	6.621
ANNELIDA												
Ampharete acutifrons	0	0	0	0	0	T	0	0	T	0	T	T
Axiothella rubrocincta	0	T	0	0	0	0	0	0	0	0	T	T
Capitella capitata	0.001	0	0.001	0	0	0	0.001	0	0	–	0.0003 ± 0.0004	0.038
Eteone nr *longa*	0.012	0	0	0.002	0	0.01	0.009	0.001	0	0.003	0.004 ± 0.005	0.471
Harmothoe imbricata	0.003	0	0.046	0	0	0	0.507	0.008	0	0.007	0.057 ± 0.159	7.270
Malococerus sp	0	0	0	0	0	–	T	0	0	T	T	T
Nephtys sp	0.597	0.345	0.170	0.675	0	0.61	0.060	1.263	0.070	1.38	0.462 ± 0.510	58.836
Nephtys sp (juv.)	–	0.014	–	–	0	0.018	–	0	–	–	0.003 ± 0.007	0.407
Paraonalla platybranchia	0	0	0	0	0	0	T	0	0	0	T	T
Phyllodoce groenlandica	0	0.015	0	0.003	0	0	0	0	0.074	0.003	0.010 ± 0.023	1.210
Polydora ?caulleryi	0.002	T	0	0	0	T	T	0	0	0	0.0002 ± 0.001	0.045
Potamilla sp	0.104	0.196	0.012	0.053	0	0.043	0.014	0.028	0.010	0.034	0.049 ± 0.060	6.290
Scoloplos armiger	0.002	0	0	0	0	0.003	0	0	0	0	0.001 ± 0.001	0.064
Spio filicornis	0.022	0.020	0.02	T	0	0.011	0.005	0.007	0.007	0.004	0.010 ± 0.008	1.229

TAXA	1	2	3	4	5	6	7	8	9	10	x ± s	Biomass/m
					-1.2' Level Cont.							
ARTHROPODA - Crustacea												
Tritella ?pilimana	T	T	0	0	0	0	0	0	0	T	T	T
MOLLUSCA - Pelecypoda												
Clinocardium nuttallii (adult)	0	0	2.10	0	0	0	0	0	0	0	0.2 ± 0.7	26.7
C. nuttallii (juv.)	0.25	0.04	0.005	0	0.44	1.20	1.15	0.005	0	0.005	0.3 ± 0.5	39.4
Macoma balthica	6.52	3.03	6.88	3.93	4.89	5.04	2.86	3.49	2.33	3.80	4.3 ± 1.5	544.5
Mya arenaria	0	0	0	0	85.56	0	0	0	0	0	8.6 ± 27.1	1089.2
M. priapus	0	0	0	25.47	0	34.08	0	0	0	23.70	8.3 ± 13.7	1059.8
M. truncata	0	0	0	0	34.58	17.47	0	0	0	0	5.2 ± 11.7	662.6
Mya spp (juv.)	0.01	0.04	1.40	0	0.81	0.25	0.43	0	0	0.19	0.3 ± 0.5	39.8
Mya sp (frag.)	2.29	0	0	0	0	0	0	0	0	0	0.2 ± 0.7	29.2
Pseudopythina sp	0	0	T	0	0	0.01	0.07	0.01	0	0.15	0.03 ± 0.05	3.2
Total	10.33	3.70	10.63	30.13	126.28	58.75	5.11	4.81	2.49	29.28	28.15 ± 38.77	3584.5

APPENDIX 4.4.19. SUMMARY OF DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT GLACIER SPIT, CHINITNA BAY, 6 APRIL 77

TAXA	Number per m^2			
	+3.6'	+2.5'	+0.9'	-1.2'
ECHIURA				
Echiurus echiurus	12.7	101.9	12.7	25.5
ANNELIDA - Polychaeta				
Abarenicola pacifica	12.7	0	0	0
Ampharete acutifrons	0	0	25.5	25.5
Aphroditoididae, unid. (?*Peisidice*)	0	38.2	0	0
Capitella capitata	12.7	25.5	25.5	12.7
Eteone nr *longa*	38.2	50.9	38.2	25.5
Glycinde polygnatha	25.5	38.2	0	38.2
Harmothoe imbricata	12.7	12.7	12.7	0
Malacoceros sp	38.2	0	12.7	12.7
Nephtys sp	63.7	89.1	165.5	127.3
Nephtys sp (juv)	89.1	140.1	211.7	267.4
Paraonidae, unid.	12.7	0	0	0
Phyllodoce groenlandica	25.5	0	25.5	12.7
Polydora caulleryi	0	25.5	25.5	12.7
Potamilla sp	63.7	76.4	318.3	38.2
Scoloplos armiger	0	0	0	12.7
?*Spio filicornis*	0	0	0	38.2
MOLLUSCA - Pelecypoda				
Clinocardium nuttallii	63.7	50.9	432.9	345.8
Macoma balthica	4647.3	4443.6	5347.6	4252.6
Macoma sp	0	0	0	12.7
Mya arenaria	89.1	63.6	0	38.2
M. priapus	0	25.5	12.7	12.7
M. truncata	0	0	0	12.7
Mya spp. (juv)	152.8	127.3	1120.5	1515.2
Pseudopythina sp	89.1	203.7	229.2	56.6
ARTHROPODA - Crustacea				
Saduria entomon	0	12.7	0	0
Tritella pilimana	0	0	0	12.7

APPENDIX 4.4.20. SUMMARY OF DENSITY OF ORGANISMS IN INFAUNAL SAMPLES BY LEVEL AT GLACIER SPIT, CHINITNA BAY, 30 JULY 77

	Number per m²			
TAXA	+3.6'	+2.5'	+1.9'	-1.2'
ECHIURA				
Echiurus echiurus	25.5	63.8	63.8	12.7
NEMERTEA, unid	0	0	0	25.5
ANNELIDA - Oligochaeta, unid.	12.7	0	12.7	0
ANNELIDA - Polychaeta				
Ampharete acutifrons	51.0	0	38.3	25.5
Axiothella rubrocincta	0	0	0	12.7
Capitella capitata	12.7	191.3	165.8	76.5
Eteone nr *longa*	63.8	178.6	127.6	114.8
E. nr *pacifica*	12.7	25.5	0	0
Harmothoe imbricata	12.7	50.9	127.6	63.8
Malacoceros sp	25.5	38.3	38.3	51.0
Maldanidae, unid.	0	12.7	0	0
Nephtys sp	140.1	140.3	153.1	140.3
Nephtys sp (juv.)	102.0	255.1	76.5	318.9
Paraonella platybranchia	0	0	0	25.5
Phyllodoce groenlandica	0	25.5	25.5	63.8
Polydora caulleryi	25.5	127.5	12.7	50.9
Polygordius sp	0	0	12.7	0
Potamilla sp	12.7	153.1	459.2	382.0
Scoloplos armiger	25.5	25.5	25.5	25.5
Spio filicornis	127.6	484.7	560.2	650.5
Spionidae, unid.	0	12.7	0	0
ARTHROPODA				
Acarina, unid.	0	0	12.7	12.7
Crangon sp	12.7	12.7	0	0
Harpacticoidea, unid.	0	25.5	0	0
Ischyroceridae, unid.	0	50.9	0	0
Pontoporeia femorata	0	12.7	12.7	12.7
Tritella ?pilimana	25.5	267.9	331.6	127.6

TAXA	Number per m^2 +3.6'	+2.5'	+0.9'	-1.2'
MOLLUSCA				
Aglaja diomedea	0	0	0	12,7
Clinocardium nuttallii (adult)	12.7	50.9	12.7	12.7
C. nuttallii (juv)	25.5	25.5	152.8	165.5
Cylichna sp	0	0	12.7	0
Macoma balthica	2253.6	2470.1	2610.3	3285.0
Mya arenaria	63.8	63.8	50.9	12.7
M. priapus	25.5	12.7	76.4	63.8
M. truncatus	0	0	38.2	25.5
Mya spp (juv)	12.7	50.9	76.4	127.3
Pseudopythina sp	89.1	114.6	216.5	140.1

APPENDIX 4.4.21. SUMMARY OF BIOMASS DISTRIBUTION AMONG ORGANISMS AND LEVELS AT GLACIER SPIT, CHINITNA BAY IN 1977

	Grams wet weight per m²							
	6 April				30 July			
TAXA	+3.6'	+2.5'	+0.9'	-1.2'	+3.6'	+2.5'	+0.9'	-1.2'
ECHIURA	(0.1%)	(1.6%)	(1.2%)	(2.9%)	(0.8%)	(1.3%)	(0.8%)	(0.1%)
Echiurus echiurus	4.84	46.35	14.01	26.10	27.76	52.78	40.04	6.62
ANNELIDA - Polychaeta	(0.1%)	(1.2%)	(4.0%)	(5.3%)	(1.6%)	(1.4%)	(2.5%)	(2.1%)
Ampharete acutifrons	0	0	0.13	0.06	T	0	T	T
Capitella capitata	0.13	T	0.01	T	T	0.17	0.38	0.04
Eteone nr *longa*	1.15	0.64	0.13	0.26	0.27	1.30	0.87	0.47
Glycinde polygnatha	0.64	1.40	1.91	0.89	0	0	0	
Harmothoe imbricata	0.13	0.38	2.55	0	2.17	12.55	10.53	7.27
Malacoceros sp	T	0	0.01	T	T	T	0.03	T
Nephtys sp	2.17	32.34	29.03	45.33	49.78	33.33	92.72	58.84
Nephtys sp. (juv)	0.26	0.89	1.15	0.51	3.48	1.12	0.08	0.41
Phyllodoce groenlandica	0.26	0	5.86	0.19	0	5.91	9.13	1.21
Polydora caulleryi	0	0.06	0.05	0.01	T	T	0.09	0.05
Potamilla sp	0.76	1.53	5.22	1.02	0.15	2.69	10.31	6.29
Scoloplos armiger	0	0	0	0.05	0.06	T	T	0.06
?*Spio filicornis*	0	0	0	0.05	0.12	1.21	1.39	1.23
ARTHROPODA - Crustacea	(0)	(T)	(0)	(T)	(T)	(T)	(T)	(T)
Pontoporeia femorata	0	0	0	0	0	0	T	T
Tritella ?*pilimana*	0	0	0	0.06	T	T	T	T
MOLLUSCA - Pelecypoda	(99.6%)	(96.6%)	(94.5%)	(91.8%)	(97.6%)	(97.4%)	(95.8%)	(97.5%)
Clinocardium nuttallii (adult)	0	0	0	0	47.1	355.9	324.6	26.7
C. nuttallii (juv)	0.51	0.51	2.55	2.55	2.4	4.4	3.1	39.4
Macoma balthica	547.5	534.7	547.5	382.0	454.6	438.0	409.6	544.5

	Grams wet weight per m^2							
	6 April				30 July			
TAXA	+3.6'	+2,5'	+0.9'	-1.2'	+3.6'	+2.5'	+0.9'	-1.2'
Mya arenaria	3565.1	2164.5	0	178.3	2680.2	2421.7	1199.8	1089.2
M. priapus	0	165.5	25.5	0.38	117.3	119.6	1072.5	1059.8
M. truncatus	0	0	0	343.8	0	0	501.1	662.6
Mya spp. (juv.)	1.02	8.91	8.9	14.01	2.4	6.4	30.8	39.8
Mya spp. (frags)	38.2	10.19	497.8	0	127.3	757.1	1162.4	29.2
Pseudopythina sp	0.76	4.33	1.78	0.89	5.3	7.5	10.4	3.2

APPENDIX 4.4.22. SHELL LENGTH (MM) DATA FOR *MACOMA BALTHICA* FROM GLACIER SPIT, CHINITNA BAY ON 6 APRIL 1977

	Frequency					
					Overall	
Size Class	+3.6'	+2.5'	+0.9'	-1.2'	f	%
0.0 - 0.9			1		1	0.07
1.0 - 1.9	3	2	1	1	7	0.5
2.0 - 2.9	60	34	44	19	157	11.2
3.0 - 3.9	66	52	97	57	272	19.4
4.0 - 4.9	43	32	73	64	212	15.1
5.0 - 5.9	13	6	28	47	94	6.7
6.0 - 6.9	11	7	11	10	39	2.8
7.0 - 7.9	4	4	5	6	19	1.4
8.0 - 8.9	10	9	11	3	33	2.4
9.0 - 9.9	21	21	9	9	60	4.3
10.0 - 10.9	33	53	35	27	148	10.6
11.0 - 11.9	25	36	42	29	132	9.4
12.0 - 12.9	34	30	17	18	99	7.1
13.0 - 13.9	24	14	30	13	81	5.8
14.0 - 14.9	9	9	10	1	29	2.1
15.0 - 15.9	3	4	3		10	0.7
16.0 - 16.9	3	2	1		6	0.4
17.0 - 17.9			1		1	0.07
n	362	315	419	304	1400	
x	7.31	8.10	6.96	6.74	7.26	
s	4.23	4.09	4.03	3.51	4.02	

APPENDIX 4.4.23. SHELL LENGTH (MM) DATA FOR *MACOMA BALTHICA* FROM GLACIER SPIT, CHINITNA BAY ON 30 JULY 1977

Size Class	Frequency +3.6'	+2.5'	+0.9'	-1.2'	Overall f	Overall %
2.0 - 2.9	2	4	5	4	15	1.9
3.0 - 3.9	2	8	7	6	23	2.9
4.0 - 4.9	2	4	5	3	14	1.8
5.0 - 5.9	7	11	10	3	31	3.9
6.0 - 6.9	10	20	18	12	60	7.5
7.0 - 7.9	27	18	43	25	113	14.2
8.0 - 8.9	19	12	22	56	109	13.7
9.0 - 9.9	12	6	11	42	71	8.9
10.0 - 10.9	6	15	7	9	37	4.7
11.0 - 11.9	19	32	19	16	86	10.8
12.0 - 12.9	22	29	20	24	95	11.9
13.0 - 13.9	22	17	12	22	73	9.2
14.0 - 14.9	11	9	12	11	43	5.4
15.0 - 15.9	5	3	8	4	20	2.5
16.0 - 16.9	3			1	4	0.5
17.0 - 17.9		1			1	0.1
n	169	189	199	238	795	
$\bar{x}$	9.28	8.92	9.33	9.73	9.76	
s	3.19	3.37	3.25	2.83	3.16	

APPENDIX 4.4.24. SHELL LENGTH (MM) DATA FOR MYA SPP. (JUVENILES) FROM GLACIER SPIT, CHINITNA BAY

6 April 1977

+3.6'	+2.5'	+0.9'	+0.9'	-1.2'	-1.2'	-1.2'
2.6	3.9	2.2	2.5	6.4	3.4	3.8
5.1	3.3	4.1	5.4	5.2	3.8	1.9
4.3	4.0	3.2	5.0	6.0	3.3	2.0
3.2	3.6	4.6	3.6	4.2	2.6	3.5
2.5	4.9	4.5	4.0	5.2	4.3	3.5
3.9	3.7	3.8	5.3	3.9	6.4	4.9
4.1	3.1	3.6	3.2	4.4	5.9	2.2
4.3	3.1	3.7	4.0	3.7	6.5	4.7
3.5	2.4	3.8	3.8	5.1	4.0	3.3
3.6		3.3	2.5	4.7	5.8	3.1
3.4		3.5	2.7	3.0	5.7	4.3
3.8		4.0	4.3	3.9	5.2	4.6
		3.4	6.0	2.2	4.3	4.5
		4.9	4.3	5.4	5.6	3.0
		5.2	5.4	3.9	5.7	3.9
		2.5	4.5	4.7	4.9	4.4
		5.5	3.9	5.8	4.8	4.8
		4.9	5.0	5.8	4.3	4.6
		2.3	4.3	5.7	4.9	5.0
		4.5	3.4	4.4	5.2	5.9
		6.2	4.1	6.0	5.6	2.5
		3.5	4.0	3.4	5.0	3.5
		2.4	5.0	3.6	4.5	5.0
		6.2	4.2	4.8	5.0	3.2
		4.2	4.6	3.2	3.4	4.1
		5.4	4.1	5.2	4.1	3.6
		3.6	3.6	4.1	3.6	2.5
		4.0	3.9	5.2	4.7	5.7
		3.4	3.8	5.7	3.9	4.6
		4.5	3.6	4.3	3.6	3.9
		3.0	4.0	4.5	2.2	19.3
		5.8	4.8	3.3	4.3	
		5.6	3.3	4.0	5.0	
		3.5	3.9	4.4	3.8	
		4.8	3.7	4.6	5.0	
		4.1	4.7	3.6	3.3	
		3.7	4.0	4.3	4.5	
		3.2	4.0	4.0	6.2	
		5.3				
		3.2				
		2.5				
		4.7				
		5.1				
		2.4				
		4.3				
		3.8				
		4.8				
		2.7				
		3.9				
		4.7				

$\bar{x}$ = 4.17
s = 0.99
n = 215

30 July 1977

+3.6'	+2.5'	+0.9'	-1.2'
13.8	3.8	9.0	5.0
	2.9	11.4	9.9
	11.6	18.1	22.9
	18.2		24.1
			15.3
			6.6
			15.7
			6.8
			4.6
			14.3

$\bar{x}$ = 11.89
s = 6.41
n = 18

APPENDIX 4.4.25. SHELL LENGTH AND WEIGHT MEASUREMENTS FOR *MYA ARENARIA* AT GLACIER SPIT, CHINITNA BAY

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
6 April 1977											
90.5	55.00	21.31	56.9	9.86	4.19	-	-	-	27.0	0.99	0.51
93.3	62.84	25.54	-	39.20	14.23				-	11.15	5.66
58.7	12.25	6.02	49.3	7.17	3.63				24.3	0.68	0.35
56.6	11.86	5.97	97.7	51.61	20.41						
91.3	52.77	19.56									
97.8	71.07	25.43									
60.4	14.22	6.50									
Average shell length ($\bar{x} \pm s$) = 67.0 ± 26.6											
Wet tissue weight: whole wet weight ratio = 0.40											
30 July 1977											
107.2	67.95	25.81	60.5	13.06	5.87	64.0	20.80	9.83	100.8	85.56	32.41
59.6	9.0	6.78	-	19.35	6.15	80.0	39.16	17.99			
88.8	54.77	21.61	47.9	8.05	4.00	56.9	23.00	6.82			
-	60.60	23.73	95.7	81.07	27.80	57.0	11.29	5.08			
65.8	18.17	9.91	-	68.66	28.0						
Average shell length ($\bar{x} \pm s$) = 73.7 ± 19.9											
Wet Tissue weight:whole wet weight ratio = 0.40											

APPENDIX 4.4.26. SHELL LENGTH AND WEIGHT MEASUREMENTS FOR *MYA PRIAPUS* AT GLACIER SPIT, CHINITNA BAY

6 April 1977

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
-	-	-	-	7.05	2.85	31.2	2.37	1.07	7.3	0.03	-
			42.2	6.10	2.69						

Average shell length ($\bar{x} \pm s$) = 26.9 ± 17.8
Wet tissue weight:whole wet weight ratio = 0.43

30 July 1977

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
22.1	1.94	0.91	46.0	9.39	3.66	62.8	19.89	11.41	59.1	23.70	9.16
42.3	7.27	3.44				-	23.44	7.44	60.4	24.38	9.92
						53.9	17.77	7.42	25.0	1.09	0.57
						54.8	17.78	7.65	61.3	19.48	8.12
						35.7	3.91	1.64	53.9	14.60	5.36
						27.5	1.44	0.71			

Average shell length ($\bar{x} \pm s$) = 46.5 ± 14.6
Wet tissue weight:whole wet weight ratio = 0.42

APPENDIX 4.4.27. SHELL LENGTH AND WEIGHT MEASUREMENTS FOR <u>MYA TRUNCATA</u> AT GLACIER SPIT, CHINITNA BAY

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
6 April 1977											
-	-	-	19.6	0.60	-	-	-	-	63.3	24.34	8.57
30 July 1977											
-	-	-	-	-	-	-	14.75	8.16	-	17.47	13.70
						-	13.87	7.82	54.6	34.58	16.39
						-	10.74	4.91			

Wet tissue weight:whole wet weight ratio = 0.44

APPENDIX 4.4.28. SHELL LENGTH (MM) DATA FOR <u>CLINOCARDIUM NUTTALLII</u> FROM GLACIER SPIT, CHINITNA BAY

6 April 1977				30 July 1977					Frequency	
+3.6'	+2.5'	+0.9'	-1.2'	+3.6'	+2.5'	+0.9'	-1.2'	Size Class	4/6/77	7/30/77
2.0	1.6	9.2	1.9	9.6	1.8	8.7	9.6	1-3	62	16
1.5	2.1	2.5	2.6	2.3	11.5	2.3	3.4	4-6	0	2
2.0	2.4	10.8	2.1	27.1	39.9	2.3	7.4	7-9	1	4
1.9	2.8	2.0	2.0		27.9	5.8	3.4	10-12	1	5
1.7		2.1	2.1		31.3	1.6	2.2	13-15	0	1
		1.8	2.2		33.6	2.2	11.8	16-18	0	0
		1.9	1.9			4.0	12.6	19-21	0	0
		2.0	1.9			2.1	12.7	22-24	0	0
		2.0	2.0			1.9	14.0	25-27	0	2
		2.0	1.5			2.2	10.9	28-30	0	0
		1.8	1.6			2.0	1.9	31-33	0	2
		2.0	2.2			2.0	2.3	34-36	0	0
		1.8	2.2			47.2		37-39	0	1
		1.6	2.4					40-42	0	0
		1.8	1.8					43-45	0	0
		1.9	2.2					46-48	0	1
		1.8	2.5							
		2.2	1.8							
		2.3	3.0							
		2.1	2.2							
		1.8	2.4							
		1.6	2.5							
		2.0	1.9							
		1.9	1.9							
		1.7								
		2.2								
		2.1								
		1.8								
		1.7								
		2.4								
		2.3								

	6 April 1977	30 July 1977
$\bar{x}$	2.25	10.63
s	1.46	12.25
n	64	34

APPENDIX 4.4.29. SHELL LENGTH AND WEIGHT MEASUREMENTS FOR CLINOCARDIUM NUTTALLII AT GLACIER SPIT, CHINITNA BAY

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
6 April 1977											
2.0	0.005	-	1.6	0.002	-	9.2	0.1	-	1.9	0.004	-
			2.1	0.01	-				1.9	0.004	-
			2.4	0.01	-						
			2.8	0.01	-						
30 July 1977											
9.6	0.18	-	1.8	0.005	-	8.7	0.15	-	2.2	0.005	-
2.3	0.01	-	11.5	0.34	-	2.0	0.005	-	11.8	0.44	-
27.1	3.70	0.96	39.9	9.83	3.0	47.2	25.50	9.73	1.9	0.005	-
			27.9	3.32	1.30				2.3	0.005	-
			31.3	7.01	2.23				-	2.10	-
			33.6	7.79	2.49						

Wet tissue weight:whole wet weight ratio = 0.34

APPENDIX 4.4.30. SHELL LENGTH (MM) DATA FOR <u>PSEUDOPYTHINA</u> SP. FROM GLACIER SPIT, CHINITNA BAY

6 April 1977						30 July 1977					
+3.6'	+2.5'	+0.9'	-1.2'	Size Class	Number	+3.6'	+2.5'	+0.9'	-1.2'	Size Class	Number
1.5	3.6	1.9	3.8	1.0-1.9	8	12.9	11.9	2.5	3.3	1.0-1.9	0
1.7	1.9	2.1	4.9	2.0-2.9	16	11.2	2.7	2.3	3.5	2.0-2.9	11
2.5	3.4	2.1	2.0	3.0-3.9	13	2.7	3.0	4.2	3.8	3.0-3.9	12
2.4	4.7	2.0	3.3	4.0-4.9	10	4.4	4.3	3.3	4.4	4.0-4.9	10
4.1	3.7	2.9	4.0	5.0-5.9	0	2.9	4.2	2.4	4.6	5.0-5.9	1
3.5	4.2	3.4		6.0-6.9	0	2.9	6.1	4.3	3.9	6.0-6.9	2
3.4	2.6	2.7		7.0-7.9	0	3.3	3.6	4.0	5.4	7.0-7.9	0
2.9	3.7	4.7		8.0-8.9	0		11.7	4.0	3.7	8.0-8.9	1
1.8	2.4	3.8		9.0-9.9	0		6.7	3.8	2.0	9.0-9.9	1
	2.7	3.0		10.0-10.9	0			9.2	10.0	10.0-10.9	1
	11.9	1.7		11.0-11.9	1			4.5	2.1	11.0-11.9	3
	1.8	2.0		12.0-12.9	0			2.1		12.0-12.9	1
	4.1	2.0		13.0-13.9	0			3.1		13.0-13.9	0
	4.2	2.8		14.0-14.9	0			16.2		14.0-14.9	0
	2.2	4.3						2.0		15.0-15.9	0
	1.6	3.4						3.7		16.0-16.9	1
		3.2						8.9			
		4.4									

	6 April 1977	30 July 1977
$\bar{x}$	3.18	5.04
s	1.60	3.37
n	48	44

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ANNUAL REPORT

Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System

James E. Blackburn

Peter B. Jackson

Alaska Department of Fish & Game

P.O. Box 686

Kodiak, Alaska 99615

March 31, 1979

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INTRODUCTION

General Nature and Scope of Study

This study is in part a survey of the nearshore finfish and commercial crab resources and food habits of lower Cook Inlet. The study is to evaluate impact of oil development in the final report. Field collections and available data are to be drawn upon as source material. Field collections were collected primarily in the northern half of Kamishak Bay with some effort in Kachemak Bay in April and October of 1978. This study is only one of a coordinated set of studies of several aspects of the Cook Inlet system which include bird, mammal, benthic invertebrate, plankton and several other studies by OCSEAP investigators.

At the present time field collections are completed, key punching is completed and initial computer runs of data have been completed. Mapped information on fisheries is partially complete. This progress report presents only a few generalities which could be drawn from the data.

Specific Objectives

1. Determine the feeding habits of principal life stages of dominant pelagic and demersal fish and provide an initial description of their role in the food web.

2. Describe the distribution and relative abundance of pelagic and demersal fish and their seasonal changes.

3. Identify areas of unusual abundance or of apparent importance to fish, especially commercially important species.

4. Review all past information on the fisheries in lower Cook Inlet including commercial and sports catch statistics in order to determine the past and future trends in the importance of these species and to define the geographical and seasonal locations of fishing areas.

5. Define the geographical locations and seasonal use of spawning areas to the highest resolution possible.

6. Identify the geographical and seasonal locations of important prey.

7. Describe and evaluate the potential for impact on commercial, potentially commercial, and sports fisheries by OCS oil and gas explorations, development, and production based on the findings of the above six objectives plus existing information on the sensitivity of various life stages of these species, and geographical areas of potential risk.

Relevance to Problems of Petroleum Development

Oil exploration in the Cook Inlet lease area constitutes a potential for environmental degradation and it is a legal requirement of the leasing agency, Bureau of Land Management (BLM), to consider this potential as a part of the cost of leasing. This study was funded by BLM as a part of the program to satisfy their requirements.

Study of the living marine resources of Cook Inlet is an especially pertinent portion of the pre-lease studies as the livelihood of the vast majority of the people of this area is based upon the harvest of renewable resources.

Acknowledgements

The personnel of the OCSEAP Juneau Project Office contributed considerably to the planning and execution of this study, especially George Lapiene and Paul Becker. All vessel support and field camp support was arranged by them.

The employees that conducted the sampling did a fine job and they were Jay Field, crew leader, Jim Sicina, Dan Locke, Robert Sanderlin, Harry Dodge and Tom Bledsoe. Ms. Karen Anderson conducted all the food habits analysis and Bill Johnson created the computer routines to analyse the data.

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office.

CURRENT STATE OF KNOWLEDGE

In the lower Cook Inlet area previous survey type data on marine resources is largely lacking. The National Marine Fisheries Service (NMFS) has conducted approximately 85 otter trawl hauls in Cook Inlet during 1958, 1961 and 1963, however, they were rigged for shrimp or crab and operated only between mid-July and late September. Various fisheries have existed in the inlet for some time and information based on these fisheries has been accumulating. The salmon fishery is conducted in summer, throughout the inlet, with local concentrations of effort and fish. The herring fishery has been active in Kachemak Bay, Kamishak Bay and in the vicinity of the Forelands. Rounsefell (1929) documented this fishery in Kachemak Bay in the early part of the century, however, due to fluctuations in price and stocks, this has not been a continuous fishery.

Halibut have been fished in Kachemak Bay, Kamishak Bay and to some extent around Kalgen Island. The International Pacific Halibut Commission conducted 26 otter trawl hauls in July of 1974 and 1976 in the mouth of Kachemak Bay as part of their work to index rearing stocks. The trawl shrimp fishery has been active but restricted to Kachemak Bay. Shrimp research has included fishery documentation and since 1971, trawl surveys have been conducted in May to index stock abundance (Davis 1976a).

The king and tanner crab fisheries have been active in Kachemak Bay and in the central inlet southeast of Augustine Island. In 1974, a pot index program for king and tanner crab abundance was initiated in Kachemak Bay and in 1975 the program was expanded to the Kamishak Bay area (Davis 1975, 1976b). Other fisheries include Dungeness crab and pot shrimp (those caught by pot as opposed to trawl) which are largely restricted to Kachemak Bay. Sport fisheries include king salmon and razor clam, which are largely restricted to the east side of the inlet between Anchor Point and the Forelands.

A compilation of existing information on the Cook Inlet fisheries was prepared by the Alaska Department of Fish and Game under a program funded by the Federal Coastal Zone Management Program Development Funds (ADF&G 1976). This work included a written narrative and a portfolio of mapped data. The narrative included characterizations of each fishery and tabularizations of statistical data. Historical catch, effort, economic value, and escapement statistics were included. The map section included distribution mappings for all significant finfish and shellfish species, major fishing areas for all commercial species, critical salmon and shellfish spawning areas by species, where known, and shellfish rearing areas by species, where known.

A study of the effects of oil on biological resources was funded by the State of Alaska as a result of public concern over Alaska's 28th Oil and Gas Lease Sale of subtidal land in Kachemak Bay. These studies included the fishery resources, birds, coastal morphology, circulation and a synthesis of the impact of oil on the Kachemak Bay environment (Trasky et. al. 1977).

The studies initiated in 1976 under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) were hastily assembled and were faced with a paucity of data concerning what to expect. The scope was broad: as much of the inlet as could be physically covered efficiently. Sampling was conducted with beach seines and surface tow nets from the east Forelands to Port Graham on the east side of the inlet and from Amakdedori Beach to Chinitna Bay (with a few samples further north) on the west side of the inlet. Surveys were repeated monthly during June through September of 1976. An otter trawl was successfully used in the central portion of the inlet during June, July, August, September 1976 and March 1977. A power purse seine and gill nets were used to study pelagic fish during July, August and September 1976. A number of conclusions resulted from this study as did some questions (Blackburn, 1978).

Since this project was initiated the lease area has been expanded into Shelikof Straits. Information on resources in Shelikof Straits is quite limited. Ronholt et. al. (1978) have gathered together the results of all past NMFS trawl surveys in the north Pacific area, including those conducted in Shelikof Straits and lower Cook Inlet. From this report general species abundance can be obtained but distributional features within Shelikof are not clear.

Commercial fishery catch statistics for Shelikof and lower Cook Inlet are being assembled from ADF&G information and these data will be presented in the final report. Certain highlights are clear. Tanner crab catches are concentrated around Cape Douglas, in Kachemak Bay, in Viekoda Bay-Kupreanof Strait and in the south of Shelikof. King crab catches are similarly concentrated but around Cape Douglas they are further north. Dungeness crab catches are greatest in outer Kachemak Bay and along both shorelines of Shelikof Strait. Shrimp fisheries have been most active in Kachemak Bay, Kukak Bay, Uganik Bay, Uyak Bay, Wide Bay and Puale Bay. Herring are known to spawn in virtually every bay on the west side of the Kodiak archipelago, in Kukak Bay, Kamishak Bay, Kachemak Bay and near the Forelands, where fisheries exist. Salmon use virtually every river and stream in the area, catches are widely distributed and the entire area is used by migrating fish. The expanding bottomfish fishery is catching walleye pollock and fewer Pacific cod in central Shelikof at very high catch rates from a relatively large, dense aggregation of these fish. Catch rates of 1000 to 5000 lbs. per hour have been documented. Further information will be presented in the final report.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

The field collections for this study were made in part of Kachemak Bay and northern Kamishak Bay. The work in Kachemak Bay was conducted continuously from May through September. Collections were made with beach seine, try net, gill net, trammel net, and surface tow net. These are described in detail below. Temperature and salinity were measured with a Yellow Springs Instrument Co. Model 33 Temperature/Salinity meter.

The field crew consisted of four people who were housed in camp facilities in Cottonwood Bay during May through September. During April and November they stayed in Homer and the Kasitsna Bay field station respectively. Two outboard skiffs, one 17 ft. (5 m) and one 21 ft. (6.4 m) in length were continuously used for sampling and the M/V HUMDINGER was irregularly available for tow net and try net sampling beginning in May.

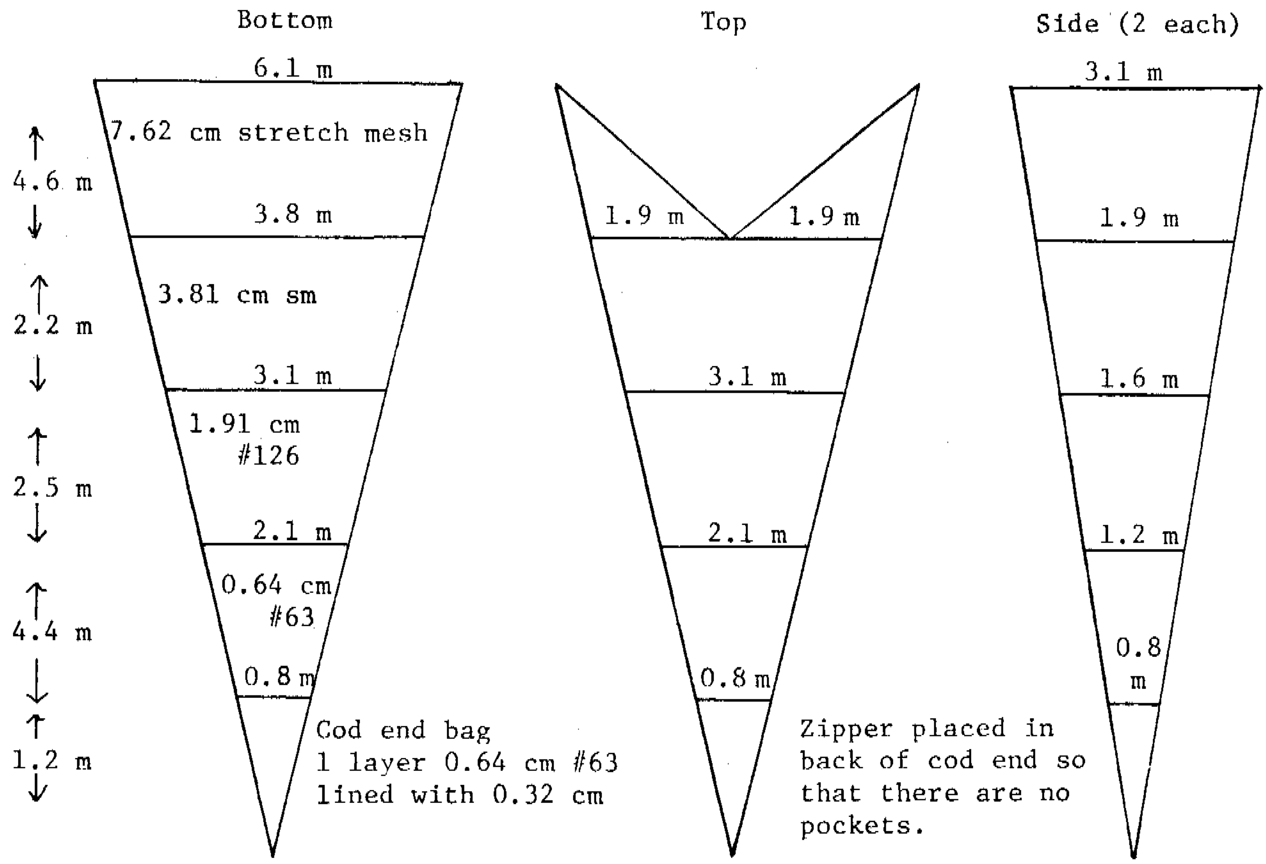
Beach Seine

The beach seine was constructed as shown in Figure 1. Approximately 50 ft. (15 m) of rope was attached to each end with one small anchor. The net was set in an arc such that each end of the net was usually within 10 ft. (3 m) of the beach and the net was immediately retrieved. Sampling stations were informally selected on suitable beaches so as to evenly cover the study area. Once stations were selected, they were visited on each successive cruise.

Try Net

The try net was a standard 20 ft. (6.1 m) try net purchased from McNeir Net and Supply Co. It had a 22 ft. (7 m) foot rope, a 20 ft. (6.1 m) was made with 1-1/2" (38 mm) #18 bag and was dipped in green gard. Otter boards were 15: X 30" (38 cm x 76 cm). It was equipped with a tickler of 3/8" (9.5 mm) chain which was slightly shorter than the footrope so that it preceeded the footrope when the net was in operation. It was pulled at about 3.5 kph so that about 0.6 km were covered in one tow. The net was considered to open about 5.3 m horizontally and 0.7 m vertically so that one tow covered about 3200 m^2. Sampling stations were selected in the field.

TOW NET



BEACH SEINE

Knotless nylon throughout

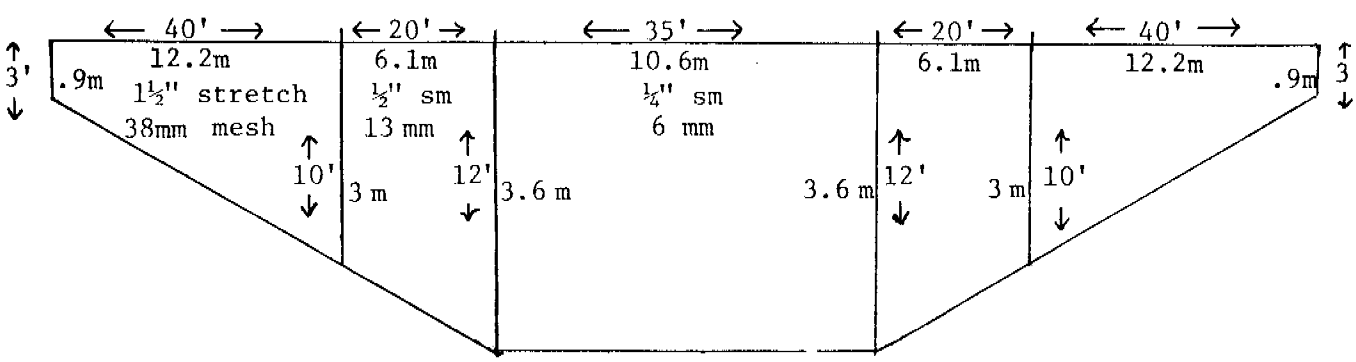


Figure 1 . Specifications of the tow net and beach seine, diagrammatic.

Gill Nets

Gill nets were 6 ft. (1.8 mm) deep and 100 ft. (30.4 m) long and each consisted of 25 ft. (7.6 m) long panels of 1", 1-1/2", 2" and 2-1/2" (25 mm, 38 mm, 51 mm and 64 mm) stretch mesh knotted nylon. The nets were hung to float, were anchored in the immediate vicinity of beach seine stations and retrieved after about a one hour soak.

Trammel Nets

The trammel nets were constructed of three adjacent panels (two outer and one inner) each 150 ft. (45.7 m) by 6 ft. (1.8 m). The two outer panels were made with 20" (0.5 m) stretch mesh of #9 twine 8 mesh deep by 168 mesh long. The single inner panel was 2" (51 mm) stretch mesh of #139 twine, 68 mesh deep by 2016 mesh long. All panels were white knotted nylon. The lead line was 75 lb. lead core rope and the floatline was 1/2" (13 mm) poly foam core line.

The trammel nets were hung to sink and were fished on the bottom. A single net was anchored in the immediate vicinity of a beach seine station and was retrieved after approximately a one hour soak.

Tow Net

The tow net was constructed as illustrated in Figure 1. It was held open vertically by spreader bars of 2" (51 mm) galvanized water pipe and was held open horizontally by a towing vessel on each side. It opened approximately 10 ft. (3 m) vertically and 20 ft. (6.1 m) horizontally when fishing. It was towed at the surface between a skiff and the charter vessel on approximately 100 ft. (30.4 m) of line for 10 minutes at approximately 3.5 kph so that about 0.6 km were covered in one tow. Sampling stations were informally selected to cover the study area.

Sample Handling

Immediately after capture, catches were sorted to species when possible, counted, weighed and recorded. Life history stage was recorded when it was possible to determine and for some species the catches were sorted by life history stage, i.e. adult, juvenile and larval. The stomach was removed from large fish after they were weighed, measured and the data recorded. Small fish were preserved whole for food habits analysis and lengths of these were not taken in the field. Lengths were recorded from a large portion of the fish that were not used for food habits analysis.

Maturity state of adult fish was recorded when they were opened for stomach removal and in some cases samples of fish were opened expressly to determine maturity state. When sex products were observed to flow freely from fish this was recorded. Due to the lack of knowledge of the appearance of the gonads before and after spawning for the many species handled, the maturity state observations are considered of value only when freely flowing sex products were observed.

Food Habits Analysis

Specimens for food habits analysis were selected from those captured using the list of priorities and maximum number per cruise shown in Table 1 . The total time available for food identification was allotted by cruise and as many specimens were examined as time allowed. During the sample analysis the project was extended and due to State of Alaska employment rules, the time available could not be extended without an extended delay, hence available time was less for analysis of later cruises.

Table 1. Priority list for selection of specimens for food habits analysis.

PRIORITY		Maximum number analyzed per cruise
1	Sandlance	25
2	Herring	25
3	Dolly Varden	25
4	Chum Salmon Fry	25
5	Chinook Salmon Fry	15
6	Red Salmon Fry	15
7	Coho Salmon Fry	15
8	Pink Salmon Fry	15
9	Whitespotted Greenling Juvenile	15
10	Whitespotted Greenling Adult	10
11	Masked Greenling Juvenile	15
12	Masked Greenling Adult	10
13	Capelin	20
14	Eulachon	5
15	Longfin Smelt	10
16	Great Sculpin	20
17	Yellowfin Sole	10
18	Starry Flounder	10
19	Rock Sole	10
20	Staghorn Sculpin	10
21	Pollock	10
22	Pacific Cod	10

Food habits analysis began with determination of the length, in mm and weight to the nearest 0.01 gm for fish less than about 300 gms and to the nearest 0.1 gm for larger fish. The stomach was removed, its fullness estimated and the weight of the total contents was determined to the nearest 0.01 gm. The gut contents of many of the small fish, especially the salmon, was so small that this was inadequate. The food items were separated, identified to the lowest possible taxon, counted and the weight determined by weighing or by estimated proportions.

STUDY AREA

Cook Inlet receives the waters of several substantial rivers including the Susitna, Matanuska, Knick, 20-mile, Kenai and Kasilof. These and others are glacier fed and contribute sufficient suspended material to the inlet that the entire upper inlet and a substantial portion of lower Cook Inlet contains intensely silty waters. The shorelines around Anchorage and into lower Cook Inlet consist of vast deposits of silt. Apparently, considerable areas of the bottom of lower Cook Inlet are covered by sand, which may be of overriding importance in the ecology of considerable portions of the inlet.

Water flow in lower Cook Inlet is dominated by tides and generally follows bathymetric contours. Tidal current velocities exceed 4 knots in the central and lower inlet and exceed about 7 knots at the Forelands. The central part of lower Cook Inlet is a region of high tidal energy, especially on the eastern side but the Coriolis effect results in reduced tidal energy on the west side. Several features of mean flow (non-tidal) are disputed but marine water enters through Kennedy Entrance and part of it exits through Shelikof Strait. Highly silty fresh water enters in the upper inlet, flows out primarily along the west side in the lower inlet and replacement inflow of entrained marine waters flows north along the east side of the inlet. The waters of Kachemak Bay are exchanged little with the water of the inlet (Science Applications Inc. 1977).

Lower Cook Inlet is virtually all less than 50 fathoms deep and a large portion is less than 30 fathoms. Shelikof Strait, however, is mostly all deeper than 100 fathoms.

Samples for this study were collected in Kachemak Bay during April and October and from Kamishak Bay during May through September 1978.

RESULTS

The collections from summer 1978 have yielded a considerable volume of data on fish catches, sizes and food habits. This data has been keypunched, proofed, edited and the analysis programs have nearly all been run in the last week. Unfortunately, there is not sufficient time to analyze and discuss the data for this report, but a brief summary of catches and some observations are included.

The beach seine catches were 29% sandlance (% of counts or numbers captured) 25% herring (mostly larvae) 10% chum salmon (mostly juveniles), 8% Dolly Varden, 6% pink salmon (mostly juveniles) and less than 5% longfin smelt. The gill net catches were 43% juvenile and adult herring (% of numbers captured), 17% adult chum salmon, 16% Dolly Varden and 6% Bering Cisco. The trammel net catches were 25% herring (% of numbers captured) 25% whitespotted greenling, 11% sturgeon poacher, 10% yellowfin sole, 5% staghorn sculpin and 5% masked greenling. Surface townet catches were 49% herring (mostly larvae; % of numbers captured), 30% sandlance, 7% capelin and 3% whitespotted greenling young-of-the-year. Try net catches were 39% yellowfin sole (% of weight captured), 23% tanner crab, 9% butter sole, 8% flathead sole, 3% halibut, and 2% rock sole.

As reported in the September quarterly report, temperatures in Kamishak Bay were relatively high. Temperatures were greatest during August, when average daily observations at the beach seine locations ranged from 12.0 to 16.5° C and extremes were 11.5 to 17.0° C. Temperatures taken with tow net and try net samples were further offshore and were lower, ranging from 10.75 to 14.75° C during August, with mean temperatures around 12.5 to 14.0° C.

Temperature profiles were made at two offshore sampling locations on August 15, 1978, with the resulting observation that even at 14 m depth water was about 11.5° C (Table 2).

Table 2. Temperature profiles for two sample locations on August 15, 1978.

	LOCATIONS	
	59° 33' 15" N 153° 12' 00" W	59° 32' 15" N 153° 09' 00" W
Depth, m	Temperature C	Temperature C
0.5	12.2	13.0
1	11.9	12.9
3	12.0	12.4
5	11.8	12.1
10	11.5	12.0
14	11.5	11.4

These high temperatures undoubtedly are important to the ecology of the area. Tanner crab abundance appeared to decrease during summer as these temperatures may be lethal to this cold water species. Tanner crab probably moved to areas of cooler water during times of peak temperature.

The larvae of herring were captured virtually everywhere in Kamishak Bay in large numbers. The coves along the shoreline regularly yielded young-of-the-year herring that were considerably larger than those captured nearby in more exposed waters.

Sandlance, which is abundant in many marine areas of Cook Inlet and Kodiak and is an important link in the food web, appears to be in relatively low abundance in the Kamishak Bay area. Results of work in 1976 suggested that sandlance were in low abundance in Kamishak Bay and showed a lower growth rate in Kamishak Bay and the northerly portions of the inlet.

Try net catches consistently yielded fair numbers of juvenile halibut and Kamishak Bay is apparently important to this commercial species.

The rocky, kelpy habitat in Kamishak Bay is characterized by few species and low abundance, as reflected in low trammel net catches. The relative absence of kelp is undoubtedly important in this respect and has been shown by Simenstad et. al. (1978) to virtually dictate abundance of greenling. Simenstad et. al. (1978) found the presence or absence of sea otters to control the numbers of sea urchins which in turn control whether kelp is present or not. This is not the mechanism existent in Kamishak Bay. Other factors, perhaps environmental, keep algae abundance minimal.

SUMMARY OF JANUARY-MARCH QUARTER

During the January to March Quarter effort was directed to preparing computer routines for data analysis, editing data and gathering other information on fishery locations etc. as necessary for the final report. Arrangements were finalized for impact analysis aspects of the study to be completed by the ADF&G personnel in Habitat Protection.

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Annual Report

Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System

James E. Blackburn

Alaska Department of Fish and Game
P.O. Box 686
Kodiak, Alaska 99615

June 30, 1978

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SUMMARY

A total of 58 otter trawl hauls, 262 beach seine hauls, 215 surface tow net hauls, 18 purse seine hauls and 58 gill net sets were successfuly completed in lower Cook Inlet during the summer of 1976 and 18 additional otter trawl hauls were completed during March 1977. The predominant taxa captured in order of importance were Pacific sandlance, Pacific herring, Dolly Varden, pink salmon fry, smelt (primarily longfin and surf smelt) and juvenile greenling (primarily whitespotted and masked greenling) in the beach seine; they were the same in the surface tow net except for the absence of Dolly Varden; Pacific herring and chinook slamon juveniles in the purse seine and gill net; and snow crab, walleye pollock, yellowfin sole, yellow Irish Lord, rock sole, Pacific halibut, Pacific cod, buttersole, king crab and great sculpin in the otter trawl. Features of temporal and spatial distribution and comments on growth and food habits are presented.

The larger sizes of nearly all demersal fish were more common at greater depths and the smaller fish were more common at shallower depths, indicating that the youngest stages were shallowest and the depth of residence generally increased with age. During winter nearly all demersal fish apparently moved to deeper waters although areal displacement (as opposed to depth displacement) was an important winter feature for some species.

The CPUE of demersal fish was distinctly lower in areas where bed forms (sand waves and dunes) have been reported by other investigators.

The food habits of 239 fish specimens of 14 species (2 cod, 4 sculpins, and 8 flounders) were examined to some extent from both lower Cook Inlet and Kodiak (Blackburn 1978). On the basis of percent occurrence in the two sampling areas, the predominant prey taxon was caridean shrimp, principally the pandalid species *Pandalus borealis* and *P. goniurus* and crangonid species. Fishes were the second most important prey taxon, with capelin and stout eelblenny the commer identifiable species.

INTRODUCTION

This study was intended to document the use of lower Cook Inlet by fish and shellfish and its use by the fishery. Few such studies have been done in Alaska and there has been very little work conducted in lower Cook Inlet, except in Kachemak Bay.

This study was designed to sample virtually all the depth zones and habitats within lower Cook Inlet with the practical limitation of a limited budget in this large and logistically difficult area to work. Beach seines and surface tow net were used from 17' Boston Whalers to cover the shoreline to 3 m deep and the surface 3 m in the less than 18 m depth zone. A power purse seine was used to sample the surface beyond 18 m depth and an otter trawl was used to sample the bottom community at depths beyond 18 m.

The scope of the study, however broad, was affected by limitations of the gears. Sampling the shore zone on the west side of the inlet proved to be expensive since it required two Boston Whalers with a crew of four camping on the beach and the chartered vessel readily available for support. Thus, areas where the chartered vessel was working dictated the shoreline areas that were sampled.

The well known currents in lower Cook Inlet severely restricted areas where the power purse seine could be used just as weather affected the time that it could be used. The otter trawl was restricted by rocky bottom to a portion of the inlet south of $59^0 50'$N.

Specific Objectives

A. Determine the spatial and temporal (May-September,March) distribution, relative abundance and inter-relationships of the various pelagic and demersal finfish and shellfish species in the study area.

B. Determine when, where, at what rate and in what relative abundance pleagic fish species (primarily salmonids) migrate into and through the study area.

C. Determine the growth rate and food habits of selected pelagic and demersal fish species.

D. Survey the literature to obtain and summarize an ordinal level documentation of commercial catch, stock assessment data, distribution, as well as species and age group composition of various shellfish species in the study area.

E. Survey the literature to inventory and characterize salmon spawning streams as well as timing of fry and smolt migrations.

F. Obtain basic oceanographic and atmospheric data to determine any correlations between these factors and migrations and/or relative abundance of various pelagic and demersal fish and shellfish species encountered.

Relevance to Problems of Petroleum Development

Oil exploration in the Cook Inlet lease area constitutes a potential for environmental degradation and it is a legal requirement of the leasing agency, Bureau of Land Management (BLM) to consider this potential as a part of the cost of leasing. This study was funded by BLM as a part of the program to satisfy their requirements, however, the objectives, as stated in the previous section of this report, are oriented toward resource investigations. This is necessary and appropriate since many of the biological features of the lease area are poorly known, as stated in the section on Status of Knowledge, and since the various features of the community are inextricably interlinked.

Acknowledgements

Mr. Peter Jackson must be given the credit for planning and implementing this study. The time between funding and study implementation, little more than one month attests to the difficulties overcome. I also wish to thank him for the continuing guidance and encouragement. All of the accomplishments of this study are to the credit of Peter Jackson. The skipper, Adolph Curry, and crew of the M/V BIG VALLEY deserve considerable credit for the successful completion of this study. I would like to thank Wes Bucher who served very ably as assistant project leader and field crew leader. I express appreciation to the field crew that put up with the discomforts and collected all the data. They were Dave Anderson, Bob Mielke, Steve Pint, Don Seagren and Phil Smith. Equipment was loaned to the staff of this project by Alaska Department of Fish and Game, Coastal Habitat Protection, to enable an early start of work and their assistance is gratefully acknowledged. Mr. Henry Yuen kindly conducted the stomach analyses of pink salmon juveniles.

CURRENT STATE OF KNOWLEDGE

Alaska is unique in the United States in that it remains poorly reconnoitered, ichthyologically. Fish distributions, although a basic characteristic, are confusing and illogically discontinuous for many species. At the same time commercial utilization of several species is considerable and knowledge related to the fisheries is considerable. The knowledge of fish and shellfish resources of lower Cook Inlet is variable, but largely lacking.

The National Marine Fisheries Service conducted approximately 85 otter trawl hauls in Cook Inlet during 1958, 1961 and 1963, however, they were rigged for shrimp or crab and operated only between mid-July and late September. In addition, the International Pacific Halibut Commission conducted 26 otter trawl hauls in July of 1974 and 1976 in the mouth of Kachemak Bay.

Rounsfell (1929) documented the fishery and presented biological data for herring of the south Kenai Peninsula and Kachemak Bay. Alaska Department of Fish and Game has conducted research on invertebrate resources of lower Cook Inlet. In 1974 a pot index program for king and tanner crab abundance was initiated in Kachemak Bay and in 1975 the program was expanded to the Kamishak Bay area (Davis 1975 and 1976a). Tagging studies of Dungeness crab in Kachemak Bay were conducted in 1963 and 1975, providing migration and fishing mortality information (Davis 1976b). Shrimp research in Kachemak Bay has included fishery documentation and since 1971 trawl surveys have been conducted during May (Davis 1976c).

STUDY AREA

The study area for this project includes lower Cook Inlet from the Forelands to 59^{0}N latitude. Across Kennedy Entrance south of Pt. Bede it is bounded on the east by 152^{0}W longitude. This encompasses approximately 4400 square miles.

Cook Inlet receives the waters of several substantial rivers including the Susitna, Matanuska, Knick, 20-mile, Kenai and Kasilof. These and others are glacier fed and contribute sufficient suspended material to the inlet that the entire upper inlet and a substantial portion of lower Cook Inlet contains intensely silty waters. The shorelines around Anchorage and into lower Cook Inlet consist of vast deposits of silt. Apparently, considerable areas of the bottom of lower Cook Inlet are covered by sand, which may be of overriding importance in the ecology of considerable portions of the inlet.

Water flow in lower Cook Inlet is dominated by tides and generally follows bathymetric contours. Tidal current volocities exceed 4 knots in the central and lower inlet and exceed about 7 knots at the Forelands. The central part of lower Cook Inlet is a region of high tidal energy, especially on the eastern side but the Coriolis effect results in reduced tidal energy on the west side. Several features of mean flow (non-tidal) are disputed but marine water enters through Kennedy Entrance and part of it exits through Shelikof Strait. Highly silty fresh water enters in the upper inlet, flows out primarily along the west side in the lower inlet and replacement inflow of entrained marine waters flows north along the east side of the inlet. The waters of Kachemak Bay are exchanged little with the water of the inlet (Science Applications Inc. 1977).

Lower Cook Inlet is virtually all less than 50 fathoms deep and a large portion is less than 30 fathoms.

SOURCES METHODS AND RATIONALE OF DATA COLLECTION

The study area was artificially divided into the following areas according to the suitability of gear to that area. Beach seines were used to sample the littoral zone for pelagic and demersal fish. A surface tow net was used to sample the surface in water approximately 3 to 18 m deep. A small mesh purse seine and variable mesh gill nets were used to sample pelagic fish in surface waters over depths greater than 18 m and an otter trawl was used to sample demersal epifauna at depths greater than 18 m.

Otter Trawl (Fig.1 A-E)

A systematic random sampling scheme was chosen as the appropriate method of station selection as it was deemed desirable to be able to make population estimates from the data.

Otter trawling stations were initially chosen by gridding the entire study area deeper than 10 fathoms (18 M) into one nautical mile squares, and numbering the squares beginning in the northwest corner and progressing west to east and north to south. There were 3,337 such squares.

The first station was chosen by randomly selecting a number between one and ten, and every 95th square thereafter was designated as a station, yielding 35 sampling stations. This sampling intensity was based on estimated sampling rate and time available. Since initial trawl hauls resulted in torn nets and lost time due to rocky bottom, a field decision was made to redefine the sampling area to include only obviously trawlable areas. This redefinition of the trawl area to be considered was accomplished with the advice of local fishermen and resulted in a reduction of the size of the total area to 795 mi^2. A second field decision to reduce the total number of stations sampled per survey within this redefined area from 35 to 20 was necessitated by the excessive running time required between stations. Trawl stations within this redefined area (Figure 1) were selected by the same procedure originally employed. In order to expand the areal coverage additional stations were sampled as time was available.

Sampling was conducted with a 400 mesh eastern otter trawl with a 30 m footrope, 27 m headrope, and was 26 m in total length with a 4 m long cod end. The net was constructed with 4 inch mesh at the mouth and 3½ inch mesh in the body and cod end and had a 1¼ inch mesh cod end liner. There were 15 floats 20 cm in diameter on the headrope, and no tickler or rollers. The bridles were 9 m long and the doors were 2.7 m (9 ft) by 1.8 m (7 ft) Astoria V design. This net is considered to open 1.5 m high by 12.2 m wide. The net was pulled with a 3 to 1 scope for 20 minutes at 3 knots so that 1 nautical mile (1.85 km) was covered and 0.02261 km^2 were covered in each haul. When the net was brought to the surface, the cod end was retrieved with a lazy line and the catch was dumped in large tubs. Catches were sorted by species as possible and total weight and number of each species was obtained and recorded directly on the keypunch data form. Unidentified species were preserved for later identification. Stomach samples and lengths were taken from selected taxa.

Tow Net (Fig. 2)

The tow net sampled the surface pelagic fish in the 3 to 10 fathom depth zone and over deeper waters in the deep estuaries around Kachemak Bay. Stations were selected informally to cover the length of this area. The net was 9 ft by 9 ft by 27 ft long. It was made of an 8 ft forward section of 1½ inch mesh, a 9 ft midsection of ½ inch mesh, a 10 ft cod end of ¼ inch mesh with a 1/8 inch mesh liner in the last 2 ft and a zipper on the cod end. The net was held open vertically by spreader bars and horizontally by a towing vessel on each side. The net was pulled for 10 minute tows at approximately 3 knots by two 17 ft skiffs with 70 hp outboards using 20 m of cable. Catches were immediately sorted by species, counted weighed, recorded and samples preserved.

Beach Seine (Fig. 2)

The beach seine was 155 ft long by 12 ft deep in the middle and tapered to 3 ft deep at the ends and dyed green. It was constructed of knotless nylon throughout with 12 ft by 35 ft rectangular ¼ inch stretch measure (sm) midsection, two 20 ft long by 12 ft by 10 ft tapered inner wings of ½ inch sm and two 40 ft long by 10 ft by 3 ft tapered outer wings of 1½ inch sm. Approximately 50 ft lines with anchors were attached to each end. The net was set from the skiff by approaching the beach as closely as possible, tossing the anchor onto the beach, usually with 10 to 30 ft of line between the edge of the water and the end of the net. The net was set in an arc roughly parallel to the beach, the boat was beached and the net immediately retrieved by the two crew members. Catches were immediately sorted by species, counted, weighed, recorded and samples preserved.

Purse Seine (Fig. 1 F-G)

Purse seine locations were selected at five mile intervals along transects (Figure 1) located between major salmon spawning areas. This strategy was chosen to cover lower Cook Inlet and facilitate delineation of in and out migrants of major tributaries. The number of stations was based on an estimate of 9 sampling days each month and 4 sets each day.

The purse seine was 200 fm (366 m) long by 10 fm (18 m) deep. Mesh size was 1 1/8 inch sm throughout the body and 1 inch sm in the bunt. The seine was set in a circle and immediately pursed. This round haul procedure was utilized in preference to holding the net open at all stations. All catches were immediately sorted, identified, counted, weighed and recorded on fish resource format (file type 023) key punch data forms.

Gill Net (Fig. 1 F-G)

There were 4 monofilament and 4 multifilament experimental gill nets used. They were constructed of 8 ft by 25 ft panels with a total of 8 panels of 1 inch sm, 4 panels of 1½ inch sm, 8 panels of 2 inch sm, and 4 panels each of 2½ inch, 3 inch, 4 inch and 5 inch sm. These nets were fastened together and used as a unit. The nets were drifted for four hours, attached to the M/V BIG VALLEY. Catches were immediately sorted by species, counted, weighed, recorded and samples preserved.

Data Limitations[1]

The community of fishes observed during faunal surveys and the relative importance of species or species groups within the community is largely a function of the sampling tools employed. Trawls, beach seines, tow nets, purse seines and especially gillnets, as most gears employed to sample marine biota, are selective. Sizes and even species of fish captured are influenced by such features as mesh size used, gear configuration, towing speed and method of employment (beach seine may be set far from the beach and pulled to shore or with the ends nearly ashore, as it was in this study). Passive gear such as the gill net depends upon the activity of the fish to become entangled, and catches are affected by the sensitivity of the fish to the presence of the net, body size and shape, presence of spines, behavior and other features. Even species within the size range which theoretically would be retained if engulfed by an active net (towed net or purse seine),may differ in their ability to escape through the mouth of the net. The selective feature of all gears thus alter the species composition and sizes and quantities of species captured from that which occur in its path. The degree to which "apparent" distribution and relative abundance differs from the actual is unknown. Thus, it is important to note that subsequent discussions of distribution and relative abundance of species reflect the results obtained with the sampling gear employed.

Identification of several taxonomic groups was less than complete. In the trawl surveys sculpins were not all identified in the first two surveys and only in the August and March 1977 surveys were the infrequent sculpin taxa reliably identified. In the beach seine surveys 80%, 34%, 11%, and 15% of the sculpins were unidentified in June, July, August and September, respectively. Sea poachers were also a problem and probably only in the March otter trawl survey were the infrequent taxa reliably identified. Regardless of the field problems with identification the species list presented is based upon careful identification.

The beach seine and tow net each yielded large numbers of age 0 fish, including larval, post larval and early juvenile stages. The early stages were difficult to identify and too numerous for field crews to include them in the data. However, several of those species remained in abundance and grew to the point they could be identified and obviously must be included in the data. Thus, a difficulty arose in interpretation of data when a sudden increase in catch occurred over a relatively short time. These problems have been dealt with individually with the various species.

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[1] This section is adapted from a similar discussion for trawls by Alverson et al. (1964), p44-45.

RESULTS AND DISCUSSION (Tab. 1)

A total of 23 families and 77 species of fish were identified in lower Cook Inlet. The fish are listed in Table 1 and the corresponding common and scientific names are given.

Several records apparently constitute range extentions. The Bering wolffish has been previously reported from the Bering Sea but not from the Pacific Coast of North America (Andriyashev 1954; Quast and Hall 1972; Wilimovski 1958). The leatherfin lumpsucker has been previously reported from the Arctic Ocean (Andriyashev 1954), arctic Alaska (Wilimovski 1958) and from the Sea of Japan to the Chukchi Sea and beyond through arctic waters by Quast and Hall (1972). The Aleutian alligatorfish has been previously reported from the Bering Sea and as far east as Kodiak (Quast and Hall 1972; Wilimovski 1958). The northern spearnose poacher has been previously reported from southeast Alaska to California (Wilimovski 1958) and as far north as the northern Gulf of Alaska (Quast and Hall 1972). And *Eurymen gyrinus*, a sculpin has been previously reported from the Bering Sea and east to Kodiak Island (Quast and Hall 1972; Wilimovski 1958).

Distribution of Effort (Tab. 2)

The distribution of sampling effort was affected by various constraints, especially time and weather, and there were some differences between successive months that are worthy of note since they affect the interpretation of the results. The number of successful hauls of each gear type by month is presented in Table 2.

Otter Trawl (Fig. 1)

The otter trawl stations sampled each month are presented in Figure 1. The most obvious feature being the lack of coverage of the southern stations during June and September. In addition, there was one station between 26 and 50 m during each of the summer months and this was alternately on the west and east side each month.

Purse Seine and Gill Net (Fig. 1)

The purse seine was received in late June and employed with minimal success during July and August at the locations indicated in Figure 1. The gill nets were employed during September as an alternative to the purse seine at the locations indicated in Figure 1. No samples were made in March.

Beach Seine and Tow Net (Tab. 3, Fig. 2)

The beach seine and tow net were used at the locations indicated in Figure 2. The number of hauls by month and general area for beach seine and tow net is given in Table 3. No samples were made in March.

In Kachemak Bay sampling was initiated on May 20 with both gear types. During May and June sampling was conducted with the tow net only in Bear Cove, Coal Bay, Sadie Cove and Tutka Bay while the beach seine was used in all areas except Sadie Cove. During July, August and September, virtually all stations in Kachemak Bay were sampled.

On the Kenai Peninsula southwest of Tutka Bay, samples were taken in early August and early September at virtually every station each month. On the eastside of lower Cook Inlet north of Anchor Point beach seining was conducted at all locations in June, July and August, tow netting was conducted at all locations in July and August but both gears were used only north of the Kenai River in September and early October.

On the westside of lower Cook Inlet beach seining was conducted at nearly all the indicated stations each month except south of Iliamna Bay in June, north of Oil Bay in August and south of Bruin Bay in September. Tow netting was not conducted in June while in July it was conducted south of Bruin Bay and between Ursus Head and Chinitna Bay. In August and September tow netting was conducted between Iniskin and Bruin Bays and also north of Chinitna Bay in September.

Relative Abundance (Tab. 4,5,6,7,8)

The numerically predominant taxa captured in the beach seine were Pacific sandlance, Pacific herring, Dolly Varden, pink salmon fry, smelt (primarily longfin and surf smelt) and juvenile greenling (whitespotted and masked; Tables 4 and 5). By weight, Dolly Varden clearly rank as predominant.

The numerically predominant taxa captured in the tow net were Pacific sandlance, Pacific herring, pink salmon fry, longfin smelt, juvenile greenling and 3 spine stickleback (Tables 4 and 6).

The numerically predominant taxa captured in the purse seine and gill net were Pacific herring and chinook salmon juveniles (Table 7). The purse seine and gill net were strongly selective for larger sized fish and against the smaller pelagic fishes which were sampled by the tow net.

The predominant taxa, by weight, captured in the otter trawl were snow crab, walleye pollock, yellowfin sole, yellow Irish Lord, rock sole, Pacific halibut, Pacific cod, buttersole, king crab and great sculpin (Table 8).

The predominant taxa captured in the otter trawl were very different between general areas and thus both station selection and the vagaries of weather and time that limited the coverage of the stations each month strongly affected the relative abundance.

Distribution of Total Otter Trawl Catch (Tab. 9, Fig.3,4)

The otter trawl catch per unit of effort (CPUE; the standard effort was a 20 minute tow) of fish in lower Cook Inlet varied considerably between areas (Figure 3) and appeared to be strongly related to the distribution of bed forms (sand waves, ridges and dunes, called sand waves below; Bouma et al. 1977, Figure 4). The greatest CPUE's occurred oceanward of the area where the sand waves occur, while CPUE within the sand wave area (stations numbered 1 through 9 except 6 in Figure 4) ranged from 3.0 to 166 kg of fish with a mean of 39.8 $\pm$ 6.4 kg of fish (n=28). The CPUE outside of the sand wave area ranged from 1.0 to 283 kg of fish with a mean of 87.8 $\pm$ 10.7 kg of fish (n=48). Within the sand wave area the smallest mean CPUE (12.3 $\pm$ 3.0 kg of fish) occurred at the station in the area of largest sand waves (station 7 of Figure 4) and the largest mean CPUE (82.2 $\pm$ 45.5 kg of fish) occurred in an area of no sand waves but surrounded by them (station 9 of Figure 4).

At the northern most station (station 1 of Figure 4) sand waves were not indicated as present but CPUE was low; 32.7 ± 12.2 kg of fish for three summer tows. At this location the currents were sufficiently strong that sampling was difficult; on at least one occasion the vessel with the net out and trawling was turned 120^0 by the currents. Although the currents may have affected sampling efficiency, it is probably more important that the environmental conditions for demersal life were severe.

The otter trawl CPUE's in the area of lower Cook Inlet which was not affected by sand waves were comparable to those (standardized to comparable area swept) reported from Shelikof Strait and less than those reported in the Kodiak area from surveys in 1961 and 1973-75 (Pereyra and Ronholt 1976). Direct comparison with Pereyra and Ronholt (1976) is difficult since they do not report total fish catch, however, the general comparison illustrates that the highest otter trawl catches in lower Cook Inlet are comparable to those in nearby areas but considerably less than those in the Kodiak area while the CPUE's in the sand wave area is considerably reduced from catch rates in surrounding oceanic areas.

The distribution of catches by depth (Table 9) was assembled without separation of sand wave and non-sand wave areas since the number of stations precludes further break down. There are no obvious trends in the data (Table 9) that lend themselves to discussion.

Spatial and Temporal Distribution and Growth

Pink Salmon Juveniles (Tab. 10,11,12, Fig.5)

Juvenile pink salmon were captured in 30 percent of the beach seine hauls and 22 percent of the tow net hauls. In numbers captured they ranked fourth in the beach seine and third in the tow net collections. Pink fry were captured throughout Cook Inlet but primarily during May, June and July.

On the east side of Cook Inlet north of Anchor Point beach seine catches of pink fry were smaller and less frequent than in other areas while tow net catches were comparable to those in other areas (Tables 10 and 11). The low catch of the beach seine may have been related to the gentle slope of the beach in this area which may have tended to keep fish beyond the zone fished effectively by the beach seine. The catch of the tow net in this area may have been positively affected by the generally muddy water, which the field crew insisted was important but for which there is no quantitative information. The relatively low tow net catch and high frequency of occurrence suggests that pink fry were more dispersed in this area than others. The tow net was not used in this area until July thus the spring abundance peak of pink fry was probably not sampled.

On the west side of Cook Inlet pink salmon fry were captured in 52 percent of the beach seine hauls and 8 percent of the tow net hauls. In this area the catch rate and frequency of occurrence were greatest in July in the beach seine and were greatest in August in the tow net (Tables 10 and 11). This is a much later peak abundance than was seen in any other area with the possible exception of the Kenai Peninsula south of Tutka Bay. The areas of greatest abundance were not sampled in June, but in all areas of Kamishak Bay where sampling was conducted in June, July and August, peak abundance was in July. The tow net catch rate was much lower on the west side than in other areas.

Greatest catches in the beach seine on the west side were made in Bruin Bay, Ursus Cove and Rocky Cove in July and in August. It is in these immediate areas that the producing streams are located. Tom Schroeder (personal communication) reported quite good returns of adult pinks to these streams (Sunday Creek, Browns Peak and Bruin Bay) in 1975.

In the Kachemak Bay area (as far west as Tutka Bay and Nubble Point) pink salmon outmigrants were captured in 20 percent of the beach seine hauls and 28 percent of the tow net hauls. The mean catch per haul was greatest during May-June for both gear types in this area (Table 11).

The Kenai Peninsula southwest of Tutka Bay was first sampled in early August. Pink salmon outmigrants were captured in 50 percent of the beach seine hauls in August but none were captured in the tow net (Tables 10 and 11). The beach seine catches in August and September in this area were the greatest that occurred during those months. The timing of catches in this area appear to be about the same as on the west side of Cook Inlet, however, sampling in this area was much less intense.

A more detailed analysis of the timing of migration of pink fry, though relying on few samples, thus less reliability, provides interesting parallels to documented patterns from other areas. In Kachemak Bay during late May to mid-June pink fry were abundant in beach seine catches and minimal in tow net catches (Table 12). During the last half of June beach seine catches decreased considerably and tow net catches increased considerably, indicative of movement into the offshore zone. The data definitely show that most of the juvenile pink salmon leave Kachemak Bay by late July (it is unlikely that they become able to avoid the gear since both beach seine and tow net catches decrease similarly), and they appear to leave the upper portion of Kachemak Bay earlier (Table 12).

Kron and Yuen (1976 ms) reported that most natural pink salmon fry migrated from Tutka Creek during the last three weeks of May in 1975. Stern (1977) added that pinks remain along shorelines for approximately 45 days then gradually move to open water areas within bays where they remain for approximately another 45 days.

Stern (1977) states that on Kodiak juvenile pinks are concentrated near the mouths of bays by August and September and departure from the bays is gradual, beginning in late June, peaking in August and lasting through September.

The evidence suggests that pinks move from shoreline to more open water in late June in Kachemak Bay and most juveniles then leave Kachemak Bay by late July, and possibly the upper portions of the Bay earlier. Pink fry also departed the northern portion of lower Cook Inlet earlier and were present in the southern and western portions later. Presence or distribution in waters more than a couple of miles from shore has not been determined.

The tow net catches tended to be greater in protected bays than in exposed areas. The long fjords of Tutka Bay and Sadie Cove yielded the greatest townet catches while small catches occurred in open waters of Kachemak Bay and infrequent or minimal catches were made in exposed areas such as the westside of lower Cook Inlet and the Kenai Peninsula southwest of Tutka Bay. Along the eastside of Cook Inlet north of Anchor Point, tow net catches were frequent and modestly large, however, the muddy water in this area may have affected their distribution and catchability and it was at least a very different habitat so that catch differences may be expected.

Beach seine catches, however, were not as clearly related to degree of exposure of a site. Larger beach seine catches may have been related to proximity of a source stream, which on the westside of Cook Inlet appeared to be the case.

Stern (1977) citing work around Kodiak by Tyler (1976 ms) stated that juvenile pink salmon that leave streams entering protected waters remain in those waters for several months and it is suspected that juvenile salmonids that leave streams along unprotected shorelines move directly offshore.

Apparent growth of pink fry was approximately 0.67 mm per day (Figure 5). A much greater growth rate, 1.05 mm per day, was reported for pink fry on Kodiak by Harris and Hartt (1977).

The northern portion of lower Cook Inlet produces a major portion of the pink salmon in Cook Inlet. The Kenai and Kasilof rivers contribute substantially as do other rivers north of the Forelands, however, reliable escapement estimates in the various rivers are not available (ADF&G 1976). The pink adults are much more abundant on even years in the northern portion of Cook Inlet thus the fry would be much more abundant on odd years (ADF&G 1976).

Pink salmon returning to streams in Kamishak Bay are more abundant on odd years so that sampling in this study coincided with a peak year and fairly good returns. Kamishak Bay streams produce only a small portion of lower Cook Inlet pink salmon, however.

Pink salmon adults returning to streams in Kachemak Bay do not show annual dominance in run size. The majority of pink salmon production in the Kachemak Bay area originates from Humpy Creek, Tutka Creek, Seldovia Creek and Port Graham with 25 percent, 5 percent, 20 percent and 50 percent, respectively, of the 90,000 to 120,000 total guideline escapement to these four streams returning to each (ADF&G 1976). The pink salmon return to Kachemak Bay is only a small portion of the Cook Inlet return.

Red Salmon Juveniles

A total of 72 red salmon smolt were captured, most of them in the beach seine, on the westside of lower Cook Inlet in July. Catches occurred in Iniskin Bay, Ursus Cove, Rocky Cove and at Amakdedori Beach. There are several minor spawning streams for red salmon in Kamishak Bay but by far the major streams for reds are in the northern portion of the inlet (ADF&G 1976).

Chum Salmon Juveniles (Fig. 6)

A total of 208 chum salmon fry were captured, all but three occurred in beach seine catches and all but eight occurred on the westside of lower Cook Inlet. They were captured from Chinitna Bay to Amakdedori Beach with greatest catches occurring in Iniskin Bay, Iliamna Bay, Ursus Cove and just north of Bruin Bay. Chum salmon spawning streams are located in this area and likely contributed significantly to the catch. Both mean catch and frequency of occurrence increased to a peak in August and then sharply decreased in September.

Growth of juvenile chum salmon was apparent mainly in the increase in maximum size of fish captured as the summer progressed (Figure 6). Fish as small as 40 mm continued to be captured as late as mid-August, indicative of emergence for perhaps as much as two months or more. The progression of both maximum size and minimum size after mid-August suggests a growth rate of about 1 mm per day. This growth rate is comparable to that reported for pink salmon fry near Kodiak (Harris and Hartt 1977).

Walker (1968 ms, as cited in Stern 1977) reported that juvenile chum salmon appeared to stay nearshore longer than pinks. Although the data from the present study admittedly is meagre, with only 208 chum fry captured, no support for this hypothesis can be found. The proportions of fish captured in beach seine and tow net may serve as a crude indicator of relative amount of time spent nearshore (time available to capture by the beach seine). Data from throughout the inlet show that the proportion of pinks captured in the tow net was much greater than the proportion of chums captured in the tow net but when only the area in which chums occurred, the west side, is considered, the proportion captured in beach seine and tow net is identical for pinks and chums.

Chinook Salmon Juveniles

Chinook salmon juveniles were the second most abundant of the Pacific salmon captured. They occurred in greatest numbers in beach seine hauls, however, the tow net and purse seine yielded small catches of them.

Beach seine catches were greatest during May-June and decreased in each succeeding month. Seasonality for this species is not clear in the catch of other gear types.

Kachemak Bay yielded most of the chinook with over 50 percent of the total catch by all gear occurring in 2 beach seine hauls in Halibut Cove in late June. On the westside of lower Cook Inlet in July 2 - 4 juvenile chinook occurred in each of 5 tow net hauls within about a mile of the mouths of Iniskin and Iliamna Bays. On the eastside of lower Cook Inlet north of Anchor Point chinooks were scattered.

Chinook juveniles were the most abundant salmonid captured in the purse seine. Their occurrence was not concentrated in any area or time in this gear. They occurred in nearshore and mid-inlet stations with the two largest catches occurring 8 and 11 miles from the west shore of the inlet.

Coho Salmon Juveniles

Juvenile coho salmon ranked fourth in abundance among the five Pacific salmon. They occurred almost exclusively in the beach seine with greatest numbers captured in Kachemak Bay, however, this is due largely to two catches which yielded 58 percent and 14 percent of the total catch of this species. Juvenile coho were captured in 24 percent of the beach seine hauls along the eastside north of Anchor Point, a much greater frequency of occurrence than in any other area or gear. No distinct seasonality was apparent in the catches.

Dolly Varden (Tab. 13)

Dolly Varden were the third most numerous species captured in the beach seine but only one individual was captured in the tow net. They occurred in all areas of lower Cook Inlet at all times, however, there was a prominent seasonality, with CPUE much greater in May-June and July than in August or September (Table 13).

The CPUE was similar in each of the four major areas of lower Cook Inlet except on the Kenai Peninsula southwest of Tutka Bay in August and September where CPUE was much greater (Table 13).

The coefficient of variation followed a similar pattern in each area; it was lowest in July and greater both earlier and later indicating that the distribution was more uniform during July than at other times.

Average weight of Dolly Varden was markedly and consistantly greater on the east side of Cook Inlet north of Anchor Point than any other area sampled. Dolly Varden averaged over 500 grams each in this area in July with individual catches averaging over 1 kg. near the mouth of the Anchor River. Total catch of Dolly Varden on the east side was greatest between Cape Ninilchik and Anchor Point. In all areas the average weight of Dolly Varden was greatest in mid-summer, July and early August, and less both earlier and later.

Dolly Varden were widely distributed within Kachemak Bay but catches were unusually great in Eldred Passage in July. In Kachemak Bay, along the Kenai Peninsula southwest of Tutka Bay and on the west side of lower Cook Inlet catches tended to be greatest in protected portions of outer coast than in bays, although there were some exceptions. On the west side specific areas of greatest catch were Oil Bay to Iliamna Bay and on the southern side of Ursus Cove and in Rocky Cove.

Pacific Sand Lance (Tab. 14, Fig. 7)

Pacific sand lance was the numerically predominant species in both tow net and beach seine samples, occurring in 35 percent of all tow net and 45 percent of all beach seine hauls (Table 4). They occurred in all major areas sampled and during all time periods but displayed a complex pattern of abundance by location and time and they displayed an unusually great variability (Table 14). When sand lance were captured in one gear in an area they were frequently captured by both gears. As an example the catch of sand lance on the west side of lower Cook Inlet in July was due almost exclusively to one large catch in both the beach seine and tow net in Oil Bay. Harris and Hartt (1977) reported a similar phenomenon for Pacific sand lance in Alitak Bay.

In Kachemak Bay, Pacific sand lance catches were greatest in May-June, were minimal in July and were successively greater in August and September (Table 14). On the east side of lower Cook Inlet north of Anchor Point, catches were greatest in August, and considerably less both before and after. On the west side of lower Cook Inlet there was a chance catch in July in both gear types and in September modest numbers were captured in all areas, somewhat in excess of the numbers recorded in the sample data and Table 14.

The coefficient of variation was greatest in July in all areas and in both gear types while it was consistantly less both earlier and later. The coefficient of variation may serve as an indication of the degree of schooling or aggregation that is occurring or, alternately as an indication of absence from the sampling area. The author believes, through personal observation, that this species is always highly schooled and the high coefficient of variation is an indication of greater areas with an absence of sand lance, and thus lower overall density.

In virtually all areas the beach seine catch per unit effort (CPUE) was numerically greater than the tow net CPUE in May-June, less in July and August and increased again in September in nearly all areas. This may be an indication that Pacific sand lance are less abundant in the intertidal zone in the summer and more abundant in the pelagic zone. If this is occurring, the July-August decrease in abundance could be the result of sand lance occupying the more offshore areas.

There were predominantly two age classes of sand lance in all areas, ages 0 and 1 (Figure 7). The age 0 class appears in Kachemak Bay samples in late July at 54 mm (range 42 to 61 mm) and is about 75 mm by late September. The age 1 class appears in the Kachemak Bay samples in May at 81 mm (range 66 to 97 mm) and is approximately 120 mm by late September. A 129 mm individual captured in late May in Kachemak Bay and a 168 mm individual captured in the trawl in early September were the only larger sand lance captured and based on their size it appears appropriate that they be assigned age 2.

The size classes captured on the west side and the east side north of Anchor Point were somewhat smaller. The age 0 are about 8 mm smaller in mid-August and 10 to 12 mm smaller in early September (by interpolation between sampling dates). The age 1 are about 16 mm smaller in July and 23 mm smaller in August than their counterparts in Kachemak Bay at the same time (Figure 7).

The smaller size of sand lance on the west side and east side of lower Cook Inlet north of Anchor Point, indicates that these populations are separate from those in Kachemak Bay. In addition, there are indications that a group of age 0 sand lance larger than those present in Kachemak Bay, moved into the bay during August and were present there in September. During late August the length frequency of individual catches made in Kachemak Bay and along the Kenai Peninsula southwest of Tutka Bay varied considerably. The mean size of individual hauls ranged from 54 to 60 mm during August 1-7, 63 to 81 mm during August 22-28, 67 to 83 mm during August 29 - September 4 and 69 to 79 mm during September 19-25. The range depends upon the number of samples measured and to some extent upon the number of fish in each sample, however, it is clear that catches were more variable in late August and September and that the mean size increased considerably, 54 mm in late July to 67 mm in late August to 75 mm in late August to early September then remained at 75 mm in late September. The time when length heterogeniety was greatest and size increased was also the time when catch per unit effort increased dramatically in Kachemak Bay. Thus, it appears likely that slightly larger age 0 sand lance moved into Kachemak Bay in late August and at least a portion of them moved in from the south.

A constant growth rate of approximately 8 or 9 mm per month for the age 0 sand lance in Kachemak Bay,obtained empirically, appears to fit the continuous portions of the data fairly well and to back calculate to the probable hatching date of about mid-January to early February (Hamada 1966; Andriyashev 1954; Blackburn 1973). However, the hatching date may be later since no information is available from Alaska for this species. Additionally, the growth rate may not be linear, especially over such a great time span. The age assignment based on length frequency agrees with data presented by Hamada (1967) and Andriyashev (1954) for *A. h. hexapterus*.

The different sizes of age 0 sand lance found in lower Cook Inlet suggests that growth of this species is very sensitive to availability of food supply. Trumble (1973) in a review of literature on sand lance reported that virtually no growth occurs during unfavorable years, citing data on a North Sea sand lance species. Hamada (1967) reported for sand lance in Japan that when the catch of adult sand lance was great the size of age 1 (equivalent to age 0 of this study but studied at the end of 1 year) sand lance was small; the inference being that growth is sensitive to the level of intraspecific food competition.

Pacific Herring (Tab. 15, Fig. 8,9)

Pacific herring were captured in all gear types and all areas except the Kenai Peninsula southwest of Tutka Bay. Herring were the predominant species captured in the purse seine and gill net, and were the second most abundant taxa captured in both the tow net and beach seine. Small catches were taken with the otter trawl.

Large numbers of herring were never captured in the trawl during summer or in March (Figure 8). The existence or locations of wintering concentrations of herring was not documented. Shrimp trawlers occasionally catch large numbers of herring in the deep area of Kachemak Bay between Tutka Bay and Homer Spit during winter and catches during the winter of 1976-77 were reportedly unusually great in this area (Dave Daisy, personal communication)

The tow net and beach seine catch by area (Table 15) requires considerable interpretation. Herring adults and juveniles are much more capable of avoiding the tow net than they are the beach seine, except in muddy water such as occurred on the eastside north of Anchor Point; only in this area were large catches of age 1 herring made. In addition, age 0 herring were incompletely recruited to the samples during July, August and September, due to size selectivity of the nets and the combination of larval and juvenile individuals present in this age class at this time. Only juveniles were routinely identified and recorded. This introduces heterogeniety and doubt as to the meaning of catch per unit effort data. A large share of the samples with larvae and juveniles were preserved and later analysis of these has provided a more complete, though somewhat qualitive, understanding of the occurrence of herring.

In May-June and July the reported catches consisted almost entirely of adults and juveniles of age 1 and older, which continued to occur at a similar low frequency and abundance through the summer. The reported catch increased in August and September largely due to the addition of the largest age 0 herring to the samples. The spatial distribution of herring has no distinct features except the already mentioned occurrence of juvenile and adult herring in the muddy water of the eastside north of Anchor Point.

The growth of Pacific herring as revealed by length frequency (Figure 9) is similar to that reported by Rounsfell (1929) but not identical. Age 0 herring were mostly 30 to 40 mm during August and September, however, variation between samples was sufficiently great to obscure growth by month. Age 1 herring were about 78 mm in mid-July; Rounsfell (1929) reported age 1 herring were 74 mm in April 1926 at Halibut Cove. Age 2 herring are apparently missing from samples presented here and Rounsfell (1929) reports 196 and 189 mm for age 3 in April and August, respectively, and 222 mm for age 4 at both times. Rounsfell (1929) did not report whether his measurements were total length or standard length, which may account for part of the discrepancy at the larger sizes. In addition, the older ages reported here may represent Kamishak Bay populations as opposed to Kachemak Bay populations reported by Rounsfell (1929).

Pacific herring are caught commercially in Kachemak Bay, Kamishak Bay and in the vicinity of the Forelands. Spawning areas are known to exist in Kachemak Bay and Kamishak Bay and are suspected to exist on the eastside north of the Forelands (ADF&G 1976 ; Dave Daisy, personal communication). The abundance of larval and juvenile age 0 herring encountered on the eastside north of Anchor Point supports the hypothesis that a herring spawning area exists north of the Forelands.

Longfin Smelt (Fig. 10,11)

Longfin smelt occurred in beach seine and tow net samples only on the east side of Cook Inlet between five miles north of Ninilchik and the Forelands, in Iliamna Bay and once four miles south of Chisik Island (Figure 10). They were abundant only on the east side of Cook Inlet where larvae and juveniles were captured throughout the summer. Adult male and female longfin smelt with mature sex products were captured in abundance between the mouth of the Kenai River and the Forelands in early October, suggesting that this anadromous smelt spawns in the Kenai River and that spawning was in progress or imminent.

Apparently the eggs remain in the river over the winter until hatching, which probably occurs in late spring (May-June), based on back calculation from growth rates. Size frequency information (Figure 11) indicates that the age 0 year class is about 15 to 25 mm in mid-July and grows to about 30 to 40 mm by early October. Age 1 longfin smelt are about 53 mm in mid-July and 65 mm in mid-August, but length frequency information is lacking for sizes between this and adult. It is highly improbable that these age 1 fish could grow to adult sizes (115 mm for female and 127 mm for male) by early October, thus the adult fish are apparently age 2 (at the completion of their third year of life). Examination of scales of a few fish confirms that this growth analysis is approximately correct.

Thus longfin smelt apparently spawn at the end of their third year in the Kenai River. This is one year later than is reported for anadromous and land-locked populations in British Columbia and Lake Washington (Dryfoos 1965; Hart 1973; Moulton 1974).

Capelin (Fig. 12)

Capelin occureed in small numbers in otter trawl catches and were reported infrequently in tow net catches. They were never reported from other gear although a couple larvae were found in preserved beach seine catches. In August and especially in September catches of larval capelin increased. They were present in large numbers in a large portion of the tow net samples in September on the west side and in Kachemak Bay. Capelin never occurred on the east side north of Anchor Point but on the west side they were captured nearly as far north as Chisik Island. Capelin virtually never occurred in beach seine samples, possibly indicating they do not enter the very near shore zone significantly, except to spawn.

Lengths obtained from preserved samples are presented in Figure 12. Two size classes are present with late August means of 25 and 65 mm standard length corresponding to ages 0 and 1. The age 1 capelin show no growth between late August and late September but this is probably due to size selectivity of the tow net. Growth is evident in the age 0 capelin but is largely obscured by variation in size between hauls. There appears to be two modes in the late September length frequency of age 0 capelin, one at 18 to 21 mm and the other at 41-42 mm, which cause the heterogeniety in average lengths.

The presence of the smaller capelin strongly suggests that spawning occurs over an extended time period. Back calculation based on estimated growth rate indicates that spawning probably occurred at least until late July. Templeman (1948) reports capelin spawning as late as the end of August in Newfoundland. Capelin have been reported spawning in August in Prince William Sound (Irving Warner, personal communication).

Surf Smelt

Surf smelt occurred in small numbers in the beach seine and rarely in the tow net. They occurred in greatest abundance in Kachemak Bay where the CPUE increased through the summer to 5 per beach seine haul in September, when 30% of the hauls contained them. They were infrequent in the bays and coves and more common at the exposed stations within Kachemak Bay, where they were present in 70% of the hauls.

Greenling (Tab. 16)

Greenling, primarily whitespotted and masked, were common in beach seine and tow net catches throughout the inlet. Catch per unit effort was greatest in July and similar in nearly all areas (Table 16). The bulk of the greenling captured were age 0 during the pelagic and early portion of the littoral stage.

Bering Cisco

A few individuals of Bering cisco were captured in beach seines near the mouth of the Kenai River, and on the westside in Chinitna Bay, Oil Bay and Iliamna Bay. They occurred in every set near Bowser Creek in Oil Bay.

Pacific Halibut (Tab. 17,18, Fig. 13)

Pacific halibut were the sixth most abundant taxon, third most abundant flatfish, constituted 20.3% of the flatfish and occurred in 68% of the otter trawl hauls. In addition three individuals were captured in the beach seine.

During summer Pacific halibut occurred at all except the seven deeper southern trawl stations with weight abundance quite scattered and they tended to be more numerous and smaller nearer shore. During March, halibut occurred in virtually all areas sampled but tended to occur in greater weight abundance in the central and southern portions of the inlet (Figure 13).

Halibut occurred over the entire depth range sampled by the otter trawl (18 to 192 m) and in the beach seine (maximum depth 3 m). Greatest weight abundance occurred at less than 100 m with CPUE inversely proportional to depth during summer, except for the occurrence of one large individual at 91 m during August (Table 17). During March CPUE at depths greater than 100 m was more than in summer (Table 17). Average weight had a weak tendency to increase with depth during both summer and winter, however, this statistic is inordinately affected by chance occurrences of large fish and is consequently quite variable. Length frequencies taken during March indicate there was considerable size overlap at a given depth but that smaller fish generally did not occur deeper (Table 18).

Seasonal features include the shifts in distribution by area and depth mentioned above, which appear to be a part of a general movement of the entire size spectrum of halibut toward shallow water in summer and deep water in winter. The CPUE in numbers by depth (Table 17) most clearly illustrates seasonal movement of halibut without the confusing trend of larger fish deeper and the variability introduced by occasional occurrence of large fish. CPUE in numbers was distinctly shifted toward the shallow range in summer and evenly spread from 27 to 192 m during March. The average weight of halibut also varied seasonally, being greatest during June through August at all depths, generally smaller in September and distinctly smaller in March. Based upon limited length frequency information, average weight information and CPUE in numbers (Table 17) this change in average size appears to result from a decrease in numbers of large halibut and a considerable increase in numbers of small halibut in March.

Yellowfin Sole (Tab. 19,20, Fig. 14,15)

Yellowfin sole was the third most abundant taxon, the second most abundant finfish, and the most abundant flatfish and constituted 23.7% of the flatfish captured in the otter trawl. It occured in 44% of the trawl hauls when sampling included deep stations (July, August and March) and 79% of the hauls when sampling did not include deep stations (June and September). Locations of greatest abundance were east and southeast of Augustine Island and in Kamishak Bay (Figure 14). They were captured from 18 to 142 m, were most abundant between 26 and 100 m (Table 19), did not occur in the beach seine but the shallow extent of distribution was not well delineated.

Seasonality is not obvious in the depth distribution although there is a trend for greater catches at 76 to 100 m in September and March (Table 20). The data indicate that there is a seasonal shift of distribution that is explained by the hypothesis that during June and July this species occupied waters of Kamishak Bay, west of and shallower than was systematically sampled by this study, then during August and September moved east, not along depth lines, to invade the area of the five stations southeast of Augustine Island where they were common. As supporting evidence of this hypothesis the five stations southeast of Augustine Island had low concentrations of yellowfin sole in June and July, the western two stations (one the shallowest, the other the second deepest of the five) had modest numbers in August and large numbers in September and the third westerly station had modest numbers in September. In March yellowfin sole were present at all five stations (Figure 14) in remarkably uniform abundance (coefficient of variation = 0.12). A few stations sampled in Kamishak Bay resulted in a large catch in northern Kamishak Bay in July which was much lower when repeated in September. Two other stations sampled only in September north of Augustine Island had modest catches.

This population of yellowfin sole is one of the more easterly populations known. A population is known to exist in Skidegate Inlet in British Columbia but between there and the Alaska Peninsula they have been only incidentally captured in previous surveys (Kitano 1969; Alverson et al. 1964; Pereyra and Ronholt 1976). Yellowfin sole are the predominant flatfish in the southeastern Bering Sea (Pereyra et al. 1976) where they engage in complex and not fully understood seasonal bathymetric and geographic movements. During winter they congregate on the outer continental shelf and upper slope, during spring and into summer they migrate to shallower more nearshore waters (Pereyra et al. 1976). Thus the shift of abundance and hypothesized movement pattern in lower Cook Inlet is similar to patterns known for this species in other areas.

Length frequency distributions obtained during August and September are presented in Figure 15. The September sample contained a large proportion of fish from less than 25 m deep, and since average size increased with depth, the sample contained many smaller fish.

<u>Starry Flounder</u> (Tab. 21,22, Fig. 16)

Starry flounder were the sixth most abundant flatfish, constituted 5.4% of the flatfish, and occurred in 28% of the otter trawl hauls. They also were the second most abundant flatfish captured in the beach seine and were the only adult flatfish captured in the tow net. Catches in the beach seine were greatest on the west side of Cook Inlet where CPUE was 0.7 fish/beach seine haul and on the east side north of Anchor Point where CPUE was 0.4 fish/beach seine haul. Catches of starry flounder in the otter trawl were almost exclusively restricted to Kamishak Bay and seven stations on the west side of the inlet generally east and southeast of Augustine Island (Figure 16).

Starry flounder occurred from the surface to 100 m with depth of greatest abundance strongly dependent upon month (Table 21). There is apparently an annual migration to shallow water in winter, where spawning occurs (Hart 1973) and deep water in summer as reported by Alverson et al. (1964, citing Alverson 1960). Except for one individual captured in June, the greatest depth of occurrence increased from June to September and the CPUE at the greater depths increased to a maximum in September. Also during September two unplanned stations in a shallow area of Kamishak Bay were sampled and moderate catches occurred. During March the CPUE was inversely correlated with depth but some fish remained in the 75 to 100 m depth interval (Table 21). The seasonal shift in depth distribution also strongly affected the locations of occurrence and abundance each month (Table 8).

Starry flounder were initially almost absent and appeared to invade the trawl sampling area more each month such that frequency of occurrence shifted from 10% in June to 64% in September and back to 28% in March.

Average size of starry flounder increased with depth to a maximum of 1.6 kg at 51 to 100 m. Average weights from the beach seine were 81 gms on the west side and 480 gms on the east side of lower Cook Inlet while average weights from the otter trawl were generally 600 to 700 gms at less than 50 m and 1600 to 1700 gms at greater than 50 m. The limited number of length measurements available ranged from 26 to 58 cm with a mean of 40.6 cm and reflect increasing size with depth (Table 22).

<u>Rock Sole</u> (Tab. 23,24, Fig. 17,18)

Rock sole were the fifth most abundant taxon, second most abundant flatfish, constituted 21.3% of the flatfish and occurred in 84% of the otter trawl hauls. Rock sole also were captured in the beach seine in greater abundance than any other flatfish. Rock sole occurred in every area of lower Cook Inlet but were most abundant in the southern portion of the inlet in both the otter trawl (Figure 17) and the beach seine. In the beach seine they occurred only once on the east side north of Anchor Point, but CPUE was 0.4 fish/beach seine haul on the west side of the inlet, CPUE was 0.3 fish/beach seine haul in Kachemak Bay, and CPUE was 1.1 fish/beach seine haul on the Kenai Peninsula southwest of Kachemak Bay. The greatest abundance of rock sole in the beach seine was in Seldovia Bay where they occurred in all hauls with a CPUE of 2.6 fish/ beach seine haul.

Rock sole occurred over the entire depth range sampled, from the surface to 192 m during the summer and 27 to 192 m during March (Table 23). The depth of greatest abundance was approximately 50 to 100 m and perhaps to 125 m during summer and 50 to 192 m during March. Rock sole reportedly range from the surface to 366 m but they are scarce below 183 m (Hart 1973; Ronholt et al. 1976; Pereyra and Ronholt 1976). Average size of rock sole increased with depth (not statistically tested) although a wide range of sizes were captured at most depths (Table 24). At a given depth, the average size was greater in March than in August (Table 24).

Pronounced seasonal changes in abundance of rock sole occurred at several stations which can be more simply described in terms of changes in area of abundance than depth of abundance. Two stations in Kennedy Entrance yielded constantly increasing catches: minimal catches when first sampled in July, one 26 kg catch when sampled in August and 30 and 56 kg catches when next sampled in March 1977. Southeast and east of Augustine Island, rock sole occurred at five stations (Figure 17) during summer with abundance minimal during June and July, greater in August and greatest in September. In March CPUE was 65% of the September value at these five stations and rock sole also occurred at two contiguous stations further southeast, at which they had been largely absent during summer. When depth of abundance is examined there is an apparent shift to greater depth in March (Table 23) but certain stations of intermediate depth never yielded rock sole in any quantity (Figure 17).

The occurrence of a greater average size at a given depth in March, together with the increasing size by depth (Table 24) suggests that rock sole were further inshore in March than in summer. The cause of this contradicting information is not known.

Length frequencies of rock sole are presented in Fugure 18. Lengths from 69 to 470 mm were captured and both juveniles and adults are represented in the catches. A mode at 100 mm occurs in August and this corresponds with the size of age 1 fish according to Levings (1967, as reported in Pereyra et al. 1976).

Butter Sole (Tab. 25,26, Fig. 19,20)

Butter sole were the eighth most abundant taxon, fourth most abundant flatfish, constituted 15.4% of the flatfish, and occurred in 62% of the hauls. They were most abundant in the central portion of the inlet between 59°10'N and 59°35'N (Figure 19). Butter sole were captured at 25 to 155 m with greatest abundance between 25 and 100 m in the otter trawl (Table 25) and eight specimens were captured in beach seine hauls at a maximum depth of three m. There was no demonstrable relationship between fish length and depth of capture (Table 26), however, the depth range at which length samples were taken was less than the total depth range of the species. The average weights had a very weak tendency to increase with depth.

The length frequencies (Figure 20) indicate that the butter sole captured included immature and mature individuals since approximate sizes at maturity are 205 mm for males and 227 mm for females according to Smith (1936) for butter sole from inner Washington waters.

Seasonal features of butter sole distribution are not clear. There is a tendency for them to be slightly deeper in March (Table 25) and their location of occurrence in March (Figure 19) included two deeper stations where they never occurred in six summer samples. The data also suggests a pronounced migration, with June abundance in the mouth of Kachemak Bay and abundance in other months in the central to western portion of the inlet.

Butter sole occur from the Bering Sea to southern California (Hart 1973; Quast and Hall 1972; and Pereyra et al. 1976) with greatest abundance found off Oregon-Washington and in the Gulf of Alaska at depths less than 91 m (Alverson et al. 1964). Abundance in the Gulf of Alaska tends to decrease to the west (Pereyra and Ronholt 1976). Smith (1976) reported butter sole in inner Washington waters to be abundant at 11 to 19 fm (20 to 35 m) but not numerous at greater depths.

Available life history information is not complete but butter sole are reported to migrate to shallow water in summer and deeper water in winter (Hart 1973) and to concentrate in winter for spawning. A large portion of the Hecate Strait butter sole population moves to Skidegate Inlet in British Columbia, where spawning occurs from March to late April (Clemens and Wilby 1961). In Washington waters butter sole concentrate in Bellingham Bay where spawning occurs from about February 15 to the latter part of April with its maximum during March (Smith 1936).

Flathead Sole (Tab. 27,28, Fig. 21,22)

Flathead sole were the seventh most abundant flatfish captured, they constituted 3.3% of the flatfish and occurred in 51% of the otter trawl hauls. They were more abundant in the southwestern portion of the inlet (Figure 21) and they were captured over the entire depth range sampled by the otter trawl 18 to 192 m) with no distinct differences in CPUE by depth (Table 27), but they were never captured in the beach seine.

Size of fish was strongly stratified by depth, with smaller fish occurring shallower throughout the entire depth range sampled (Table 28). Flathead sole smaller than 200 mm were not captured deeper than 100 m in August and September while larger fish were captured at all depths but in greater relative abundance deeper and maximum size increased steadily with depth from 18 to 192 m.

The catch of flathead sole consisted mostly of immature fish (less than 200 mm, the size at first maturity, Pereyra et al. 1976) as a natural result of the strong size stratification by depth and the concentration of effort in the shallower portion of their depth range. The bulk of the sampling effort, 58%, was expended between 50 and 100 m and flathead sole range from the surface to 550 m with greatest abundance at 91 to 181 m in the Gulf of Alaska and 182 to 237 m south of the Alaska Peninsula (Pereyra et al. 1976).

Length frequencies of flathead sole (Figure 22) were taken during August and September. Those taken in August were mostly from deep stations, therefore, disproportionately representing the contribution of fish greater than 200 mm to the total catch. Approximately half the flathead sole captured in August were less than 200 mm. The September length frequency is a fairly representative sample of total catch. There are two modes at 110 and 170 mm apparent in the September length frequency that may represent two age groups, which would be ages 1 and 2, assuming maximum reasonable growth rate. The growth data for flathead sole presented by Pereyra et al. (1976) suggests that 110 mm is a reasonable size for age 1, with older fish included in the larger portion of the group, but the 170 mm mode may be composed of age 2 to 5 fish.

Flathead sole apparently conducted a seasonal bathymetric migration to shallower water in summer. There was a seasonal shift in size by depth zone with fish less than 200 mm in length captured at 137 m in March but never deeper than 100 m in summer, as discussed above, and adult sized flathead sole were captured during the summer, not in March. The CPUE by depth zone (Table 27) indicated a tendency for greatest catch at all depths in September, while the only substantial catches at less than 75 m occurred during July, August and September. The mean weight of flathead sole captured decreased during the entire study, apparently due to recruitment of juvenile fish to the samples and winter departure of adult fish.

Arrowtooth Flounder (Tab. 29,30, Fig. 23,24)

Arrowtooth flounder were the eleventh most abundant taxon, the fifth most abundant flounder, constituted 8.2% of the flatfish and occurred in 76% of the otter trawl hauls in lower Cook Inlet. They were present in all areas but were most abundant south of 59°20'N (Figure 23). They occurred over the entire depth range sampled by the otter trawl, 18 to 192 m, did not occur in the beach seine hauls and greatest catches tended to occur between 100 and 150 m (Table 29).

The average size of fish was progrssively greater with depth in both summer and March (Table 30) as also reported by Pereyra et al. (1976) but the depth range of arrowtooth flounder was not adequately covered in this study.

In the eastern Bering Sea adult arrowtooth flounder may be found at 300 to 500 m during winter and 200 to 400 m during summer with immatures extending onto the shelf to at least 80 m during summer (Pereyra et al. 1976).

In the northeast Gulf of Alaska arrowtooth flounder was the predominant flatfish with catches decreasing further west and greatest catches occurring between 100 and 400 m (Ronholt et al. 1976). Arrowtooth flounder were, in general, less abundant in lower Cook Inlet than Ronholt et al. (1976) report at comparable depths in western NEGOA.

There were several features that indicate the existence of seasonal migrations. The CPUE was greatest during July and August, intermediate in June and September and lowest in March. In July through September this species was present in all areas but during June and March it was absent from the more northerly stations. The average size of fish was cyclic with the largest fish present in July and August and smallest fish present in March.

Length frequencies of arrowtooth flounder, taken during August, September and March are presented in Figure 24. There are modes present in the frequency, however, it is not possible to determine if these represent age classes.

<u>Rex Sole</u> (Tab. 31, Fig. 38)

Rex sole occurred in 33% of the hauls and constituted 1.1% of the flounders captured in the otter trawl. They occurred from 58 to 148 m, primarily at 5 stations east and southeast of Augustine Island which ranged from 58 to 100 m in depth (Figure 38). Lengths of 111 rex sole taken from otter trawl hauls in August and September ranged from 98 to 338 mm and averaged 208.7 mm (Table 31), corresponding to ages 1 to 13 based upon mean length at age presented by Hosie and Horton (1977).

Rex sole apparently conduct a seasonal bathymetric migration to shallower water in summer since they were found further south and deeper in March than during summer. In addition the average weight was greatest in August and progressively smaller both earlier and later while size distinctly increased with depth (Table 31).

The size of rex sole captured (Table 31) was distinctly smaller than those reported by Ronholt et al. (1976) from the northeast Gulf of Alaska waters out to 400 m depth. Ronholt et al. (1976) also reported that 61% of the standing stock of rex sole occurred between 200 and 400 m and only 15% occurred between 1 and 100 m. Apparently the smaller portion of the rex sole population were present in the study area, due to the characteristic of inhabiting greater depths at greater sizes combined with the general depth distribution being much deeper than the study area.

<u>Other Flounders</u> (Fig. 38)

A total of four other species of flounders were reported and they were, in the order of greatest weight abundance in the otter trawl catches: Alaska plaice, dover sole, sand sole and English sole. The English sole was only identified in the initial samples, was not substantiated with a specimen and may be in error.

Alaska plaice occurred in 14% of the hauls and constituted 0.8% of the flounders captured in the otter trawl. They occurred from 18 to 91 m during summer and 57 to 137 m in March. They were captured in every haul at two stations southeast of Augustine Island and at two shallow stations in Kamishak Bay immediately north of Augustine Island which are sampled only in September (Figure 38). Length of 13 fish meansured ranged from 25 to 36 cm.

Dover sole occurred in 20% of the hauls and constituted 0.3% of the flounders captured in the otter trawl. They occurred from 113 to 192 m during summer and 77 to 192 m in March. Throughout the study they occurred in 14 of 17 hauls made at five stations from Kennedy Entrance toward Augustine Island (Figure 38). Size of 25 fish measured ranged from 203 to 348 mm, averaging 273 mm.

Sand sole occurred in 3% of the hauls and constituted 0.1% of the flounders captured in the otter trawl. They were also captured in 2% of the beach seine hauls and constituted 5.4% by number of the flatfish captured in the beach seine. In beach seine hauls they were most common between Cape Ninilchik and Cape Kasilof on the east side of lower Cook Inlet.

Walleye Pollock (Tab. 32,33, Fig. 25,26,27)

Walleye pollock was the second most abundant taxon, the most abundant finfish and occurred in 72% of the otter trawl hauls (Table 8). Pollock occurred at nearly every sampling station over the entire depth range sampled in summer (18 to 192 m) and in March (27 to 192 m), but greatest catches were all deeper than 73 m (Table 32) and in the southern portion of the study area (Figure 25). Larger fish were found deeper and the smallest fish, 88 to 118 mm, mean 104 mm, were found in 18 to 27 m in Kamishak Bay (Table 33, Figure 25).

Seasonal migration of walleye pollock is apparent in the CPUE by month (Table 8) and the bathymetric distribution (Table 32). Walleye pollock were much more abundant during the summer than during March (Table 8) and they tended to be shallowest during August, in obviously lesser abundance in September at depths shallower than 150 m, and not abundant at any depth in March (Table 32). This data strongly indicates that the bulk of walleye pollock retreated from the southern portion of the inlet during winter. Hughes and Alton (1974) report that pollock are common throughout Shelikof Strait in May-June and late summer and it seems likely that the pollock in Shelikof Strait move into lower Cook Inlet in the process of their seasonal migrations,

Lengths and apparent age classes obtained from fresh walleye pollock are presented in Figure 26. The growth rate obtained in this manner is graphically compared to that of walleye pollock from the eastern Bering Sea (Figure 27) as reported by Yamaguchi and Takahashi (1972). Walleye pollock from lower Cook Inlet apparently grow at a slightly greater rate than those in the eastern Bering Sea.

Pacific Cod (Tab. 34,35, Fig. 28,29)

Pacific cod was the second most abundant cod captured in the otter trawl and occurred in 67% of the summer hauls and 33% of the March hauls. During summer they occurred in greatest abundance in the southern portion of Cook Inlet and in the central inlet at the latitude of Homer to Anchor Point, while in March they were largely restricted to Kennedy Entrance (Figure 28).

Pacific cod occurred from 57 to 191 m during summer and 49 to 192 m during March. The CPUE generally increased with depth and tended to be greatest at 151 to 175 m in summer and at 176 to 200 m during March. The CPUE at depths less than 100 m tended to be greatest in June and decrease through the summer and into March (Table 34). Size of Pacific cod was related to water depth with smaller fish found shallower (Table 35).

Seasonal bathymetric migration of Pacific cod was quite marked with the change in location of abundance most obvious (Figure 28). During March they were deeper and during summer they were shallower, with greatest abundance in shallow water apparently in June. During June a few large fish, up to 7.7 kg average weight, were captured at the four most northerly mid-inlet stations. Three of these stations were not sampled in March but during July through September catches in this area were smaller and fish size was smaller. Generally, average weight was greatest in June and decreased to a minimum in September, and slightly increased in March. This trend is generally consistent within stations and appears to reflect recruitment of young and also disappearance of larger fish.

The ubiquity or degree of clumping of the distribution of Pacific cod varied seasonally. The frequency of occurrence was greatest in August (84%) and least in June (40%) and March (33%) and the coefficient of variation was greatest in March(2.5) and least in August (1.4).

Seasonal migrations of this species to shallower water in spring and deeper water in fall, are reported throughout their range except the most southerly portion in the western Pacific where Pacific cod have the reverse pattern, shallow in winter and deep in summer (Ketchen 1961). The amplitude of the seasonal migration varies considerably in different areas and Ketchen (1961) suspects that temperature is of over-riding importance in the geographic and bathmetric distribution of cod in the North Pacific.

Length frequencies of Pacific cod taken in otter trawl hauls in July, August and September of 1976 and March 1977 are presented in Figure 29. Comparison with growth data for Pacific cod (Ketchen 1961) suggests that the August mode at 180 to 280 mm, mean 228 mm, are age one fish (in their second year of life). This mode appears to grow to about 375 to 450 mm, mean about 310 or 320 mm, by March. This growth rate suggests that the August mode at about 350 mm to 450 mm are largely age two fish which apparently grow to about 430 to 480 mm by March. Confidence in this growth picture suffers from small sample sizes and the lack of age determinations, however, it is consistent.

Saffron Cod (Fig. 30)

Saffron cod were captured in the tow net and beach seine primarily north of Cape Ninilchik on the east side of lower Cook Inlet but a few individuals were captured in other areas (Figure 30). Sizes from age 0 to adult were captured with juveniles more widely spread. North of Cape Ninilchik on the east side of lower Cook Inlet saffron cod were common and in September and early October abundance of adults increased and they became one of the predominant species.

Saffron cod live permanently in the coastal zone, migrate to deeper (30 to 60 m) areas in summer and approach the coast where they spawn in the zone of tidal current influence during winter (Andriyashev 1954). The data and the literature citation permit the inference that during winter this species may be abundant in the northern portion of lower Cook Inlet where they apparently spawn.

Sculpins (Fig. 37)

A total of 19 taxa of sculpins were identified, 18 to species and one to genus. Yellow Irish Lord, great sculpin and *Gymnocanthus* spp accounted for over 80% by number and 90% by weight of the sculpins captured in the otter trawl. Only the great sculpin and Pacific staghorn sculpin were recorded from beach seine and tow net collections.

Ribbed sculpin occurred in 33% of the otter trawl hauls from August through March. They occurred from 27 to 87 m in summer and from 49 to 137 m in March (Figure 37).

Forktail sculpin were identified from one haul in August but may have been more common. They were found in three hauls in March between 128 and 137 m and in all momths were moderately numerous when encountered, with catches of up to 75 fish occurring.

Yellow Irish Lord (Tab. 36, Fig. 31,32)

Yellow Irish Lord was the fourth most abundant taxon, the most abundant sculpin and comprised at least 57% by weight and 71% by number of the sculpins captured in the otter trawl. They occurred in at least 64% of the otter trawl hauls and in nearly every location, however, abundance was clearly much greater in the southerly portion of the inlet (Figure 31).

In summer yellow Irish Lord occurred from 27 to 192 m with greatest catches between 100 and 150 m and in March they occurred from 49 to 192 m with greatest catches at 192 m in Kennedy Entrance (Table 36). Average weight clearly increased with depth. In July, August and September, average weight was less than 200 gms (with one exception in ten occurrences) at depths less than 82 m and never less than 200 gms deeper. Average weight ranged between 200 and 300 gms at 82 to 155 m and was greater than 300 gms at 192 m, in Kennedy Entrance. During March the sizes increased by depth in a similar manner but the depth below which average weight less than 200 gms did not occur was about 137 m. The length frequency presented in Figure 32 was taken from depths ranging from 127 to 192 m in March.

Yellow Irish Lord had a distinct seasonal shift in bathymetric distribution, with greatest abundance occurring deeper in March than during the summer (Table 36).

Great Sculpin (Tab. 37, Fig. 33)

Great sculpin was the tenth most abundant taxon, the second most abundant sculpin and comprised at least 32% by weight and 9% by number of the sculpins captured in the otter trawl. They were the most ubiquitous sculpin, occurring in at least 66% of the otter trawl hauls and 22% of the beach seine hauls.

In the otter trawl they were distinctly less frequent in the more southerly, deeper stations (Figure 33). In the beach seine they never occurred on the east side north of Anchor Point, being most abundant in Kachemak Bay and the Kenai Peninsula southwest of Tutka Bay where they occurred in up to 64% of the beach seine hauls in August and September.

Great sculpin occurred from the surface to 138 m during summer, with greatest abundance within the otter trawl found between 51 and 100 m (Table 37), however, catches in the beach seine seem to be considerably greater per unit area than the otter trawl catches. They occurred over nearly the entire depth range sampled in March, 31 to 192 m, with CPUE evenly spread by depth (Table 37). Average weight is not clearly related to depth.

Great sculpin clearly were deeper in March than in summer but distribution changes within summer were obscured by taxonomic confusion in the June and July cruises.

Gymnocanthus (Fig. 37)

Sculpins of the genus *Gymnocanthus* could not be identified to species, except one male *G. pistiliger* with characteristic "pistils" on the side of its body. This genus was the third most abundant sculpin taxa in the otter trawl collections and during August through March they comprised 3% of the sculpins by weight and 4% by number, and occurred in 33% of the hauls. This taxon occurred from 57 to 146 m with no demonstrable difference in depth distribution between summer and March (Figure 37).

Pacific Staghorn Sculpin

Pacific staghorn sculpin were captured in the beach seine in greater numbers than any other sculpin. They were most abundant on the west side of lower Cook Inlet where 81% of the total number were captured and 27% of the beach seine effort was expended. During July, the catch rate was nearly 3 fish per beach seine haul on the west side. Phinney (1972) reported this species to be common in beach seine hauls in Chignik Lagoon. This species occurred in the otter trawl hauls only in September and March but occurred as deep as 84 m; thus this species is primarily intertidal in the summer but is somewhat deeper through the winter.

Sea Poachers (Fig. 34)

A total of eight species of sea poachers were identified. The sturgeon poacher, sawback poacher and northern spearnose poacher accounted for 89%, 7% and 2% by number, respectively, of the poachers captured in the otter trawl. The sturgeon poacher occurred in 66% of the otter trawl hauls and at nearly every location (Figure 34). They were captured from 3 to 155 m with greatest abundance and frequency between about 58 and 80 m. They were most abundant at six stations east to southeast of Augustine Island, with progressively greater densities toward the west. The catch rate in March was much greater than in summer indicating that this species apparently moved into the study area in winter, probably residing shallower than most of the sampling effort during summer.

Sawback poachers were first identified in August and may have been more abundant than recorded during summer. During March they occurred in 33% of the hauls but were in 66% of those deeper than 77 M. They occurred from 57 to 146 m in August and 77 to 192 m in March.

The tubenose poacher was the most common poacher in beach seine and tow net collections. They were most common in Kamishak Bay where they occurred in 42% of the beach seine hauls in August. Young of the year were also captured and total lengths increased from a mean of 35 mm (n=7, range=31-38 mm) in early July to a mean of 52 mm (n=4, range=48-58 mm) in early August, indicating an approximate growth of 17 mm per month and that they were probably about 2 months old in early July.

<u>Snow Crab</u> (Tab. 38, Fig. 35)

Snow crab occurred in the otter trawl in greater abundance than any other taxon and occurred in 87% of the hauls. They occurred in greatest biomass in the western half of lower Cook Inlet south of about 59°25'N and at one station near Seldovia in the summer (Figure 35). The greatest catches occurred at depths of 50 to 150 m (Table 38).

In March at one station near Cape Douglas (59°01'30"N, 153°04'00"W) a large number of tiny (probably young-of-the-year) snow crabs were captured. Howard Feder (personal communication) also has captured juvenile snow crab in abundance in this vicinity.

Seasonality of snow crab is not very pronounced. The depth distribution (Table 38) tends to be shallower in mid-summer and deeper in September. In March the catch was spread evenly between 50 and 150 m but females were deeper than males. This data is insufficient by itself to establish seasonality.

Snow crabs in Kachemak Bay reportedly have ill defined migratory patterns. Some remain in shallow waters throughout the year but in January those in deep water begin a slow movement toward shallow water and this movement continues through July. During July some snow crabs begin to move back to deeper waters, but the movement is slow and irregular (Bright 1967).

Depth is not the only factor important in the distribution. Areal components are obvious, especially in the more northern areas of lower Cook Inlet where snow crab occurred in low abundance at prime depths.

<u>King Crab</u> (Tab. 39, Fig. 36)

King crab was the second most abundant crustacean and the ninth most abundant taxon captured in the otter trawl. It occurred in 60% of the hauls during summer and 33% of the hauls in March. Like snow crab, king crab occurred in greatest biomass in the western half of lower Cook Inlet south of about 59°25'N and one station near Seldovia, only in summer (Figure 36). Unlike snow crab, king crab occurred in Kennedy Entrance during summer and was uncommon at the most southwestern two stations during summer. Greatest catch rates generally occurred between depths of 25 to 150 m.

There was a marked seasonality in king crab catches. In March the area of occurrence was considerably reduced and the CPUE was reduced at nearly all stations (Figure 36). Greatest catches in March occurred at the shallowest depths sampled (Table 39). The deepest occurrences and greatest catches at deeper stations were made in August.

The seasonal changes in depth distribution are well known and Bright (1967) described them in Kachemak Bay king crab. Males begin moving to shallow water early in the year and by about March they are in depths of about 20 fathoms. Females begin migration to shallow water in February and complete it in May. In mid-June male king crab begin movement to deeper water, followed more slowly and erratically by females, and the movement is complete by the end of July.

Tag recovery information indicates Kachemak Bay king crab exhibit a predominant westward and southward movement out of Kachemak Bay during late summer or early fall (Davis 1976). Similar tag information indicates Kamishak Bay king crab move south out of Kamishak Bay and even out of the Cook Inlet fishery registration area during late summer or early fall. The route and timing of return to Kamishak and Kachemak Bays are not known.

Skates (Fig. 37)

Three species of skates were reported in incidental numbers, big skate, black skate and longnose skate and one egg case each of starry skate and big skate were captured. The identification of longnose skate was not confirmed. The abundance of skates was comparable to the CPUE reported by Pereyra and Ronholt (1976) for *Raja* sp. from the Kodiak and Shelikof areas in 1961 and 1973-75. The catches were very localized east and southeast of Augustine Island (Figure 37).

Searcher (Fig. 37)

The searcher occurred in 32% of the otter trawl hauls between depths of 25 and 142 m in summer and 57 and 137 m in March (Figure 37). The data suggests a seasonal migration from deeper water residence during winter, perhaps as late as July, to shallower water in August and September. Their penetration north into the inlet was greatest and depth of occurrence was shallowest during August and September.

They were decidedly more common east and southeast of Augustine Island at depths of 57 to 100 m where they occurred in 100% of the hauls at five stations during August and September (Figure 37). During March they were present in this area but much less common. During July they were absent in this area but present deeper, between 122 and 142 m. Average weight tended to increase with depth.

Food Habits

Juvenile Pink Salmon (Fig. 39)

The stomach contents of 72 pink salmon captured July 26 to 28, 1976 between 9:00 A.M. and 3:30 P.M. in Kachemak Bay were examined and frequency of occurrence and number of items were recorded for each food component. The diets consisted of insects, fish larvae, ostracods, brachyura zoea, gammarid amphipods, harpacticoids and calanoids, in order of decreasing frequency of occurrence (Appendix Table 1). The 43 fish captured in 5 beach seine hauls contained somewhat different food than did the 29 fish captured in 3 tow net hauls (Figure 39), however, the tow net caught fish were slightly larger, 83.2 vs. 80.6 mm. The diet is much more strongly related to size class (Figure 40) than to location of capture (Figure 39). Calanoid and harpacticoid copepods were much more importand to fish less than 80 mm in length while fish larvae were much more important to fish larger than 80 mm in length. Insects were important to all size classes but decreased in frequency of occurrence and percent of content by count as size increased. Amphipods and to a lesser extent brachyura zoea tended to be used most by the intermediate size classes. Several items, especially fish eggs, polychaete worms and barnacle nauplii appeared to be highly random in occurrence thus this data conveys little information on importance of these items.

The contribution of various taxonomic categories or ecological groups to the nutrition of a predator is the important inference of food habits work. This data is weak in that only frequency of occurrence and count of abundance were recorded; biomass of each food component is more important as an indicator of caloric contribution to the nutrition of the predator. The data was displayed (Figures 39 and 40) in a manner identical to that employed by Harris and Hartt (1977) so that the relation between counts and biomass could be visually examined by comparison with their report. Harris and Hartt (1977) state in reference to the diet of juvenile pink salmon that "Gammaridean amphipods, fish eggs, and miscellaneous larval crustacea contributed to the diet in terms of numbers but very little in terms of weight.... Larval capelin contributed most of the weight in the entire sample, but came from the stomachs of only a few large juveniles".

Bailey et al. (1975) examined food habits of pink and chum salmon fry 28 to 56 mm in fork length in Southeast Alaska and found copepods, barnacle nauplii and cyprids and cladocerans to be the major food items. Yuen and Kron (1976 ms) examined food habits of 1301 juvenile pink salmon captured between May 5 and June 20 in and near the Tutka Bay portion of Kachemak Bay and found them feeding upon copepods and to a lesser extent decapoda and invertebrate eggs. Mean fork length from the various samples ranged from about 32 to 41 mm. Gosho (1977) as reported by Harris and Hartt (1977) studied food habits of pink salmon from Kiliuda and Alitak bays on Kodiak Island and identified many factors that affect their diet including season, time of day and location within the bays. The diets included mainly copepodids, nauplii, decapod zoea and planktonic eggs in the day and barnacle cypris, insects, pteropods, copepodids, zoea and *Oikopleura* at night.

Demersal Fishes

The food habits analysis of fishes in lower Cook Inlet was accomplished by contract to the University of Washington Fisheries Research Institute and is presented in Appendix 1.

Literature Survey

The literature survey information was compiled by Coastal Zone Management funds and is presented in Appendix 3.

Relation of Basic Oceanographic and Atmospheric Data to Features of Fish Occurrences

This objective was not adequately achieved in this study. Information was obtained on wind and temperature at many of the beach seine and tow net sites and water temperature information is presented in Figure 41. No attempt was made to correlate catch with temperature since the information is incomplete, and the variation is not great and appears to be related to location (the more oceanic areas, South Kenai and Kachemak Bay, were colder than the more estuarine west and east sides). No attempt was made to relate catch to wind velocity since sampling was only conducted in relatively calm condition thus there is little variation in the parameter.

CONCLUSIONS

1. Fish species present in lower Cook Inlet were identified, their relative abundance in beach seine, surface tow net, otter trawl, purse seine and gill net were determined and 5 species never previously recorded in this geographic area were identified.

2. Fish abundance in otter trawl catches was found to be distinctly lower in the portion of lower Cook Inlet where bedforms (sand waves, ridges and dunes, Bauma et al. 1977) were present than in adjacent areas. North of the described areas of bed forms the catches were also depressed.

3. Most species of fish were found to increase in size with depth and to occur at greater depths in winter than in summer. Only butter sole and great sculpin did not demonstrably increase in size with depth, while those that did were Pacific halibut, yellowfin sole, starry flounder, rock sole, flathead sole, arrowtooth flounder, rex sole, walleye pollock, Pacific cod, yellow Irisy Lord and searcher. Of these same 13 species only starry flounder and rock sole did not demonstrably reside deeper in winter, but apparently resided shallower in winter. The seasonal distributions of both yellowfin sole and rock sole were complex and unclear.

4. Juvenile pink salmon were most abundant in waters of lower Cook Inlet from about mid-May (in Kachemak Bay based on literature, Kron and Yuen]976 ms) through July. In Kachemak Bay pink fry were concentrated in the very nearshore zone until mid-June, then dispersed into protected open water areas where their abundance decreased with time to very low values in August. Pink fry apparently departed the upper portion of the inlet earlier and the seaward areas (Kamishak Bay and the southern Kenai Peninsula) later.

5. Since Pacific sand lance were the most abundant forage fish species captured and they matured at the end of their second year of life (comparatively young), their role in fish production should be quite large. Three groups of sand lance were separated on the basis of size and evidence was found of sand lance migration out of Kachemak Bay in the late spring and back into it in the late summer.

6. The presence of larval and juvenile age 0 herring near the Forelands supports the previously held hypothesis that a herring spawning area exists north of the Forelands.

7. Longfin smelt were found to be abundant in the northern part of lower Cook Inlet and apparently they mature at the end of their third year of life, a year later than in other populations.

8. Capelin spawning occurred in Kachemak Bay over an extended time, from late May-early June through at least late July.

9. Saffron cod were common in the northern portion of lower Cook Inlet and it is inferred that they are quite abundant there in winter, when spawning occurs.

10. A large number of tiny (probably young-of-the-year) snow crabs were found near Cape Douglas in March has Howard Feder has also reported.

11. Food habits of juvenile pink salmon were found to change with increasing size. Fish smaller than 80 mm consumed more calanoid and harpacticoid copepods while those larger than 80 mm consumed more fish larvae. Insects were important to all size classes (58 to 102 mm) but decreased in frequency of occurrence and percent of content by count as size increased.

RECOMMENDATIONS FOR FURTHER RESEARCH

The present study has produced a data base describing the fish species present, their relative abundance and several spatial and temporal distribution features. It has also provided growth rate, food habit and life history information for several fish species. Additional work should complete the gaps in knowledge left after this work and answer questions raised by this or other works in lower Cook Inlet, as dictated by the data needs of the funding agency.

1. There needs to be more research conducted in Kamishak Bay. The demersal evidence from other portions of the inlet suggest that Kamishak Bay is important in the distribution of yellowfin sole, starry flounder, and probably several other species of bottomfish. There is some direct evidence of its importance to halibut and other researchers have suggested it it is important to snow crab. The shallow water regions are typically inhabited by smaller fish thus they are collectively important areas for production of biomass. Kamishak Bay is virtually all less than 20 fathoms deep and a large portion is less than 10 fathoms. These depths plus inadequate charts of the area, typically bad weather and scarcity of shelter make it a difficult area to work.

2. There needs to be more research conducted in the upper portion of lower Cook Inlet, near the Forelands. The basic question to be answered in this region is winter abundance and time and location of spawning of longfin smelt and saffron cod. These species could be important in the diet of beluga whales in the winter as belugas were concentrated near the docks of Nikiski in early winter 1977-78 (Paul Arneson, personal communication).

   A more thorough study in this area could be justified on the general basis that it is very active biologically and the potential for oil impact from tanker traffic is great. In addition the decomposition of detrities has been found by other investigators to be much more important in this area than further south, and thus the food chain may be quite different. This may affect the species assemblage of the area which is somewhat unique in the inlet. Thus comparative food habits work between upper and lower portions of the inlet may be productive.

3. There needs to be more research conducted on the pelagic community. The migration patterns of juvenile salmonids were to be researched by this study, however, the results are certainly not conclusive. More work on the movements of juvenile pink salmon could be done since methods of capturing them relatively efficiently (i.e. tow net) have been developed. The migration of juvenile pink salmon from the upper inlet, which produces most of the pinks in Cook Inlet, apparently was largely completed before this study was in the field. More work on the early life of herring and of sand lance could be simultaneously conducted. Both of these species are relatively important and sand lance especially are poorly understood.

4. The migratory patterns of king and snow crab are only partially documented in lower Cook Inlet and should be researched. These crab are quite important in the inlet due to their abundance, their seasonal habitation of relatively shallow water (thus their vulnerability to oil impact) and their commercial importance.

5. More work on cummunity structure should be done. This was one of the objectives of this study but was too much to complete for this report. The partial results look as though they are well worthwhile and a completion of the work with this and additional data is planned. An integration of this with food habits analysis may provide important clues to the functioning of the system.

6. Food habits research needs to be expanded and has been so in the ongoing 1978 work. Food habits work provides a number of valuable insights, including a completely different selection of community elements and insight into the nutritional components of the community.

7. Computer modeling of the functioning of the productive chain could provide considerable insight. The strength of modeling (in the words of one vaguely versed in modeling) lies in the assemblage of pertinent information into an integrated unit.

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Table 1. Fish species captured in Cook Inlet by otter trawl, beach seine, surface tow net, purse seine and gill net from June 1976 through March 1977.

Petromyzontidae	
Arctic lamprey	*Lampetra japonica*
Squalidae	
Spiny dogfish	*Squalus acanthias*
Rajidae	
Big skate	*Raja binoculata*
Black skate	*Raja kincaidi*
Longnose skate	*Raja rhina*
Clupeidae	
Pacific herring	*Clupea harengus pallasi*
Salmonidae	
Bering cisco	*Coregonus laurettae*
Pink salmon	*Oncorhynchus gorbuscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Sockeye salmon	*Oncorhynchus nerka*
Chinook salmon	*Oncorhynchus tshawytscha*
Dolly Varden	*Salvelinus malma*
Osmeridae	
Surf smelt	*Hypomesus pretiosus*
Capelin	*Mallotus villosus*
Longfin smelt	*Spirinchus thaleichthys*
Eulachon	*Thaleichthys pacificus*
Gadidae	
Saffron cod	*Eleginus gracilis*
Pacific cod	*Gadus macrocephalus*
Pacific tomcod	*Microgadus proximus*
Walleye pollock	*Theragra chalcogramma*
Zoarcidae	
Shortfin eelpout	*Lycodes brevipes*
Wattled eelpout	*Lycodes palearis*
Gasterosteidae	
Threespine stickleback	*Gasterosteus aculeatus*
Trichodontidae	
Pacific sandfish	*Trichodon trichodon*
Bathymasteridae	
Searcher	*Bathymaster signatus*

Table 1 . (cont.)

Stichaeidae	
Daubed shanny	*Lumpenus maculatus*
Snake prickleback	*Lumpenus sagitta*
Pholidae	
Crescent gunnel	*Pholis laeta*
Anarhichadidae	
Bering wolffish	*Anarhichas orientalis*
Cryptacanthodidae[1]	
Zaproridae	
Prowfish	*Zaprora silenus*
Ammodytidae	
Pacific sand lance	*Ammodytes hexapterus*
Scorpaenidae	
Rockfish	*Sebastes* sp
Hexagrammidae	
Masked greenling	*Hexagrammos octogrammus*
Whitespotted greenling	*Hexagrammos stelleri*
Lingcod	*Ophiodon elongatus*
Cottidae	
Silverspotted sculpin	*Blepsias cirrhosus*
Spinyhead sculpin	*Dasycottus settiger*
	Eurymen gyrinus
Soft sculpin	*Gilbertidia sigalutes*
	Gymnocanthus sp
Thread sculpin	*Gymnocanthus pistiliger*
Red Irish Lord	*Hemilepidotus hemilepidotus*
Yellow Irish Lord	*Hemilepidotus jordani*
Bigmouth sculpin	*Hemitripterus bolini*
Northern sculpin	*Icelinus borealis*
Thorny sculpin	*Icelus spiniger*
Staghorn sculpin	*Leptocottus armatus*
Blackfin sculpin	*Malacocottus kincaidi*
Great sculpin	*Myoxocephalus polyacanthocephalus*
Eyeshade sculpin	*Nautichthys pribilovius*
Tadpole sculpin	*Phychrolutes paradoxus*
Scissortail sculpin	*Triglops forficata*
Ribbed sculpin	*Triglops pingeli*

[1] Larvae of unidentified Cryptacanthodid captured. Speciman no longer on hand.

Table 1. (cont.)

Agonidae	
Northern spearnose poacher	*Agonopsis emmelane*
Sturgeon poacher	*Agonus acipenserinus*
Smooth alligatorfish	*Anoplagonus inermis*
Aleutian alligatorfish	*Aspidophoroides bartoni*
Gray starsnout	*Asterotheca alascana*
Fourhorn poacher	*Hypsagonus quadricornis*
Tubenose poacher	*Pallasina barbata*
Sawback poacher	*Sarritor frenatus*
Cyclopteridae	
Leatherfin lumpsucker	*Eumicrotremus derjugini*
Pacific spiny lumpsucker	*Eumicrotremus orbis*
Spotted snailfish	*Liparis callyodon*
Ribbon snailfish	*Liparis cyclopus*
Marbled snailfish	*Liparis dennyi*
Pleuronectidae	
Arrowtooth flounder	*Atheresthes stomias*
Rex sole	*Glyptocephalus zachirus*
Flathead sole	*Hippoglossoides elassodon*
Pacific halibut	*Hippoglossus stenolepis*
Butter sole	*Isopsetta isolepis*
Rock sole	*Lepidopsetta bilineata*
Yellowfin sole	*Limanda aspera*
Dover sole	*Microstomus pacificus*
English sole[1]	*Parophrys vetulus*
Starry flounder	*Platichthys stellatus*
Alaska plaice	*Pleuronectes quadrituberculatus*
Sand sole[1]	*Psettichthys melanostictus*

[1]Reported but not substantiated by specimen.

Table 2. Hauls successfully completed by gear type and month during 1976 and 1977 in lower Cook Inlet.

Month/Year	Otter Trawl	Beach Seine	Tow Net	Purse Seine	Gill Net[1]
May-June, 1976	10	56	19	0	0
July, 1976	15	66	79	9	0
August, 1976	19	70	62	9	0
Sept.-Oct., 1976	14	70	55	0	58
March, 1977	18	0	0	0	0

[1] Number of 4 hour sets of variable mesh experimental gill nets.

Table 3. Number of successful beach seine and tow net hauls by month and area during summer 1976 in lower Cook Inlet.

Date	West Side of Cook Inlet	East Side of C.I. North of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	12	12	32	0
July	25	13	28	0
August	19	12	25	14
September	15	12	29	14
Tow Net				
May-June	0	0	19	0
July	15	17	47	0
August	16	16	22	8
September	18	5	21	11

Table 4. Beach seine and townet catches in numbers of fish by species and cruise in lower Cook Inlet during 1976.

Taxa	Beach Seine				Townet			
	May June	July	Aug.	Sept. Oct.	May June	July	Aug.	Sept. Oct.
Flounders								
Starry	17	32	28	4			1	1
Rock sole	27	23	19	29				
Sand sole	2		9					
Butter sole	2	5		1				
Halibut		2	1					
Larva			1				1	5
Sculpins								
Soft sculpin						2		2
Great sculpin	11	7	39	61				
Staghorn	3	84	39	14				
Silverspot			4					
Undetermined	57	47	10	13	3	1		
Salmonids								
Pink fry	598	519	197	13	903	260	16	
Adult		20						
Chum fry	2	76	120	7			3	
Adult		3	4					
Red fry	2	57	2			9	1	
Adult	3	5	1					
Chinook[1]	260	72	8	3	2	17	13	
Coho	28	5	5	69[2]		2		1
Dolly Varden	595	732	258	90		1		
Bering Cisco	3	8	3	4				
Cod								
Safron cod	7	3	8	66[3]		1	2	18
Pollock							3	
Undetermined				1				
Greenling								
Whitespot	6	13	60	24			1	1
Masked	4	12	7	6		26	1	
Kelp				1				
Lingcod				2			4	
Undetermined	65	356	17		28	187		2
Stickleback	10	7	25	3	0	179	2	2
Smelt								
Capelin							97	10
Surf smelt		1	44	158			1	5
Longfin	8	1	141	165		434[4]	52	212
Undetermined[5]	51	19[6]	32	1				
Herring[7]	273	120	566	4887		452	258	1833
Sandfish	1	2	6			11	11	6

Table 4. (cont.)

Taxa	Beach Seine May June	Beach Seine July	Beach Seine Aug.	Beach Seine Sept. Oct.	Townet May June	Townet July	Townet Aug.	Townet Sept. Oct.
Snailfish								
Undetermined			6	1			6	5
Rockfish		1						1
Sandlance[7]	16,248[8]	580	1398	16,547	1350	1970	6521	8086
Prickleback								
Longsnout		62	20					1
Snake prickleback	56	50	20		1	6	1	
Crescent gunnel	5	2						
Lamprey	2					9		
Prowfish						1	8	
Wolffish						1		
Poachers								
Sturgeon	1		1				1	
Tubenose		2	32	13			2	1
Undetermined species							1	
Number of Hauls	56	66	70	70	19	79	62	55

[1] All sizes of chinook salmon were combined - 3 fish about 1.5 kg each are the largest included.
[2] One catch of 63 in Halibut Cove included.
[3] Added effort on the oil spill increased this figure from 11.
[4] One large catch of 400.
[5] Table does not reflect abundance of larvae.
[6] One quart of larvae not counted.
[7] Many larvae captured also.
[8] One catch of 13,400 included.

Table 5 . Relative abundance and rank by family and month of fish numbers captured by beach seine in lower Cook Inlet during 1976.

	June		July		August		Sept		Overall	
Family	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%
Sandlance	1	88.6	2	19.8	1	44.7	1	74.6	1	74.6
Pacific herring	3	1.5	5	4.1	3	18.1	2	22.0	2	12.5
Salmon	2	8.1	1	51.1	2	19.1	4	0.8	3	8.1
Smelt	6	0.3	8	0.7	4	6.9	3	1.5	4	1.3
Greenling	4	0.4	3	13.0	6	2.7	8	0.1	5	1.2
Sculpins	5	0.4	4	4.7	5	2.9	5	0.4	6	0.8
Pricklebacks	7	0.3	6	3.8	8	1.3	-	-	7	0.4
Flounders	8	0.3	7	2.1	7	1.9	7	0.2	8	0.4
Cod	10	<0.1	10	0.1	11	0.3	6	0.3	9	0.2
Poachers	13	<0.1	11	0.1	9	1.1	9	<0.1	10	0.1
Stickleback	9	<0.1	9	0.2	10	0.8	11	<0.1	11	0.1
Sandfish	13	<0.1	11	0.1	12	0.2	-	-	12	<0.1
Snailfish	-	-	-	-	12	0.2	10	<0.1	13	<0.1
Gunnel	11	<0.1	11	0.1	-	-	-	-	14	<0.1
Lamprey	12	<0.1	-	-	-	-	-	-	15	<0.1
Rockfish	-	-	14	<0.1	-	-	-	-	16	<0.1

Table 6 . Relative abundance and rank by family and month of fish numbers captured by a surface tow net in lower Cook Inlet during 1976.

	June		July		Aug		Sept		Overall	
Family	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%
Sandlance	1	59.0	1	55.2	1	93.1	1	79.3	1	77.8
Pacific herring	-	-	2	12.7	2	3.7	2	18.0	2	11.0
Salmon	2	39.6	4	8.1	4	0.5	11	<0.1	3	5.3
Smelt	-	-	3	12.2	3	2.1	3	2.2	4	3.5
Greenling	3	1.2	5	6.0	7	0.1	8	<0.1	5	1.1
Stickleback	-	-	6	5.0	11	<0.1	9	<0.1	6	0.8
Sandfish	-	-	7	0.3	5	0.2	5	0.1	7	0.1
Cod	-	-	11	<0.1	9	0.1	4	0.2	8	0.1
Snailfish	-	-	-	-	7	0.1	7	<0.1	9	<0.1
Prickleback	5	<0.1	9	0.2	13	<0.1	11	<0.1	10	<0.1
Lamprey	-	-	8	0.3	-	-	-	-	11	<0.1
Prowfish	-	-	11	<0.1	6	0.1	-	-	12	<0.1
Flounders	-	-	-	-	11	<0.1	5	0.1	13	<0.1
Sculpins	4	0.1	10	0.1	-	-	9	<0.1	14	<0.1
Poachers	-	-	-	-	10	<0.1	11	<0.1	15	<0.1
Rockfish	-	-	-	-	-	-	11	<0.1	16	<0.1
Wolffish	-	-	11	<0.1	-	-	-	-	17	<0.1

Table 7. Total number of fish captured in the purse seine (July and August) and in the gill net (September) by month and by species.[1]

	July	August	September
Chinook salmon	11	36	1
Pink salmon	0	1	1
Red salmon	1	0	0
Coho salmon	3	0	0
Dolly Varden	2	0	0
Pacific herring	149	55	18
Pacific sand lance	0	1	0
Soft sculpin	10	0	0
Bering wolffish	3	0	0

[1] Otter trawl was the only gear used in March 1977 cruise.

Table 8. Otter trawl catch in kilograms per 20 minute haul in lower Cook Inlet by taxon and month, June 1976 through March 1977.

Taxa	June	July	Aug.	Sept.	March
Spiny dogfish				0.4	
Big skate[1]				1.3	1.0
Black skate			0.3		
Longnose skate		0.5		0.6	
Starry skate[1]					
Pacific herring			T	0.3	T
Capelin	T	T	T	T	
Eulachon		T	T	T	0.1
Pacific cod	8.9	6.9	7.0	2.4	3.2
Pacific tomcod	T	T		T	0.2
Walleye pollock	0.9	16.2	24.2	2.4	0.6
Shortfin eelpout		T	T		T
Wattled eelpout	T	T			
Pacific sandfish	0.3	0.1	0.1	T	0.3
Searcher	T	T	0.4	0.3	T
Daubed shanny	T		T	T	T
Snake prickleback	T	T		T	
Pacific sand lance				T	T
Rockfish spp		T	T		0.1
Masked greenling	T				
Whitespotted greenling	0.3	T	T	0.3	T
Atka mackerel					T
Sculpin spp	3.0	2.4	T[2]		
Spinyhead sculpin		T	T	T	T
Gymnocanthus spp		0.2	0.9	0.3	0.2
Red Irish Lord	T		T		
Yellow Irish Lord	1.1	5.6	15.2	1.3	15.4
Bigmouth sculpin		0.3	0.2		0.1
Northern sculpin			T		T
Thorny sculpin		T	T	T	T
Staghorn sculpin				0.1	0.1
Blackfin sculpin		0.2	T		0.2
Great sculpin	4.4	2.9	7.2	5.2	4.6
Eyeshade sculpin			T		
Tadpole sculpin	T		T		
Scissortail sculpin			0.1		0.4
Ribbed sculpin		T	T	0.1	T
Sea poacher (spp)	T	T			
Northern spearnose poacher			T	T	
Sturgeon poacher	.7	.2	.1	.1	1.5
Smooth and Aleutian alligatorfish		T	T	T	T
Gray starsnout		T	T	T	
Fourhorn poacher			T		
Tubenose poacher					T

Table 8. (cont.)

Taxa	June	July	Aug.	Sept.	March
Sawback poacher			T		0.1
Snailfish spp	T	T	T	T	T
Pleuronectidae spp	0.6[3]				
Arrowtooth flounder	0.5	3.4	7.6	2.3	1.0
Rex sole	T	0.2	0.4	1.2[3]	0.2
Flathead sole	0.2	0.5	1.9	3.0	0.3
Pacific halibut	10.1	5.3	8.6	5.1	7.5
Butter sole	4.8	7.0	4.1	7.4	4.4
Rock sole	2.1	2.7	10.3	11.4	12.0
Yellowfin sole	2.2	7.9	4.7	22.1	6.1
Dover sole		.2	.2	T	T
Starry flounder	0.1	0.2	1.9	6.5	1.0
Alaska place	0.4	T	0.2	0.9	0.1
Sandsole	0.2		T		
King crab	5.3	4.6	8.6	6.8	1.9
Snow crab	11.8	25.5	23.2	10.8	30.2
Dungeness crab	0.5				
Shrimp	T	T	0.7	0.9	T

[1]Egg case captured, identification tentative for starry skate.
[2]*Eurymen gyrinus*
[3]Identification dubious. Originally identified as Dover sole but were in wrong place, of wrong size and aggregated as Dover never were.

Table 9 . Otter trawl catch per unit effort in kilograms and standard error of mean of fish, all species, by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	39.5 ± 14.0	NS
26-50	61.9	167.9	10.8	43.6	15.4 ± 5.8
51-75	37.4 ± 12.6	41.2 ± 13.4	64.9 ± 17.7	82.7 ± 31.4	52.1 ± 13.4
76-100	34.7 ± 23.7	77.4 ± 11.6	138.7 ± 106.3	109.1 ± 49.1	79.1 ± 3.2
101-125	NS	99.5	248.6	NS	NS
126-150	NS	48.6 ± 26.0	116.9 ± 24.9	42.1 ± 6.9	50.6 ± 27.9
151-175	NS	40.0	222.1	NS	NS
176-200	NS	84.7	17.1	NS	283.2

Table 10. Juvenile pink salmon percent frequency of occurrence in beach seine and tow net by cruise and major sampling area in lower Cook Inlet, 1976.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	42	33	34	NS
July	72	8	39	NS
August	58	0	4	50
September	13	0	0	7
Tow Net				
May-June	NS	NS	63	NS
July	7	59	36	NS
August	19	12	9	0
September	0	0	0	0

Table 11. Juvenile pink salmon catch per unit effort and standard error in beach seine and tow net by cruise and major sampling area in lower Cook Inlet, 1976.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	1.0 ± 0.6	0.8 ± 0.4	18.0 ± 12.3	NS
July	16.8 ± 5.4	0.2	3.5 ± 1.3	NS
August	3.6 ± 1.2	0	0.1	9.4 ± 6.2
September	0.3 ± 0.3	0	0	0.6
Tow Net				
May-June	NS	NS	69.5 ± 42.6	NS
July	<0.1	2.9 ± 1.2	4.4 ± 2.4	NS
August	0.4 ± 0.2	0.5 ± 0.4	0.1	0
September	0	0	0	0

Table 12. Juvenile pink salmon catch per unit effort (number of samples) by time period and area within Kachemak Bay with overall mean catch per unit effort and standard error in beach seine and tow net.

Date	Bear Cove to Glacier Spit	Halibut Cove to Peterson Bay	Middle Kachemak Bay	Coal Bay	Eldred Passage	Sadie Cove	Tutka Bay	Overall Mean
Beach Seine								
5/21-6/8				21.6 (7)			0.2 (4)	13.8 ± 7.8
6/18	2 (1)	60.4 (7)						52.9 ± 48.2
6/21-6/30	0 (1)			0 (4)	0 (7)		0 (1)	0
7/26-7/29	0.3 (3)	2.6 (7)		0 (3)	9.3 (6)	4.2 (5)	0.5 (4)	3.5 ± 1.3
8/24-8/28	0 (3)	0 (7)			0 (6)	0 (5)	0.5 (4)	0.1
9/2-9/29	0 (3)	0 (7)		0 (3)	0 (6)	0 (5)	0 (5)	0
Tow Net								
5/20-5/29				1.0 (8)		1 (1)	6.5 (4)	2.6 ± 1.1
6/22-6/30	14.7 (3)			1.0 (1)		11 (1)	813 (1)	149 ± 134
7/7							17.8 (6)	17.8 ± 17.6
7/15-7/17					0 (1)		1.6 (12)	1.5 ± 0.6
7/26-7/30	0.2 (4)	0.2 (4)	1.3 (3)	0 (1)	9.0 (2)	9.2 (4)	3.1 (7)	3.3 ± 1.4
8/24-8/27	0 (4)	0 (4)	0 (1)		0 (2)	0.5 (4)	0 (7)	0.1
9/2-9/29	0 (4)	0 (4)		0 (1)	0 (2)	0 (3)	0 (7)	0

Table 13. Dolly Varden catch per unit effort and standard error in beach seine hauls by cruise and major sampling area in lower Cook Inlet, 1976.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	8.6 ± 7.2	10.4 ± 6.7	11.5 ± 3.8	NS
July	6.5 ± 2.0	5.9 ± 2.6	17.6 ± 5.3	NS
August	3.9 ± 1.4	1.1 ± 0.7	0.7 ± 0.3	10.8 ± 4.3
September	0.5 ± 0.2	0.2 ± 0.2	0.5 ± 0.3	4.7 ± 3.1

Table 14. Pacific sand lance catch per unit effort and standard error in beach seine and tow net by cruise and major sampling area in lower Cook Inlet, 1976.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	<0.1	0	508 ± 420[1]	NS
July	22.2 ± 18.1	0	0.9 ± 0.9	NS
August	1.3 ± 0.9	95.4 ± 53.6	7.2 ± 4.2	3.5 ± 1.9
September	2.1 ± 1.0	0	289 ± 153	580 ± 360
Tow Net				
May-June	NS	NS	71.0 ± 37.4	NS
July	30.9 ± 29.9	3.6 ± 3.5	30.7 ± 17.5	NS
August	0.2	144 ± 81	191 ± 102	0.6
September	13.2 ± 7.0	0.4	373 ± 117	0

[1] One large catch of 13,400, when eliminated the mean = 92.0 ± 60.3.

Table 15. Pacific herring catch per unit effort and standard error in beach seine and tow net by cruise and major sampling area in lower Cook Inlet, 1976.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	0	22.6 ± 21.1	<0.1	NS
July	3.2 ± 2.1	2.8 ± 2.4	<0.1	NS
August	17.2 ± 16.4	11.0 ± 4.4	4.2 ± 2.7	0.2
September	21.7 ± 9.3	0.2[1]	157 ± 56	0
Tow Net				
May-June	NS	NS	0	NS
July	<0.1	26.4 ± 8.2	<0.1	NS
August	0	15.3 ± 3.7	0.6	0
September	52.9 ± 16.5	20.0 ± 17.5	37.2 ± 25.6	0

[1] Samples were not taken south of the Kenai River in September, and this was the area where beach seine catches were greatest during earlier months.

Table 16. Catch per unit effort of greenling, exclusive of lingcod, and standard error in beach seine and tow net by cruise and major sampling areas.

Date	West side of Cook Inlet	East side of C.I. north of Anchor Point	Kachemak Bay	Kenai Peninsula Southwest of Tutka Bay
Beach Seine				
May-June	0.6 ± 0.5	1.1 ± 0.6	1.7 ± 0.4	NS
July	2.3 ± 1.0	11.0 ± 3.1	6.5 ± 2.0	NS
August	1.2 ± 0.6	2.2 ± 0.6	0.7 ± 0.3	1.3 ± 0.9
September	0.3 ± 0.2	0	0.2	1.5 ± 0.9
Tow Net				
May-June	NS	NS	1.5 ± 0.5	NS
July	10.7 ± 8.7	1.1 ± 0.7	0.7 ± 0.5	NS
August	<0.1	0	<0.1	0
September	0.1	0.2	0	0

Table 17. Catch per unit effort[1] of Pacific halibut by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
CPUE in kg					
0-25	NS	NS	NS	11.6 ± 9.3[2]	NS
26-50	37.2	44.9	10.7	4.9	1.5 ± 1.0
51-75	7.1 ± 4.5	5.2 ± 3.8	7.1 ± 1.9	3.1 ± .9	12.1 ± 7.4
76-100	6.8 ± 3.1	4.1 ± 4.1	42.6 ± 42.6	6.8 ± 3.9	1.5 ± .2
101-125	NS	0	3.1	NS	NS
126-150	NS	0	<.1	0	8.4 ± 5.1
151-175	NS	0	0	NS	NS
176-200	NS	.8	0	NS	5.1
CPUE in numbers					
0-25	NS	NS	NS	25.0 ± 17.0	NS
26-50	33	14	10	8	6.0 ± 4.2
51-75	2.0 ± 1.0	1.8 ± 0.9	3.3 ± 0.7	2.8 ± 0.5	9.5 ± 4.6
76-100	4.0 ± 3.0	1.0 ± 1.0	3.0 ± 3.0	4.2 ± 2.7	7.0 ± 1.0
101-125	NS	0	1	NS	NS
126-150	NS	0	0.2 ± 0.2	0	9.8 ± 5.8
151-175	NS	0	0	NS	NS
176-200	NS	1	0	NS	8

[1] A unit of effort is a 20 minute otter trawl haul.
[2] ± one standard error.

Table 18. Length frequency of Pacific halibut by depth during March, 1977 in lower Cook Inlet otter trawl catches.

Length mm	27-75 m	137-148 m	192 m
150-175	2		
176-200	5		
201-225	5		
226-250	6	1	
251-275	2	1	
276-300	7	5	
301-325	2	8	
326-350	2	6	1
351-375	1	2	1
376-400	1	1	2
401-425		1	
426-450	2		1
451-475		1	
476-500		2	1
501-525			
526-550		1	
<550	4	1	
n	39	30	6
Mean, mm	333	378	400

Table 19. Otter trawl catch per unit effort and standard error of yellowfin sole by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	8.8 ± 2.2	NS
26-50	.6	90.7	0	24.8	1.4 ± 1.4
51-75	3.1 ± 1.3	2.8 ± 1.3	8.7 ± 4.4	22.8 ± 16.5	9.6 ± 4.2
76-100	.2 ± .2	6.4 ± 5.8	5.4 ± 5.4	37.9 ± 35.2	22.5 ± 1.8
101-125	NS	0	0	NS	NS
126-150	NS	.2 ± .2	0	.8 ± .8	.4 ± .4
151-175	NS	0	0	NS	NS
176-200	NS	0	0	NS	0

Table 20. Length frequency of yellowfin sole by depth from August and September 1976 otter trawl catches in lower Cook Inlet.

Length, mm	18-27 m	57-73 m	100 m	138 m
126-150	3			
151-175	15	2		
176-200	17	9		
201-225	11	30		
226-250	1	45	1	
251-275	2	32	2	
276-300		9	1	2
301-325		10	4	2
326-350	1	3		
n	50	140	8	4
mean, mm	183	244	290	307

Table 21. Otter trawl catch per unit effort and standard error of starry flounder by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	13.1 ± .5	NS
26-50	0	1.9	0	2.0	3.2 ± 3.2
51-75	0	.2 ± .2	3.9 ± 2.6	10.7 ± 3.8	1.3 ± .9
76-100	.4 ± .4	0	.9 ± .9	2.2 ± 2.2	.3 ± .3
101-125	NS	0	0	NS	NS
126-150	NS	0	0	0	0
151-175	NS	0	0	NS	NS
176-200	NS	0	0	NS	0

Table 22. Length frequency of starry flounder by depth from August and September 1976 and March 1977 otter trawl catches in lower Cook Inlet.

	August, September		March
Length, mm	25-27 m	60-64 m	27 m
251-275	2		3
276-300	2		1
301-325	2		1
326-350	2		1
351-375	2		1
376-400	1		2
401-425		1	3
426-450		1	2
451-475		3	1
476-500		1	
501-525		3	
526-550	1	2	
551-575			
576-600		3	
n	12	14	15
mean, mm	343	506	364

Table 23. Otter trawl catch per unit effort and standard error of rock sole by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	.2 ± .2	NS
26-50	1.2	1.7	0	<.1	3.0 ± 2.4
51-75	2.3 ± 1.2	4.1 ± 1.7	15.6 ± 8.6	18.3 ± 9.1	13.0 ± 6.7
76-100	2.0 ± 1.4	7.7 ± 5.6	12.9 ± 5.2	17.0 ± 9.2	12.3 ± 6.1
101-125	NS	.2	26.0	NS	NS
126-150	NS	.5 ± .5	.2 ± .2	0	12.4 ± 8.9
151-175	NS	.3	.7	NS	NS
176-200	NS	0	2.5	NS	30.2

Table 24. Length frequency of rock sole by depth from August 1976 and March 1977 otter trawl catches in lower Cook Inlet.

	August						March		
Length mm	57-64 m	69-73 m	82 m	113 m	146-155 m	192 m	49 m	137 m	192 m
51-75	1								
76-100	9	1							
101-125	23	1							
126-150	7	3	1				1		
151-175	15	6	8				1		
176-200	20	16	29				8		
201-225	35	22	19	3			3	5	1
226-250	27	35	6	19	3		6	9	4
251-275	22	33	2	18	2	3	8	24	4
276-300	5	13	4	18	2	2	2	11	10
301-325	9	11	1	8		3	1	11	8
326-350	1	6	1	13			1	10	5
351-375	1	5		5			1	8	8
376-400	1	3		2			5	5	5
401-425		2		1				3	2
426-450	1	2						1	5
451-475		1							1
n	177	160	71	87	7	8	37	87	53
mean, mm	203	241	209	286	262	286	258	298	333

Table 25. Otter trawl catch per unit effort and standard error of butter sole by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	.2 ± .2	NS
26-50	10.5	17.8	0	<.1	<.1
51-75	3.4 ± 2.1	6.0 ± 2.0	7.0 ± 3.6	10.0 ± 3.6	6.0 ± 2.4
76-100	6.9 ± 6.9	28.3 ± 3.9	7.6 ± 7.4	13.2 ± 10.4	17.2 ± 12.2
101-125	NS	0	0	NS	NS
126-150	NS	0	0	0	1.4 ± 1.0
151-175	NS	.2	0	NS	NS
176-200	NS	0	0	NS	0

Table 26. Length frequency of butter sole by depth from July, August and September, 1976 otter trawl catches in lower Cook Inlet.

Length, mm	57-60 m	64 m	69-73 m	82-87 m	100 m
121-130	1				
131-140	1		2		
141-150	2		1		1
151-160	2	1	1		
161-170	2	2	4		1
171-180	11	2	7		2
181-190	19	2	8		4
191-200	18	7	10		2
201-210	12	4	13		8
211-220	9	7	14	1	8
221-230	5	5	6		3
231-240	1	5	9	2	2
241-250	8	3	9		4
251-260	2	5	3		3
261-270	1	4	2		1
271-280	2	10	1	1	
281-290	1	6			
291-300	1	6			
>300	1	3	3	1	
n	99	72	93	5	39
mean, mm	202	226	213	254	215

Table 27. Otter trawl catch per unit effort and standard error of flathead sole by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	2.4 ± 1.6	NS
26-50	0	1.8	0	4.2	<.1
51-75	.2 ± .2	<.1	2.1 ± 1.2	2.4 ± 1.2	.1
76-100	0	.8 ± .8	1.7 ± 1.7	3.4 ± 2.5	2.8 ± 1.1
101-125	NS	0	0	NS	NS
126-150	NS	.9 ± .9	2.6 ± 1.5	3.8 ± 3.8	<.1
151-175	NS	.8	2.7	NS	NS
176-200	NS	0	1.3	NS	0

Table 28. Length frequency of flathead sole by depth in August and September 1976 otter trawl catches in lower Cook Inlet.

Length, mm	25-27 m	57-69 m	84-100 m	137-192 m
76-100	2	13		
101-125	9	34	1	
126-150	3	20		
151-175	22	30	2	
176-200	19	12	1	1
201-225	1	4	1	3
226-250	2	6	4	11
251-275		6	1	30
276-300		1		25
301-325		1		6
326-350				4
351-375				1
376-400				1
n	58	127	10	82
mean, mm	164	152	218	272

Table 29. Otter trawl catch per unit effort and standard error of arrowtooth flounder by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	.2 ± .1	NS
26-50	0	0	0	0	0
51-75	.7 ± .4	1.6 ± .6	3.3 ± 1.4	1.7 ± .6	<.1
76-100	0	2.9 ± 2.2	6.0 ± 2.2	3.6 ± 2.5	1.2 ± .7
101-125	NS	12.2	11.4	NS	NS
126-150	NS	3.8 ± 2.5	17.4 ± 3.8	4.0 ± .4	2.3 ± 1.1
151-175	NS	1.0	16.3	NS	NS
176-200	NS	4.8	5.5	NS	1.4

Table 30. Length frequency of arrowtooth flounder by depth from August and September, 1976 and March, 1977 otter trawl catches in lower Cook Inlet.

	August and September					March
Length, mm	57-73 m	82-87 m	100-113 m	137-155 m	192 m	128-137 m
76-100	1					
101-125	4					
126-150	22	1				
151-175	28	1	11			
176-200	9	1	5			4
201-225	16	4	13	11		11
226-250	18		12	53		7
251-275	4	1	4	26		6
276-300	3		2	28		19
301-325	4	2	6	41		6
326-350	1		1	46	2	3
351-375	1		7	35	1	
376-400	2	1	6	25		1
401-425	2		1	4	1	1
426-450	1		1	5	3	1
451-475		1		5	1	
476-500		1		1		
<500				1		
n	116	13	69	281	8	59
mean, mm	202	278	260	313	403	270

Table 31. Length frequency of rex sole by depth from August and September 1976, otter trawl catches in lower Cook Inlet.

Length, mm	57-58 m	64-69 m	91-100 m	146 m
75-100		1		
101-125	1	1		
126-150	2			
151-175	8	2		
176-200	25	16		
201-225	8	14	2	
226-250	3	8	4	
251-275		6	3	
276-300	1		4	1
<300			1	
n	48	48	14	1
mean, mm	192	209	261	290

Table 32. Otter trawl catch per unit effort and standard error of walleye pollock by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	<.1	NS
26-50	1.8	.8	0	.8	<.1
51-75	1.0 ± .6	6.4 ± 5.8	.4 ± .2	.3 ± .2	.4 ± .2
76-100	0	9.3 ± 9.3	35.3 ± 35.2	1.2 ± .9	1.1 ± 1.0
101-125	NS	29.9	26.5	NS	NS
126-150	NS	24.7 ± 17.0	47.8 ± 10.6	13.5	.4 ± .2
151-175	NS	3.6	163	NS	NS
176-200	NS	59.0	5.8	NS	4.0

Table 33. Length frequency of walleye pollock by depth during July, August and September 1976 from otter trawl hauls in lower Cook Inlet.

Length, mm	25-27 m	57-87 m	113-122 m	137-147 m	155 m	191-192 m
51-100	10					
101-150	12		1	1		
151-200	1	48	2	14	1	
201-250	2	12		8		
251-300		1	6	41		1
301-350			21	56	4	9
351-400			65	154	39	28
401-450			7	69	26	7
451-500		1		34	11	
501-550		1		4	3	
551-600				2		
>600				1	1	
n	25	63	102	384	85	45
mean, mm	116	202	357	381	409	369

Table 34. Otter trawl catch per unit effort and standard error of Pacific cod by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	0	NS
26-50	0	0	0	0	0
51-75	10.2 ± 6.6	1.7 ± .9	3.2 ± 1.5	.4 ± .3	.1 ± .1
76-100	9.0 ± 2.4	5.8 ± 1.5	4.0 ± .8	1.4 ± .6	<.1
101-125	NS	1.0	8.3	NS	NS
126-150	NS	9.0 ± 6.8	13.1 ± 5.8	13.4 ± 8.0	4.3 ± 3.0
151-175	NS	32.4	34.4	NS	NS
176-200	NS	13.6	0	NS	30.2

Table 35. Length frequency of Pacific cod by depth in July, August, September 1976 and March 1977 from otter trawl catches in lower Cook Inlet.

Length, mm	57-64 m	69-91 m	113-147 m		155-192 m	
			Summer	March	Summer	March
151-200	1					
201-250	15	5	4			
251-300	1	13	3	8		
301-350	1		4	16		3
351-400	4	3	20	4	3	1
401-450	7	7	30	4	18	4
451-500	2	3	9	6	6	5
501-550	1	1	5		10	3
551-600	1	3	6	1	12	1
601-650	1	3	4	1	3	
651-700			2		4	2
n	34	38	87	40	56	19
mean, mm	329	378	431	367	507	479

Table 36. Otter trawl catch per unit effort and standard error of yellow Irish Lord by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	NS	NS	NS	0	NS
26-50	0	4.8		<.1	<.1
51-75	1.6 ± 1.2	<.1	.6 ± .4	.5 ± .3	.2 ± .2
76-100	0	.5 ± .5	6.6 ± 2.6	1.4 ± .8	<.1
101-125	NS	52.6	137	NS	NS
126-150	NS	5.9 ± 4.7	32.5 ± 24.4	4.6 ± 2.8	12.4 ± 9.3
151-175	NS	0	1.2	NS	NS
176-200	NS	2.2	1.3	NS	202

Table 37. Otter trawl catch per unit effort and standard error of great sculpin by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

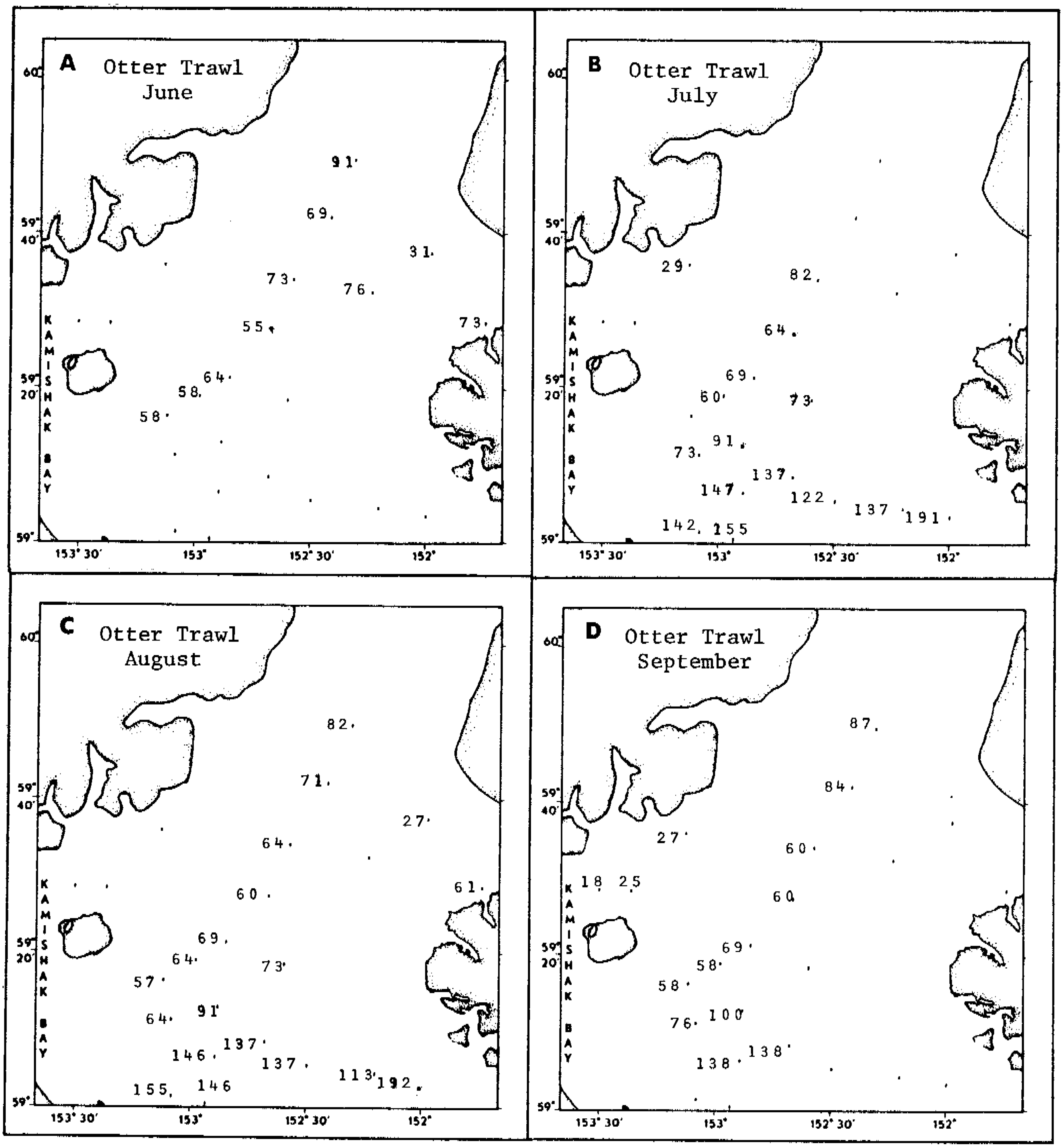
Depth Meters	June.	July	August	September	March
0-25	NS	NS	NS	.2 ± .2	NS
26-50	9.0	0	0	1.4	5.4 ± 3.9
51-75	5.0 ± 1.9	6.2 ± 3.4	9.0 ± 2.6	7.9 ± 3.0	2.6 ± .7
76-100	0	4.5 ± 4.5	13.3 ± 8.0	7.5 ± 3.0	8.0 ± 2.7
101-125	NS	0	25.1	NS	NS
126-150	NS	.8 ± .5	1.0 ± .6	.4 ± .4	5.1 ± 4.8
151-175	NS	0	0	NS	NS
176-200	NS	0	0	NS	4.2

Table 38. Otter trawl catch per unit effort and standard error of snow crab by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Meters	June	July	August	September	March
0-25	ns	ns	ns	0.1	ns
26-50	2.3	11.8	9.0	0	7.2 ± 7.2
51-75	16.6 ± 10.6	38.2 ± 16.8	17.3 ± 5.1	9.3 ± 3.9	36.5 ± 18.5
76-100	<0.1	49.0 ± 42.0	87.2 ± 87.0	12.5 ± 10.0	29.9 ± 23.4
101-125	ns	1.2	0.8	ns	ns
126-150	ns	19.6 ± 14.7	18.2 ± 5.2	27.2 ± 1.2	40.0 ± 21.2
151-175	ns	1.0	28.1	ns	ns
176-200	ns	0	0.3	ns	2.8

Table 39. Otter trawl catch per unit effort and standard error of king crab by depth interval and month in lower Cook Inlet, June through September 1976 and March 1977.

Depth Interval - m	June	July	Aug.	Sept.	March
0-25				0	
26-50	1.8	18.1	1.15	2.3	9.1 ± 8.5
51-75	7.3 ± 4.2	5.2 ± 2.0	8.2 ± 3.9	6.6 ± 4.3	1.9 ± 1.2
76-100	0	6.2	1.9 ± 1.9	11.4 ± 6.9	1.1 ± 1.1
101-125		0	0		
126-150		3.7 ± 3.7	12.0 ± 6.5	7.4 ± 5.6	0
151-175		0	0		
176-200		0	9.0		0


A Otter Trawl
June
91
69
31
73
76
55
73
64
58
58
B Otter Trawl
July
29
82
64
69
60
73
91
73
137
147
122
137
191
142
155
C Otter Trawl
August
82
71
27
64
60
61
69
64
73
57
64
91
137
146
137
113
192
155
146
D Otter Trawl
September
87
84
27
60
18
25
60
69
58
58
76
100
138
138
KAMISHAK BAY
60°
59° 40'
59° 20'
59°
153° 30'
153°
152° 30'
152°

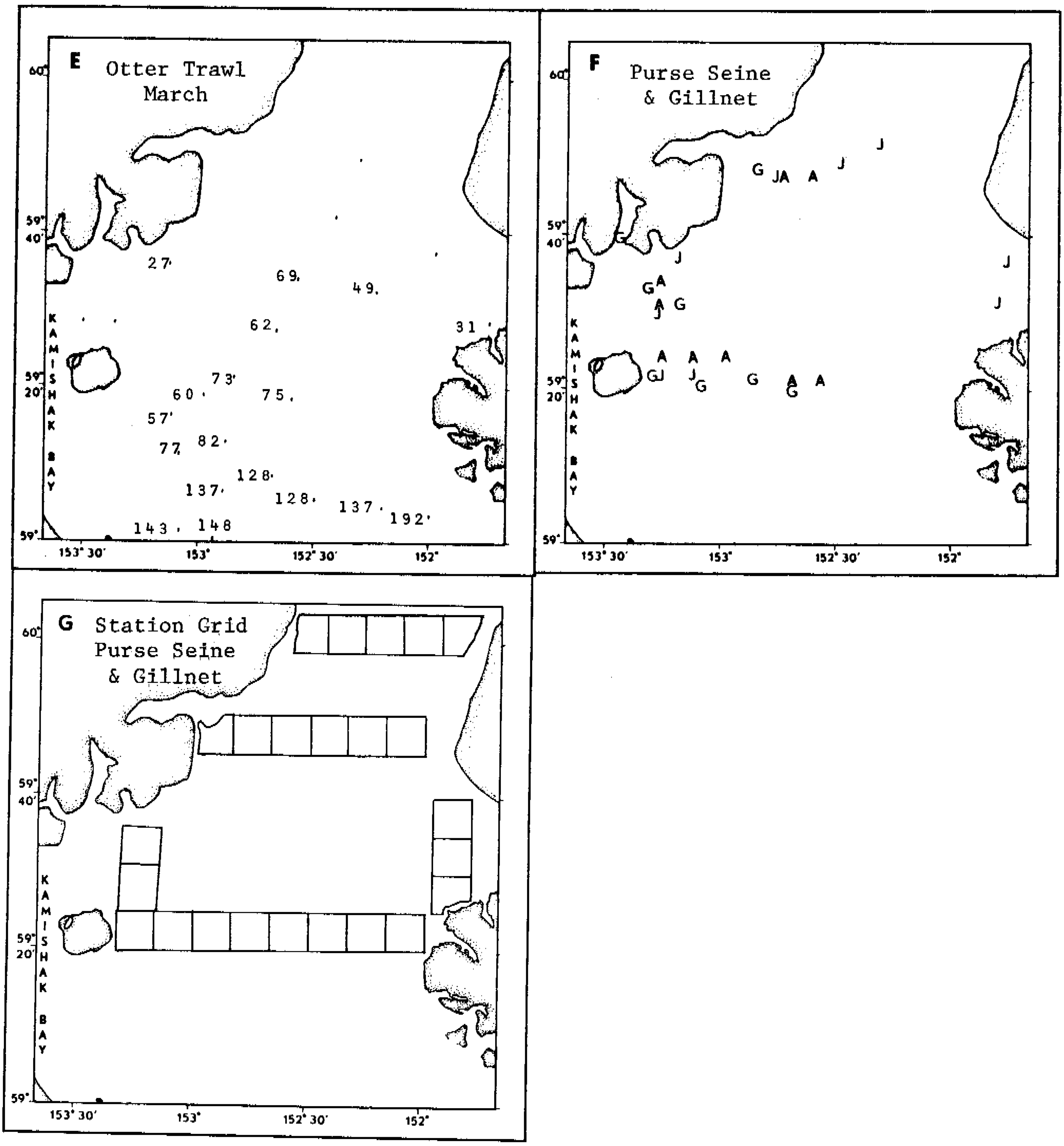


Figure 1. Locations sampled with otter trawl (A-E), purse seine and gillnet (F) by cruise and purse seine and gillnet transects (G). Otter trawl stations sampled are indicated by the depth in meters at the time of sampling. In F, gillnet stations are designated by G and were sampled during September 1976 while purse seine stations are designated by J = July and A = August.

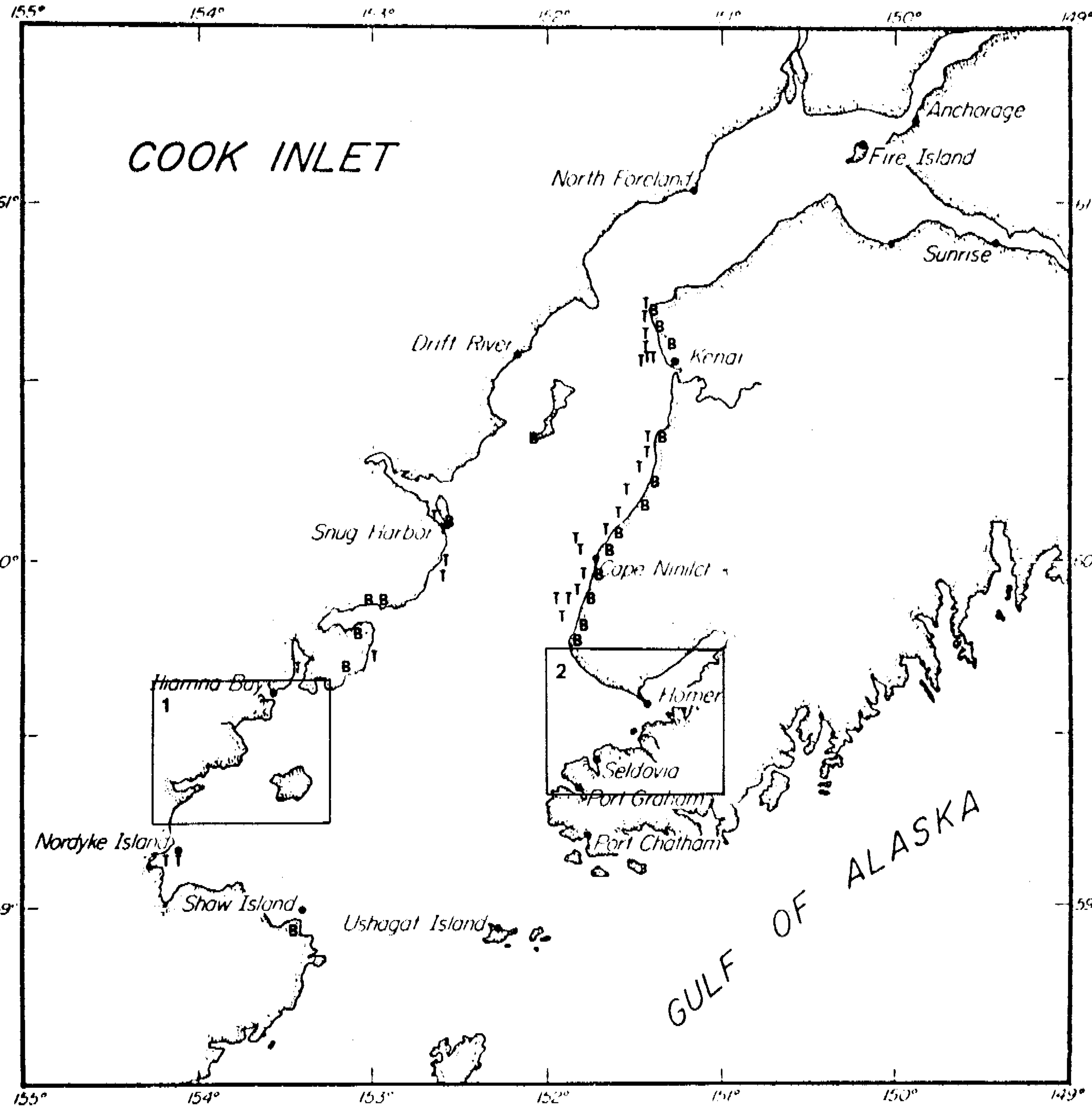
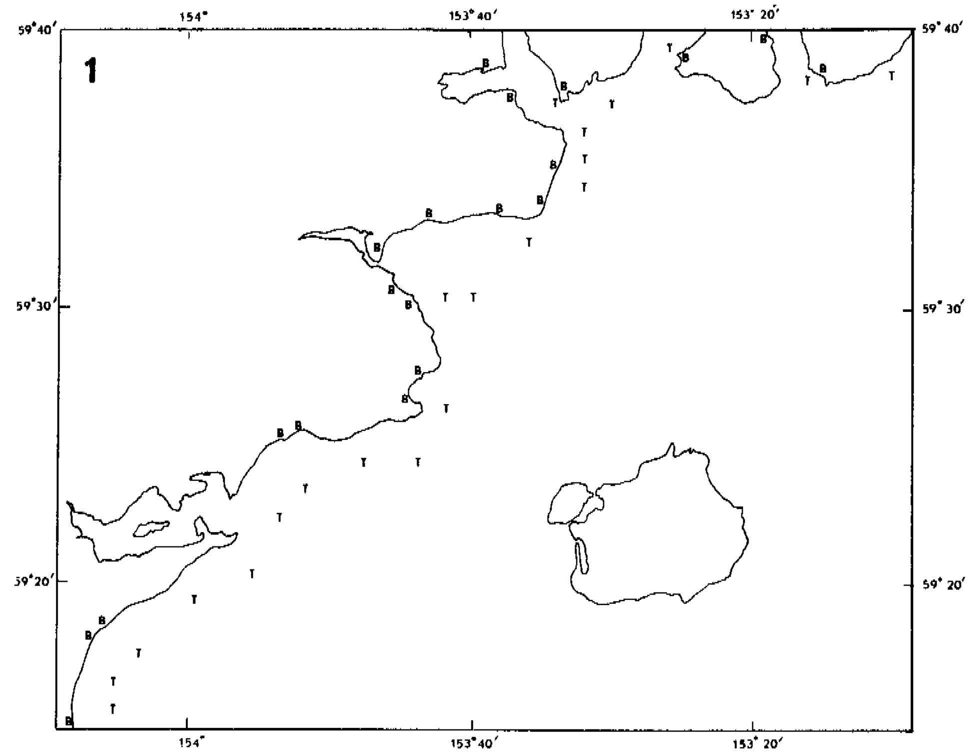
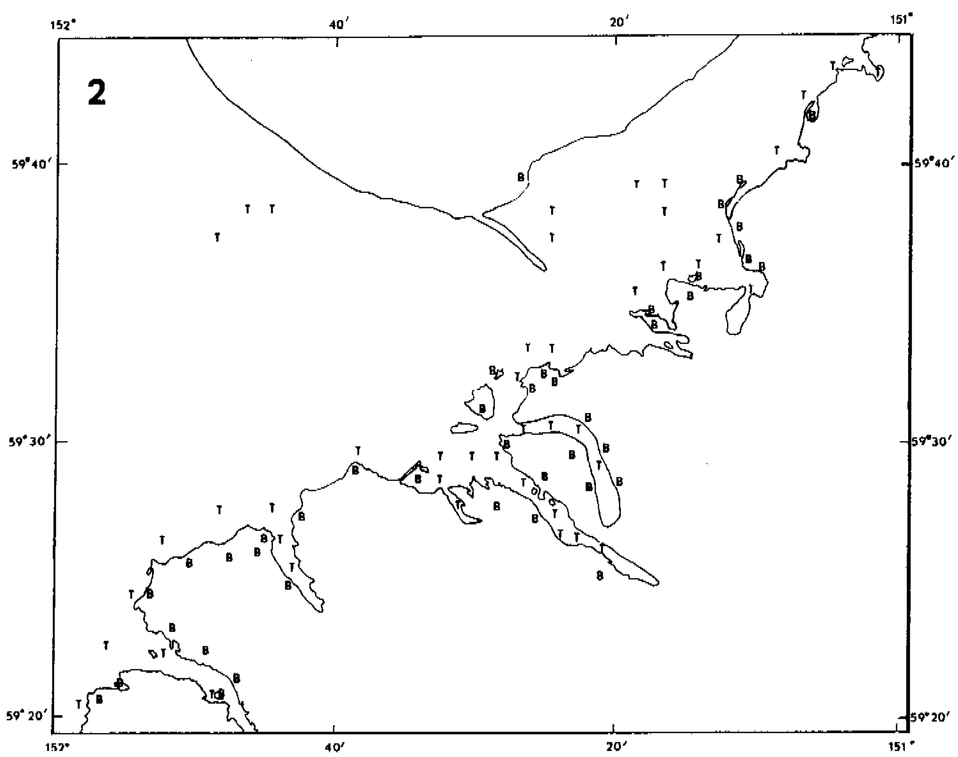


Figure 2. Sampling locations for beach seine (B) and tow net (T) in lower Cook Inlet during May through September 1976. Insets 1 and 2, opposite page, show sampling locations in Kamishak and Kachemak Bays, respectively.


1
59°40′
154°
153°40′
153° 20′
59° 40′
59°30′
59° 30′
59°20′
59° 20′
154°
153°40′
153° 20′


2
152°
40′
20′
151°
59°40′
59°40′
59°30′
59°30′
59° 20′
59°20′
152°
40′
20′
151°

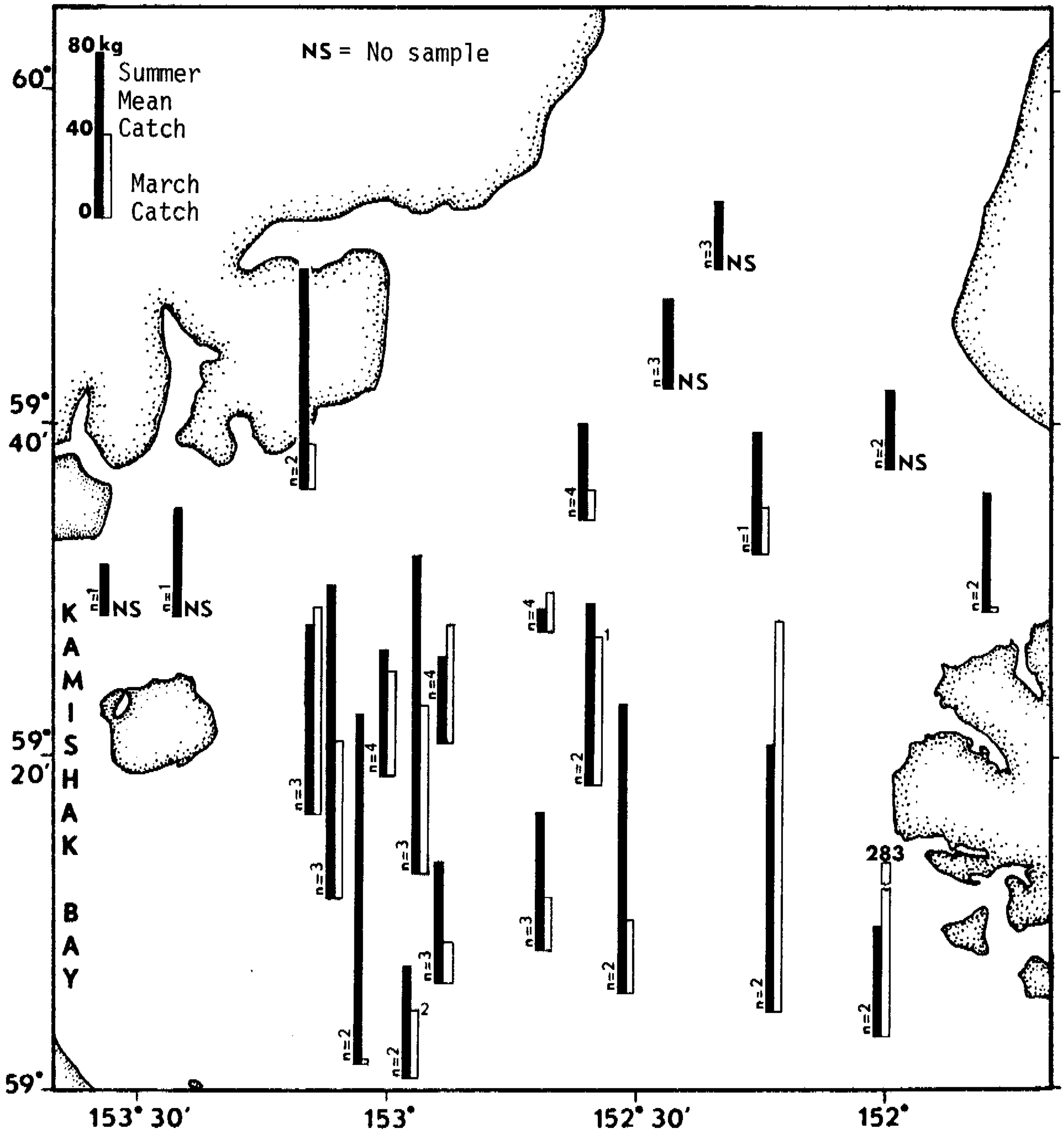


Figure 3 . Distribution and mean catch in kg per 20 minute otter trawl haul of fish, all species, in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977. Footnote 1 indicates one halibut constituted 48.5 kg of 71.3 kg caught and footnote 2 indicates one halibut constituted 30.8 kg of 32.4 kg caught.

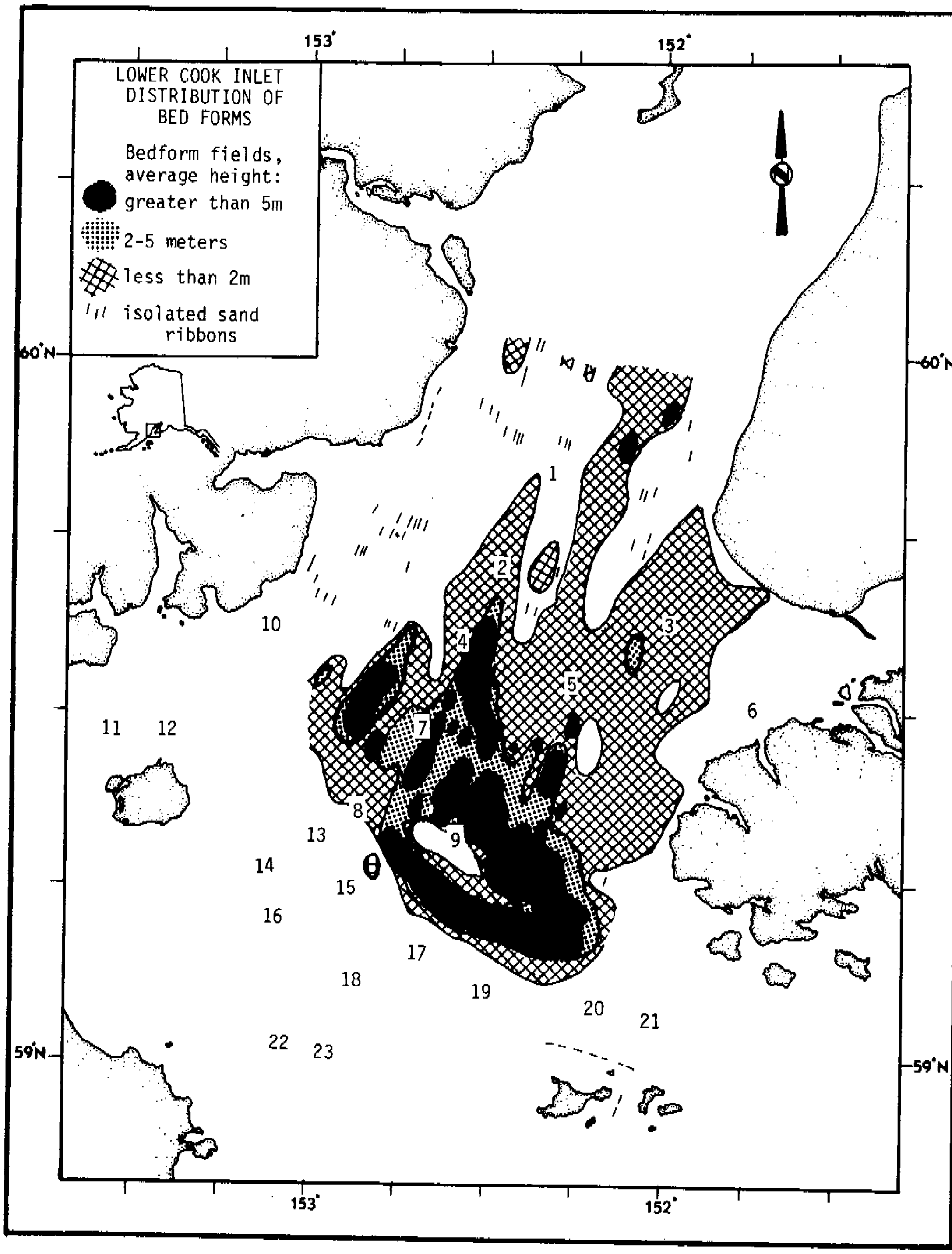


Figure 4 . Distribution of bed forms in lower Cook Inlet adapted from material supplied by Bouma (personal communication) with the location of successfully trawled stations indicated by numbers. The bed forms are primarily sand waves, ridges and dunes as indicated in Bouma et al. (1977).

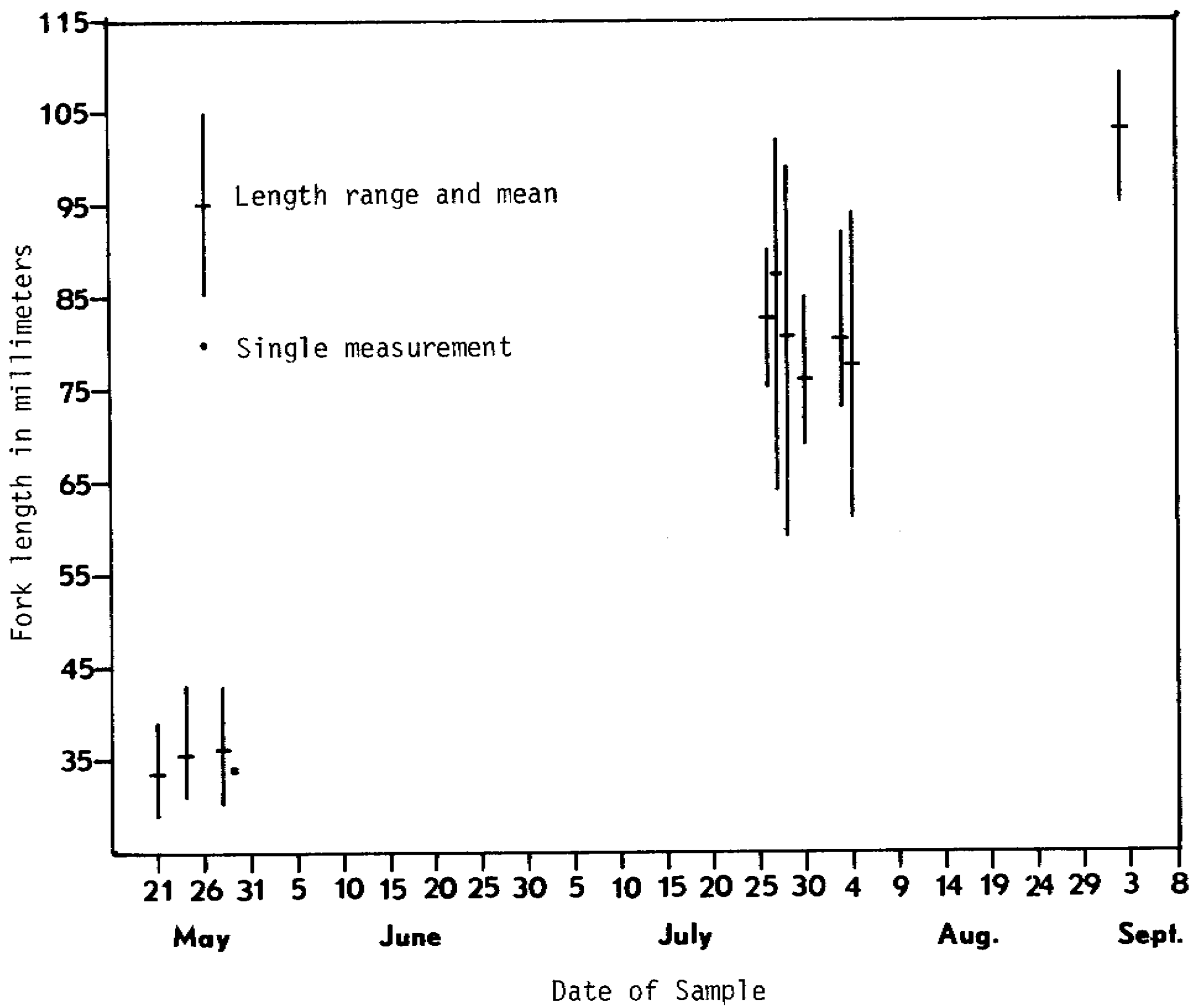


Figure 5. Pink salmon (*Oncorhynchus gorbuscha*) fork length by sample date for samples taken in beach seine and tow net from all protions of lower Cool Inlet.

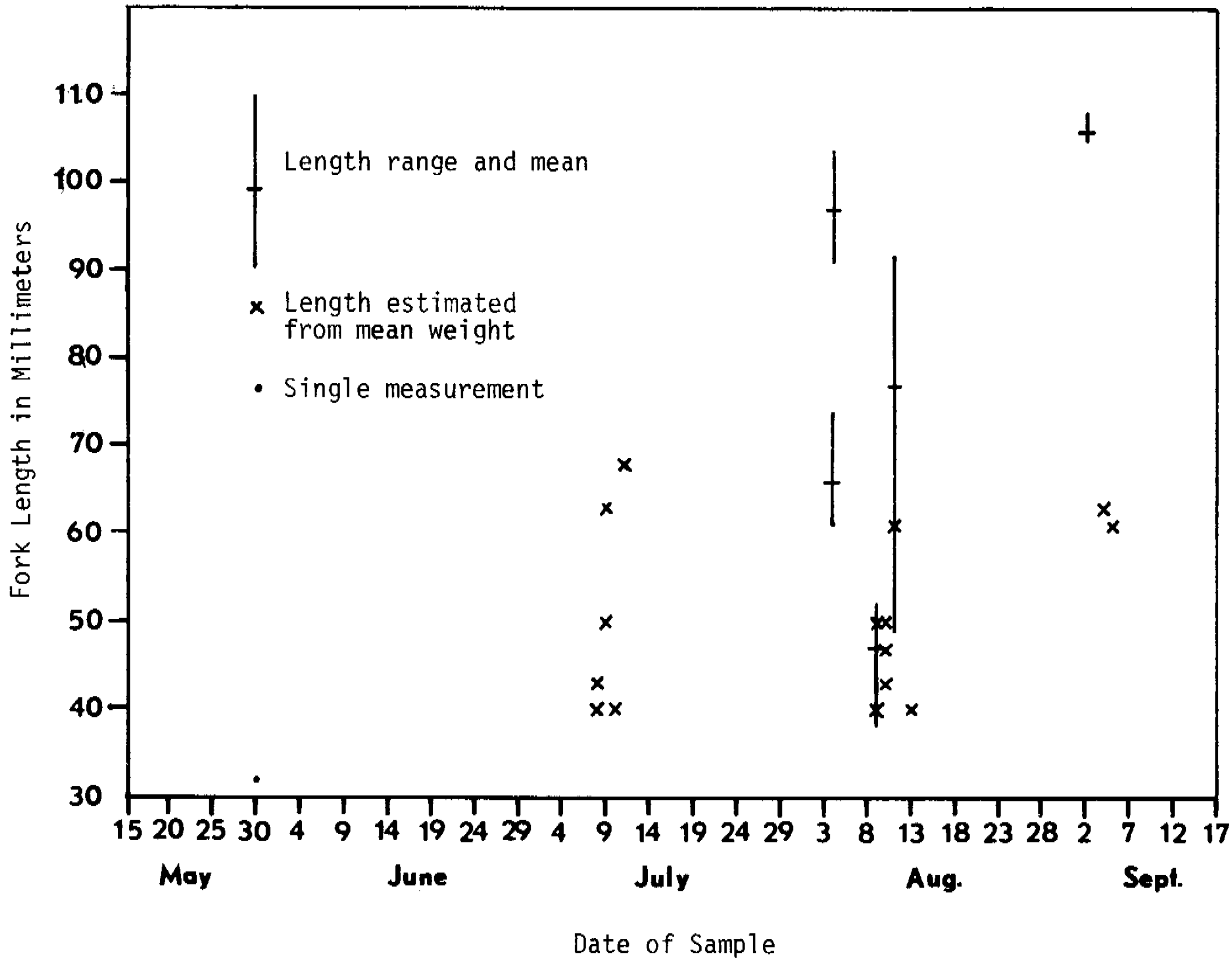


Figure 6. Chum salmon (*Oncorhynchus keta*) fork length by sample date for samples taken in beach seine and tow net from all portions of lower Cook Inlet. Length measurements are supplemented by lengths estimated from mean weight by use of a length-weight plot. Lengths estimated in this way will be slight over-estimates due to the curve of the length-weight relationship.

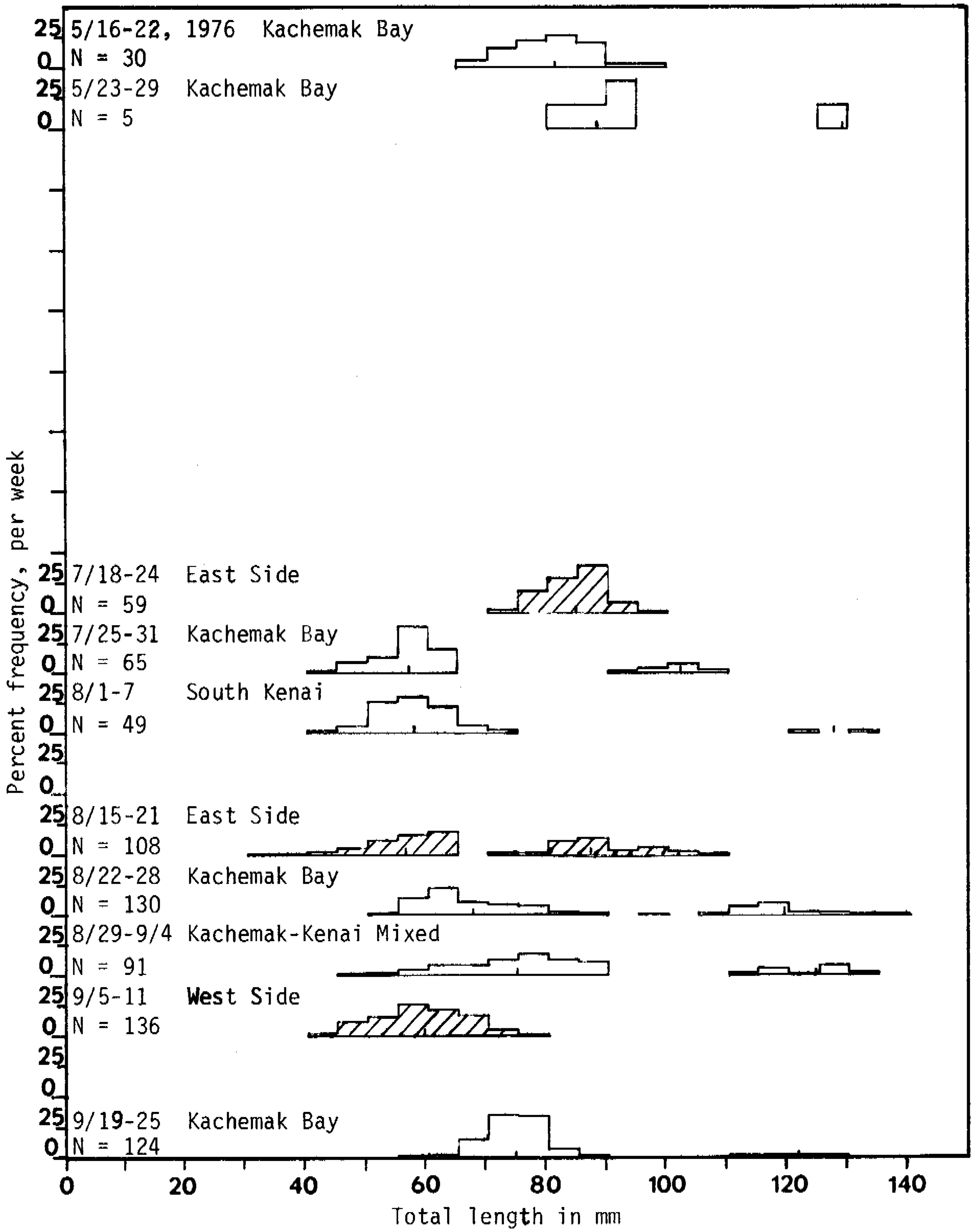


Figure 7. Relative length frequency profiles of Pacific sand lance (*Ammodytes hexapterus*) taken in beach seine and tow net catches in lower Cook Inlet during May through September, 1976. Baselines are spaced to represent weekly progressions.

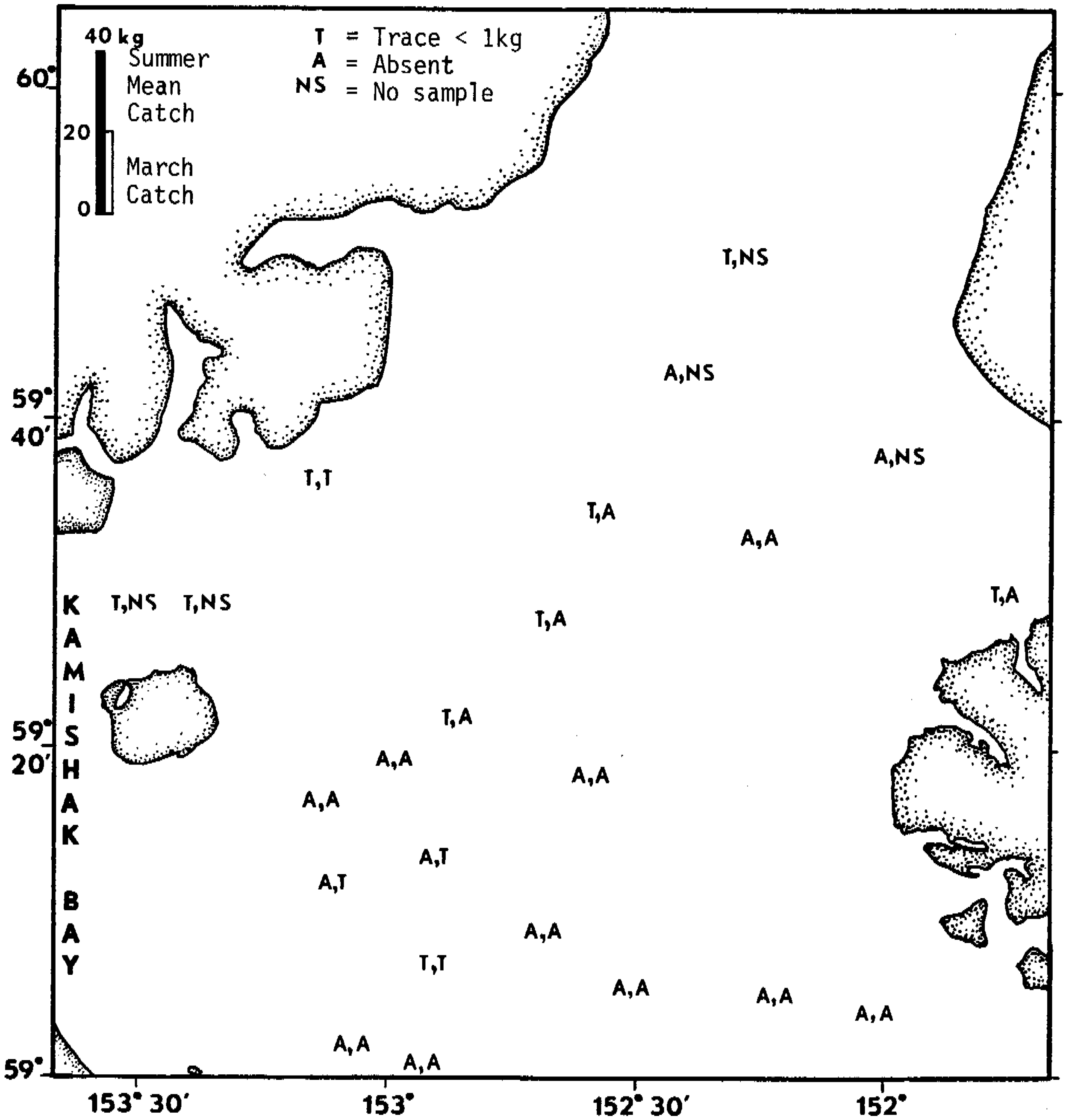


Figure 8 . Distribution and mean catch in kg per 20 minute otter trawl haul for Pacific herring (*Clupea harengus pallasi*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976.and open bar is the catch in March 1977.

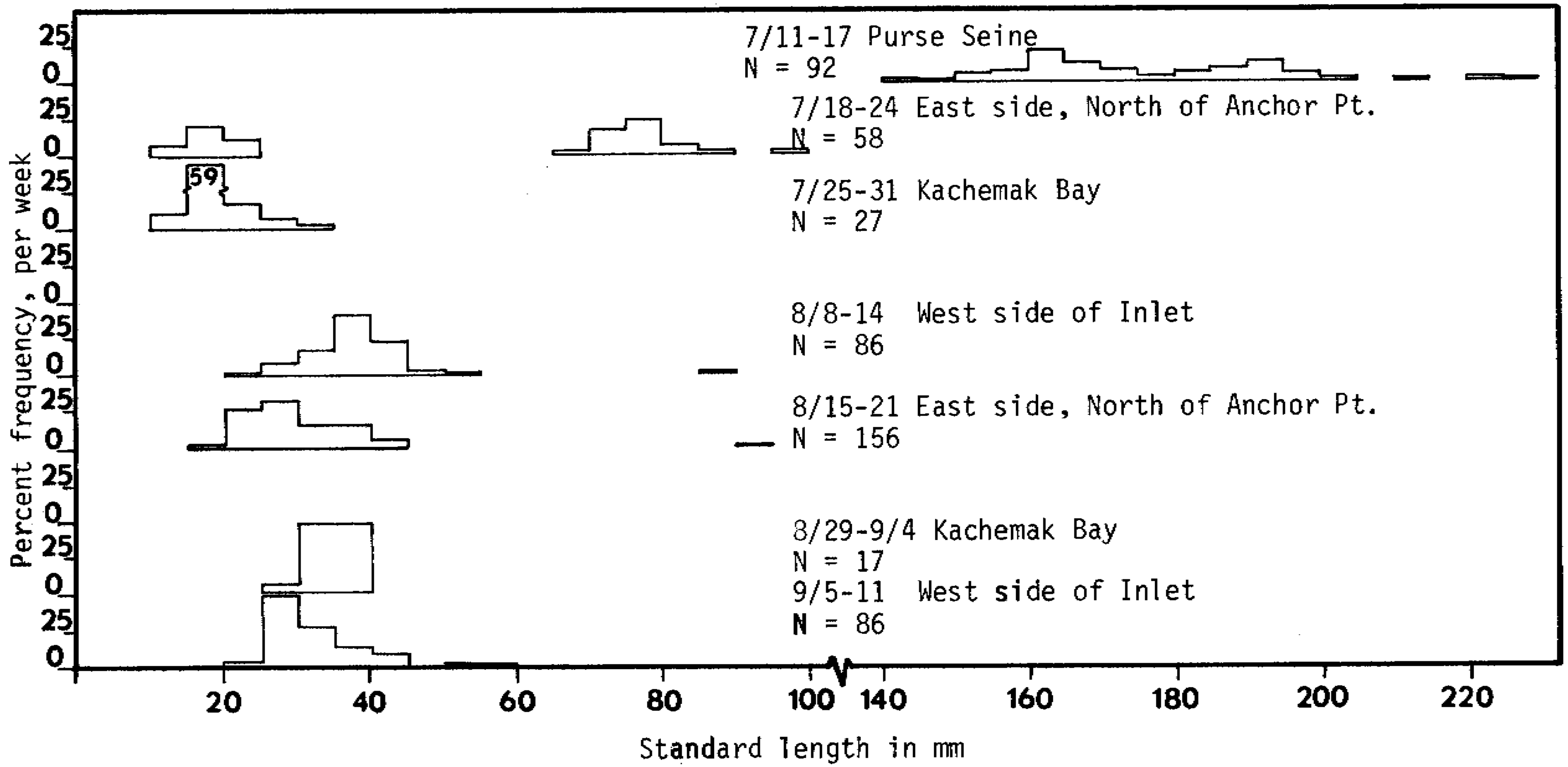


Figure 9. Relative length frequency profiles of Pacific herring (*Clupea harengus pallasi*) taken in purse seine (July 11 to 14, 1976 only; measured fresh) beach seine and tow net catches (measured preserved) in lower Cook Inlet during July through September, 1976. Baselines are spaced to represent weekly progressions. Age 0 is on the left, 10 to 60 mm, age 1 is in the middle, 65 to 100 mm, age 2 is apparently missing and probable modes for ages 3 and 4 occur at 163 and 193 mm, respectively, in the purse seine catches.

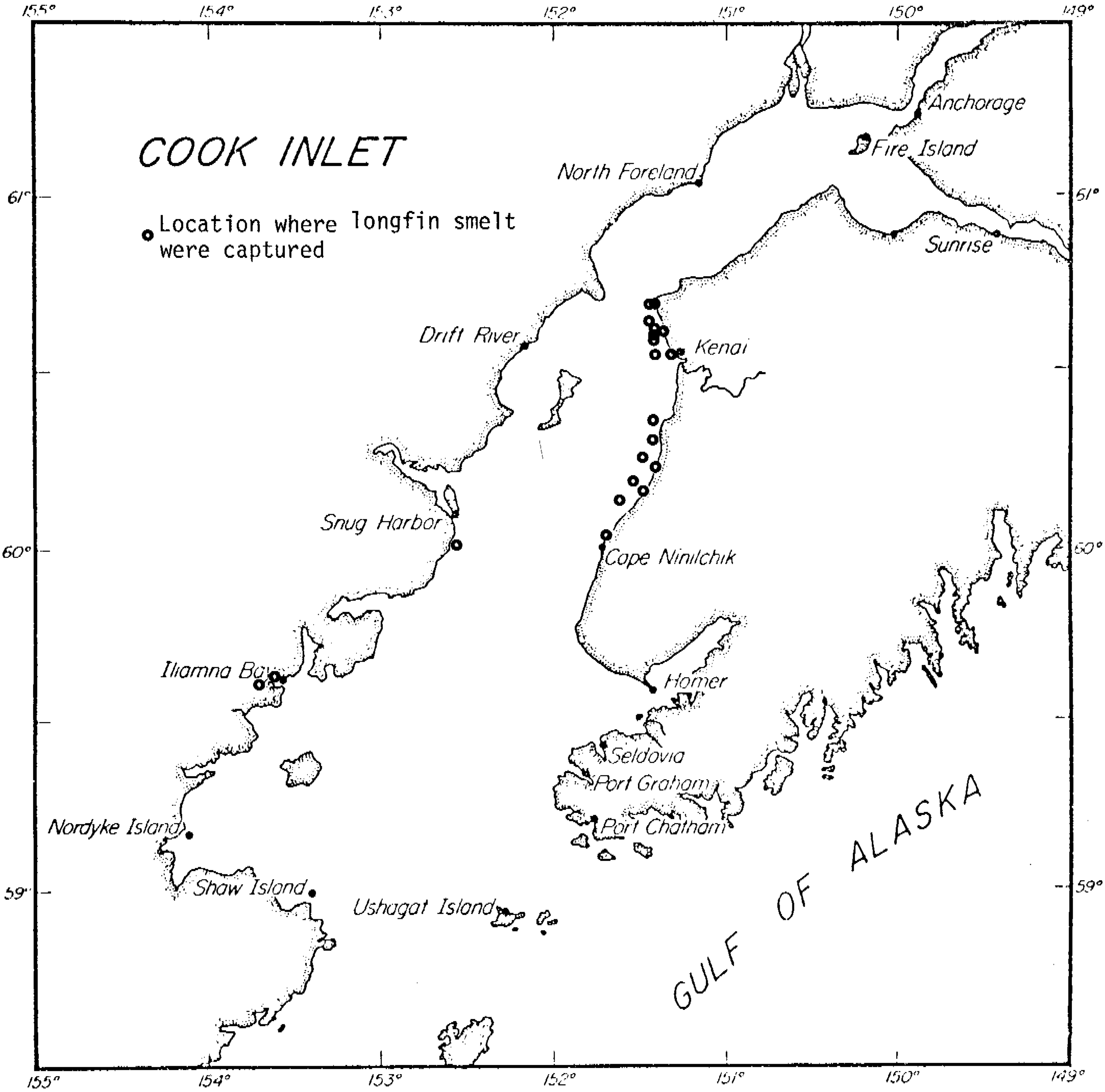


Figure 10. Locations of capture of longfin smelt (*Spirinchus thaleichthys*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

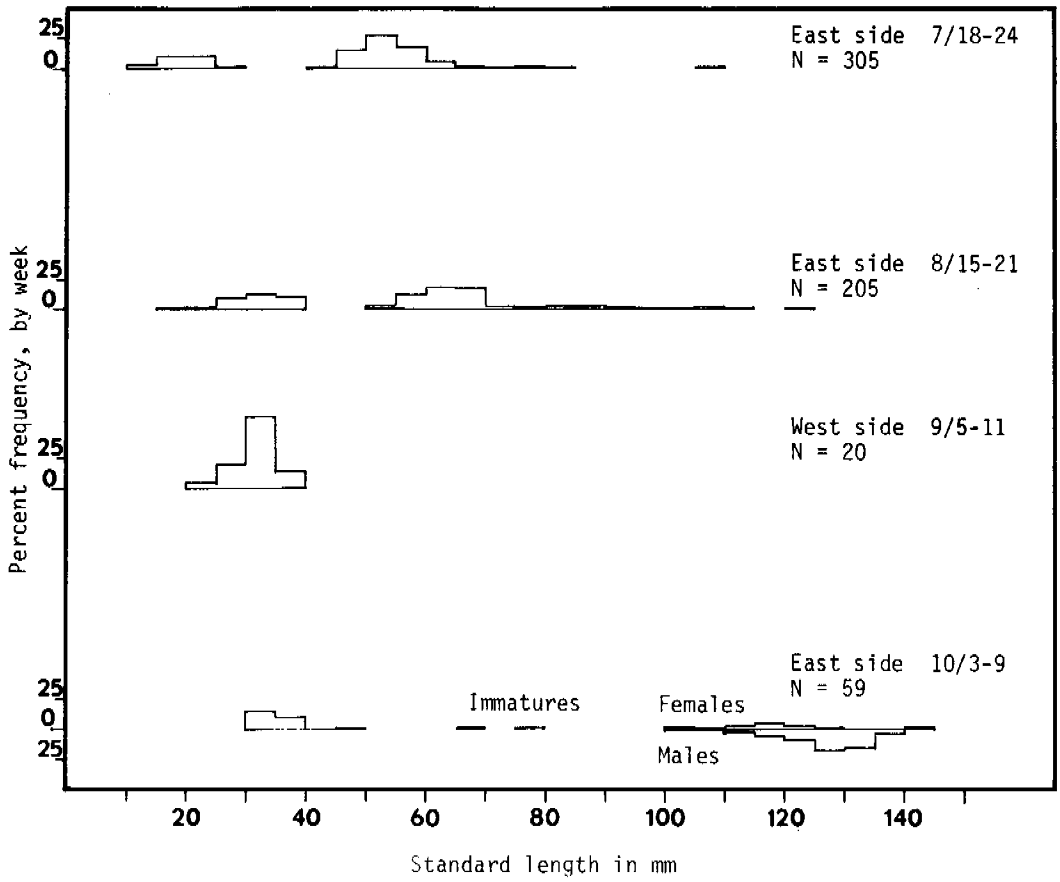


Figure 11. Relative length frequency profiles of preserved longfin smelt (*Spirinchus thaleichthys*) taken by tow net and beach seine in lower Cook Inlet during 1976. Baselines are spaced to represent weekly progressions.

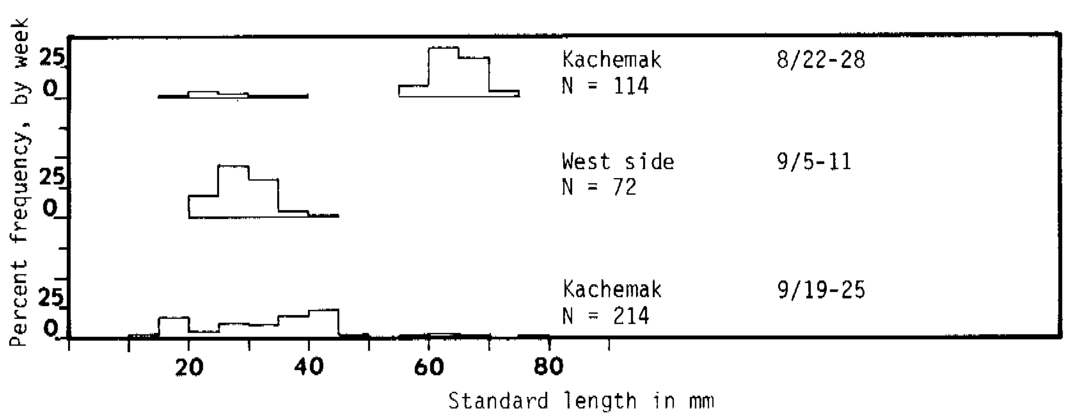


Figure 12. Relative length frequency profiles of preserved capelin (*Mallotus villosus*) taken by tow net in lower Cook Inlet during 1976. Baselines are spaced to represent weekly progressions.

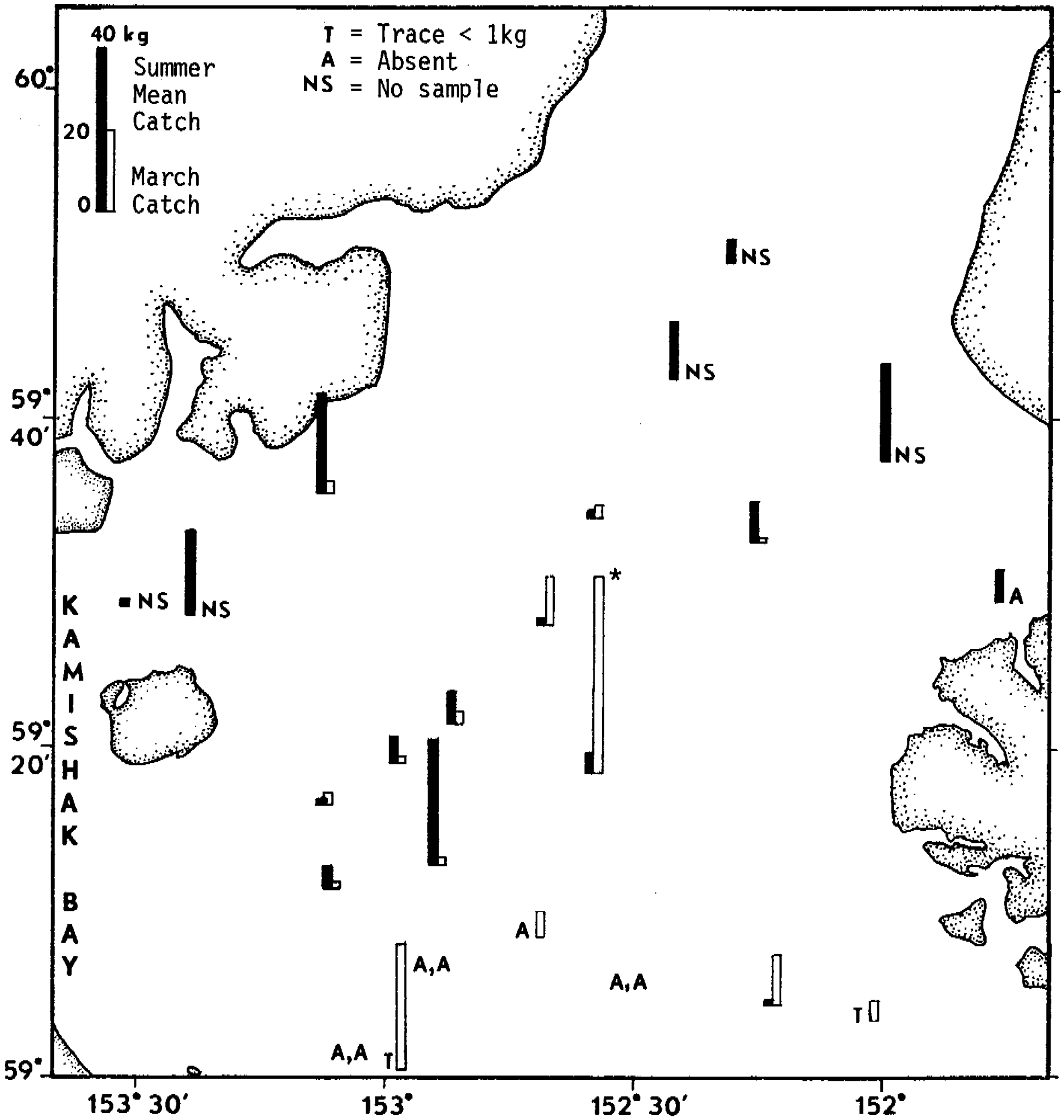


Figure 13. Distribution and mean catch in kg per 20 minute otter trawl haul for Pacific halibut (*Hippoglossus stenolepis*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977. * - only one large individual was captured.

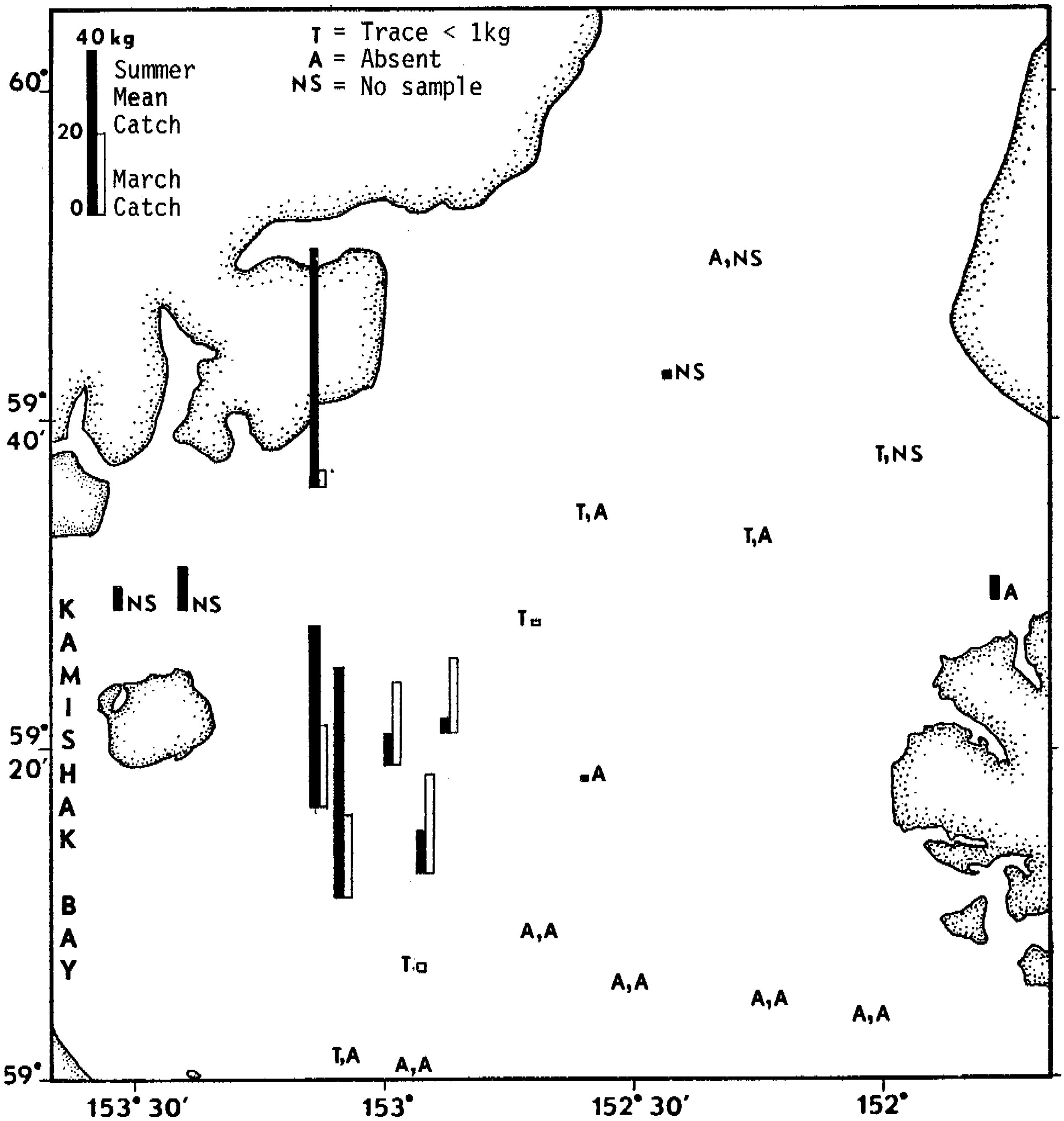


Figure 14. Distribution and mean catch in kg per 20 minute otter trawl haul for yellowfin sole (*Limanda aspera*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

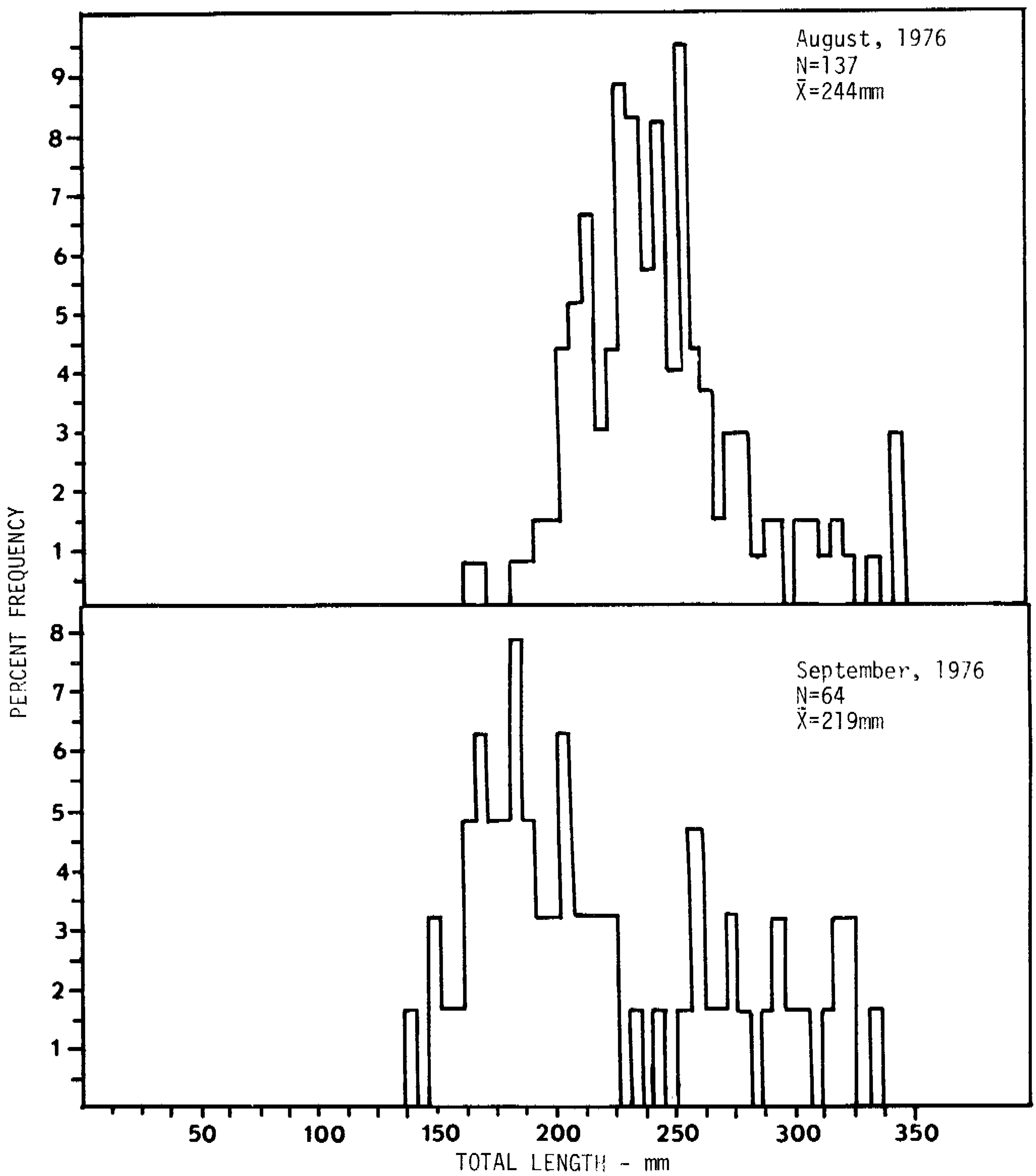


Figure 15. Relative length frequency profiles of yellowfin sole (*Limanda aspera*) taken in otter trawl catches from lower Cook Inlet during August and September, 1976.

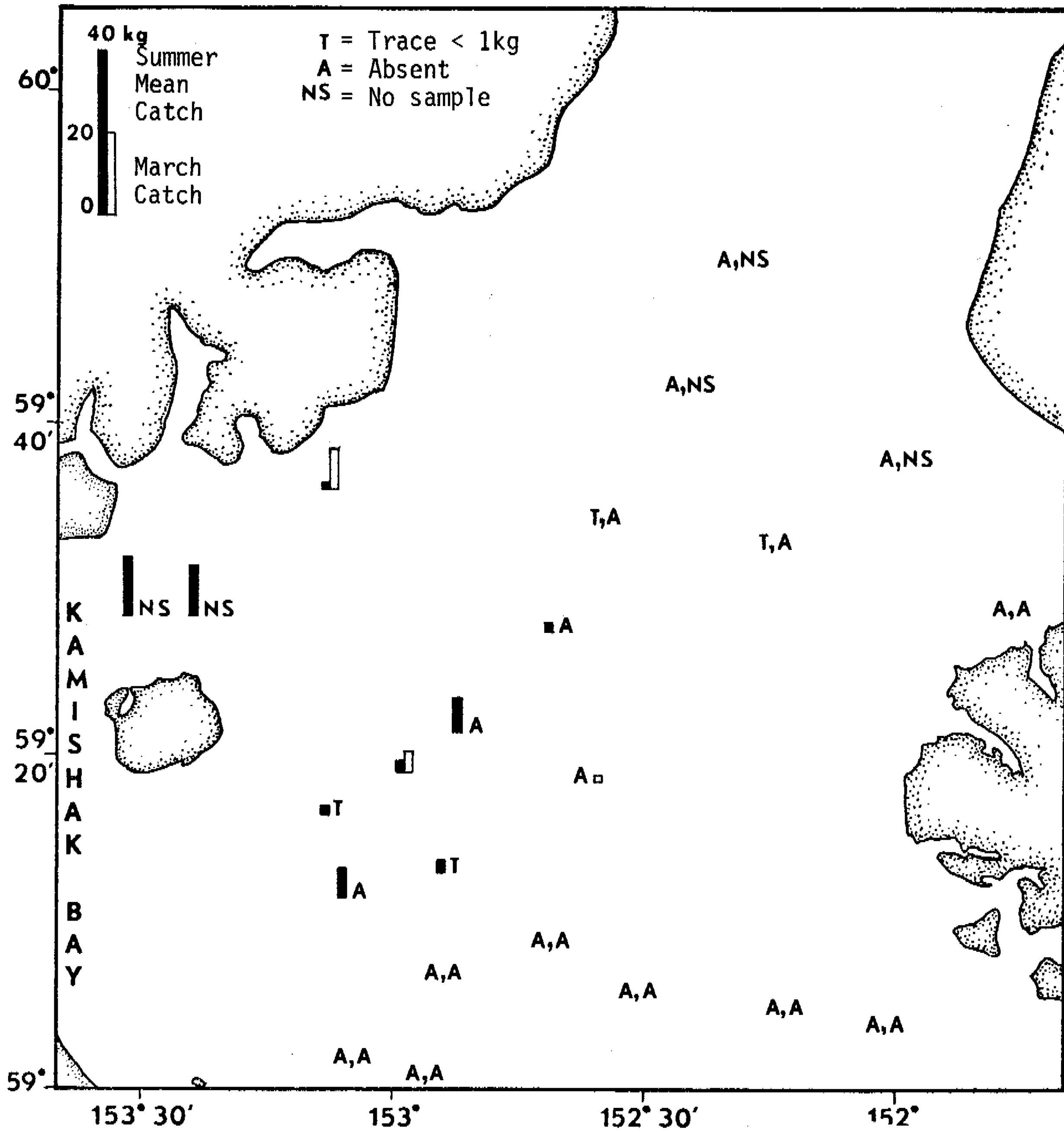


Figure 16. Distribution and mean catch in kg per 20 minute otter trawl haul for starry flounder (*Platichthys stellatus*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

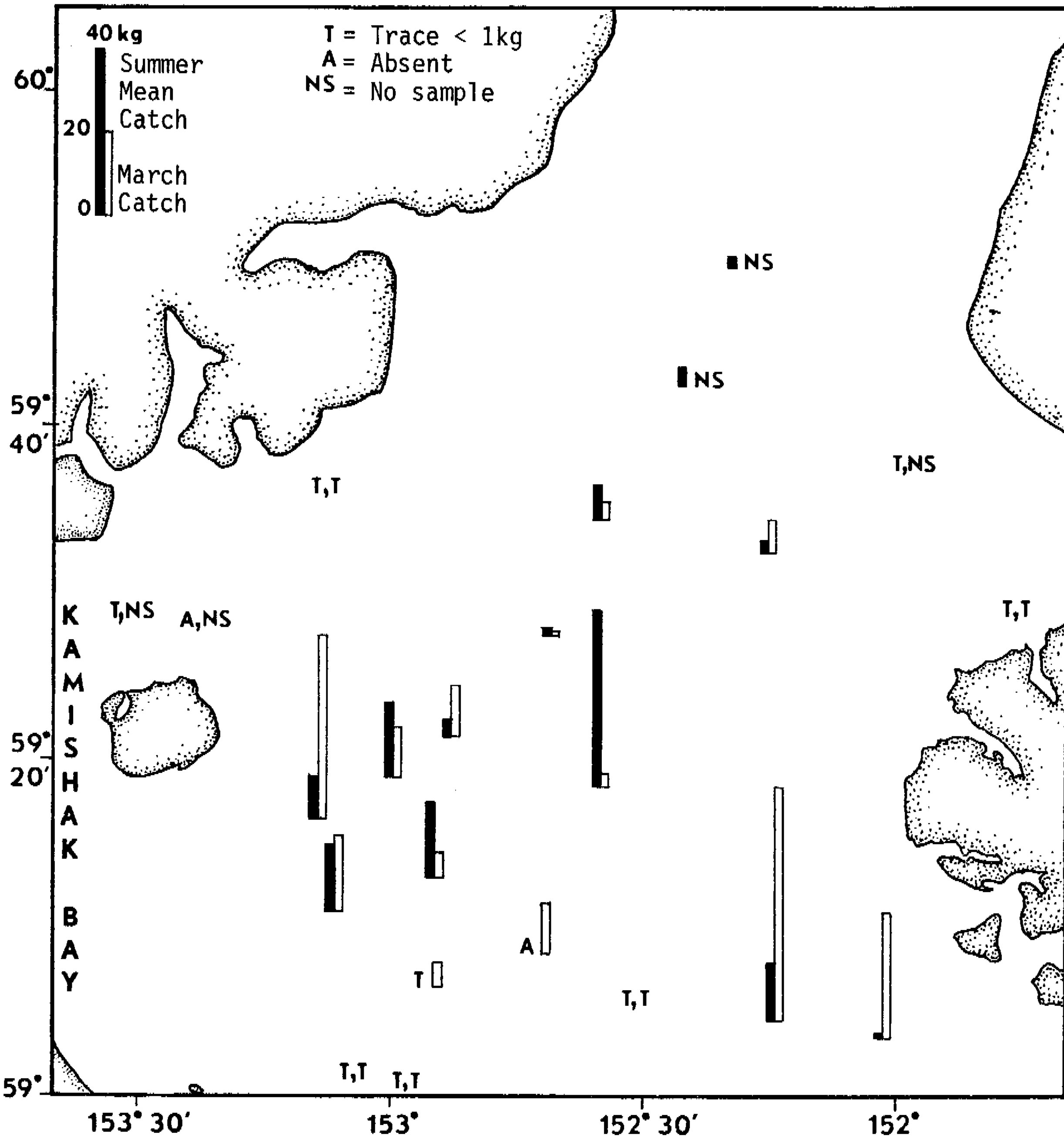


Figure 17. Distribution and mean catch in kg per 20 minute otter trawl haul for rock sole (*Lepidopsetta bilineata*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

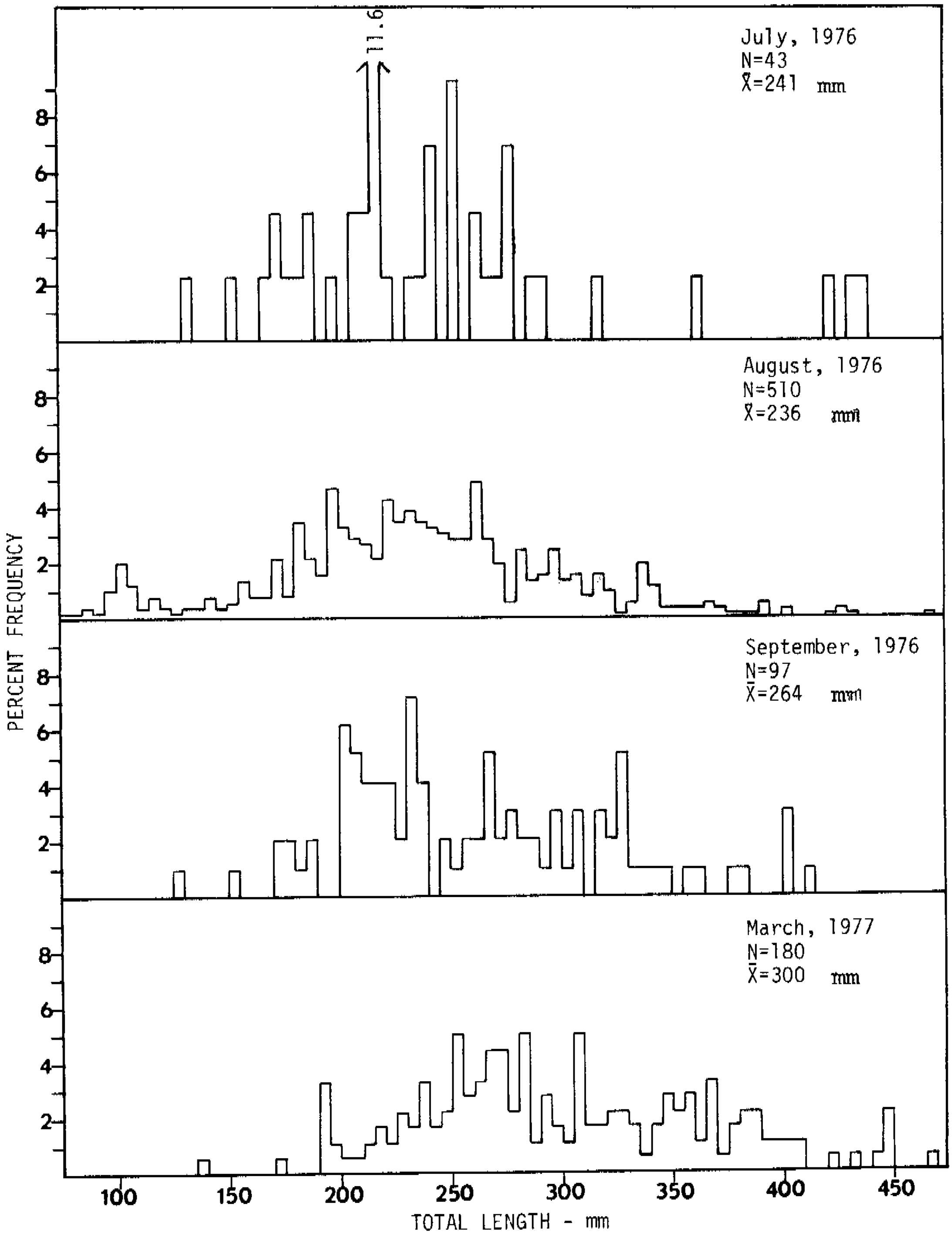


Figure 18. Monthly length frequency profiles of rock sole (*Lepidopsetta bilineata*) taken in otter trawl catches from lower Cook Inlet, July 1976 through March 1977.

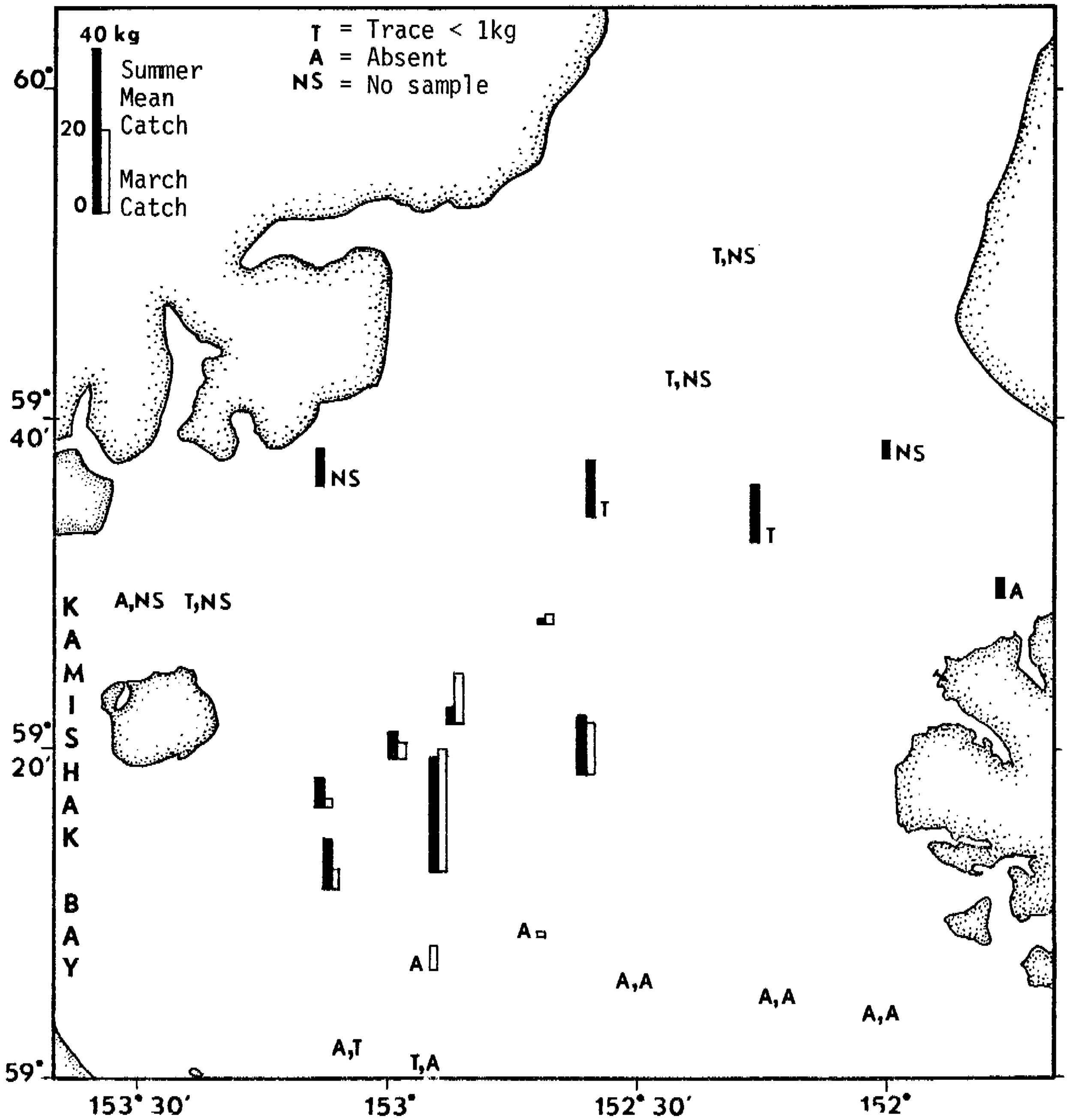


Figure 19. Distribution and mean catch in kg per 20 minute otter trawl haul for butter sole (*Isopsetta isolepis*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

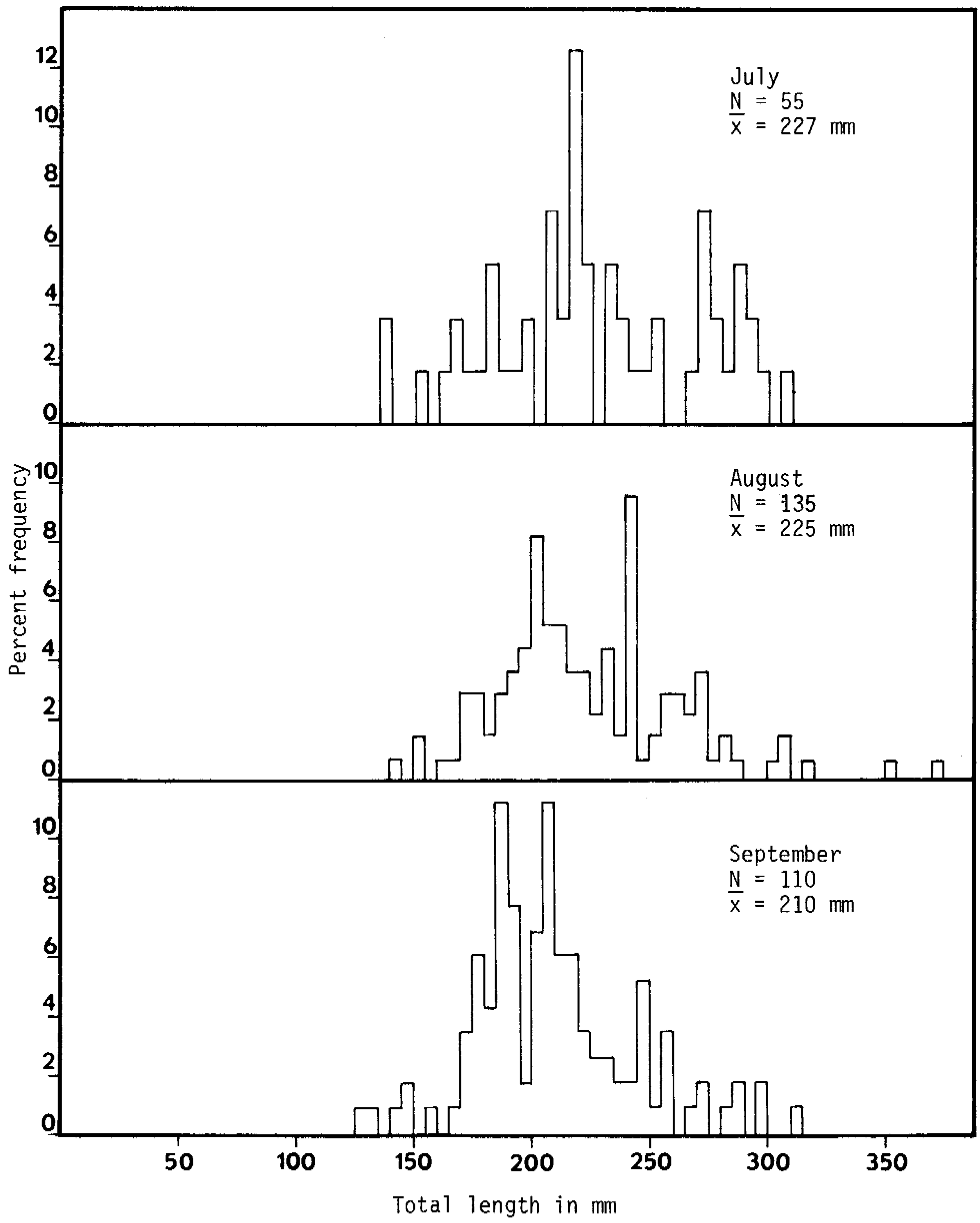


Figure 20. Monthly length frequency profiles of butter sole (*Isopsetta isolepis*) taken in otter trawl catches from lower Cook Inlet in 1976.

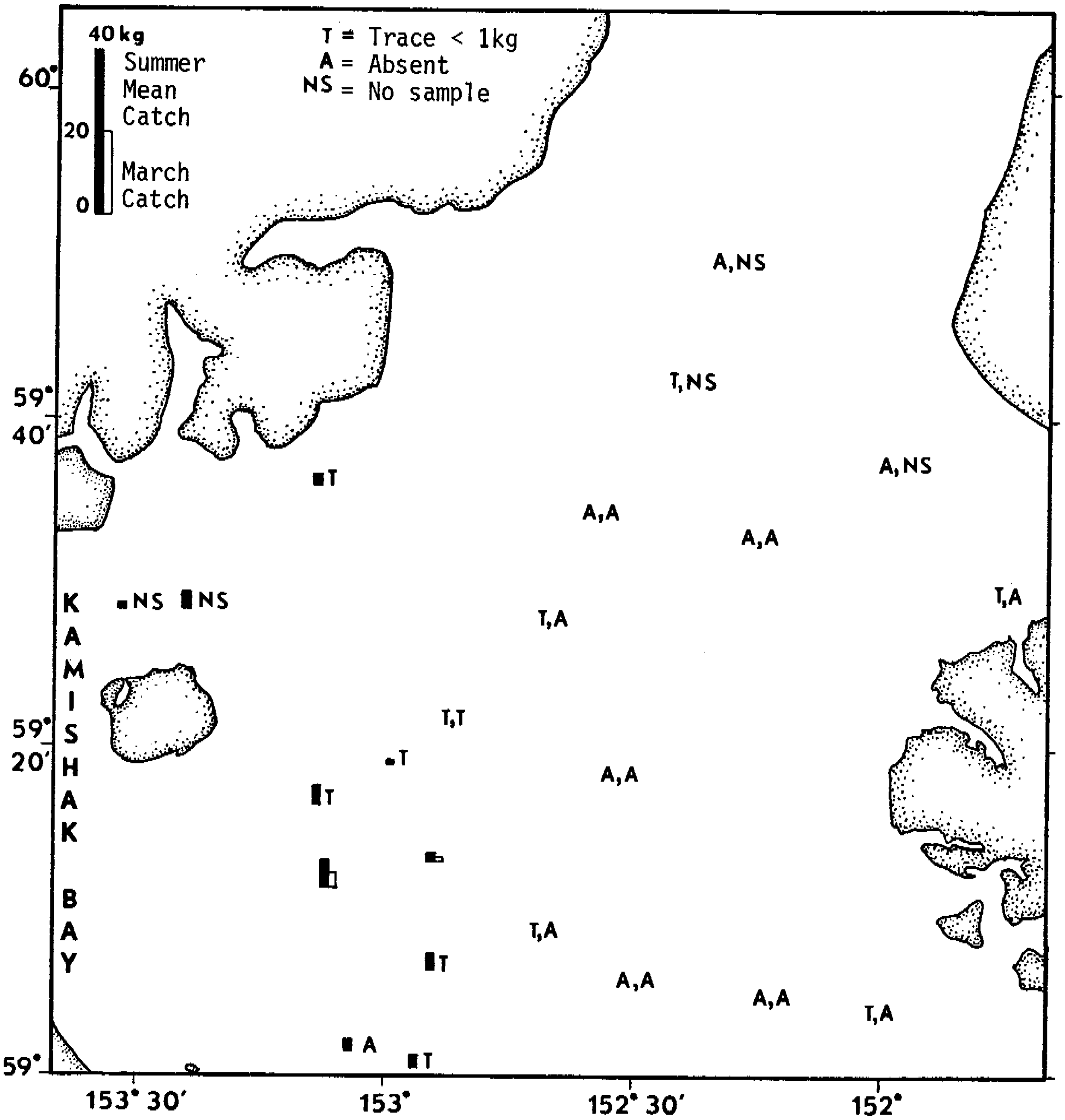


Figure 21. Distribution and mean catch in kg per 20 minute otter trawl haul for flathead sole (*Hippoglossoides elassodon*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

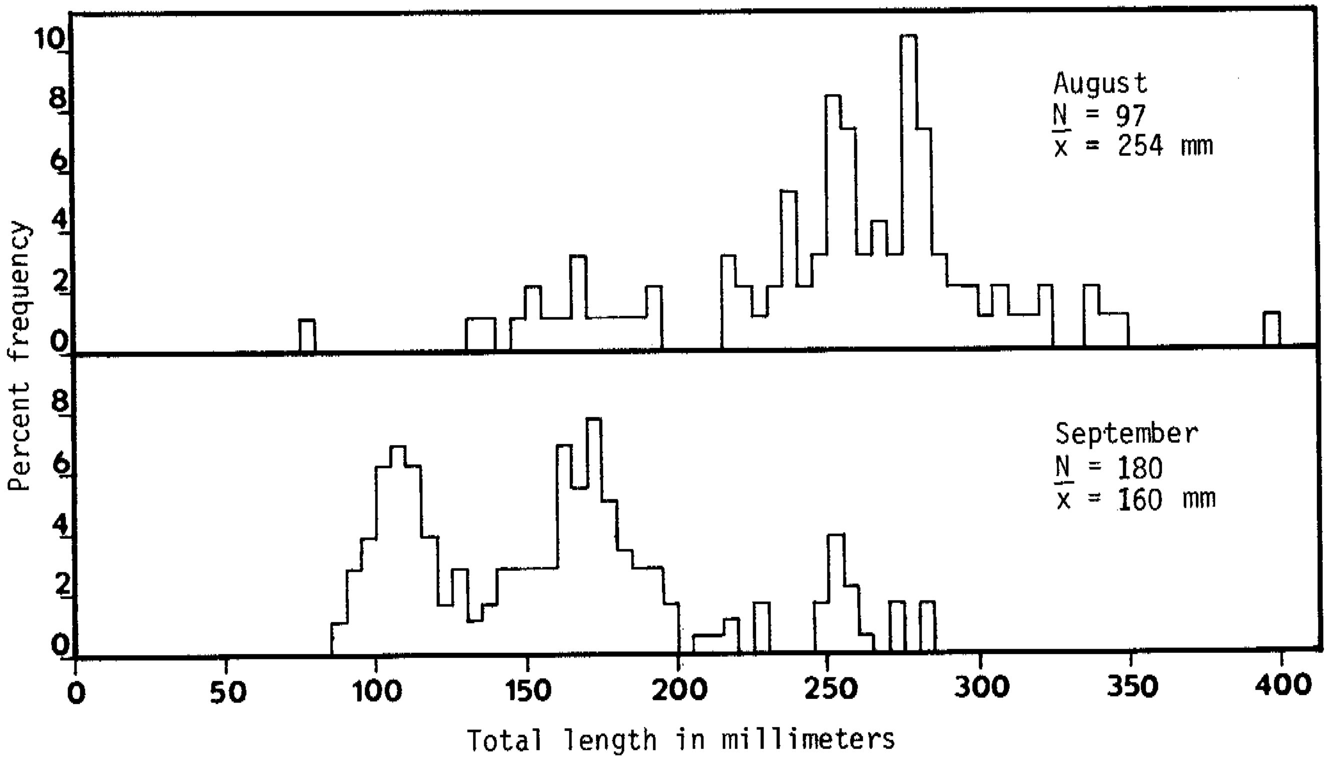


Figure 22. Relative length frequency profiles of flathead sole (*Hippoglossoides elassodon*) taken in otter trawl hauls from lower Cook Inlet, August and September, 1976.

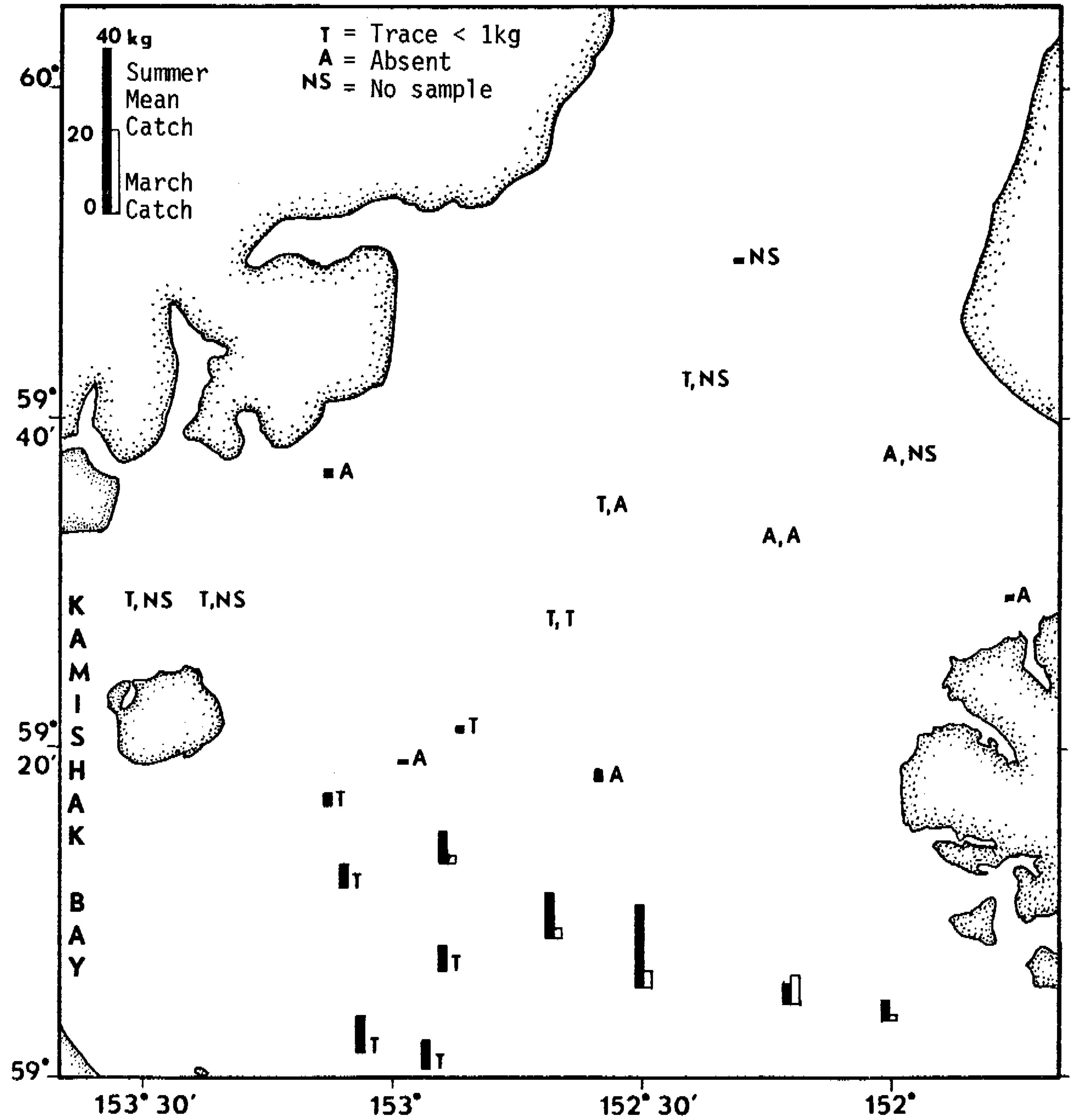


Figure 23. Distribution and mean catch in kg per 20 minute otter trawl haul for arrowtooth flounder (*Atheresthes stomias*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

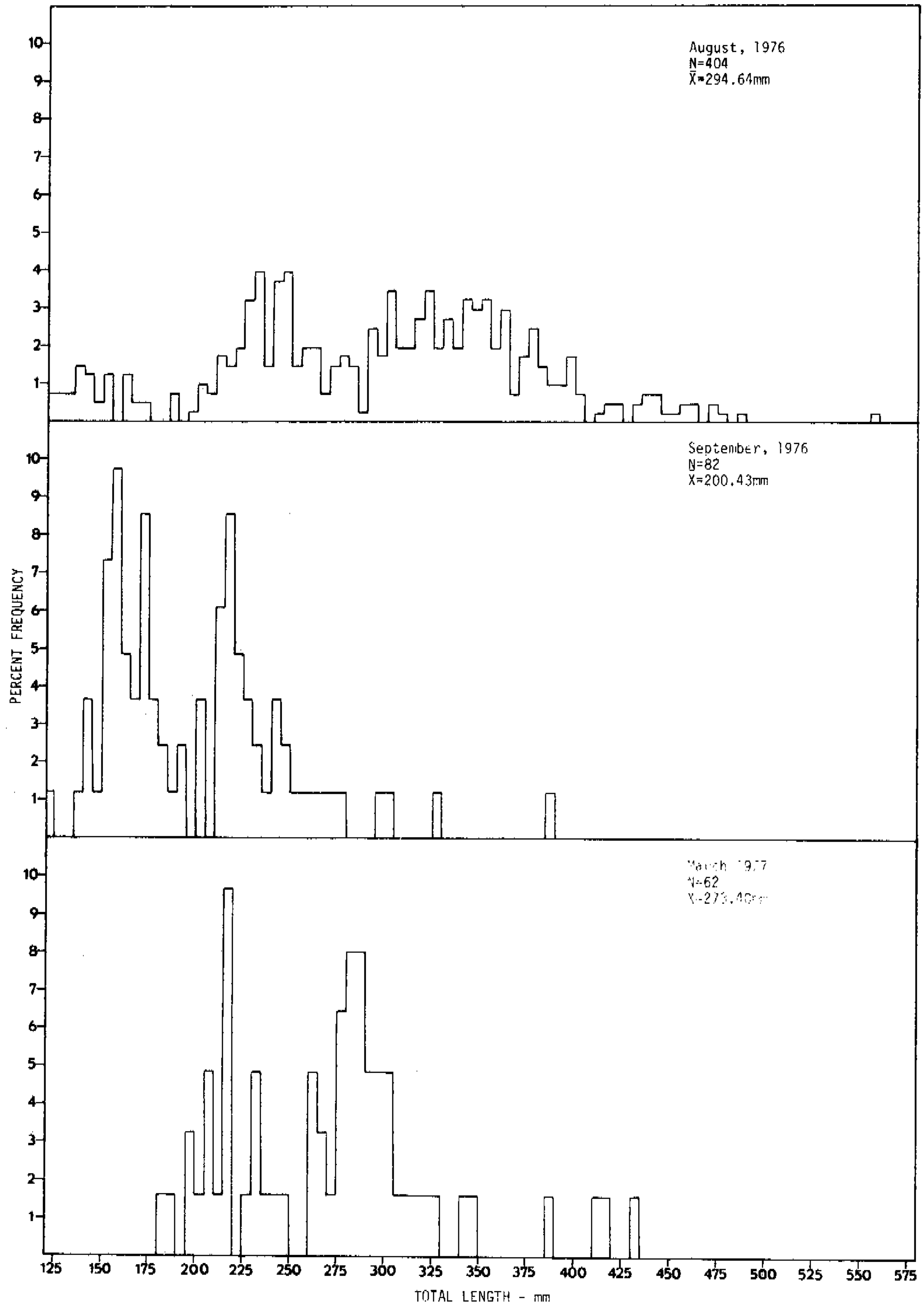


Figure 24. Monthly length frequency profiles of arrowtooth flounder (*Atheresthes stomian*) taken in otter trawl catches in lower Cook Inlet, August 1976 through March 1977.

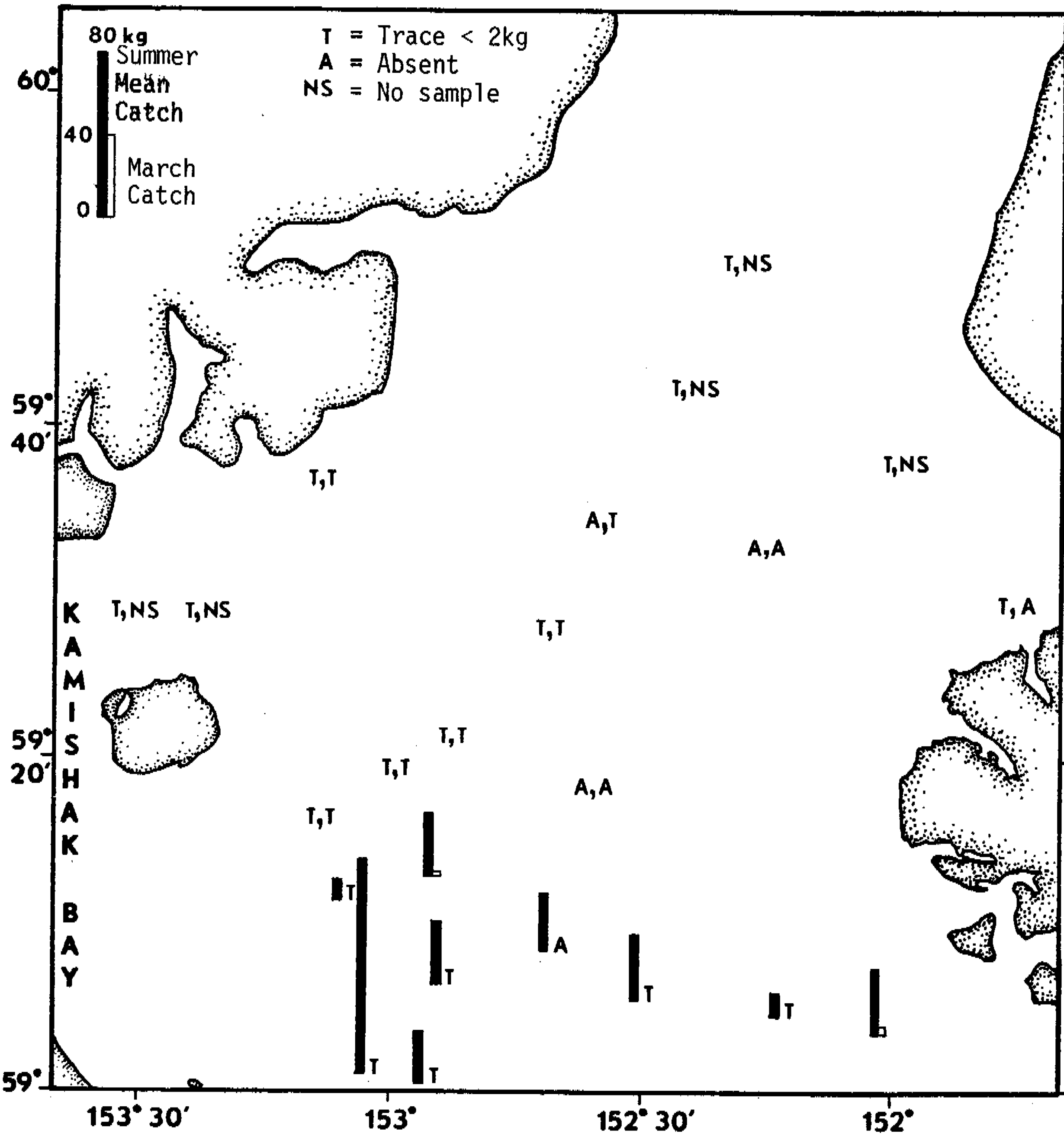


Figure 25. Distribution and mean catch in kg per 20 minute otter trawl haul for walleye pollock (*Theragra chalcogramma*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

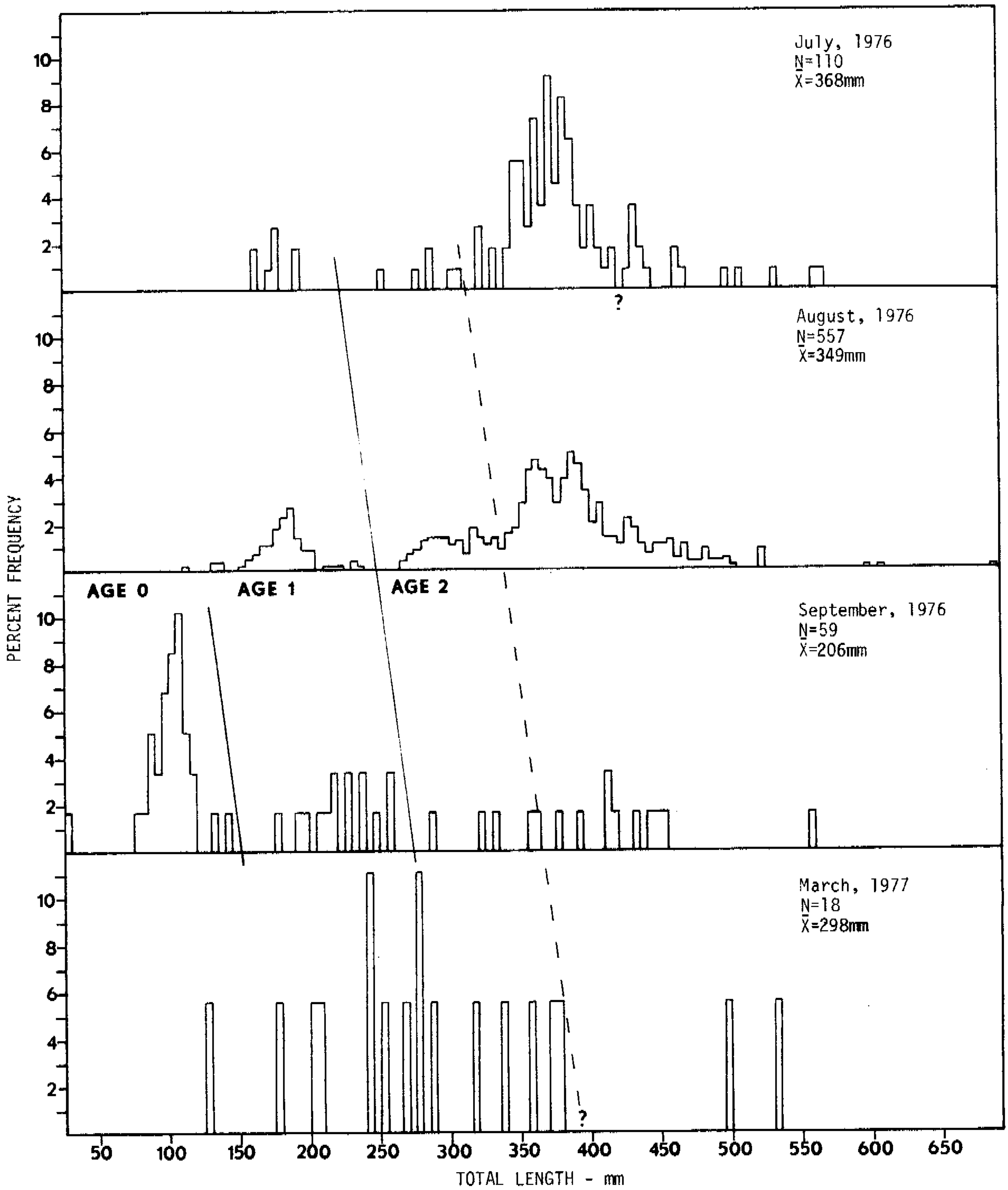


Figure 26. Monthly length frequency profiles of walleye pollock (*Theragra chalcogramma*) taken in otter trawl catches from lower Cook Inlet, July, 1976 through March 1977.

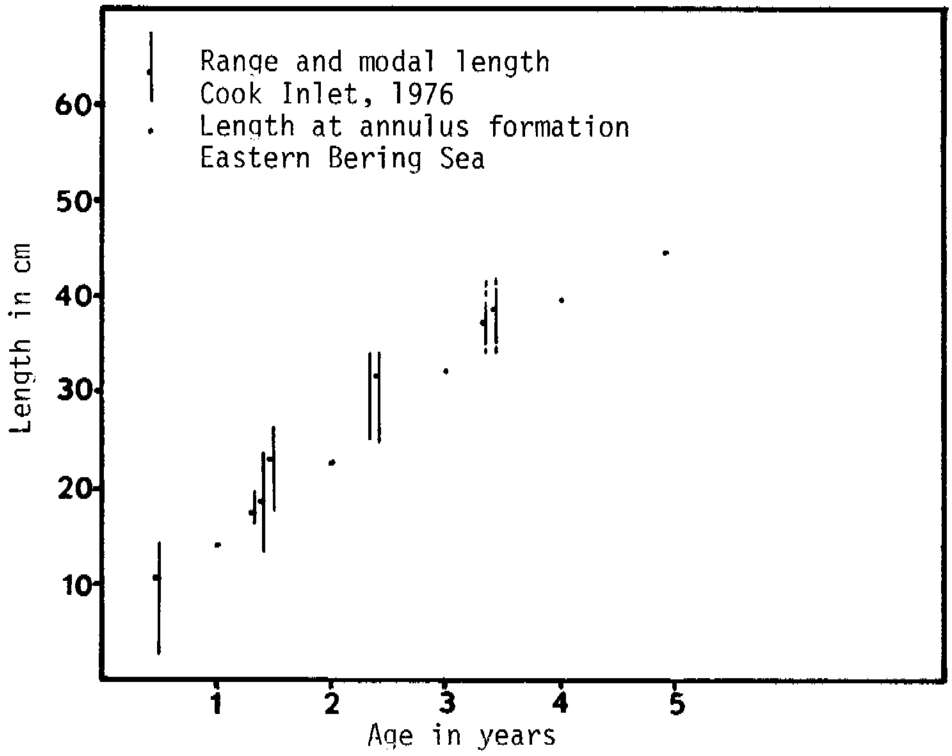


Figure 27. Length at age for walleye pollock (*Theragra chalcogramma*). Range and modal length estimated from length frequencies of fish from lower Cook Inlet, July, August and September 1976 and mean length at annulus formation (assumed to be March) of pollock from eastern Bering Sea, from Yamaguchi and Takahashi (1972).

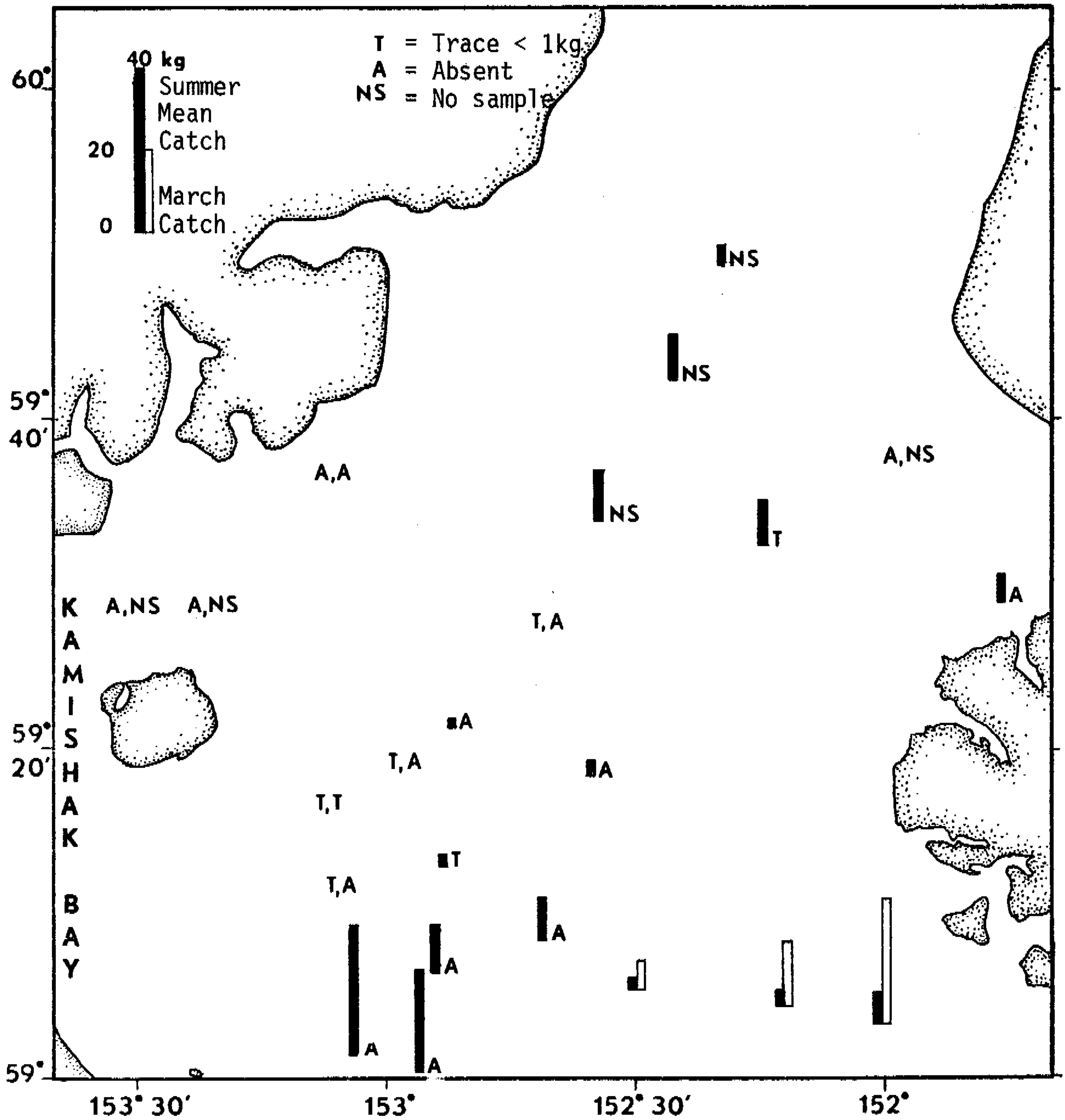


Figure 28. Distribution and mean catch in kg per 20 minute otter trawl haul for Pacific cod (*Gadus macrocephalus*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

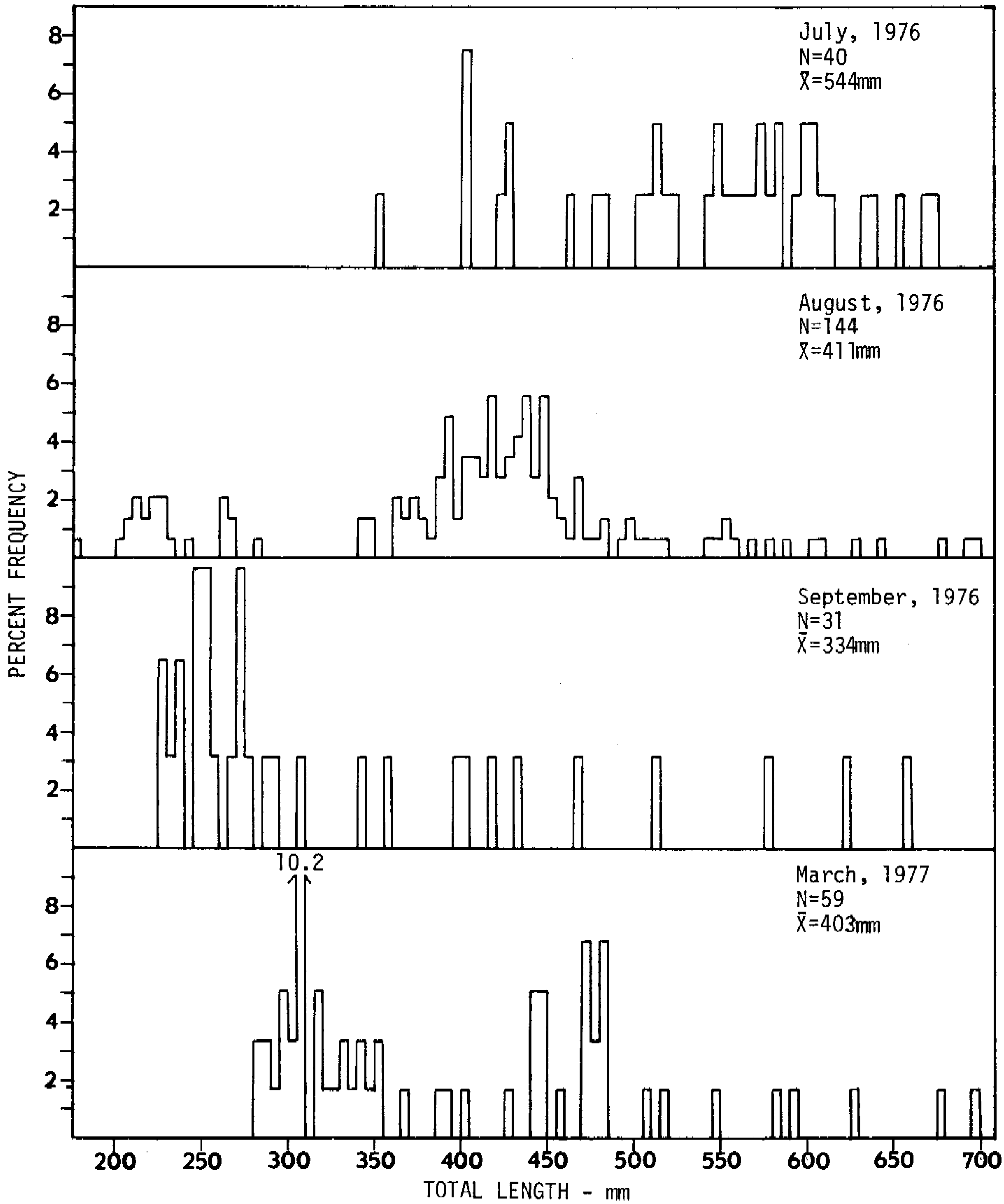


Figure 29. Monthly length frequency of Pacific cod (*Gadus macrocephalus*) taken in otter trawl catches from lower Cook Inlet, July 1976 through March 1977.

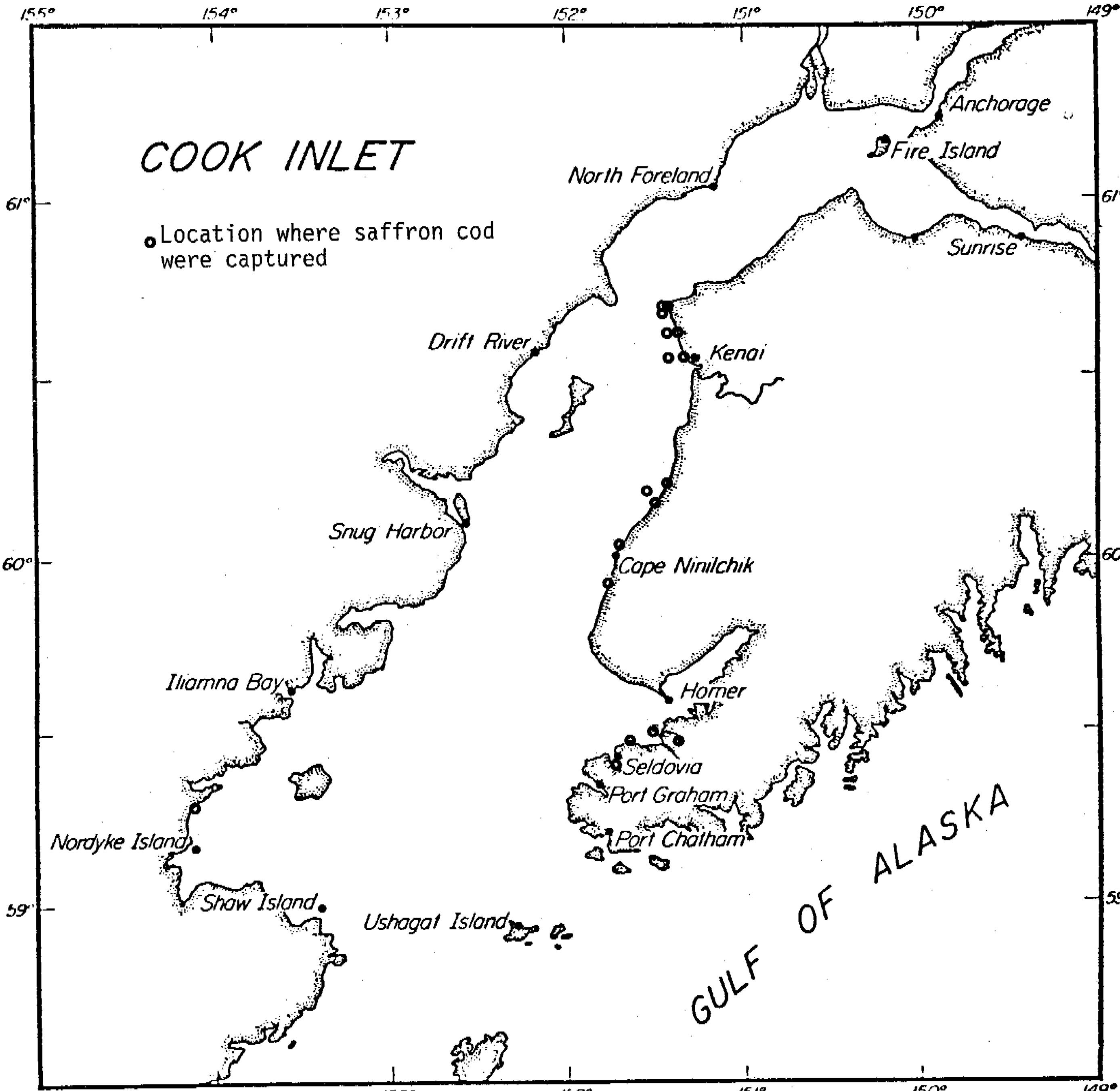


Figure 30. Locations of capture of saffron cod (*Eleginus gracilis*) in lower Cook Inlet. Beach seine and townet effort covered the entire eastern shoreline of lower Cook Inlet between the Forelands and Port Graham and the western shoreline between Snug Harbor and Amakdedori Beach.

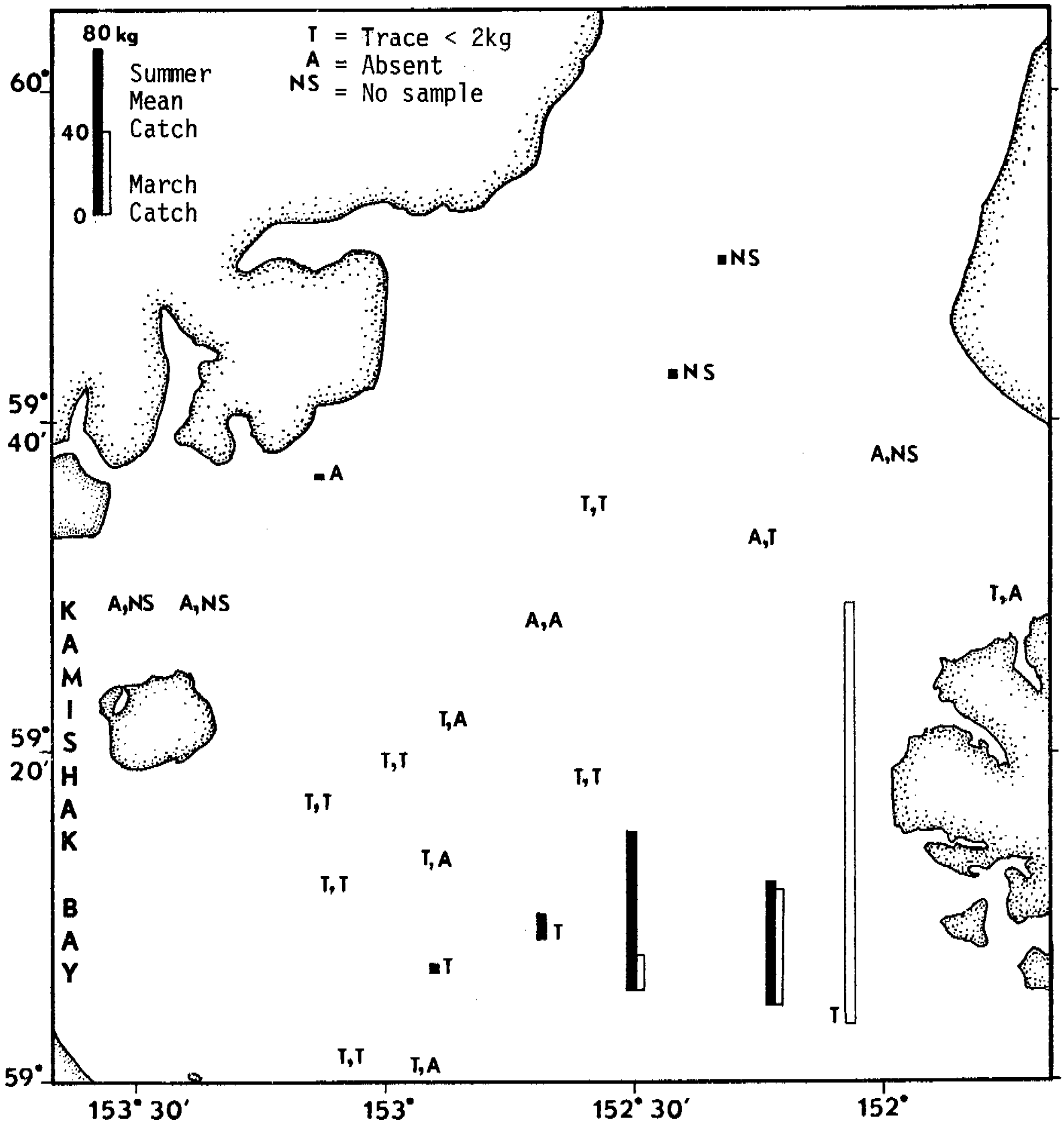


Figure 31. Distribution and mean catch in kg per 20 minute otter trawl haul for yellow Irish Lord (*Hemilepidotus jordani*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

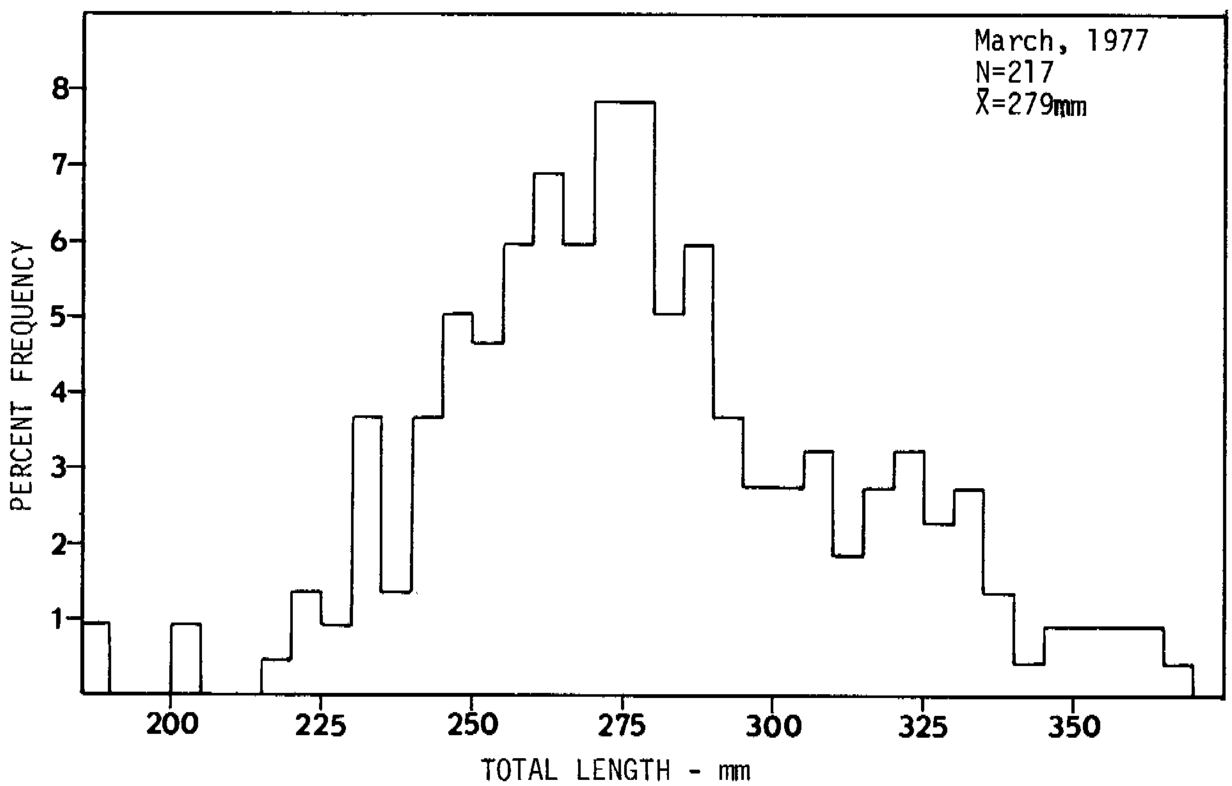


Figure 32. Relative length frequency profile of yellow Irish Lord (*Hemilepidotus jordani*) taken in otter trawl catches from lower Cook Inlet, March 1977.

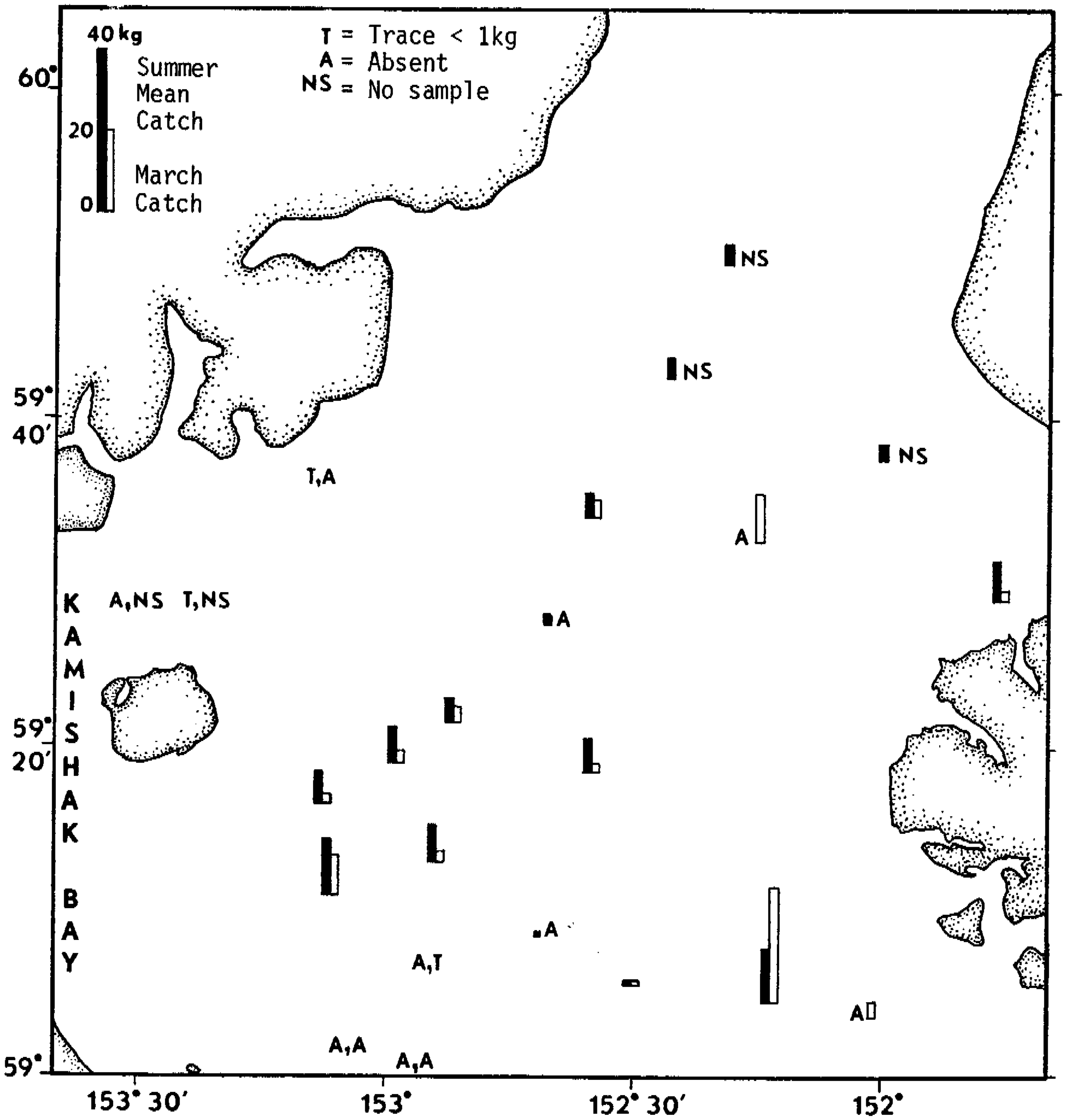


Figure 33. Distribution and mean catch in kg per 20 minute otter trawl haul for great sculpin (*Myoxocephalus polyacanthocephalus*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

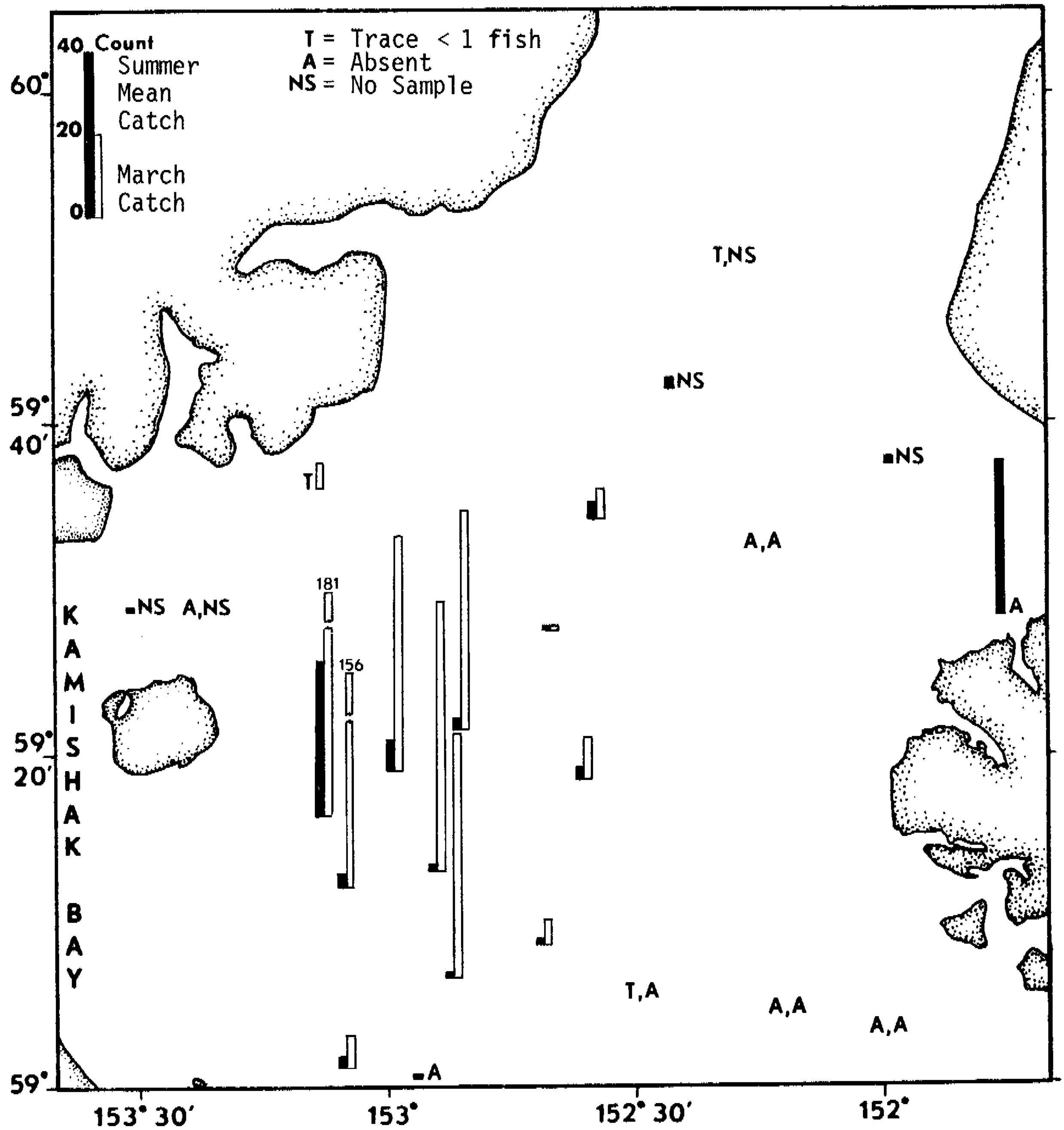


Figure 34. Distribution and mean catch in number per 20 minute otter trawl haul of sturgeon poacher (*Agonus acipenserinus*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

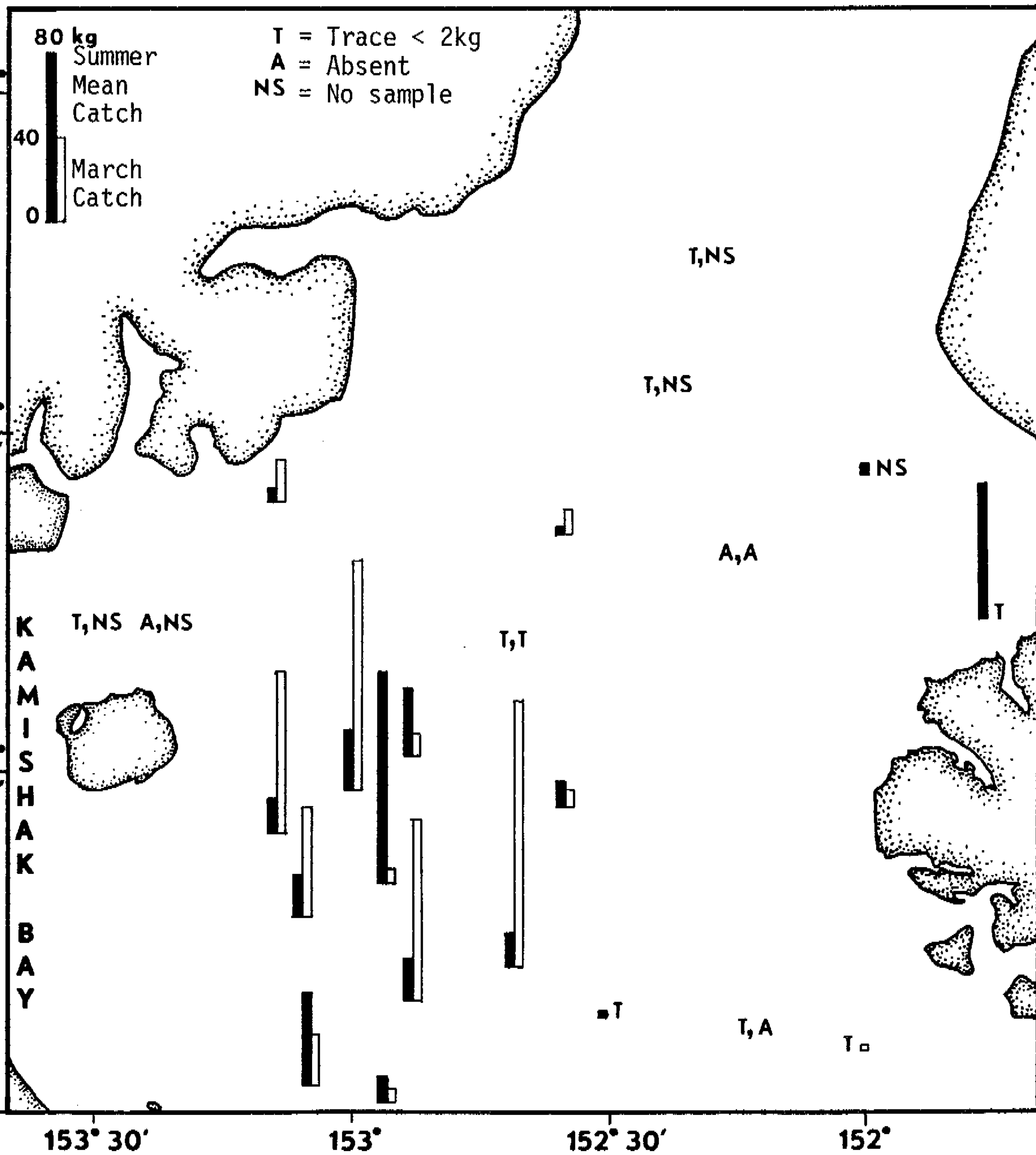


Figure 35. Distribution and mean catch in kg per 20 minute otter trawl haul for snow crab (*Chionoecetes bairdi*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July, August and September 1976 and open bar is the catch in March 1977.

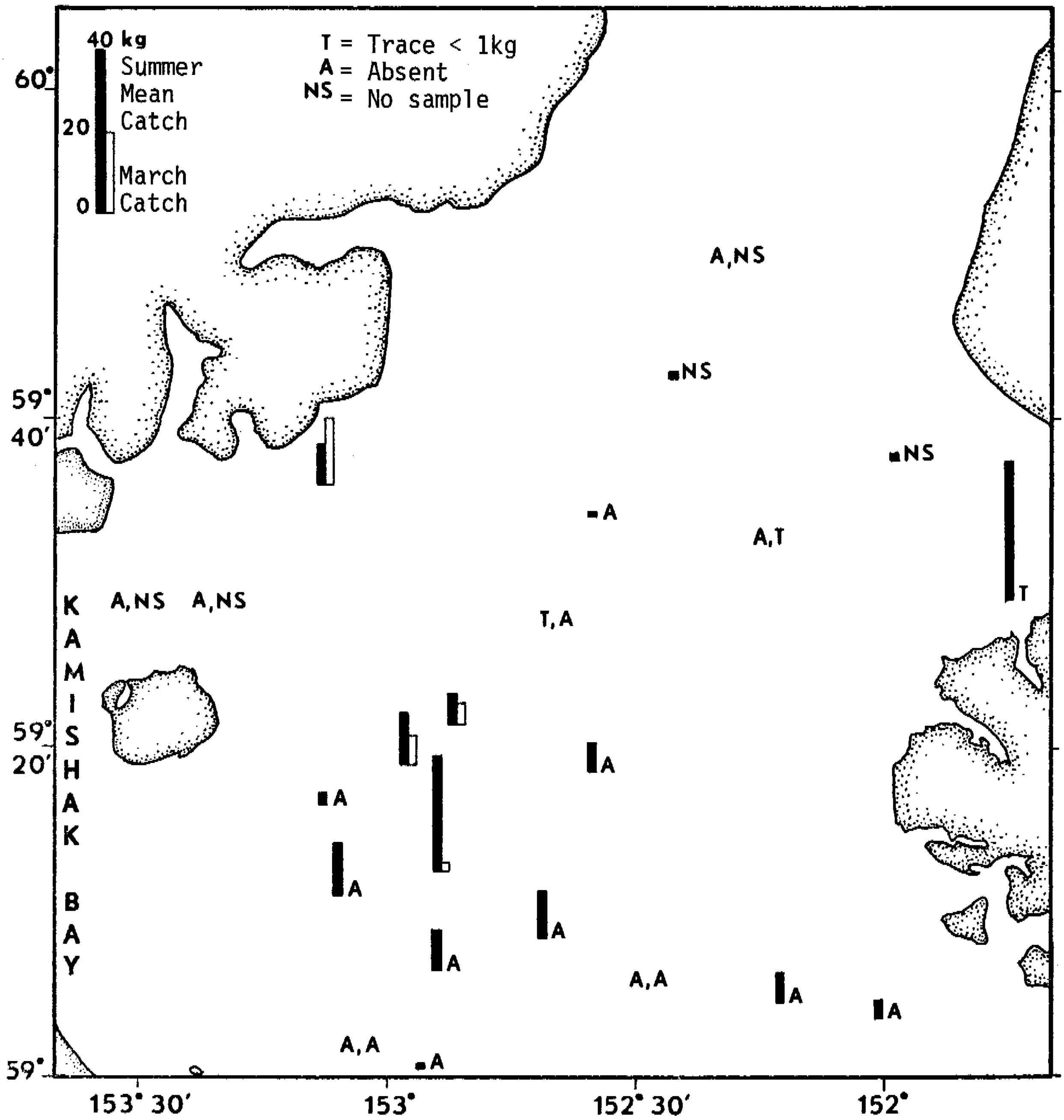


Figure 36. Distribution and mean catch in kg per 20 minute otter trawl haul for king crab (*Paralithodes camtschatica*) in lower Cook Inlet. Solid bar is the mean catch during cruises in June, July August and September 1976 and open bar is the catch in March 1977.

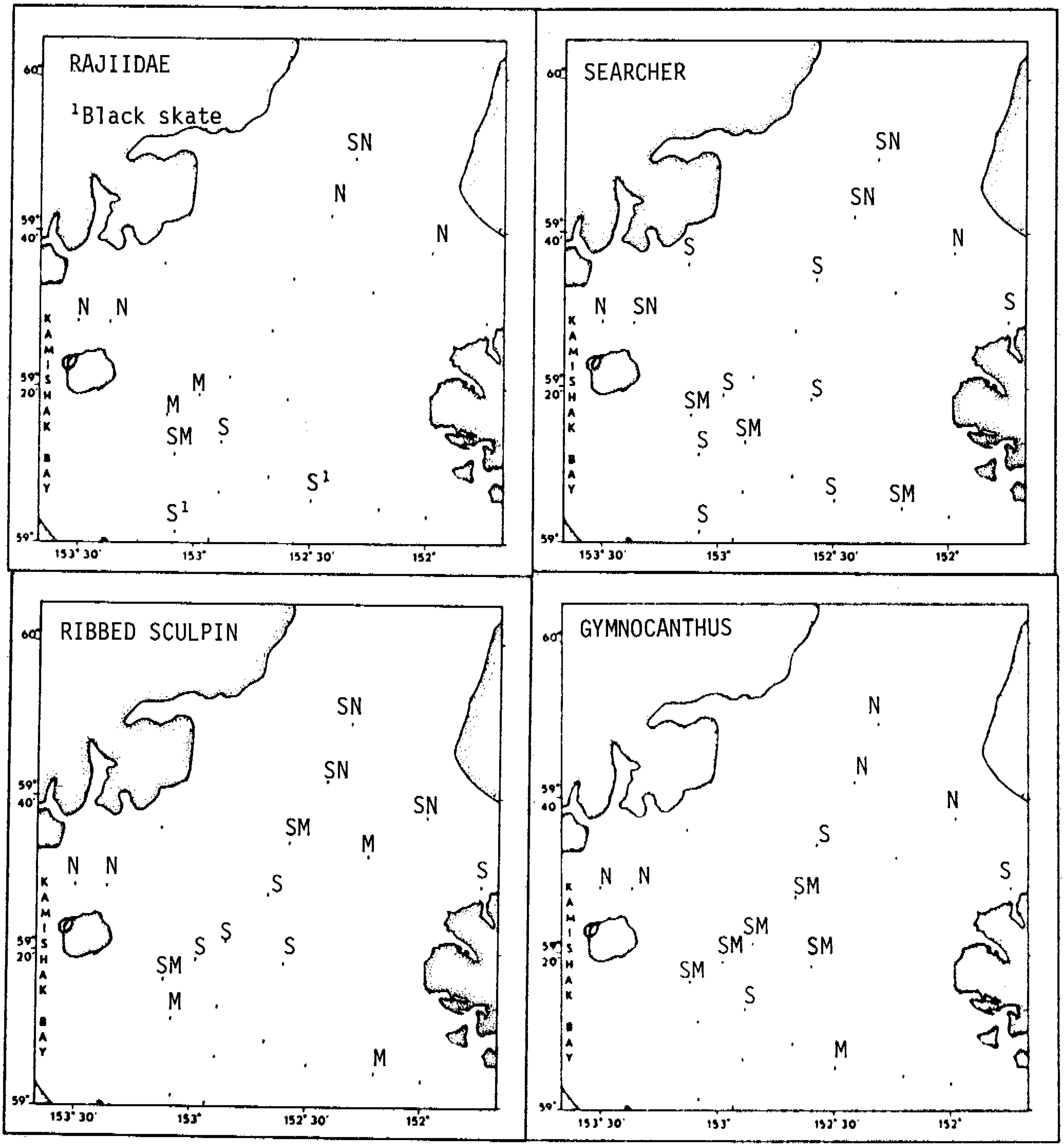


Figure 37. Locations at which the indicated taxa were captured in otter trawl hauls in lower Cook Inlet during summer 1976 = S, and March 1977 = M, N = not sampled in March 1977.

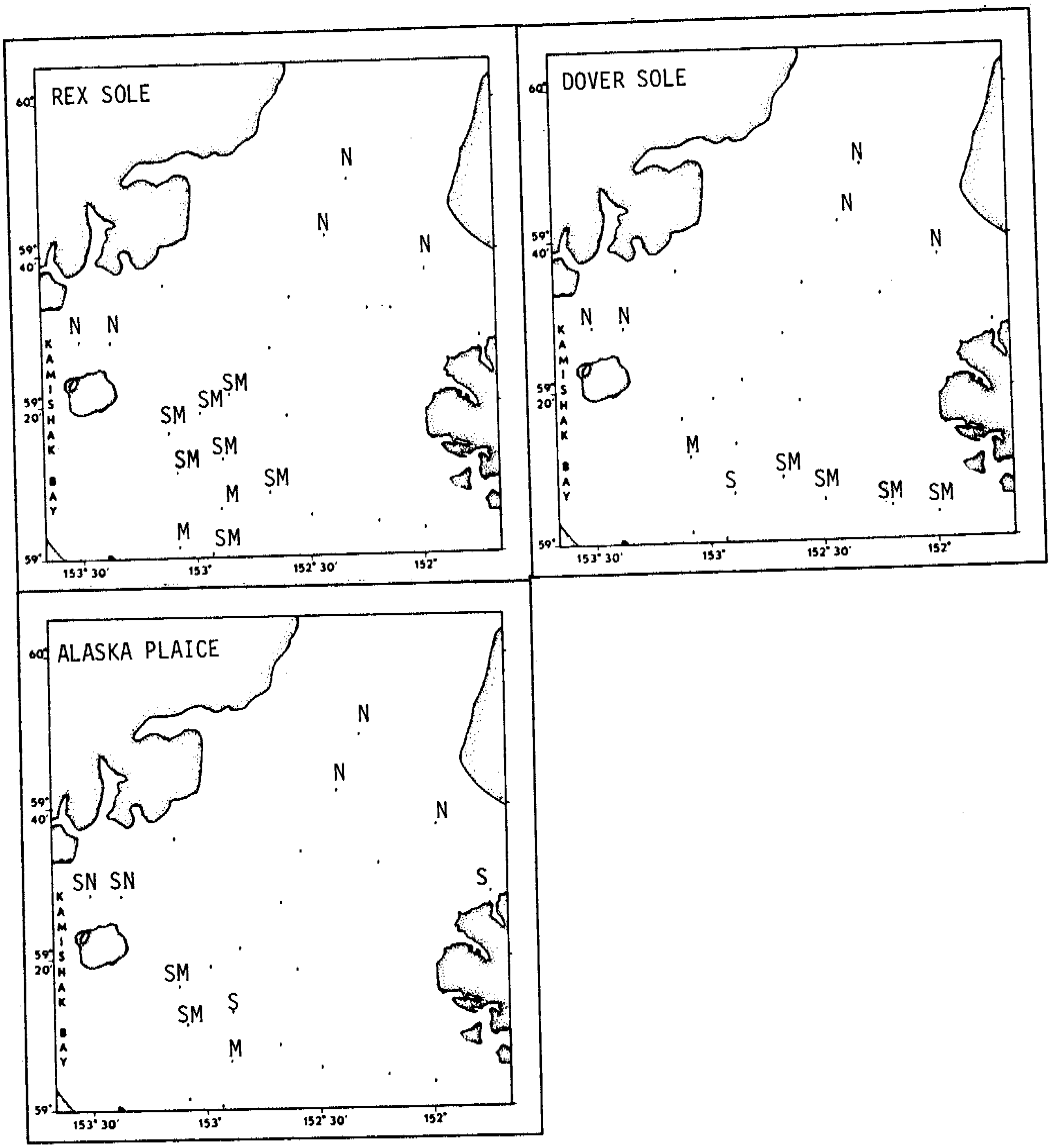


Figure 38 Locations at which the indicated taxa were captured in otter trawl hauls in lower Cook Inlet during summer 1976 = S, and March 1977 = M, N = not sampled in March 1977.

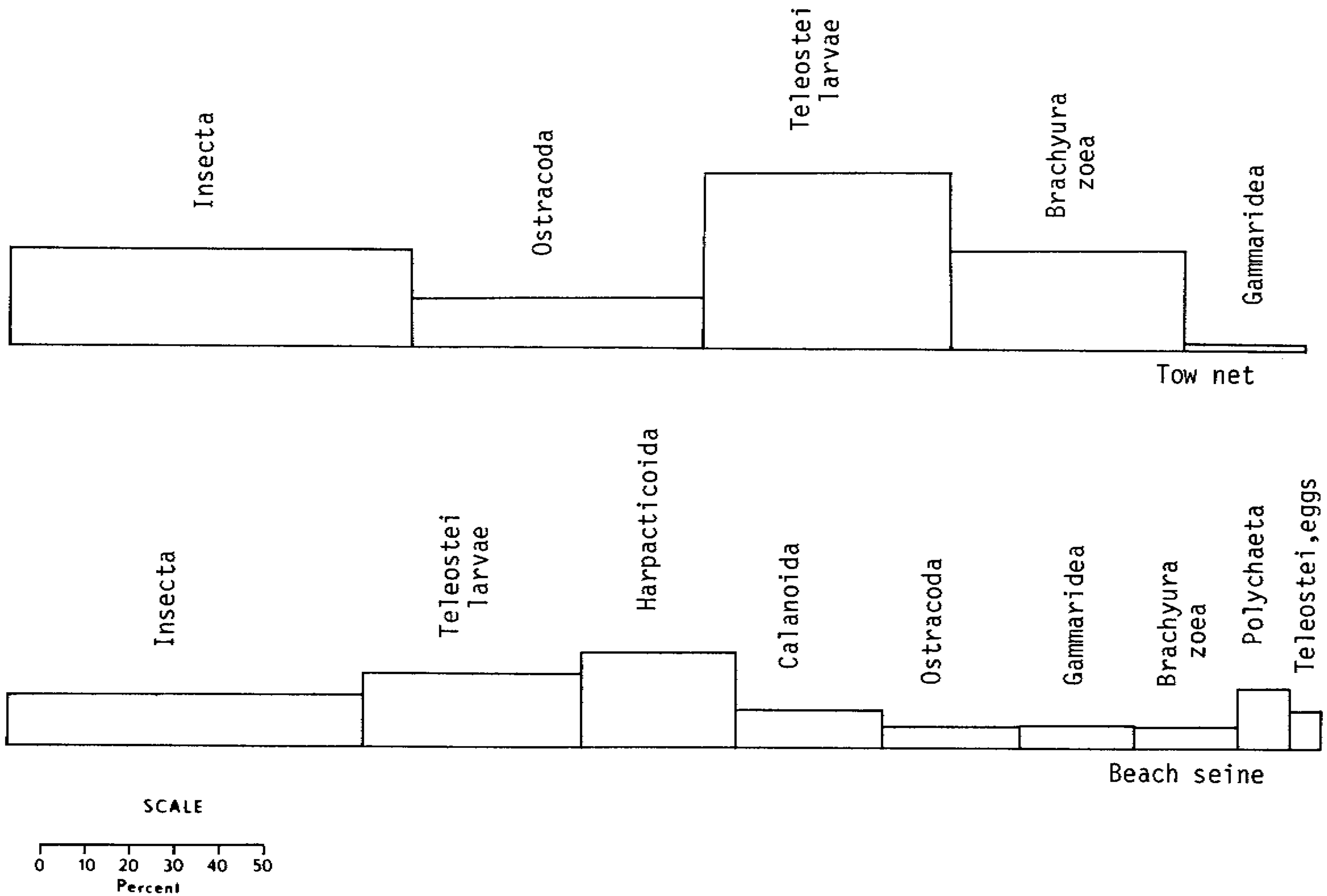


Figure 39 Prey spectrum of 72 juvenile pink salmon captured in Kachemak Bay on July 26 to 28, 1976 in the pelagic zone (Tow net, n = 29) and the intertidal zone (beach seine, n = 43). There were no empty stomachs, and unidentified material was present in 12.5 percent of the stomachs and comprised less than 0.5 percent by count of the contents. The horizontal axis is percent frequency of occurrence and the vertical axis is percent composition by numbers. Categories represented by less than 5 percent for frequency of occurrence or less than 1 percent by count are not included.

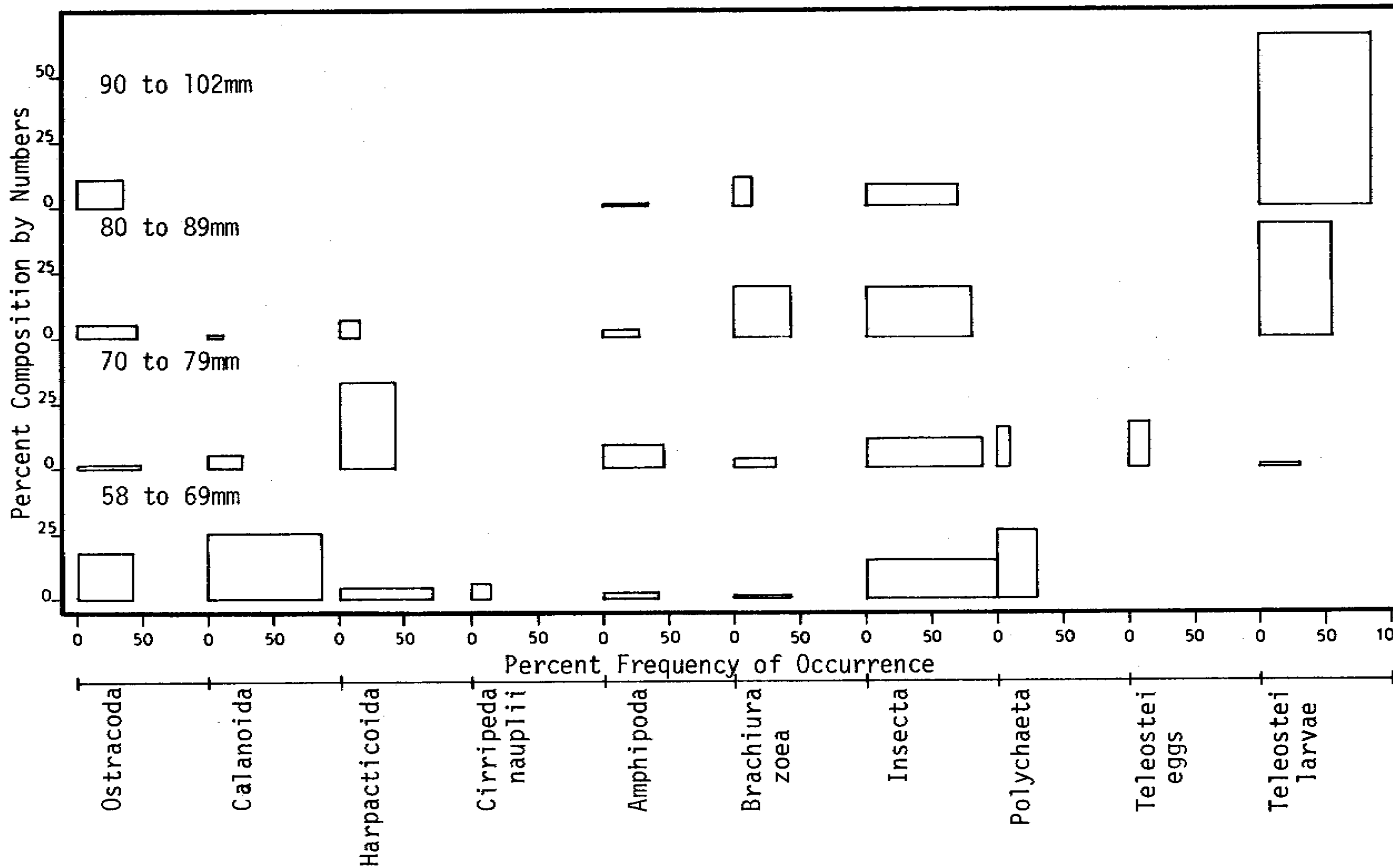


Figure 40. Prey spectrum of 72 juvenile pink salmon captured in Kachemak Bay on July 26 to 28, 1976 displayed by size class of predator. Prey categories represented by less than 5 percent for frequency of occurrence or less than 1 percent by count are not included.

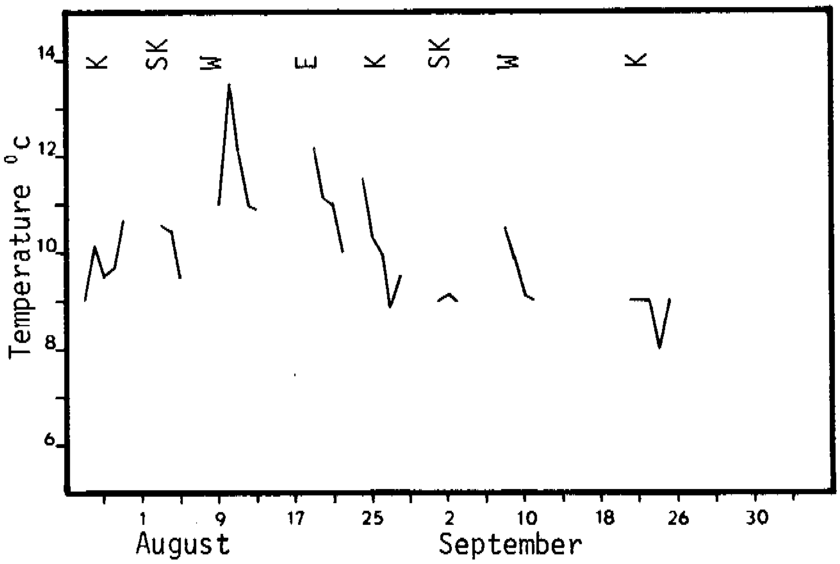


Figure 41. Mean daily surface temperatures taken concurrectly with beach seine and tow net samples in lower Cook Inlet during 1976. Daily temperature ranges were usually within ± 1°c. Extreme temperatures were 6°c measured August 28 in Kachemak Bay and 14°c measured at two stations August 10 in Ursus Cove in Kamishak Bay. The Symbols K = Kachemak Bay, W = west side of the inlet, E = east side of the inlet north of Anchor Point and SK = Kenai Peninsula, southwest of Tutka Bay.

Appendix Table 1. Stomach content analysis data for pink salmon juveniles captured in Kachemak Bay during July 26 to 28, 1976 in beach seine and tow net. The symbol P represents number of stomachs in which the item occurred and N represents the total count of that taxon in the stomachs.

	Fork Length							
	58-69mm		70-79mm		80-89mm		90-102mm	
Taxon	P	N	P	N	P	N	P	N
Cladocera	1	2	2	9	1	1		
Ostracoda	3	103	9	25	15	57	5	45
Copepoda			1	1				
Nauplii	2	3			1	1	1	1
Calanoida	6	147	5	79	4	15		
Harpacticoida	5	25	8	480	5	82		
Cirripeda nauplii	1	35	1	2				
Cumacea			2	4	1	1		
Amphipoda	1	2	3	8	1	2		
Hyperiidea	1	1					1	1
Gammaridea	1	11	6	115	8	31	4	4
Hypolitidae					5	8		
Anomuran larvae	1	1			3	11	2	2
Brachyura zoea	3	10	6	52	14	222	2	43
Unident Crustacean parts			1	3				
Insecta	7	81	17	163	26	210	10	32
Polychaeta	2	155	2	216	1	1		
Teleostei eggs			3	248				
Teleostei larvae	1	1	6	19	18	500	12	253
Unknown	1	1	1	2	8	11		
Number of Items	578		1426		1153		381	
Number of Fish	7		19		32		14	

Appendix Table 2. Beach seine and tow net catches in numbers of fish by species and cruise on the east side of lower Cook Inlet between Anchor Pt and the Forelands during 1976.

Taxa	Beach Seine				Tow net		
	June	July	Aug.	Sept. Oct.	July	Aug.	Sept.
Flounders							
Starry	6	3	11	1	0	0	0
Rock sole	0	2	0	0	0	0	0
Sand sole	2	0	8	0	0	0	0
Butter sole	0	5	0	0	0	0	0
Halibut	0	1	0	0	0	0	0
Larva	0	0	0	0	0	1	0
Sculpins							
Soft sculpin	0	0	0	0	0	0	2
Staghorn	0	8	6	0	0	0	0
Undetermined	13	0	0	0	0	0	0
Salmonids							
Pink fry	9	2	0	0	50	8	0
Adult	0	14	0	0	0	0	0
Red fry	0	1	1	0	0	0	0
Adult	3	5	0	0	0	0	0
Chinook[1]	18	12	1	0	1	11	0
Coho	8	5	3	5	1	0	1
Dolly Varden	125	77	15	3	1	0	0
Bering Cisco	0	1	0	3	0	0	0
Cod							
Safron cod	7	1	6	66[2]	1	1	18
Pollock	0	0	0	0	0	2	0
Greenling							
Whitespot	2	0	24	0	0	0	1
Masked	0	0	2	0	0	0	0
Lingcod	0	0	0	0	0	2	0
Undetermined	11	143	0	0	18	0	0
Stickleback	1	0	0	0	0	0	0
Smelt							
Surf smelt	0	0	21	0	0	0	0
Longfin	8	0	140	165	434[3]	52	211
Undetermined[4]	51	19[5]	11	0	0	0	0
Herring[6]	271	37	132	3	449	245	100
Sandfish	1	0	5	0	11	0	0
Snailfish							
Undetermined	0	0	3	1	0	5	4
Rockfish	0	0	0	0	0	0	1
Sandlance[6]	0	0	1145	0	61	2305	2
Prickleback							
Longsnout	0	8	17	0	0	0	0

Appendix Table 2. (cont.)

Taxa	Beach Seine June	Beach Seine July	Beach Seine Aug.	Beach Seine Sept. Oct.	Tow net July	Tow net Aug.	Tow net Sept.
Snake prickle-back	7	6	1	0	6	1	0
Lamprey	2	0	0	0	9	0	0
Poachers							
Tubenose	0	1	2	6	0	1	0
Undetermined species	0	0	0	0	0	1	0
Number of Hauls	12	13	12	12	17	16	5

[1] All sizes of chinook salmon were combined - 3 fish about 1.5 kg each are the largest included.
[2] Added effort on the oil spill increased this figure from 11.
[3] One large catch of 400.
[4] Table does not reflect abundance of larvae.
[5] One quart of larvae not counted.
[6] Many larvae captured also.

Appendix Table 3. Beach seine and tow net catches in number of fish by species and cruise on the west side of lower Cook Inlet during 1976.

	Beach Seine				Tow net		
Taxa	June	July	Aug.	Sept.	July	Aug.	Sept.
Flounders							
Starry	4	29	14	3	0	0	1
Rock sole	2	16	7	2	0	0	0
Sand sole	0	0	1	0	0	0	0
Butter sole	0	0	0	1	0	0	0
Halibut	0	1	1	0	0	0	0
Sculpins							
Great Sculpin	3	3	7	1	0	0	0
Staghorn	3	73	31	6	0	0	0
Silverspot	0	0	3	0	0	0	0
Undetermined	5	14	1	11	1	0	0
Salmonids							
Pink Fry	12	419	64	5	1	6	0
Adult	0	3	0	0	0	0	0
Chum fry	1	75	117	4	0	3	0
Adult	0	3	4	0	0	0	0
Red fry	-	55	1	-	9	1	-
Adult	-	-	1	-	-	-	-
Chinook[1]	1	3	-	-	16	2	-
Coho	0	0	0	1	1	0	0
Dolly Varden	103	162	74	7	0	0	0
Bering Cisco	3	7	3	1	0	0	0
Safron cod	0	0	1	0	-	-	-
Greenling							
Whitespot	0	4	21	5	0	0	0
Masked	0	0	1	0	0	1	0
Lingcod	0	0	0	0	0	1	0
Undetermined	7	53	0	0	161	0	2
Stickleback	2	0	3	1	0	0	2
Smelt							
Surf smelt	0	0	12	9	0	1	0
Longfin	0	1	1	0	0	0	1
Undetermined[2]	0	0	0	1	0	0	0
Herring[3]	0	81	326	325	1	0	952
Sandfish	0	2	1	0	0	4	0
Snailfish							
Undetermined	0	0	3	0	0	0	1
Sandlance[3]	1	554	25	31	464	3	242
Prickleback							
Longsnout	0	2	2	0	0	0	1
Snake prickleback	3	1	19	0	0	0	0

Appendix Table 3. (cont.)

	Beach Seine				Tow net		
Taxa	June	July	Aug.	Sept.	July	Aug.	Sept.
Poachers							
Sturgeon	0	0	1	0	0	1	0
Tubenose	0	0	26	8	0	1	1
Undetermined species							
Number of Hauls	12	25	19	15	15	16	18

[1] All sizes of chinook salmon were combines - 3 fish about 1.5 kg each are the largest included.
[2] Table does not reflect the abundance of larvae.
[3] Many larvae captured also.

Appendix Table 4. Beach seine and tow net catches in numbers of fish by species and cruise in Kachemak Bay and west to Nubble Point during 1976.

Taxa	Beach Seine				Tow net			
	May June	July	Aug.	Sept.	May June	July	Aug.	Sept.
Flounders								
Starry	7	0	1	0	0	0	1	0
Rock sole	25	5	0	7	0	0	0	0
Butter sole	2	0	0	0	0	0	0	0
Larva					0	0	0	5
Sculpins								
Soft sculpin	0	0	0	0	0	2	0	0
Great sculpin	8	4	22	40	0	0	0	0
Staghorn	0	3	1	6	0	0	0	0
Silverspot	0	0	1	0	0	0	0	0
Undetermined	39	33	4	1	3	0	0	0
Salmonids								
Pink fry	577	98	2	0	903	209	2	0
Adult	0	3	0	0	0	0	0	0
Chum fry	1	1	0	0	0	0	0	0
Red fry	2	1	-	-	-	-	-	-
Chinook[1]	241	57	-	-	2	-	-	-
Coho	20	0	1	63[2]	0	0	0	0
Dolly Varden	367	493	18	14	0	0	0	0
Safron cod	-	2	1	-	-	-	-	-
Greenling								
Whitespot	4	9	14	4	0	0	1	0
Masked	4	12	4	1	0	26	0	0
Lingcod	0	0	0	1	0	0	1	0
Undetermined	47	160	0	0	28	8	0	0
Stickleback	7	7	20	1	0	179	2	0
Smelt								
Capelin	0	0	0	0	0	0	96	10
Surf smelt	0	1	11	145	0	0	0	5
Undetermined[3]	0	0	21	0	0	0	0	0
Herring[4]	2	2	105	4559	0	2	13	781
Sandfish	0	0	0	0	0	0	6	6
Snailfish								
Undetermined	0	0	0	0	0	0	1	0
Rockfish	0	1	0	0	0	0	0	0
Sandlance[4]	16,247[5]	26	179	8394	1350	1445	4208	7842
Prickleback								
Longsnout	0	52	1	0	0	0	0	0
Snake prickleback	46	43	0	0	1	0	0	0

Appendix Table 4. (cont.)

Taxa	Beach Seine				Tow net			
	May June	July	Aug.	Sept.	May June	July	Aug.	Sept.
Crescent gunnel	5	2	0	0	0	0	0	0
Prowfish	0	0	0	0	0	1	8	0
Wolffish	0	0	0	0	0	1	0	0
Poachers								
Sturgeon	1	0	0	0	0	0	0	0
Tubenose	0	1	1	2	0	0	0	0
Number of Hauls	32	28	25	29	19	47	22	21

[1] All sizes of chinook salmon were combined - 3 fish about 1.5 kg each are the largest included.
[2] One catch of 63 in Halibut Cove included.
[3] Table does not reflect the abundance of larvae.
[4] Many larvae captured also.
[5] One catch of 13,400 included.

Appendix Table 5. Beach seine and tow net catches in numbers of fish by species and cruise on the Kenai Peninsula between Barabara Point and English Bay during 1976.

	Beach Seine		Tow net	
Taxa	Aug.	Sept.	Aug.	Sept.
Flounders				
Starry	2	0	0	0
Rock sole	12	20	0	0
Sculpins				
Great Sculpin	10	20	0	0
Staghorn	1	2	0	0
Undetermined	5	1	0	0
Salmonids				
Pink fry	131	8	0	0
Chum fry	3	3	0	0
Chinook[1]	7	3	-	-
Coho	1	0	0	0
Dolly Varden	151	66	0	0
Cod				
Pollock	-	-	1	-
Undetermined	-	1	-	-
Greenling				
Whitespot	1	15	0	0
Masked	0	5	0	0
Kelp	0	1	0	0
Lingcod	0	1	0	0
Undetermined	17	0	0	0
Stickleback	2	1	0	0
Smelt				
Capelin	0	0	1	0
Surf smelt	0	4	0	0
Herring[2]	3	0	0	0
Sandfish	0	0	1	0
Sandlance[2]	49	8122	5	0
Tubenose	3	3	0	0
Number of Hauls	14	14	8	11

[1] All sized of chinook salmon were combined - 3 fish about 1.5 kg each are the largest included.
[2] Many larvae captured also.

APPENDIX I

FRI-UW-7735
October 1977

Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

ADF&G-OCS FISH FOOD HABITS ANALYSIS

by

Charles A. Simenstad

Final Report
March 1977 - October 1977
Prepared for
ALASKA DEPARTMENT OF FISH AND GAME
Kodiak, Alaska 99615
Contract No. 11-41-3-406-380

Approved:

Submitted 25 October 1977

Robert L. Burgner, Director
Fisheries Research Institute

Introduction

Fisheries Research Institute (FRI) was contracted in March 1977 by the Alaska Department of Fish and Game (ADF&G) to examine, identify, and quantify the contents of approximately 500 stomachs from marine and estuarine fishes collected by ADF&G as a part of National Oceanic and Atmospheric Administration's OCSEAP studies in southern Cook Inlet and in Ugak and Alitak bays on Kodiak Island, Alaska. This report summarizes the condition, abundance, biomass, and composition of prey organisms in the stomach contents of these fishes. Where sample size permitted, comparisons between prey spectra from Cook Inlet and Kodiak Island fishes are presented.

Materials and Methods

Stomach Collection

Fish stomach samples originated principally from otter trawl collections but included some specimens from beach seine collections. The otter trawl was a 400-mesh Eastern-style net. The beach seine was 47.3 m (155 ft) long and 3.7 m (12 ft) deep at the bag with 6.4-mm (1/4 inch, stretch measure) mesh at the bag section.

Station and trawl transect locations as well as catch compositions and catch per unit effort (numbers of fish and kilograms of fish per 20-min. haul for trawls) were identified in Blackburn (1976a,b,c,d).

Stomach Analysis

In the laboratory, the stomach samples were removed from the preservative or the preserved whole fish and soaked in cold water for at least two or three hours before examination. The stomach was then identified according to information on the label and processed. Processing involved taking a total (damp) weight (to nearest 0.1 g) and removing the contents from the stomach and weighing the empty stomach, which gave a total contents weight (including unidentifiable material) by subtraction. Subjective numerical evaluations of the stomach condition or degree of fullness--scaled from 1 (empty) to 7 (distended)--and stage of digestion--scaled from 1 (all digested) to 5 (no digestion)--were made at this time. The individual stomach contents were then sorted and identified as far as practical, using a zoom binocular dissecting microscope, and the sorted organisms were counted and a total (damp) weight of each taxon obtained (to nearest 0.01 g). If a sorted taxon was represented by too many individuals to count, the number was estimated using a random grid counting procedure.

All stomach analysis data were recorded directly on NOAA/EDS format No. 100 computer forms.

Data Analysis

All data were processed using FORTRAN computer programs specifically written for the NOAA/EDS format record types, including statistical analyses of stomach content data; calculation of Shannon-Weiner (H') diversity indices* using both numbers and biomass; and generation and plotting of IRI (see next section) values.

Trophic Diagrams

In the presentation of the food habit data, a modification of Pinkas, et al. (1971), "Index of Relative Importance" (IRI) has been utilized to rank the importance of prey organisms. The IRI values for food items are

----

*Shannon-Weiner diversity indices are comparable between species only when the mean digestion factors are not significantly different.

displayed graphically where justified by sample size ($n \geq 10$). These three-axis graphs illustrate frequency of occurrence (that proportion of stomachs containing a specific prey organism) plotted on the horizontal axis, and percentage of total abundance and percentage of total biomass plotted for each prey item above and below the horizontal axis, respectively (Fig. 1). Prey taxa of differing stages of digestion (e.g., partly digested shrimp, "Natantia--unidentified", as opposed to family, "Pandalidae", or species, "*Pandalus borealis*") are graphed separately.

All prey groups, including those assigned to a broad phylogenetic level (family, order, class) because of advanced digestion, have been arranged from left to right by decreasing frequency of occurrence. Items of taxa with less than 5% frequency of occurrence or 1% of total abundance or biomass were not graphed. Prey items that occurred in more than 5% of the stomachs appear on the graph, but if either the abundance or the biomass of a particular item was less than 1% of the total, a bar was not drawn. Hence, if a prey taxon appears on the graph but no bars extend above or below the horizontal axis, that particular taxon was present in more than 5% of the stomachs but contributed less than 1% to abundance (above) and biomass (below).

The IRI value was computed as follows. IRI = % frequency of occurrence$_i$ [% numerical composition$_i$ + % gravimetric composition$_i$], and is equivalent to the area encompassed by the bar for each prey category i composing the IRI diagrams. In order to compare the IRI values between prey spectra with different sample sizes, the overall contribution of general prey taxa (e.g., all shrimp, including "Unidentified Natantia" and those identified to family and species, added together) have been discussed as a percentage of the total combined IRI (areas) of the

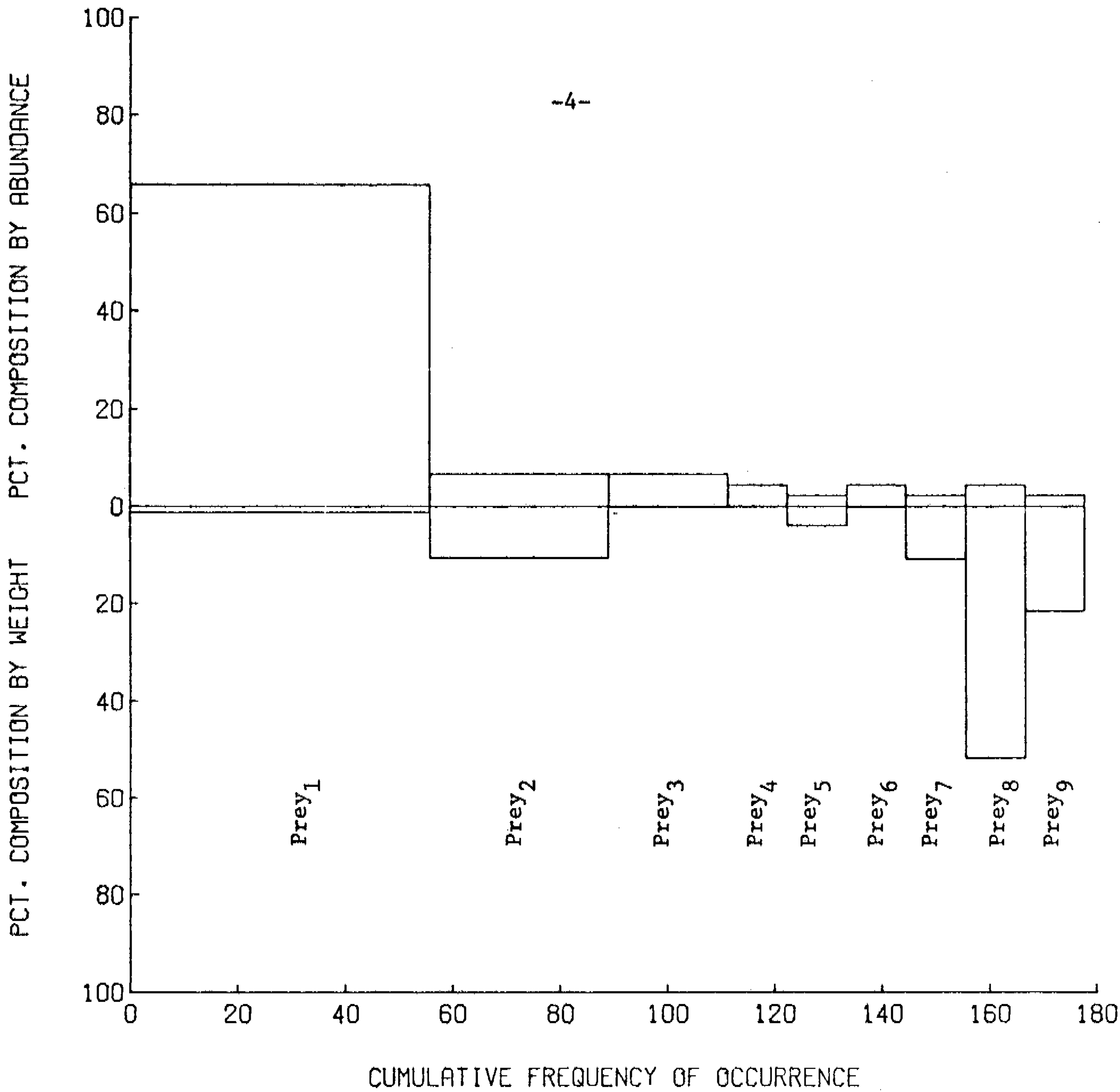


Fig. 1. Example IRI (Index of Relative Importance) diagram.

Table 1. Example computation of IRI values and percentages of total IRI from data illustrated in Fig. 1.

Prey category	% Freq. occur.	% num. compos.	% grav. compos.	IRI value	% Total IRI
1	55.6	65.9	1.2	3729.5	65.8
2	33.3	6.7	10.7	583.7	10.3
3	22.2	6.7	0.1	152.5	2.7
4	11.1	4.6	0	50.5	0.9
5	11.1	2.3	3.8	67.9	1.2
6	11.1	4.6	0.1	51.8	0.9
7	11.1	2.3	10.9	146.3	2.6
8	11.1	4.6	51.7	624.6	11.0
9	11.1	2.3	21.5	264.4	4.7

different prey taxa. Table 1 illustrates an example of the IRI values and percentages of total IRI generated from the data illustrated in Fig. 1.

The IRI values essentially represent a single index of prey importance incorporating normalized values for (1) the frequency (%) in which a particular prey taxon is represented in the food habits of a sample of fish--i.e., its occurrence in the diet of a population at any one time; (2) the numerical composition (%) which that prey taxon represents of the total number of prey items consumed; and (3) the composition (%) by biomass represented by that prey taxon over the total consumed (identifiable organism) biomass. Thus, numerically rare but high biomass taxa (e.g., $prey_8$, Fig. 1); infrequently occurring but abundant or high biomass (when eaten) taxa; and numerically abundant or frequently occurring taxa (but which contribute little in the way of trophic input, e.g., $prey_1$, Fig. 1) do not overpower the more representative prey organisms.

Results and Discussion

Condition of Stomachs

Of the 313 stomach samples processed in the FRI laboratory, 74 (24%) had to be completely discarded because of extensive deterioration due to improper preservation at the time of collection. These samples originated from lower Cook Inlet. The samples from Kodiak Island, however, appeared to be in much better condition. Of those stomachs with obvious deterioration, most were very full of food organisms; empty stomachs did not undergo extensive deterioration. Accordingly, the data obtained from the lower Cook Inlet samples that were processed undoubtedly were biased by partial deterioration. Therefore, in interpreting the food habit data of Cook Inlet fishes, it should be realized that the percentage of empty stomachs, percentage of unidentifiable material, digestion factor, and stomach contents weight values will provide impressions of lower feeding activity and ration size and higher digestive rates than actually occurred. Appendix Table 1 lists the stomach samples that were discarded.

Food Items

All food items identified from the stomach contents and their percentage frequencies of occurrence are listed in Table 2. On the basis of percent occurrence in the two sampling areas, the dominant prey taxon was caridean shrimp, principally the pandalid species *Pandalus borealis* and *P. goniurus* and crangonid species. Fishes were the second most important prey taxon, with the capelin (*Mallotus villosus*) and the prickleback (*Lumpenus medius*) being the commoner identifiable species.

Although the predator species composition varied in the samples from Kodiak Island and lower Cook Inlet, there appear to exist significant differences in the epibenthic and benthic prey resources of demersal fish assemblages in the two regions. Notable examples of these differences include: (1) More polychaete annelids in the lower Cook Inlet stomachs than in the Kodiak Island stomachs; (2) no gastropods in Kodiak Island stomach samples; (3) percentage occurrence of mysids in predator diets is higher in lower Cook Inlet than in Kodiak Island; (4) percentage of gammarid amphipods in predator diets is higher in lower Cook Inlet than in Kodiak Island; (5) similar utilization of caridean shrimps in both regions but with different occurrences of some species--e.g., *P. borealis* is absent in the stomachs of Kodiak Island predators; and (6) the importance of fishes in the food habits of Kodiak Island predators, as compared with the near lack of fishes in the stomachs of lower Cook Inlet fishes.

Table 2. Percent composition (numerical) of food items in stomachs of demersal fishes from Kodiak Island and lower Cook Inlet, Alaska, collected during ADF&G-OCS studies, June 1976 - March 1977.

Food item	Frequency of occurrence (Subtotals in parentheses)		
	Kodiak Island	Lower Cook Inlet	Overall
Algae			
Ulotrichales	0.4	...	0.2
Ulva sp.	1.6	...	0.9
Unidentified	0.4 (2.4)	0.6 (0.6)	0.5 (1.6)
Vascular plants			
Zostera marina	0.4	...	0.2
Hydroids, hydrozoans, medusae			
Cnidaria	0.4	...	0.2
Worms			
Trematoda (parasitic)	4.3	...	2.6
Nematoda (parasitic)	9.7	9.7	9.7
Polychaeta	0.8	10.3	4.5
Maldanidae	0.4	...	0.2
Terebellidae	... (1.2)	1.2 (11.5)	0.5 (5.2)
Snails			
Gastropoda	...	0.6	0.2
Puncturella multistriata	...	1.8	0.7
Natica clausa	...	0.6 (3.0)	0.2 (1.1)
Clams			
Bivalvia	2.7	4.2	3.3
Nuculana spp.	1.6	...	0.9
N. fossa	0.4	...	0.2
Veneroida	0.4	...	0.2
Mactridae	...	0.6	0.2
Spisula spp.	...	0.6	0.2
Veneridae	1.2 (6.3)	3.0 (8.4)	1.9 (6.9)
Crustaceans			
Crustacea	1.2	2.4	1.7
(Barnacles) Cirripedia	0.4	...	0.2
(Mysids) Mysidacea	2.3	14.5	7.1
(Isopods) Cymothoidae	0.4	...	0.2
Bopyridae	0.4 (0.8)	...	0.2 (0.4)
(Amphipods) Gammaridea	0.8	10.3	4.5
Caprellidea	0.4 (1.2)	... (10.3)	0.2 (4.7)
(Euphausiids) Euphausiacea	7.8	1.2	5.2
Decapoda	1.2	1.2	1.2
(Shrimp) Decapoda-Caridea	9.3	11.5	10.2
Hippolytidae	1.9	1.8	1.9
Eualus biunguis	0.4	...	0.2
Heptacarpus spp.	0.4	...	0.2
Pandalidae	3.5	1.8	2.8
Pandalus spp.	1.6	...	0.9
P. borealis	3.5	...	2.1

Table 2. Percent composition (numerical) of food items in stomachs of demersal fishes from Kodiak Island and lower Cook Inlet, Alaska, collected during ADF&G-OCS studies, June 1976 - March 1977, cont'd

Food item	Frequency of occurrence (Subtotals in parentheses) Kodiak Island	Lower Cook Inlet	Overall
P. goniurus	3.1	5.5	4.0
Pandalopsis spp.	0.8	...	0.5
Crangonidae	1.2	6.1	3.1
Crangon spp.	3.1	4.2	3.5
C. communis	0.4	...	0.2
Argis spp.	0.8	...	0.5
A. dentata	1.2 (31.2)	... (30.9)	0.7 (30.8)
(Crabs) Lithodidae	0.4	...	0.2
Paralithodes spp.	0.4	...	0.2
Decapoda-Brachyura	...	0.6	0.2
Oxyrhyncha	...	0.6	0.2
Pugettia gracilis	0.4 (1.2)	... (1.2)	0.2 (1.0)
Brittlestars Ophiuroidea	0.4	...	0.2
Sea cucumbers Holothuroidea	1.2	0.6	0.9
Fishes Osteichthys	14.7	2.4	9.9
Clupea harengus pallasi	0.8	...	0.5
Osmeridae	1.9	...	1.2
Mallotus villosus	1.9	...	1.2
Zoarcidae	0.8	0.6	0.7
Lycodes brevipes	0.4	...	0.2
Cottidae	0.4	...	0.2
Hemilepidotus jordani	0.4	...	0.2
Stichaeidae	0.4	...	0.2
Lumpenus spp.	1.9	...	1.2
L. medius	1.6	...	0.9
Pleuronectidae	0.4	...	0.2
Hippoglossoides elassodon	0.4 (26.0)	... (3.0)	0.2 (16.8)
Rocks	1.2	1.2	1.2
	100%	100%	100%

Food Habits

Fourteen predator species--two gadoids (codfishes), four cottids (sculpins), and eight pleuronectids (right-eyed flounders)--were examined for stomach contents (Table 3).

Gadus macrocephalus, Pacific cod. Stomachs of Pacific cod were typically quite full of food items and over 50% of these were usually identifiable. The combined prey spectrum (Fig. 2) indicated a generally benthophagous feeding behavior based on epibenthic macrocrustacea and fishes. Euphausiids accounted for 44.7% of the total IRI; shrimps (principally Pandalus goniurus but also P. borealis and several Crangon spp.), 26.6%; and fishes (including Clupea harengus pallasi, Hemilepidotus jordani, Hippoglossoides, and Lumpenus medius, and species of osmerids, zoarcids, stichaeids, and pleuronectids), 17.5%.

When the data were separated into collections from Kodiak Island and lower Cook Inlet, euphausiids were seen to dominate the IRIs at Ugak Bay on Kodiak, with fishes and shrimp providing the remaining prey items. The prey spectrum of lower Cook Inlet cod was composed almost entirely of shrimp, and mysids made up most of the remaining prey (Table 4).

Theragra chalcogramma, walleye pollock. As with Pacific cod, stomachs from the walleye pollock averaged 75% full with close to 75% of the contents identifiable. They also appeared to be benthophagous, feeding principally upon epibenthic crustacea--mysids, shrimp, and euphausiids--and fish (Fig. 3), although the biomass diversity ($H'_{biomass} = 2.13$) was half that of Pacific cod ($H'_{biomass} = 4.36$). Mysids dominated the total prey IRI with 71.6%, shrimp (Pandalus goniurus, Eualus biungius, Heptacarpus sp., and Crangon sp.) composed 9.2%, and fish (identifiable only as cottids) composed 6.8%. The nematodes included in the prey spectra were parasitic and should not be considered as food items.

Table 3. Predator species and sample size; stomach fullness and contents digestion; prey abundance and biomass; and diversity of demersal fishes from Kodiak Island and lower Cook Inlet, Alaska, collected during ADF&G-OCS studies, June 1976 - March 1977.

Species	Sample size		% empty stomachs	Fullness factor $\bar{x}$ ± S.D.	Digestion factor $\bar{x}$ ± S.D.	Prey abund. $\bar{x}$±S.D.	Prey biomass $\bar{x}$±S.D. (grams)	Shannon-Weiner Diversity Index H'	
	Cook Inlet	Kodiak						Abundance	Biomass
Gadus macrocephalus Pacific cod	12	15	0	5.2±1.1	4.8±0.7	52.7±76.2	23.9±27.7	2.84	4.36
Theragra chalcogramma walleye pollock	10	11	0	5.0±1.6	4.7±1.2	23.4±31.9	13.8±38.8	2.72	2.13
Gymnocanthus sp. sculpin	0	16	43	2.7±1.9	2.6±2.0	1.9±3.1	1.6±2.6	2.85	2.19
Hemilepidotus jordani yellow Irish lord	0	9	22	5.0±2.3	4.3±1.9	3.0±2.3	8.6±6.9	3.19	2.44
Myoxocephalus sp. sculpin	0	3	0	3.0±1.0	5.0±0	1.3±0.6	6.2±3.1	2.00	1.88
Myoxocephalus polyacanthocephalus, great sculpin	0	9	22	3.0±1.5	4.2±1.9	2.7±2.1	5.3±6.2	3.74	2.90
Atheresthes stomias arrowtooth flounder	6	7	30	3.4±2.1	3.5±2.1	3.4±4.5	2.7±6.1	2.53	2.05
Hippoglossoides elassodon, flathead sole	3	13	18	3.9±2.1	4.1±1.9	18.7±42.2	2.0±3.0	1.39	2.84
Isopsetta isolepis butter sole	6	6	41	2.7±2.0	2.5±1.9	3.1±7.4	0.7±1.3	2.42	2.59
Lepidopsetta bilineata rock sole	19	5	29	2.6±1.5	3.2±2.1	6.5±11.2	0.5±0.8	3.11	3.45
Limanda aspera yellowfin sole	5	60	36	2.3±1.5	3.3±2.2	3.9±18.6	1.5±4.4	2.76	3.41

Table 3. Predator species and sample size; stomach fullness and contents digestion; prey abundance and biomass; and diversity of demersal fishes from Kodiak Island and lower Cook Inlet, Alaska, collected during ADF&G-OCS studies, June 1976 - March 1977, cont'd

Species	Sample size: Cook Inlet	Sample size: Kodiak	% empty stomachs	Fullness factor $\bar{x} \pm$ S.D.	Digestion factor $\bar{x} \pm$ S.D.	Prey abund. $\bar{x}\pm$S.D.	Prey biomass $\bar{x}\pm$S.D. (grams)	Shannon-Weiner Diversity Index H': Abundance	Shannon-Weiner Diversity Index H': Biomass
Microstomus pacificus Dover sole	17	0	5	3.8±1.5	4.1±1.4	6.5±5.7	0.1±0.1	2.56	2.52
Platichthys stellatus starry flounder	3	1	75	1.3±0.5	1.8±1.5	1.5±3.0	0.1±0.1	1.46	1.07
Pleuronectes quadrituberculatus, Alaska plaice	3	0	0	2.0±0	4.0±2.0	5.0±6.9	0.1±0.1	1.75	1.54
Total stomach sample	84	155							

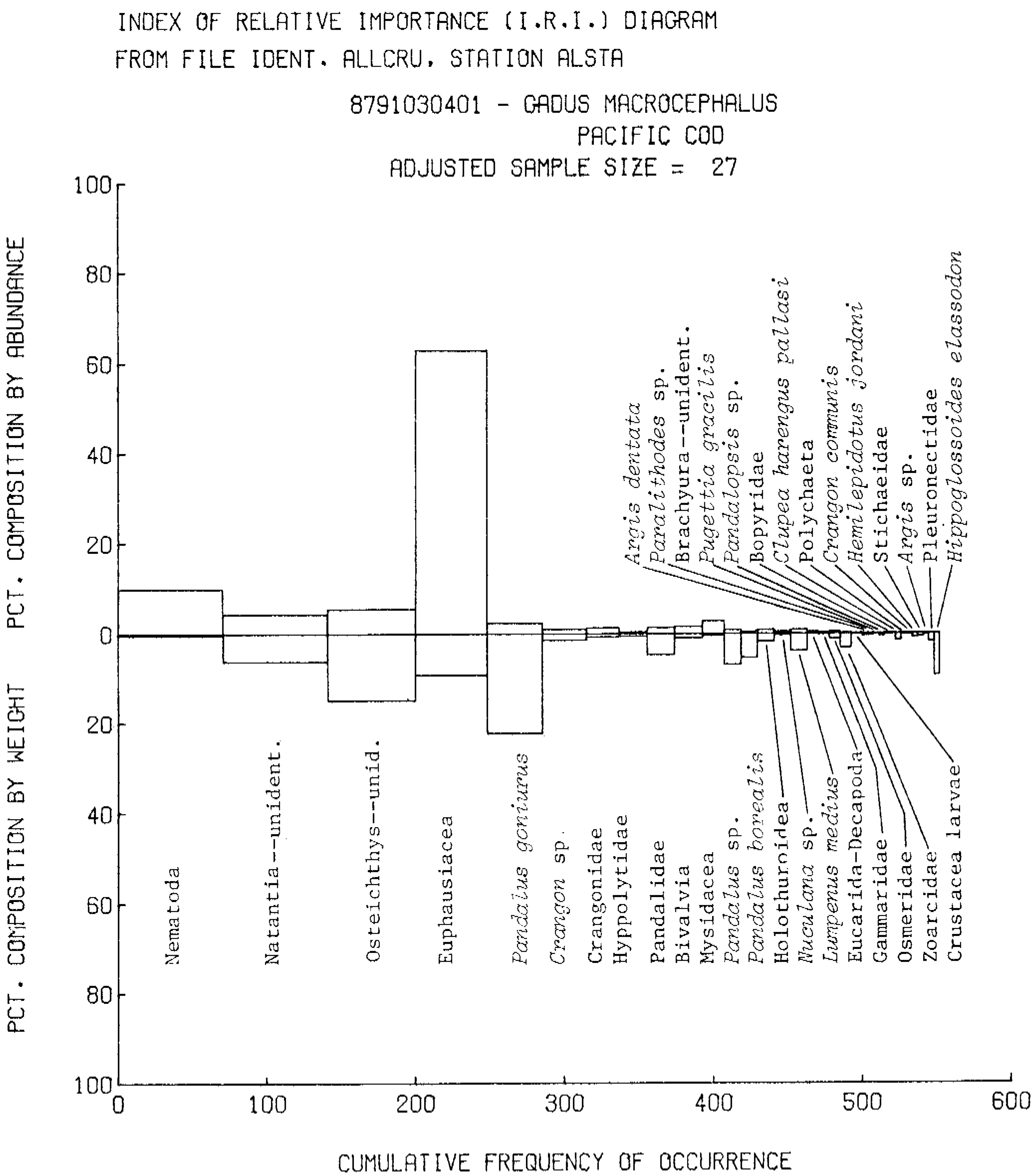


Fig. 2. Composite IRI diagram for prey organisms of Pacific cod, Gadus macrocephalus.

Table 4. Percent IRI composition for dominant prey taxa in stomachs of Pacific cod from Kodiak Island and Lower Cook Inlet.

Taxon	Ugak Bay, Kodiak July 1976 n=15	Lower Cook Inlet September 1976 n=12
Euphausiacea	65.33	0.13
Osteichthys	17.66	0.0
Natantia	15.35	91.71
Bivalvia	1.01	0.0
Holothuroidea	0.51	0.0
Reptantia	0.10	0.28
Mysidacea	0.0	6.17
Polychaeta	0.0	0.14
Amphipoda	0.0	1.43

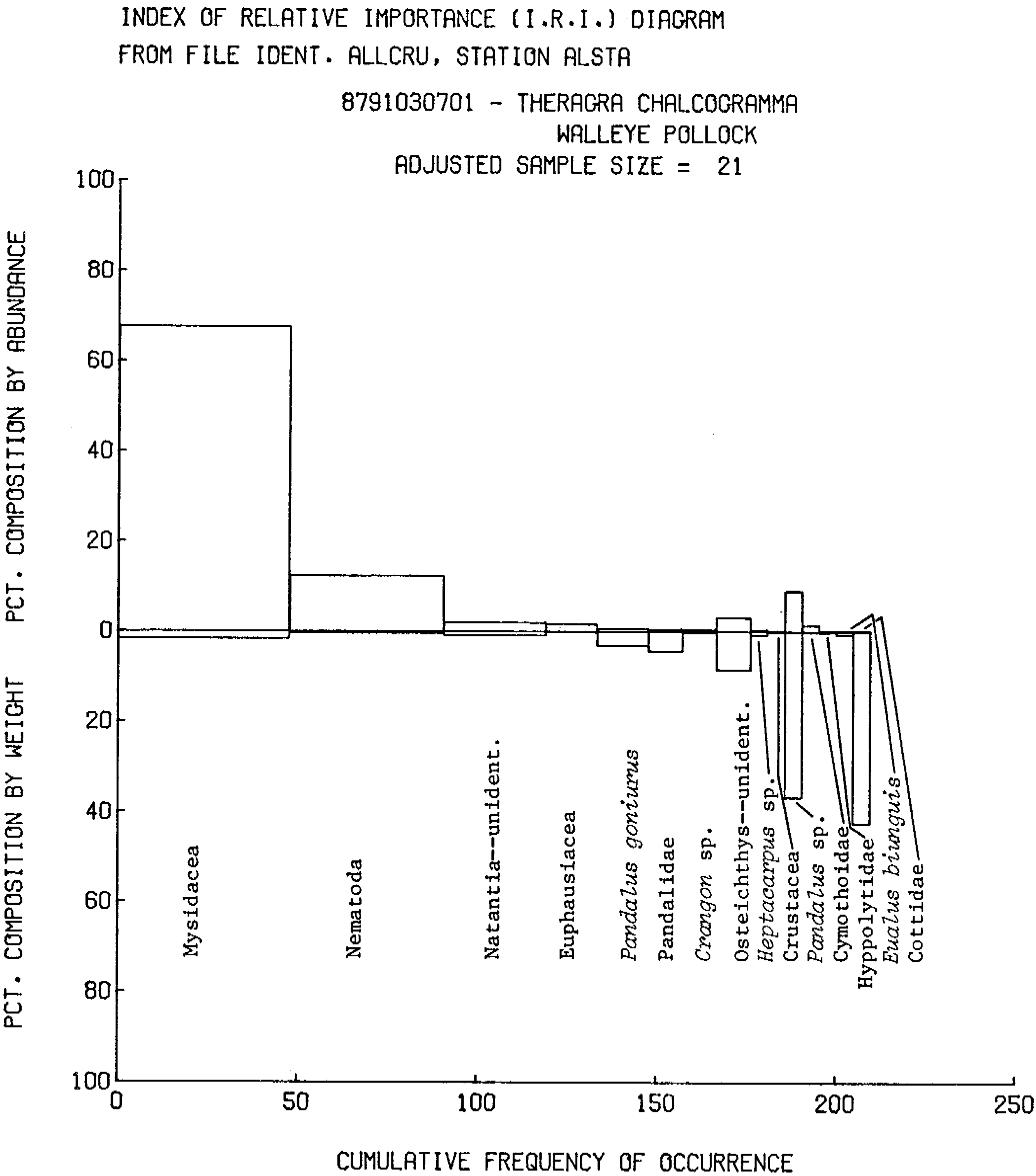


Fig. 3. Composite IRI spectrum for prey organisms of walleye pollock, Theragra chalcogramma.

While shrimp and fish were the more important prey organisms around Kodiak Island, mysids were much more important to the diet of walleye pollock in lower Cook Inlet and shrimp proportionally less so (Table 5).

Gymnocanthus sp., sculpin. These cottids originated from August and September 1976 collections in Ugak Bay. Because of a high percentage of empty stomachs (43%), the resulting sample size did not permit a quantitative representation of the prey spectrum. Fishes, Mallotus villosus and Lumpenus sp., formed the greatest percentage of the total IRI with lesser contributions by euphausiids and mysids.

Hemilepidotus jordari, yellow Irish lord. Of the nine specimens of H. jordani collected in Ugak Bay in August 1976, the stomachs of two (22%) were completely empty. Shrimp was the major prey item; Pandalus borealis and P. goniurus provided 64.5% and 21.7% of the total IRI, respectively.

Myoxocephalus sp., sculpin. We examined the stomachs of three unidentified cottids of the genus Myoxocephalus captured in Ugak Bay in August and September 1976. IRI values were equally shared by the shrimp P. borealis and two fishes, Mallotus villosus and Lumpenus medius, but the low sample size does not allow quantitative generalizations.

Myoxocephalus polyacanthocephalus, great sculpin. Of the nine specimens of this species identified from the August 1977 collections at Ugak Bay, seven had identifiable stomach contents, a sample size too small to allow quantitative evaluation. Fishes (principally Lumpenus sp. and M. villosus) composed the highest percentage of the total IRI; shrimp (Argis dentata, Crangon sp., Hyppolytidae, and Pandalidae) were second in importance, followed by euphausiids.

Table 5. Percent IRI composition for dominant prey taxa in stomachs of walleye pollock from Kodiak Island and lower Cook Inlet.

Taxon	Ugak Bay, Kodiak I., 7-9/76 Alitak Bay, Kodiak I., 3/77 (n=11)	Lower Cook Inlet, 9/76 (n=10)
Natantia	47.97%	9.07%
Osteichthys	24.79	0
Mysidacea	5.67	90.85
Euphausiacea	2.38	0.08
Isopoda	2.36	0

Atheresthes stomias, arrowtooth flounder. Seven A. stomias stomach samples originated from Ugak Bay collections in July and September 1976; and six samples were collected in lower Cook Inlet in September 1976. The stomachs of 30% of the combined samples were empty, creating a low sample size.

Mysids were the prevalent prey organisms for arrowtooth flounder, accounting for 65.8% of the total IRI; fish (Mallotus villosus, Osmeridae, and Zoarcidae) composed most of the remaining IRI percentage.

Hippoglossoides elassodon, flathead sole. Most of the H. elassodon stomach samples originated from the August 1977 collections at Ugak Bay. Of the 16 samples, three (18%) were empty. Samples with food items averaged nearly half full and usually over half of the prey were identifiable.

Flathead sole fed almost exclusively upon epibenthic crustaceans. Mysids constituted the main prey organism, especially on the basis of percent numerical composition--72.5% of the total IRI (Fig. 4), producing a low diversity diet, numerically ($H'_{abundance} = 1.39$). Shrimp (predominately Pandalus goniurus and P. borealis) composed 14.0% and fish (Clupea harengus pallasi and Lumpenus sp.) 8.5% of the total IRI.

Isopsetta isolepis, butter sole. The stomachs of six butter sole were taken from September 1976 collections both at Ugak Bay and lower Cook Inlet; five (41%) of these were empty. The reduced sample size did not permit quantitative interpretations, but crustaceans (shrimp and mysids), bivalves (Veneridae, Nuculana sp.) gastropods, fish, and polychaetes were the major food items. The polychaetes, bivalves, and gastropods appeared to be more important in the diet of Ugak Bay flathead sole, whereas fish and shrimp were more important in lower Cook Inlet.

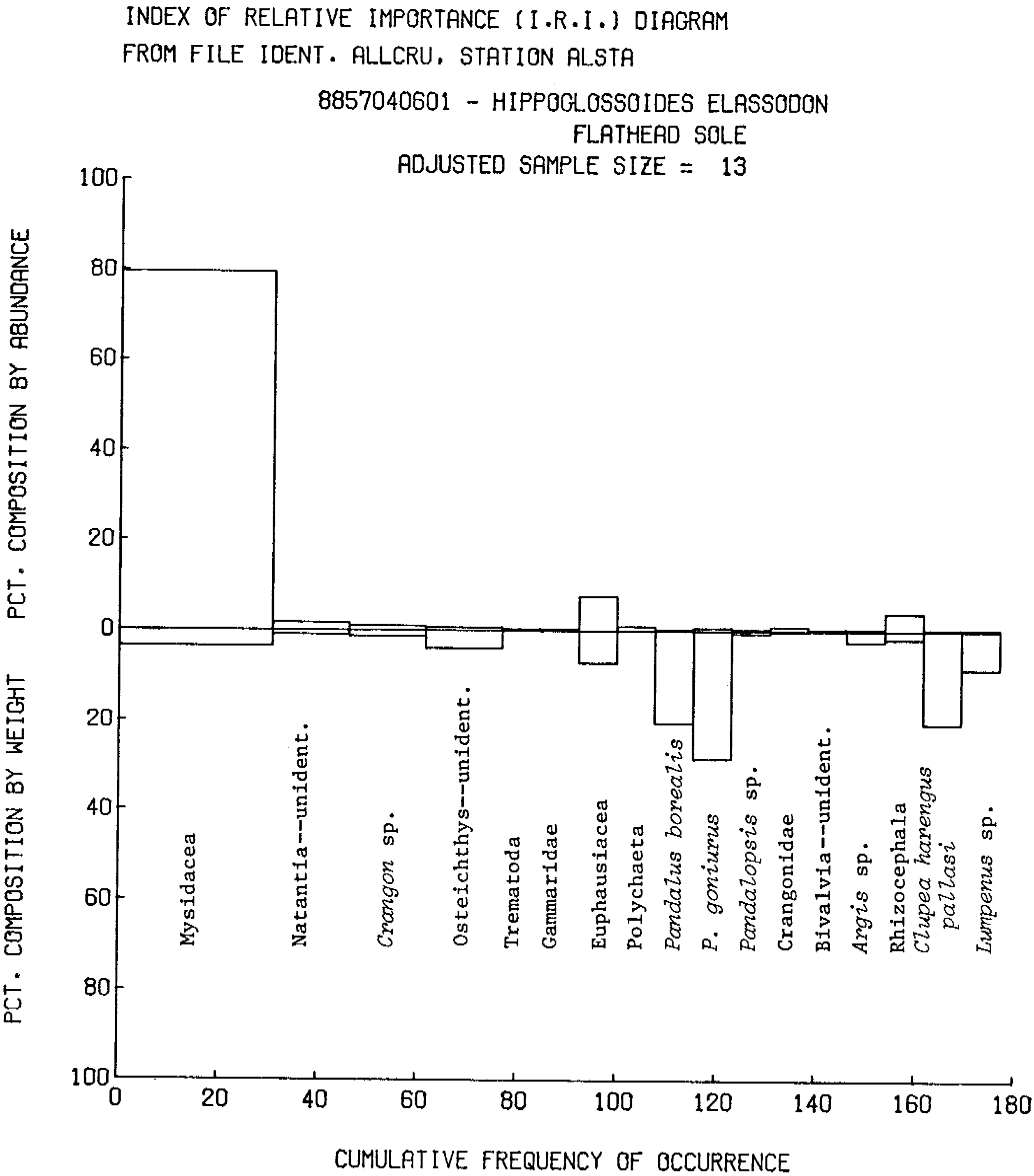


Fig. 4. Composite IRI spectrum for prey organisms of flathead sole, Hippoglossoides elassodon.

Lepidopsetta bilineata, rock sole. Rock sole were captured mainly in lower Cook Inlet (September), although five stomach samples were retained from the Ugak Bay collections in September 1976. A high percentage (29%) of these were empty and the remainder averaged less than 25% full; typically, less than 50% of the contents were identifiable.

These rock sole were benthophagous; polychaete annelids (Terebellidae) and gastropods (Puncturella multistriata and Natica clausa) were the more important prey organisms, constituting 89.8% and 33.0% of the total IRI, respectively (Fig. 5). Bivalves (Veneridae, Nuculana fossa, Spisula sp., 14.2% of total IRI), mysids (6.1%), and shrimp (Crangon sp., 4.6%) were the secondary food items.

Despite the low sample size for Ugak Bay, there appears to be a basic difference in prey composition for rock sole collected there and in lower Cook Inlet in that the polychaete annelids were prominent only in the lower Cook Inlet samples.

Limanda aspera, yellowfin sole. Large numbers of stomach samples were taken from yellowfin sole collected at Ugak Bay in June through September 1976; only five samples were retained from the lower Cook Inlet collections, in September 1976. Over 36% of these stomachs were empty. Those with food items were seldom over 25% full, nor were more than half the organisms identifiable.

Both benthic and epibenthic organisms were important prey, according to the IRI prey spectrum (Fig. 6). Fishes (Lycodes brevipes and Osmeridae), polychaete annelids (including Maldanidae), and shrimp (Crangon sp. and Pandalidae) were the most important prey, with 35.7%, 23.8%, and 22.8% of the total IRI, respectively. The trematodes within the stomachs were probably parasites and it is likely that the algae, Ulva sp., were consumed incidentally with food organisms.

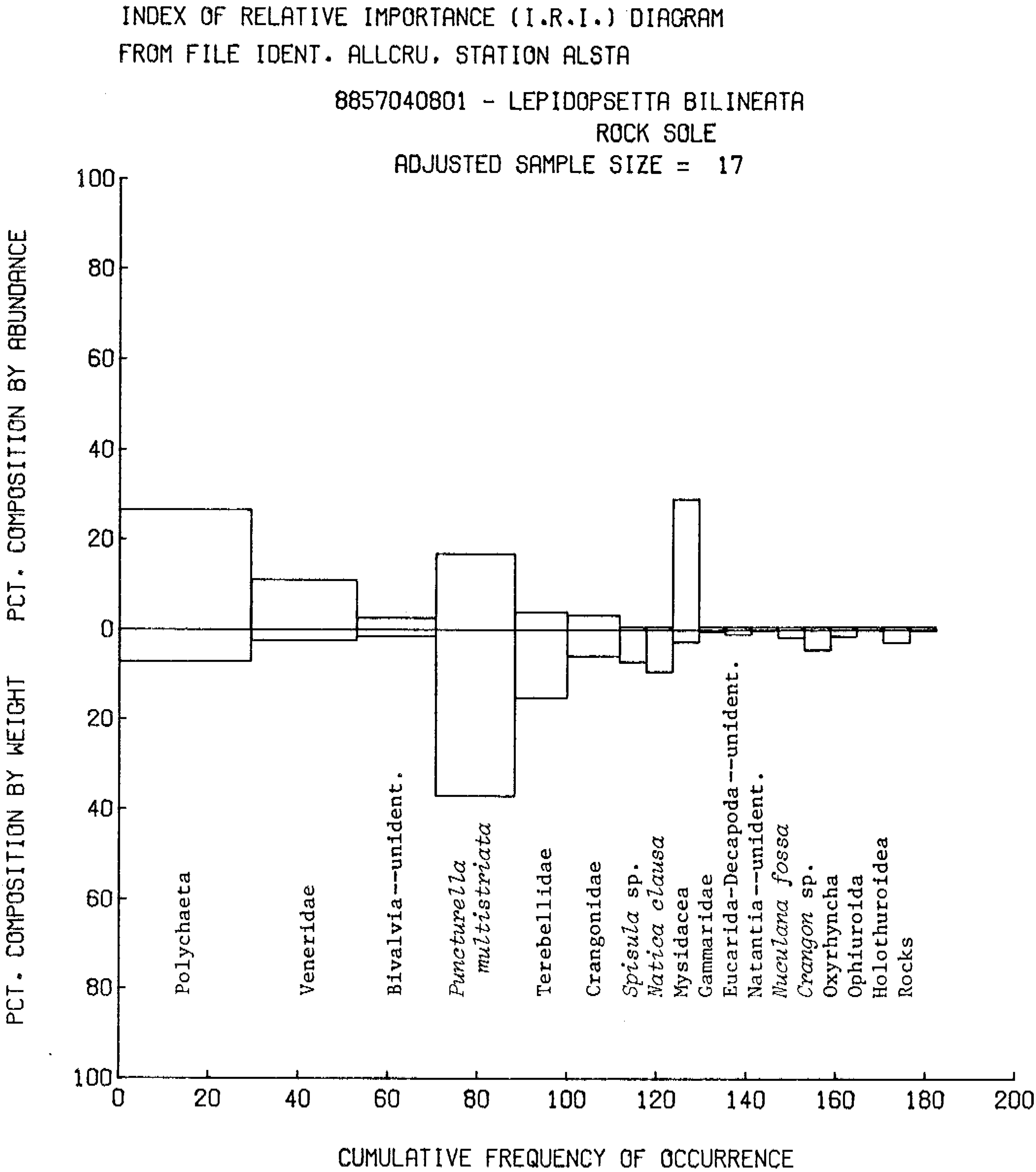


Fig. 5. Composite IRI spectrum for prey organisms of rock sole, Lepidopsetta bilineata.

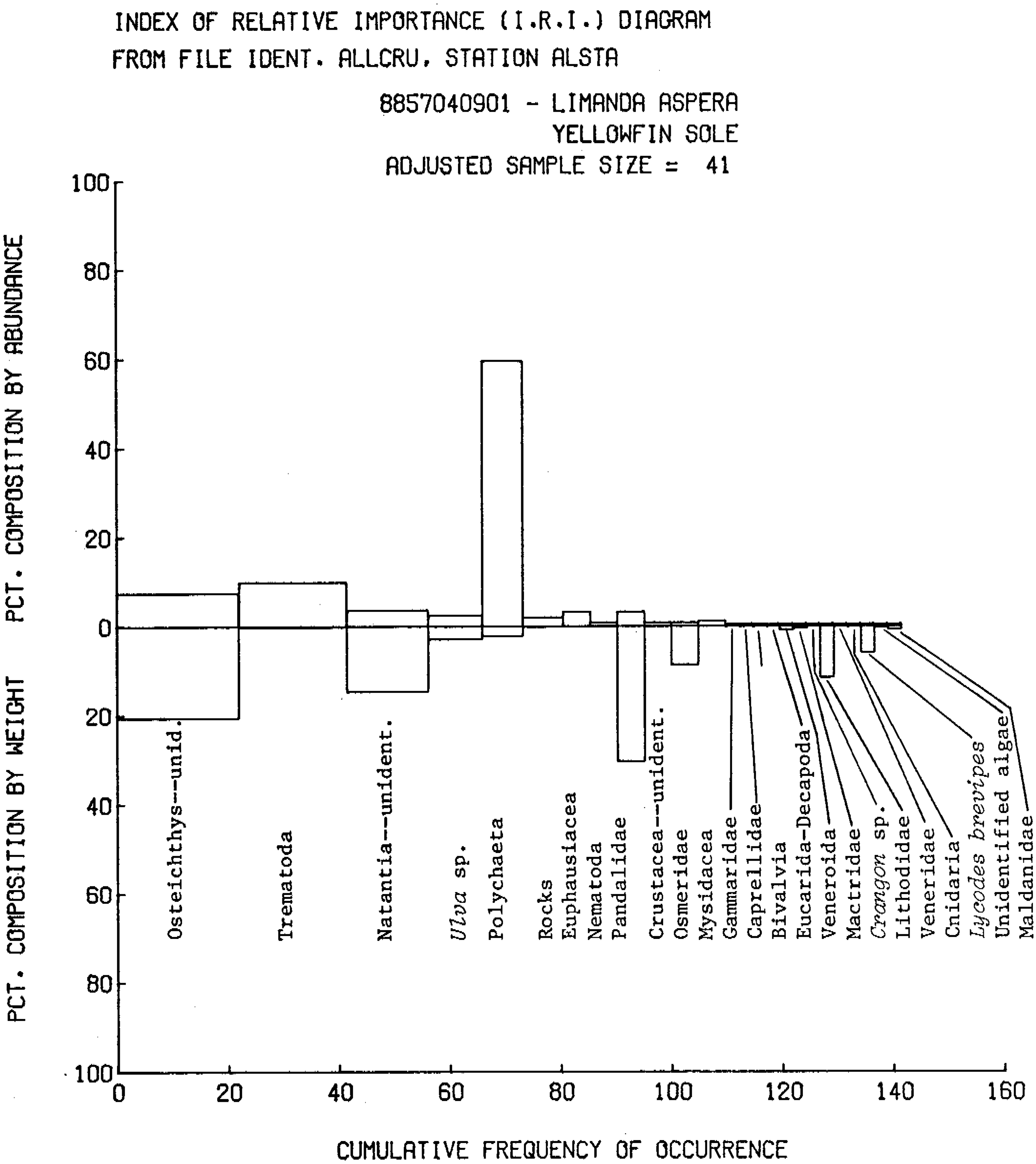


Fig. 6. Composite IRI spectrum for prey organisms of yellowfin sole, Limanda aspera.

Microstomus pacificus, Dover sole. Dover sole specimens were collected only during the September 1976 lower Cook Inlet cruise. Five of the 17 stomachs collected were empty but the remaining stomachs averaged close to 50% full with 50-75% of the organisms considered identifiable.

Gammarid amphipods completely dominated the IRI prey spectrum (Fig. 7), making up 86.1% of the total IRI. Polychaete annelids and shrimp (Crangonidae) were secondary prey, with 7.1% and 6.2% of the total IRI, respectively.

Discussion

Faulty preservation of almost 25% of the stomach samples collected in the course of ADF&G's OCS studies in lower Cook Inlet and Kodiak Island unfortunately reduced the sample sizes of many species below the point where their food habits could be quantitatively described or regional differences reliably detected. In addition, a naturally high incidence of empty stomachs, notably in the pleuronectids, reduced sample sizes to below that permitting quantitative interpretation. It is suggested that, in future studies in which predator food habits are an important objective, at least twice the number of samples desired be obtained of dominant predators found at a station.

Given the results from the remaining analyses, we can gain a broad view of the trophic position of the demersal fishes in the two regions of the western Gulf of Alaska (Table 6). Seven of the 12 fish studied were facultative planktivores--i.e., predators feeding principally upon epibenthic crustaceans such as shrimp, mysids, euphausiids, and amphipods. These would also prey (secondarily) upon benthic organisms--gastropods, bivalves, and polychaetes--or epibenthic fishes. Four species, mostly sculpins, were considered facultative piscivores by their reliance upon

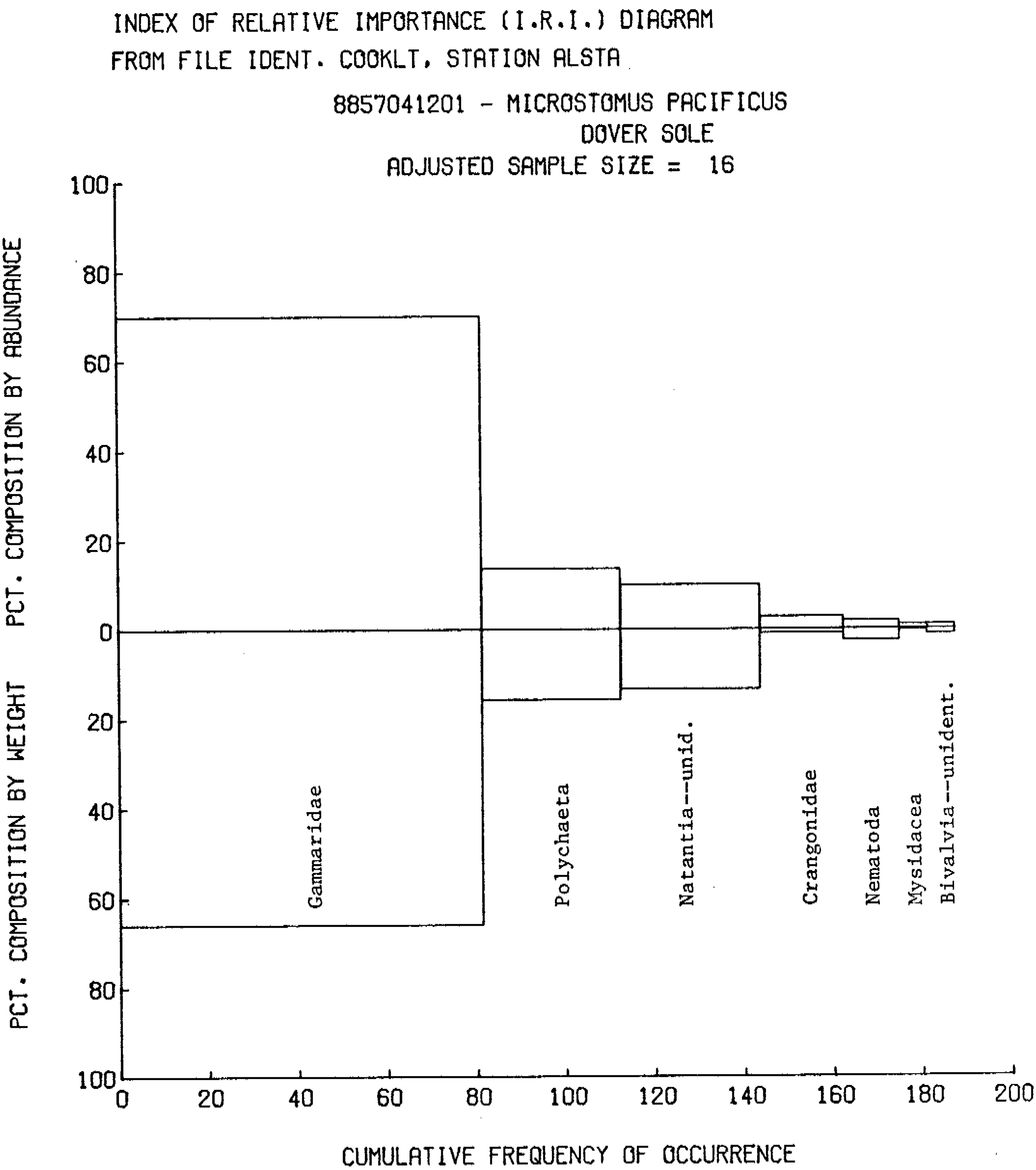


Fig. 7. Composite IRI spectrum for prey organisms of Dover sole, Microstomus pacificus.

Table 6. Feeding classifications of 12 species of demersal fish predators from Kodiak Island and lower Cook Inlet collected during ADF&G-OCS studies, June 1976 - March 1977.

Predator species	Classification	Feeding realm	Prey organisms in general order of importance
Gadus macrocephalus *Theragra chalcogramma* *Hemilepidotus jordani* *Atheresthes stomias* *Hippoglossoides elassodon* *Isopsetta isolepis* *Microstomus pacificus*	Facultative planktivore	Epibenthic Benthic	Shrimp Mysids Euphausiids Amphipods Fishes Polychaetes Bivalves Gastropods
Lepidopsetta bilineata	Facultative benthivore	Benthic Epibenthic	Polychaetes Gastropods Bivalves Mysids Shrimp
Gymnocanthus sp. *Myoxocephalus* sp. *M. polyacanthocephalus* *Limanda aspera*	Facultative piscivore	Epibenthic Benthic	Fishes Shrimp Polychaetes Euphausiids Mysids

epibenthic fishes but with supplemental predation upon epibenthic crustaceans or benthic organisms. Only one species, the rock sole, was described as a facultative benthivore, preying mainly upon truly benthic prey and only secondarily upon epibenthic crustaceans or fishes. There was no indication that any of these predator species, at least as adults, could be considered an obligate planktivore, obligate benthivore, or obligate piscivore.

If these data truly represent trophic interactions of the demersal fish assemblages in the Kodiak Island and lower Cook Inlet regions, it is apparent that prey resources available to these predators were distinctly different in the two regions. Lower Cook Inlet fishes appear to have exploited more benthic (especially soft-bottom) organisms--polychaetes, gastropods, bivalves--whereas fishes of the Kodiak Island embayments seem to have relied more upon smaller demersal fishes. Both assemblages, however, were surprisingly similar in their prominent exploitation of epibenthic crustaceans--caridean shrimp, mysids (more prevalent in lower Cook Inlet samples), euphausiids (more prevalent in Kodiak Island samples), and amphipods.

Acknowledgements

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Appendix Table 1. Lower Cook Inlet stomach samples discarded due to improper preservation.

Collection date	Site No.	Time, GMT	Species	Length range, mm	No.
9/3/76	718	0218	*Hippoglossoides elassodon*	250-255	2
			Lepidopsetta bilineata	215-328	5
9/3/76	A28	1748	*L. bilineata*	230	1
			Limanda aspera	250-280	2
			Pleuronectes quadrituberculatus	220-350	4
9/3/76	AM1	2120	*H. elassodon*	242-288	4
			Isopsetta isolepis	220-240	2
			L. bilineata	380-400	2
9/4/76	230	2315	*Platichthys stellatus*	462-500	4
9/4/76	595	2145	*Gadus macrocephalus*	250	1
			I. soplepis	200-220	2
			L. bilineata	310	1
			L. aspera	260-290	3
9/4/76	*	*	*L. bilineata*	320	1
9/5/76	V75	0257	*H. elassodon*	176-195	5
			L. aspera	162-218	5
			P. stellatus	325	1
			Theragra chalcogramma	88-230	10
9/5/76	S36	2012	*H. elassodon*	255	1
			I. isolepis	210-298	3
			L. bilineata	315	1
9/5/76	X37	1737	*I. isolepis*	220-300	4
			L. bilineata	247-405	6
			P. stellatus	470-505	2
9/5/76	P67	2245	*G. macrocephalus*	260-270	2
					74

*No data recorded on tag.

Appendix 2

Oil Spill Site Sampling

On October 5, 1976 the U.S. Navy vessel SEALIFT PACIFIC ran aground near Nikiski with a cargo of 175,000 barrels of jet fuel. Nine of 21 cargo tanks were damaged and 130,000 to 300,000 gallons of jet fuel were estimated spilled. The tidal currents of the inlet were too extreme for fuel spill equipment to be utilized and the weather was too severe for offloading to begin until October 7. The weather also made the location of spilled oil generally impossible to detect visually, probably by mixing it with surface waters, hence, no cleanup operations were attempted.

The spill was very close to stations our field crew had been routinely sampling and they returned and made 6 beach seine hauls after the spill (Table 1). Catches before and after the spill were similar, however, more species were caught in fewer hauls before the spill; and both saffron cod (*Eleginus gracilis*) and longfin smelt (*Spirinchus thaleichthys*) catches tended to be greater after the spill. These trends could be random, related to seasonality, or they may be related to effect of oil on the fish and on the catchability of those fish. Saffron cod, longfin smelt, one pink salmon (*Oncorhynchus gorbuscha*) and one Dolly Varden (*Salvelinus malma*) were captured in a visible oil slick (Table 1) and they appeared to be unusually sluggish, that is they did not flop around much when captured. The visual appearance strongly suggested that these fish were adversely affected by the oil.

With the existence of the oil facilities at Nikiski and treacherous conditions of Cook Inlet, especially in the vicinity of the Forelands, additional oil spills are possible.

Table 1. Beach seine catch at the area of an oil spill in Cook Inlet at East Foreland with comparative before spill catches.

Before Spill	E. Forelands 60°43'10"N 151°24'30"W			Between Forelands and Kenai River 60°37'30"N 151°20'45"W		Near Kenai River 60°34'45"N 151°19'25"W
Date of haul	9-27			9-28		9-28
Time of haul, Zulu	2345			0150		0245
Saffron cod	1			5		4
Longfin smelt	14			13		
Coho salmon, Juv.	1			1		2
Dolly Varden	1					
Bering cisco				2		
Starry flounder	1					
Snailfish sp.						1
Pacific herring	1			2		
After Spill						
Date of haul	10-9	10-9[1]	10-13	10-9	10-14	10-10
Time of haul, Zulu	2140	2205	2330	2335	0100	0015
Saffron cod	4	4	7	10	7	23
Longfin smelt	11	23	45	20	20	14
Pink salmon, Juv.		1				
Dolly Varden		1				
Bering cisco						1
Larval fish				+		

[1] Oil was observed in shallow water and saffron cod and longfin smelt were abnormally sluggish when captured.

Addendum to Annual Report

Research Unit 512

Pelagic and Demersal Fish Assessment

in the Lower Cook Inlet Estuary System

After completion of the annual report several comments and suggestions were received on its contents. Changes were made where they were warranted and where it would not involve excessive retyping of the manuscript. Additional responses to specific comments follow.

Page 1.

The comment was made that the introduction should be changed to indicate that shrimp were not addressed, but it would be incorrect to do so as shrimp were caught in very small numbers (Table 8) but were not discussed due to their infrequence.

Page 7.

The limited coverage by otter trawl in June resulted from confusion surrounding project initiation on short notice. Approval to conduct this study was received on April 23; gear was obtained, the field crew were hired, the first samples were taken by tow net on May 20th, and the charter started on June 1st. The author began work on June 7th, at which time six trawls had been completed, three with satisfactory gear performance and the only otter trawl we had received had been seriously torn several times. On June 7th two trawls resulted in unsatisfactory gear performance due to tearing of the net by rocky bottom. On June 9th the author traveled to Homer and in conference with the vessel skipper, the field crew, and Pete Jackson, decided to limit the trawl area to bottom that was suspected to be trawlable. On June 10th the vessel departed Homer with the entire field crew and the author aboard with the objective of completing the trawling and all the beach seining on the west side of the inlet in time for the vessel to depart for Kodiak by June 15th; none of the crew had ever worked any of the beach area but the field crew chief had flown the beaches looking for suitable beach seine sites. On June 10th, the inlet was crossed, a beach seine crew with a tent and a borrowed Avon raft was put on the beach in Iliamna Bay, and four trawls were completed. On June 11th, 12th, and 13th the charter vessel ferried the beach seine crew as far north as Kalgin Island searching for and sampling beach seine sites. On June 13th three additional otter trawl hauls were made after searching for trawlable areas with the depth recorder along the vessel track between Kalgin Island and the most northerly site trawled. On June 14th the vessel was unloaded and it departed for Kodiak on June 15th to conduct sampling for R.U. 486. During the remainder of the charter the first 5 days of the month were used for trawling and the last 10 days for purse seining and ferrying beach seine crew. The time was sufficient to complete trawling in July and August, but during September weather precluded the completion of trawling. Due to the restricted selection of stations, the field crew was given the instructions to sample other areas as opportunity presented itself, thus the three stations in the mouth of Kachemak Bay were added.

Only four stations were consistently sampled with the trawl on all of the five cruises, while eight stations were sampled on every cruise except June.

Other sampling was limited since the purse seine and two whalers were received in late June. All tow netting and beach seining conducted before

July was accomplished with borrowed equipment. Since the beach seining and tow netting involved a considerable learning experience, due to lack of opportunity to plan, sampling was expanded as it became apparent that time was available and it was later reduced when costs or risks were recognized as excessive. Thus the June excursion to the north end of Kalgin Island resulted in one sample on Kalgin Island, but that area was never resampled due to the excessive running time. During July the beach seine and tow net crew was placed ashore near Shaw Island, at the extreme southern end of Kamishak Bay. They sampled from there to Iliamna Bay, where they were picked up a couple of days later. During August and September the crew was put ashore in Iliamna Bay and they ran to the south, which resulted in one fewer stations being sampled in August and four fewer in September. In August beach seine and tow net sampling was not conducted north of Oil Bay on the west side due to what was felt to be excessive running time for a couple stations. In September the beach seine and tow net coverage was severely restricted by bad weather.

The purse seining was initially intended to delineate "in and out migrants of major tributaries" (page 8). However, due to a large number of factors these goals could not be realized. (These factors include the fact that most juvenile salmon passed through the web of the net, the currents in the inlet dictated the net be roundhauled which is less productive than holding it open, sampling was extremely limited by weather, catches were small and highly variable and according to Hartt (1975)[1] the purse seine is not a suitable synoptic sampling tool).

Page 8.

The comment was received that the catches should be discussed by habitat zones and not by gear type. I wish to point out that catches of different gears are extremely difficult to equate and due to the different characteristics of the gears there is a much greater habitat difference between beach seine, surface tow net, otter trawl, and purse seine/gill net than within any gear. It was considered to be impossible to separate catches of one gear by habitat type.

There was a question received as to the validity of the relative abundance information for the otter trawl. As was stated in the last paragraph under relative abundance, the limited coverage of stations each month strongly affected the composite of the catch. This was due to the pronounced differences between areas within the inlet. As Figure 3 illustrates, there was a considerable difference in the volume of the catch between areas, with the catches of the southernmost stations much larger. The five stations east and southeast of Augustine Island were characterized by flatfish, (Figures 14,17, & 19). Pacific cod and pollock were important at the southernmost stations (Figures 25 & 28), at the two stations in Kennedy Entrance yellow Irish Lords were predominant in March (Figure 31) while king crab and snow crab were localized in the southwestern portion of the study area.

[1]Hartt, A.C. 1975. Problems in sampling Pacific salmon at sea. Int. North Pacific Fish. Comm. Bull. 32: 165-231.

With such pronounced differences present the fact that large parts of the inlet could not even be considered samplable is a much greater bias in establishing relative abundance charactertistic of Cook Inlet. Thus, the relative abundance was never identified as characteristic of the inlet, only as characteristic of our trawl survey.

The discussion of the relationship between total otter trawl catch and the bedforms was questioned and even labeled as an artifact due to the comparison of stations not consistently sampled. As is shown in Addendum Table 1, when the samples are separated into those inside and outside the sandwave area by month, there is no between month influence and, with the exception of June, the mean catch inside the sandwave area is about half or less of the catch outside the sandwave area. During June only three samples were made in areas not influenced by sandwaves thus the comparison from June is relatively weak. Comparison of the mean catches for the individual months indicates that there is less than one chance in five that the mean catch within the sand wave area is the same as that outside it during July, August, and September, while in March the chance is about one in two. When the entire set of samples is combined and the means are compared there is less than one chance in one hundred that the mean catches are the same in the two areas.

A closer examination of the catch data (Addendum Table 2) illustrates the specific differences in catch at the stations and their consistency. The stations are identified by the number given on Figure 4, page 67 of the report. Those stations inside the sandwave area were grouped and sequenced according to their placement within the sandwave area. Station 7 is in an area influenced by 2-5 m high sandwaves; stations 4,5,2 and 3 are in areas of sandwaves less than 2 m high and stations 8,9 and 1 are in areas of marginal influence by sandwaves. Station 8 is on the border of the sandwave area, station 9 is in an area with no sandwaves but surrounded by them (it was grouped with sandwave stations for geographic continuity) and station 1 is outside of the sandwave influence but further within the inlet. The lowest mean catch was at station 7, which was sampled every cruise and was an area of larger sandwaves than any other station. The largest catches from within the sandwaves area were at station 9 which was in fact located where sandwaves were absent.

The otter trawl catches are definitely lower in the areas where sandwaves exist and are lowest where the sandwaves are most pronounced.

Addendum Table 1. Catch of fish by otter trawl in June through September 1976 and March 1977 summarized in respect to presence or absence of sandwaves. The term N is the number of hauls, $\bar{x}$ is the mean, S is the variance and SE is the standard error of the mean.

	June	July	Aug.	Sept.	March	Overall
Inside Sandwave Area						
N	7	4	7	5	5	28
$\bar{x}$	43.4	32.1	46.9	33.9	36.9	39.8
S	30.9	25.8	55.4	17.8	25.7	33.8
SE	11.7	12.9	20.9	7.9	11.5	6.4
Outside Sandwave Area						
N	3	11	12	9	13	48
$\bar{x}$	29.7	74.4	124.9	95.4	70.7	87.8
S	33.8	46.6	82.1	75.1	81.4	73.9
SE	19.5	14.0	23.7	25.0	22.6	10.7

Addendum Table 2. Catch of fish in kilograms by otter trawl in June through September 1976 and March 1977 by stations and month, organized to contrast stations within the region of sandwaves with those outside of it. The term $\bar{x}$ is the mean of all hauls at a station, S is the variance and SE is the standard error of the mean. See text for an explanation and discussion.

Station	June	July	Aug.	Sept.	March	$\bar{x}$	S	SE
Inside sandwave area								
7	3.0	14.7	8.0	17.2	18.8	12.3	6.7	3.0
4	67.1	65.8	18.3	33.4	14.4	39.9	25.3	11.3
5	58.4	-	-	-	22.7	40.5	25.3	17.9
2	81.2	-	32.6	15.5	-	43.1	34.1	19.7
3	61.9	-	10.8	-	-	36.4	25.6	14.8
8	21.3	38.4	60.4	50.4	57.4	45.6	16.0	7.2
9	-	9.4	165.9	-	71.3	82.2	78.8	45.5
1	11.0	-	32.5	53.3	-	32.2	21.2	12.2
Outside sandwave area								
6	66.9	-	46.4	-	3.8	39.0	32.2	15.6
10	-	167.9	-	43.6	19.7	77.1	79.5	45.9
11	-	-	-	24.5	-	24.5	-	-
12	-	-	-	53.4	-	53.4	-	-
13	1.0	66.6	40.6	132.5	49.5	58.0	48.1	21.5
14	21.1	-	76.7	179.8	101.3	94.7	65.9	32.9
15	-	88.9	245.0	129.9	82.3	136.5	75.3	37.6
16	-	76.6	134.9	237.8	75.9	131.3	76.2	38.1
17	-	63.4	83.2	48.9	25.2	55.2	24.4	12.2
18	-	5.8	135.6	35.2	20.2	49.2	58.8	29.4
19	-	99.5	178.4	-	34.6	101.2	72.0	41.6
20	-	9.6	248.6	-	188.3	148.8	124.3	71.8
21	-	84.7	17.1	-	283.2	128.3	138.3	79.9
22	-	115.8	222.1	-	3.0	113.6	109.5	63.2
23	-	40.0	70.5	-	32.4	47.6	20.2	11.6

Quarterly Report
Period 9/1/78-2/20/79
R.U. 542

Shallow Water Fish Communities in the Northeastern Gulf of Alaska: Habitat Evaluation, Temporal and Spatial Distribution, Relative Abundance and Trophic Interactions.

Principal Investigator
Richard J. Rosenthal
Alaska Coastal Research
P.O. Box 937
Homer, Alaska 99603

February 28, 1979

ABSTRACT

The marine fishes are an important component of the inshore fauna of the northeastern Gulf of Alaska. Direct observations of fishes living in Hinchinbrook Entrance and Montague Strait were made during August-September 1978. The shallow water fish communities of this region are represented by at least 50 species which are typically found in the nearshore zone. Twenty-two percent (11/50) of the fishes identified to date were previously unreported in these waters, and as such represent northern range extensions in the eastern Pacific.

During 1978, 2,790 square meters of sea floor were examined for fish density, and vertical distribution along randomly or haphazardly placed transects. Another 2,310 square meters of underwater terrain was surveyed within fixed transect bands. The data gathered during this, and other sample periods will be used to determine relative abundance, biomass and depth distribution of fish populations in the NEGOA region. Most of the counts were replicated to account for differences in tidal height and current direction, time of day and the activity patterns of the individual fish. The nearshore areas were comprised of both solitary and schooling fish. The rockfishes (Scorpaenidae); greenlings (Hexagrammidae); wolffishes (Anarchichadidae) and ronquils (Bathymasteridae) dominated the exposed rocky habitats, while more protected locations were numerically dominated by sculpins (Cottidae); pricklebacks (Stichaeidae), sand lances (Ammodytidae); righteye flounders (Pleuronectidae); greenlings (Hexagrammidae) and codfishes (Gadidae).

Patterns of habitat utilization are also being studied in relation to a few key parameters which seemingly effect spatial distributions and contribute to resource partitioning in the nearshore zone. In situ observations suggest that these distributions are effected by: (1) the depth of the water column, (2) type of bottom topography, (3) vegetation structure or zone and (4) degree of exposure in relation to ocean swell and net water flow. Emphasis has been placed on studying the characteristic or representative important species in these habitats. Fishes have been included in this category on the basis of their numerical impottance, commercial value or functional role in the maintence of the natural system.

Samples from these fish populations have been taken for the purpose of describing their food habits, thus leading to a better understanding of trophic interaction and energy flow in the coastal zone. Most of the specimens were collected during daylight hours with spears and hand nets. The remainder were either caught in gillnets or taken on hook and line. The stomach contents of 48 specimens were inspected for food items during this summer sample period. In all, a total of 275 specimens, comprised of 24 species, have been examined for food material. There was considerable dietary overlap between the bottom fishes, however this imbrication is thought to be more of a sharing of a common resource rather than competition in its true sense. Important prey of the bottom feeders included gammaridean amphipods, brachyuran crabs, caridean shrimps, ophiuroids, caprellid amphipods, gastropods, mussels and fish eggs. Whereas, schooling fishes that feed and spend a great deal of time in the water column preyed heavily upon zooplankters such as calanoid copepods, megalops crab larvae, tomopterid polychaetes, chaetognaths, small fishes and amphipods.

Additional qualitative data and natural history information, i.e. periods of reproduction, larval release time etc., which are pertinent to a basic understanding of nearshore systems have also been recorded to aid in our assessment of the vulnerability of shallow water fish populations to both natural and man-induced perturbations in the northeastern Gulf of Alaska.

I. Task Objectives

The goals of this present study are to provide a detailed description, and an ecological analysis of fishes inhabiting the shallow waters of the northeastern Gulf of Alaska. This is being accomplished by:

A) Describing the major habitats and evaluating patterns of habitat utilization by fish populations in the nearshore waters of the NEGOA region.

B) Improving the species lists or inventories of the fishes that inhabit the inshore zone.

C) Estimating numerical density, biomass and depth (vertical) distributions of these fish populations.

D) Assessing spatial and temporal distributions of these fish populations.

E) Analyzing the food habits of some common inshore species. Analyses of fish stomachs and direct observations while diving should lead to a better understanding of trophic interaction, dietary overlap and, or variability.

F) Gathering pertinent natural history information involving fish spawning, larval release time and territoriality.

II. Field and Laboratory Activities

A. Field Activities: F.V. Searcher

1. August 11-16, 1978 Montague Strait & Hinchinbrook Entrance
2. August 27-30, 1978 Hinchinbrook Entrance
3. September 6-15, 1978 Hinchinbrook Entrance & Montague Strait

B. Scientific Party

1. Richard J. Rosenthal, Alaska Coastal Research - Principal Investigator
2. Dr. D. Craig Barilotti, San Diego State Univ. - Biologist/Consultant
3. Thomas M. Rosenthal, Alaska Coastal Research - Diver/Biologist
4. Dr. Rimon C. Fay, Pacific Bio-Marine Laboratories - Consultant
5. Dr. Ronald Shimek, University of Alaska - Consultant

C. Methods

Shallow subtidal field work was conducted while scuba diving. A total of 45 dives were made in the study areas from 8/11-9/11/1979, and this represented 63.5 man hours of underwater bottom time. Analysis of food items, and identifications of fish were done in the field aboard the F.V. Searcher Numerical information on fish density and distribution was obtained from both fixed and random transect lines.

D. Sample Localities

Direct observations were made, and samples were obtained from 8 specific locations, representing 5 general sites in the northeastern Gulf of Alaska

(Figure 1). These included:

1) Latouche Island - Southwest end of the Island
2) Danger Island - Southern shoreline
3) Zaikof Point - Northern tip, entrance to Zaikof Bay
4) Schooner Rock - North side of islet, Hinchinbtook Entrance
5) Constantine Harbor - Entrance channel and estuary

E. Data Collected or Analyzed

1. Types of Samples/Observations
   a. 2,790 square meters of sea floor were examined during 1978 for fish density and distribution along random transects.
   b. Fixed transects were placed in four of the study sites, and these lines totaled 470 meters in length. Replicate counts were made along these lines, and another 2,310 square meters of underwater terrain was surveyed.
   c. Patterns of habitat utilization were analyzed using a frequency of occurrence table. Field data was obtained on 85 specimens.
   d. To date, 50 species have been identified and, or collected from these study areas. Fish have been collected with the aid of spears, nets and chemicals.
   e. The stomach contents of 48 specimens were inspected for food material during 1979, and this brings the total to 275 specimens.
   f. In addition to the food analysis, all fish were measured (standard length), weighed and the sex was determined when possible. These size composition data will be used to determine fish biomass in each area.
2. Types of Analysis

   A variety of statistical procedures are being used to test for differences or similarities among data sets.
   a. The fish density information was normalized and has been tabulated according to the number of fish/square meter, and fish/hectare.
   b. The Mann-Whitney U-distribution test will be used to test for differences between the estimated densities in different study areas and between seasons.
   c. Differences between transect replicates and comparisons between fixed and random transects will be examined using a Wilcoxon T-test, Mann-Whitney U-test and the Kruskal and Wallis test.
   d. The Spearman Rank Correlation Coefficient will be used to measure association or similarity between the species composition in the different study areas.
   e. Laboratory examinations and confirmation of fish identifications for range extensions and systematic studies has been done during the fall and winter 1978-79 and will be continued through 1979.

F. Milestone Chart - 1979

Field Work - Mar., Apr., May, June, July, Aug., Report Prep. Sept., Oct., Nov.

1) Departure for Prince William Sound aboard the F.V. Searcher in late March, 1979. Laboratory and statistical analyses of the data will take place during, and at the conclusion of the field season. Preparation of the final report will begin in September.
2) Slides in the proposed schedule were encountered because of our inability to carry out the late fall survey. The survey was scheduled for November,

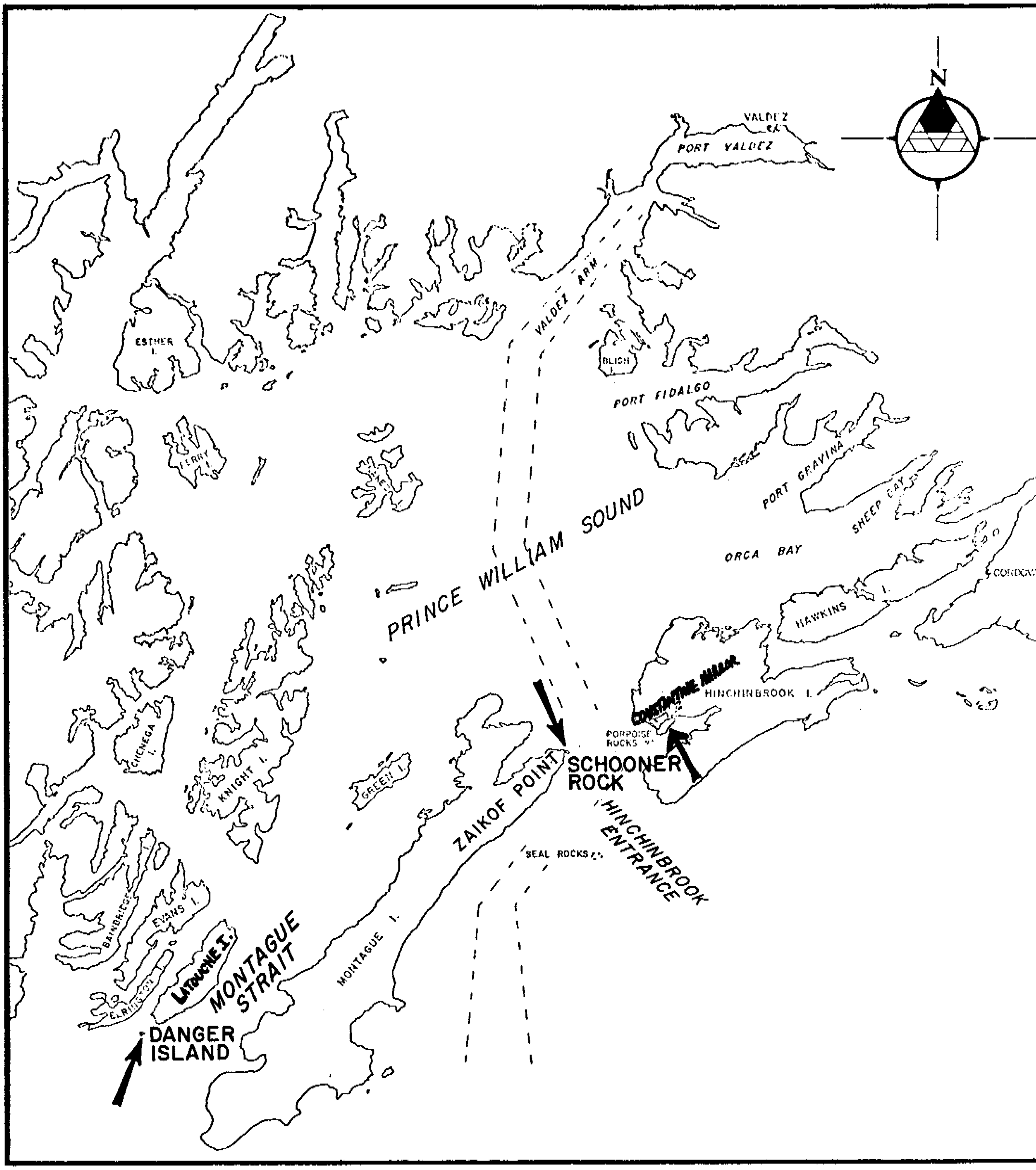

FIGURE 1

SHALLOW WATER STUDY SITES
IN
NORTHEASTERN GULF OF ALASKA

NAUTICAL MILES

0 10 20 30

however, the vessel Cora-B which was chartered for the trip received damage to it's hull, and was abandoned just prior to meeting our scientific party at Evans Island. The lack of other charter vessels, and the deterioration of the weather in Prince William Sound prompted us to wait until late March 1979 to initiate the seasonal field work.

III. Results

A. Diving surveys have been conducted at five areas: Danger Island, Latouche Point, Zaikof Point, Schooner Rock and Constantine Harbor. Estimates of numerical density have been obtained from transects (fixed and random) emplaced between 0 and 27 m. Variability between replicate transects was an indication of the patchiness of the nearshore environment.

B. Schooner Rock had the highest numerical density, followed by Zaikof Point, Danger Island and Constantine Harbor. Mean density estimates ranged from 0.111 fish/sq. m at Constantine Harbor to 0.967 fish/ sq. m at Schooner Rock. These data convert to 1,111 and 9,667 fish/hectare. Variability between mean density and biomass are expected from summer to winter, based on direct observations made in March 75-76.

C. The black rockfish (*Sebastes melanops*) was the most abundant schooling fish in the inshore zone, whereas the kelp greenling (*Hexagrammos decagrammus*) was the most abundant solitary bottom species. The rock greenling (*Hexagrammos lagocephalus*) was common to all five sites. Other abundant solitary species were the alaskan ronquil and whitespotted greenling.

D. To date, 50 species representing 16 families have been identified from the shallow waters of the NEGOA region. At least 11 of the species (11/50), or 22 percent of the ichthyofauna had not been reported from these waters prior to the present study. These species are: tubesnout, yellowtail rockfish, china rockfish, lingcod, sailfin sculpin, longfin sculpin, brown rockfish, brown irish lord, scalyhead sculpin, mosshead warbonnet and bonyhead sculpin. Most of the previously over looked fish were not uncommon in these waters, but instead were conspicuous members of the nearshore zone.

E. In terms of species composition, Schooner Rock and Zaikof Point were most similar, while Danger Island and Constantine Harbor were least similar. Danger Island and Schooner Rock were dominated by schooling species, while solitary bottom species such as the kelp greenling and whitespotted greenling dominated the counts at Zaikof Point and Constantine Harbor.

F. Vertical distributions of fish indicated that the 0-5 m depth interval was the least utilized bathymetric zone, whereas the 10-15 m depth interval was heavily populated, at least off Schooner Rock and Zaikof Point. Fish abundance and species composition at Danger Island increased below 20 m. Seasonal patterns in vertical distribution have not been established, however qualitative observations suggest that most of the species that were found in shallow waters ($<$10m) during late summer, moved to slightly deeper depths during winter months. There is also an indication that some of the solitary bottom species such as the greenlings become more quiescent or inactive during oceanic winter.

G. The subtidal boulder fields and rocky outcrops below the kelp forests characterically supported the highest density of fish. The eelgrass meadows and seaweed beds were typically high in species richness, particularly during late spring and summer when there was an influx of fish into these habitats. However, this richness and abundance is apparently not sustained on a year-round basis, but is instead highly seasonal.

H. Since the inception of this study in August 1977, approximately 275 specimens, representing 24 species have been examined for food material. The most commonly consumed prey of the bottom species were gammaridean amphipods, brachyuran crabs, caridean shrimps, ophuiroids, caprellid amphipods, gastropods, mussel and fish eggs. Whereas, the schooling fish preyed heavily on pelagic zooplankton such as calanoid copepods, megalops crab larvae, tomopterid polychaetes, chaetognaths, amphipods and small fish.

IV. Auxiliary Material

A. Bibliography of References - Update

1.) Moulton, L. 1977. An Ecological Analysis of Fishes Inhabiting the Rocky Nearshore Regions of Northern Puget Sound, Washington Ph.D. thesis, Univ. of Washington, Seattle. 144pp.

2.) Cross *et al*. 1978. Nearshore Fish and Macroinvertebrate Assemblages Along the Strait of Juan De Fuca Including Food Habits of the Common Nearshore Fish. MESA Puget Sound Project. Final Report NOAA ERL MESA - 32. 188pp.

B. It is anticipated that 2-3 scientific papers will result from this OCSEAP study. This is in addition to the final report.

1.) Shallow Water Fish Communities in the NEGOA region-Ecol.
2.) Range Extensions & Depth Distributions of Some Nearshore Fishes in the Northeastern Gulf of Alaska.

C. Oral Presentations:

1.) An abstract and slide show dealing with this present study was presented at the: 2nd Pac. N.W. Tech. Workshop Fish Food Habits Studies, Wash. Sea Grant, Univ. of Washington, Oct. 1978.
2.) A slide show will be given on March 17, 1979 at the "Man In The Sea Symposium", Seattle Washington.
3.) On March 14, 1979 a lecture has been scheduled in the Bottom Fisheries Class at the University of Alaska, Juneau, campus.

V. Problems Encountered/Recommended Changes

Weather and logistics continues to be our biggest problem in conducting seasonal field work in the northern Gulf of Alaska. The late fall (1978) survey was aborted because of charter boat problems. Although this should not present a problem in 1979, since we are going to provide all of our own logistics. No doubt, weather will hinder some of our field activities, as it has in past years. However, the amount of field time and the data accumulated should be more than was originally proposed because of the availability of our diving platform the F.V. Searcher from March to mid August 1979.

VI. Estimate of Funds Expended

To date, $23,314.56 has been billed on the current study, leaving a balance of $64,685.44 with which to complete the field work and write the final report.

ANNUAL REPORT

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Research Unit No.:	RU551
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Number of pages:	75

SEASONAL COMPOSITION AND FOOD WEB RELATIONSHIPS OF MARINE ORGANISMS IN THE NEARSHORE ZONE

Co-Principal Investigators

Jean R. Dunn, Arthur W. Kendall, Jr.,
Robert W. Wolotira
with
Langdon Quetin and John H. Bowerman, Jr.

Northwest and Alaska Fisheries Center

Seattle, Washington

March, 1979

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

A field program was designed to elucidate the distribution in time and space of the zooplankton (both holo- and meroplankton) of continental shelf waters contiguous to Kodiak Island. These planktonic forms are of vital importance to the marine food web of the area, not only as food for higher trophic levels, but because most finfish and shellfish of the area spend critical early parts of their life histories as members of the plankton community. Prior to this study, virtually nothing was known about the specific composition and abundance of the zooplankton community, nor was the seasonal occurrence and areal distribution of larval forms of species contributing to the fisheries of the area known. With the knowledge of these distributions, the effects of chronic or catastrophic impacts of mineral development can be evaluated. Certain areas and seasons may be more critical than others to the success of year classes as they pass through their planktonic phase.

II. Introduction

A. General Nature and Scope of Study

The general approach to our objectives is to sample plankton in Kodiak Island shelf waters using a centric-systematic sampling grid during seasonal cruises. Biological sampling at each station includes surface ichthyoneuston tows, integrated oblique bongo tows from near bottom to the surface and, at selected stations, discrete depth Tucker tows. Associated environmental data are collected. Such sampling enables us to identify dominant taxa, their distribution in time and space, relations between near-shore, mid-shelf and slope fauna, and to assess the influence of bathymetric and oceanographic features of the region on the distribution of organisms.

B. Specific Objectives

Our overall objectives are to determine the seasonal composition, distribution, and apparent abundance of marine organisms of ecological or economic importance and to investigate relations among these parameters and environmental conditions with emphasis on ichthyoplankton and meroplankton.

Specifically, the objectives are: (1) determine seasonal composition, distribution, and apparent abundance of major life-stages of selected planktonic taxa, including fish eggs and larvae, larvae of shrimp and crab, and euphausiids; (2) examine observed biological distributions in relation to bathymetry and available hydrographic data; and (3) compare the distribution of planktonic organisms in nearshore, mid-shelf, and slope waters.

C. Relevance to Problems of Petroleum Development

There are significant gaps in knowledge of the temporal and spatial changes in the composition of planktonic organisms of ecological or economic importance in the Kodiak Island shelf area. Of critical need in attempts to evaluate the potential impact of mineral development on the early life history of important components of the marine ecosystem is the evaluation of what species are where, in what abundance, and at what time of the year during their egg and larval stages. Evaluation of the food web, through coordination with marine mammal and bird studies and other relevant programs, may well indicate critical times or areas where contamination could severely impact upper trophic level production and year class success of species that are subjects of fisheries.

We are finding that many species are neustonic, that is, they occur in the upper few centimeters of the water column, during some of their early life history stages. This area is particularly vulnerable to contamination since most oil floats at the sea surface and disperse widely from the site of a spill. Laboratory studies are showing the extreme sensitivity of early life history stages to oil and its components (e.g. Strusaker et al., 1974; Mironov, 1969). Thus the importance of knowing the seasonal and spatial distribution of the meroplankton in waters around Kodiak Island by species is obvious.

III. Current State of Knowledge

Very little was known about the seasonal composition of plankton in waters contiguous to Kodiak Island prior to initiation of the present OCSEAP sponsored studies. Although several wide-ranging plankton sampling cruises have been conducted by a number of organizations, both foreign and domestic, few have concentrated on studies in the Kodiak Island region. A brief historical account of studies pertinent to the Kodiak Island archipelago follows:

The International Pacific Halibut Commission conducted ichthyoplankton sampling in the Gulf of Alaska from 1926-34 (Thompson and Van Cleve, 1936). Their station grid included a number of stations in the Kodiak Island area. These authors reported only the occurrence of Pacific halibut (*Hippoglossus stenolepis*) eggs and larvae in their plankton samples.

Halibut eggs were found southeast of Cape Chiniak, but the majority of halibut eggs were distributed east of 150°W, where sampling was more intense. Early larvae of the halibut were distributed offshore on the southeast side of Kodiak Island and late-larvae were apparently carried inshore to the western end of Kodiak Island and northwest of Trinity Islands (Thompson and Van Cleve, 1936).

In 1955, a multi-nation cooperative study of the North Pacific Ocean, called NORPAC, was conducted (Anon., 1960). Multi-discipline cruises by three nations (United States, Canada, and Japan) were conducted aboard 19 research vessels from 14 institutions. Only the RV *Brown Bear* (University of Washington) sampled waters near Kodiak Island. The *Brown Bear* sampled ten stations from the southwest end of Kodiak Island northeastward and through Shelikof Straits using a Clark-Bumpus sampler. Detailed data, however, were not reported.

The Fisheries Research Board of Canada collected zooplankton samples in the Northeast Pacific Ocean, north of 45°N and west to 160°W, from 1956-1964. During these years only a few stations were occupied over slope waters near Kodiak Island. LeBrasseur (MS 1965) reported the results of vertical tows made with NORPAC nets from these cruises. He included figures showing wet weight (g/1000 m^3) of total zooplankton, copepods, euphausiids, amphipods, chaetognaths, and pteropods for all years surveyed. For 1962 and 1963 he included figures depicting size and number of three species of copepods, three euphausiids, one pteropod and one chaetognath.

LeBrasseur (MS 1970) reported on the identification of fish larvae collected during these surveys in 1956-59. Rockfishes (Scorpaenidae) and searchers (Bathymasteridae) were the dominant forms found in waters near Kodiak.

Broad scale exploratory plankton sampling was conducted in the North Pacific Ocean from 1956-1977 by the Faculty of Fisheries, Hokkaido University, Japan (Anon., 1978). Only a few stations were sampled in waters near Kodiak Island and, other than station data, results were not routinely reported.

Aron (1962) reported the results of wide-scale surveys of midwater plankton and nekton in the North Pacific Ocean conducted by the University of

Washington in 1957 and 1958. Again, only a few stations were sampled in the vicinity of Kodiak Island.

In the early 1960's, Soviet researchers conducted plankton surveys directed at Pacific ocean perch (Sebastes alutus) off Kodiak Island. Lisovenko (1964) described the catches of rockfish larvae (assumed to be S. alutus). According to this author, Sebastes larvae were found over the slope in the Yakutat, Kodiak, Shumagin, and Unimak areas at concentrations up to 120 per m^2 in April and May over depths of 200-700 m; other species of fish larvae collected during these surveys were not reported.

In April and May 1972, the NWAFC conducted a multi-discipline survey in waters contiguous to Kodiak Island. Ichthyoplankton composition was reported by Dunn and Naplin (MS 1974). Twenty-three kinds of fish larvae and 12 kinds of fish eggs were captured.

Pollock eggs (Theragra chalcogramma), which accounted for 97.2% of all fish eggs captured, were most abundant just west of Kodiak Island (near 56°30'N, 156°20'W). The largest catch of pollock eggs was 104,645 per $10m^2$ of sea surface. Eggs of flathead sole (Hippoglossoides elassodon) occurred at 31 stations, primarily inside the 200 meter contour. Rex sole (Glyptocephalus zachirus) eggs occurred at eight stations between the 200 - 2,000 m isobath.

Pollock were also the predominant larvae, constituting 62% of the total catch. They occurred at 21 stations scattered throughout shelf and slope waters; the largest catch (standardized catch of 12,118 per $10m^2$ of sea surface) occurred southwest of the Trinity Islands (at 55°51'N, 154°56'W) over 327 m of water.

Sand lance (Ammodytes hexapterus) larvae accounted for 11.3% of the total catch, followed by sculpins (Cottidae) 7.5%, and rock sole (Lepidopsetta bilineata) 6.9%.

The results of physical oceanography studies from this cruise were reported by Ingraham and Fisk (1973), Ingraham and Hastings (1974), Favorite et al. (MS 1975), and Favorite and Ingraham (1977). Surface nutrient concentrations were discussed by Sanborn (MS 1973); the occurrence and distribution of monstrillid copepods by Threlkeld (MS 1973, 1977).

Gosho (MS 1977) took plankton samples in certain estuaries of Kodiak Island while studying the food habits of juvenile pink salmon. Harris and Hart (MS 1977) studied the pelagic and nearshore fishes in three bays (Ugak, Kaiugnak, Alitak) on the east and south coasts of Kodiak Island (OCSEAP RU 485 final report). Their sampling equipment (tow net, herring trawl, beach seine and try net) had mesh sizes too large to sample ichthyoplankton quantitatively. They reported, however, the occurrence of "larval" fishes when captured. Based on length frequency data, the dominant larvae captured were hexagrammids (greenling) and cottids (sculpins).

IV. Study Area

The study area is about 68,000 km^2 and encompasses the continental shelf off Kodiak Island from approximately the 40 m contour to the 2,000 m contour (Figures 1-6). Stations extend from Portlock Bank on the east to Trinity Islands on the west. Albatross Bank and Kiliuda and Chiniak Trough lie within the sampling area.

V. Sources, Methods and Rationale of Data Collection

A series of five offshore research cruises to sample zooplankton of the Kodiak shelf have been conducted in this program (Table 1).

A pattern of stations was laid out in the continental shelf area off Kodiak Island (Figs.1-6). The pattern was modified from a stratified centric design to a systematic centric design after the first two cruises, but the areal coverage remained basically the same. Some planned stations were deleted on specific cruises due to inclement weather and other operational difficulties. During periods of inclement weather some stations designated by RU553 in the bays of Kodiak Island were occupied.

Plankton was collected at each station, using several types of nets and towing schemes to investigate depth distribution and diel migrations as well as large scale areal distribution. Field sampling was conducted in general accordance with standard MARMAP procedures (Smith and Richardson, 1977), so these data will be comparable with others collected in other programs.

The use of Sameoto neuston samplers allows identification of the near surface components of the plankton. The use of an integrated tow (60-cm bongo nets) allows estimation of biomass and determination of areal distribution of organisms. Discrete depth sampling (Tucker trawl) enables identification of which strata organisms occupy and allows investigation of diel migrations. Replicate tows were made at selected stations to assess sampling variability. Additionally, diel studies were made at locations where large catches of ichthyoplankton occurred. At those stations, a surface neuston tow and multiple Tucker trawl tows were made every other hour for at least 24 hours.

To assess the importance of inshore areas to recruitment of shrimp and crab larvae, zooplankton was sampled bi-weekly in four bay systems along the southern and eastern shores of Kodiak and Afognak Islands (see RU553). Initially, five stations were located in the central and inner portions of Izhut, Kalsin, Kiliuda and Kaiugnak Bays. Three additional stations were added to the Izhut and Kiliuda station patterns to increase sampling density in the inner portions of these bays.

All stations were sampled during each two-week survey period, including 24-hour diel observationsat one of the stations in both Izhut and Kiliuda Bays. The station sampling pattern and diel observations were expected to indicate spatial occurrence and vertical migration, respectively, of decapod larvae. Diel sampling was also expected to identify changes in species diversity and abundance, by depth zone and time of day. The most seaward stations sampled during the inshore surveys corresponded with nearshore sampling locations of the offshore plankton surveys.

Plankton samples were preserved in 5% Formalin buffered with sodium tetraborate and returned to shore for processing. The settled volume of each sample was determined (Kramer et al., 1972). All fish eggs and larvae (i.e., samples are not split) were sorted out of the neuston, 0.505 mm bongo and one-meter Tucker trawl. Fish eggs and larvae were identified to lowest taxa, counted (abundant taxa were measured), and life history stage noted. Zooplankton from the 0.333 mm bongo nets, after volumes were determined, were sorted to major categories (e.g., class, phyla, or order) from an aliquot of the total (ca 500 organisms) and enumerated. A separate subsample was taken to yield an aliquot containing approximately 200 adult euphausiids which were identified to species, enumerated, lengths measured, and wet weights (Weibe et al., 1975) determined. Samples from the 0.505 mm Tucker trawl were subsampled for ca 200 euphausiids which were handled as above. An additional subsample of about 500 organisms was taken for separation of shrimp (Natantia) and decapod crab (Reptantia) larvae. Additional subsampling as necessary was conducted by the Kodiak Laboratory, NWAFC, to provide adequate numbers of decapod larvae for analysis.

Selected bulk samples (i.e. that portion remaining after removal of the 500 organism aliquot) were examined further. Either subsamples containing a minimum of 500 Natantia were obtained or all Natantia and Reptantia were removed from the bulk samples. The resulting shrimp and crab larvae were also identified to lowest taxonomic classification-life stage development and enumerated.

Analyses of the cruise data are in progress now. Similar analyses are performed on all of the taxonomic groups investigated under this program (e.g. ichthyoplankton, shrimp and crab larvae, and euphausiids); however, priority will be given to thorough analysis of ichthyoplankton and shrimp and crab larval data.

Geographic analysis consists of plotting species distribution on charts of the area. Isolines of abundance for species of interest on a logarithmic scale are plotted on the charts. Biomass is expressed as numbers per 10 m^2 of surface area for each station. For abundant species of interest, biomass estimates for entire cruises or portions thereof are derived by calculating the areas represented by each station and summing the biomasses at the stations of interest.

As hydrographic data become available, their distribution are plotted and compared with that of biomass plots of plankton species.

Comparisons of the geographic, bathymetric, and hydrographic distribution of plankton biomass on a seasonal basis are made by comparing the several cruises with each other. Species lists, rank orders of abundance, and size or stage distributions are compared. The importance of each season to the reproduction of economically and ecologically important species in the area is evaluated by examining the abundance of their larval stages on a seasonal basis.

An analysis of the community structure of the zooplankton of the area will employ a variety of numerical classification techniques. These analyses allow statements concerning the co-occurrence of species which may in some way (e.g., competition for food) influence the distribution and survival of each other.

Discrete depth tows with the neuston net and the Tucker trawl allow comparisons of densities at various depths on a diel cycle. Experiments are designed so that, with transformation (e.g., $\log_{10} x + 1$), a factorial analysis of variance can be performed -- the factors being depth, time of day, species, and replicates.

VI. Results

The offshore survey of plankton of the Kodiak area has consisted of five cruises (Table 1). The cruise tracks and station locations are shown in Figures 1-6. Collections have been made as described above, and analyses are now in progress.

The following section will describe in a preliminary manner results obtained so far for the hydrography, sea bed drifters, ichthyoplankton, and invertebrate zooplankton from the Fall 1977 and Spring 1978 cruises. Additional detail is provided for the decapod larvae combining results of the inshore survey (RU553) with those of the offshore survey. Comparison between seasons, nets, and areas are made as appropriate. Analysis of data from the Spring cruise collected east of 150°W are incomplete and not shown on the figures. Changes of scale of abundance are noted in figure legends.

HYDROGRAPHY

Fall, 1977

Circulation and hydrography near Kodiak Island in September-November, 1977, was discussed by Schumacher et al. (In Press). We use these data herein because of CTD failures during our cruise 4MF77.

Surface temperatures in October - November, 1977 ranged from only 7°-8°C in the area covered by our cruise track (Figure 7). Water over the banks was relatively cool at 7°C and water of this temperature extended out over the slope. Water to the northeast was warmer than to the southwest, but observations in the latter area were made 2 to 3 weeks later than those to the west (Schumacher, et al., In Press). Surface salinity increased uniformly with distance from shore ranging from 31.5‰ nearshore to 32.5‰ in slope waters (Figure 8). Temperatures at 50 m (Figure 9) indicated relatively warm 7°C water over banks with a sharp decrease to 5° or 6°C off the slope. Salinity at 50 m (Figure 10) increased from inshore to offshore. Bottom (or 200 m) temperatures decreased uniformly from 7°C over banks inshore to 4.0°C over slope waters (Figure 11). Bottom (or 200 m) salinity increased from 32‰ over banks to 33.5‰ over slope waters (Figure 12). Tongue of relatively high salinity (33‰) extended into Kiliuda, Chiniak, and Stevenson Troughs.

Schumacher et al. (In Press) discussed the general oceanographic conditions observed in the fall, 1977. The observed transport in the Alaskan Stream off Kodiak Island was approximately 12 x 10^6 m^3 s^{-1}. They noted that weak southwestward flow extended onto the continental shelf and found gyre-like features present in the troughs. These authors found essentially homogenous water over banks.

Spring, 1978

Our observations during the Spring Cruise (March 28 - April 20, 1978) showed 4.0°C water over North Albatross Bank (Figure 13) and over South Albatross Bank and the Trinity Islands. Temperatures of 4.5°C covered portions of Kiliuda Trough and Middle Albatross Bank. A pocket of 5.0°C water covered portions of Portlock Bank and Stevenson Trough. Surface salinities (Figure 14) were 32.2‰ nearshore with the 32.4‰ contour extending from near the shelf break over South Albatross Bank to shore over Middle Albatross Bank, thence southeasterly over Northern Albatross Bank. The 32.6‰ contour essentially followed the 2000 m contour. Temperature and salinity at 50 m were essentially the same as surface measurements. Bottom (or 200 m) temperature (Figure 15) contours indicated that the 5°C isotherm roughly paralleled the 200 m contour; colder (<4°C) water covered portions of North Albatross Bank and the Trinity Island flats. Bottom (or 200 m) salinity contours (Figure 16) indicated low salinity (<32.4‰) waters encompassing much of the nearshore zone to mid-shelf. Less saline (<32.4‰) water also covered North Albatross Bank. The 33.2‰ isotherm generally coincided with the slope break.

Schumacher et al. (1978) discussed hydrographic conditions over the Kodiak Island shelf region from March 2-10, 1977. Our observations taken the following year from March 28-April 20, 1978 parallel those of Schumacher, et al. (1978). They found two subsurface cores of warm saline water, one near the shelf break and one extending northwestward from the shelf break into Amatuli Trough. The 5.0°C bottom (or 200 m) isotherm in 1977 paralleled the shelf break; water warmer than 5.0°C (bottom or 200 m depth) enveloped parts of Stevenson Trough and Portlock Bank. A tongue of higher salinity (>33.0‰) water at bottom (or 200 m) extended into Stevenson Trough.

SEA-BED DRIFTER RECOVERIES

A total of 3,536 sea-bed drifters was released at 16 points during the five cruises (Table 1). Recoveries to date total 32, or 1 percent, from releases made in November, 1977 through November, 1978. Drifters generally were recovered inshore from their release locations, although some variability is evident (Figure 17). Recoveries from releases made in the entrance to Stevenson Trough were made at the head of the trough. Recoveries from releases made over middle Albatross Bank generally were made in Kiliuda Trough, northwest of the point of release. Other recoveries were in Kaiugnak Bay from releases made just outside the entrance of the bay.

ICHTHYOPLANKTON

From the Fall, 1977 and Spring, 1978 cruises we see that eggs and larvae of fishes form a diverse community in the Kodiak area. Eggs and/or larvae of 26 taxa occurred five or more times in a particular life history stage-gear-net combination (Table 2). Many taxa cannot be identified at the species level, due to inadequate descriptions of early life history stages. In the following section the distribution and abundance of several taxa is discussed in relation to the two seasons, differences in neuston and bongo catches, and areas of occurrence and abundance.

Mallotus villosus (Capelin)

Capelin larvae were widely distributed in Fall as shown in bongo net catches (Figure 18). They seemed to be most abundant close to shore. This is to be expected since the adults spawn intertidally on beaches in Fall (Hart, 1973). A few larvae were taken at widely scattered locations in the neuston net in Fall (Figure 18). In Spring, they were more abundant in the neuston net than in the bongo (Figure 19). They were also not as close to shore as they were in Fall. This apparently results from a change to more neustonic habits as the larvae grow, since those in Spring were larger than those in Fall.

<u>Theragra</u> <u>chalcogramma</u> (Walleye pollock)

Pollock eggs were taken in both bongo and neuston nets in both Fall and Spring (Figures 20-21). In both seasons the areas of occurrence were similar in both nets; however, the bongo catches seemed to show a little more detail. In Fall most eggs were nearshore, concentrated in two areas - off Marmot Bay and off Sitkalidak Island. A few were also taken in the neuston net offshore over the troughs. In Spring the distribution was broader which may in part reflect the larger area sampled at that time. Most were taken south of Kiliuda Bay with the highest abundances in the southeast part of Shelikof Strait. It appears that their distribution extended beyond our survey area to the south and west. Again, as in Fall, a few were also caught offshore at widely scattered stations.

<u>Hexagrammos</u> I (Greenling)

The larvae we designate <u>Hexagrammos</u> I are probably <u>Hexagrammos</u> <u>decagrammus</u> (Kelp greenling), but precise identification awaits further analysis. In the Fall small larvae of this greenling were taken in neuston tows and their distribution was centered over Kiliuda Trough where they extended from nearshore to the edge of the shelf (Figure 22). Some were also over Middle Albatross Bank. By Spring, larvae were taken in the neuston collections throughout the study area (Figure 23). They appeared most abundant over Middle Albatross Bank, although concentrations occurred in several other areas. Some were also taken in the bongo net in Spring, occurring in areas of high abundance as indicated by neuston collections (Figure 23).

<u>Hexagrammos</u> <u>stelleri</u> (Whitespotted greenling)

In Fall, whitespotted greenling were taken in the neuston net at nearly every station, and they also occurred at scattered stations in the bongo catches (Figure 24). They were abundant at nearshore as well as offshore stations. However, they were absent at a few of the most shoreward stations. In Spring they occurred in neuston collections, at stations widely spread over the survey area (Figure 25). They also occurred in areas that were not sampled in Fall. The widest area of distribution was over Southern Albatross Bank.

<u>Pleurogrammos</u> <u>monopterygius</u> (Atka mackerel)

Atka mackerel larvae were taken in Fall and Spring, primarily in the neuston net (Figures 26-27). In Fall they were abundant over Kiliuda Trough and occurred at scattered stations to the north. A few were taken in the bongo tows over Kiliuda Trough in Fall. In Spring they were present over Northern and Middle Albatross Banks. They were also present at two stations just east of Shelikof Strait, south of Kodiak Island. Most occurred over the middle of the shelf.

Hemilepidotus sp. (Irish lords)

Several species of Irish lords may be represented by larvae in our collections. Work is continuing on distinguishing these larvae. Some of the irregularities in geographic patterns may be the result of overlapping occurrences of more than one species. In Fall these larvae were taken in nearly every tow of both the bongo and neuston net (Figure 28). They were fairly evenly distributed over the study area, but did show areas of increased abundance near the edge of the shelf off Kiliuda and Chiniak Troughs. In Spring they were more widespread but not as evenly distributed (Figure 29). Several areas of abundance were seen, and the bongo and neuston catches show dissimilar patterns of distribution.

Ammodytes hexapterus (Pacific sand lance)

Sand lance larvae were taken in bongo and neuston net tows in Spring (Figure 30). They appear much more widespread in bongo catches, where they were taken mostly over the inner half of the shelf and to the south of Kodiak Island. They were abundant nearshore south of Kodiak Island, between it and Trinity Islands. They were also taken at isolated stations offshore.

Hippoglossoides elassodon (Flathead sole)

Eggs of flathead sole were taken in a relatively small area in neuston and bongo net tows in Spring (Figure 31). They were all associated with water over troughs. Most were over Kiliuda Trough, while some also occurred over Chiniak and Sitkalidak Troughs.

INVERTEBRATE ZOOPLANKTON

The following is a report of the horizontal and seasonal distributions and abundances of major zooplankton taxa and euphausiid species. These results are based on catches from the bongo nets. Bongo nets were towed at nearly every station on each cruise. Too few Tucker trawl samples were collected during the Fall cruise to allow adequate inter-cruise comparisons for that sampling method. The bongo nets also sampled the entire water column on every tow. This eliminated the need to consider diel changes in the vertical distribution of animals as a source variable and enabled data to be combined regardless of the time collected.

The contour plots (Figures 33 to 43) illustrate representative distributions of some zooplankton taxa. These plots are typical of the variations of distributions found in the area studied.

Seasonal patterns of abundance and occurrence of different zooplankton taxa are shown in Tables 3 and 4. Comparisons in these tables were based on 43 stations from each cruise whose locations and bathymetry were similar (Figure 32). If taxa were not caught at the stations examined for seasonal comparisons but were present at other stations or in the Tucker trawl samples, their presence was indicated in Tables 3 and 4. Abundance is presented as the log of the number of individuals caught per $10m^2$ per station. This will be used throughout the following discussion. Cruises will be referred to as either Fall (Cruise 4MF77) or Spring (Cruise 4DI78).

The taxa are listed below as two groups - the major zooplankton taxa and Euphausiacea species. Life history stages are not determined for major taxa except Cirripedia, Gastropoda, Echinodermata, and Euphausiacea. Cirripedia larvae were examined because of their high abundance during parts of the year. Euphausiid larvae and juveniles were examined because of their ecological and economical importance to the area.

Major Zooplankton Taxa

As expected, the Copepoda were the dominant zooplankton in the area. Cnidarians, pteropods, amphipods, chaetognaths, and larvaceans occured at ≥70% of the stations and occurred more frequently in the Fall than Spring. These same taxa also tended to be more abundant than others. Taxa that occurred at less than 5% of the stations (Tables 3 and 4), were Siphonophora, Mollusca, Heteropoda, Mysidacea, and Thaliacea. The taxa below are discussed in order of greatest to least percent occurrence.

Copepoda (Figure 34)

Copepoda occurred at all stations examined. Generally the abundance of copepods was evenly distributed over the shelf with no apparent change between Spring and Fall. A preliminary investigation of the data from Fall showed 45 species were captured. All were in the copepodid stage of development (Bruce Wing, personal communication). This is consistent with the findings that *Calanus hyperboreas* near Maine do not become adults until late fall or early winter (Conover, 1965).

Cnidaria (Figure 33)

Cnidaria were abundant and occurred at all the stations in Fall. In Spring, only a 70% occurrence was found as well as a decrease in abundance. In Fall Cnidaria were evenly distributed over the shelf, but in Spring there were areas of low or no occurrence. A particularly noticeable area of low abundance was the area north of the Trinity Islands. The Fall cruise did not sample this area, so it is not known if this low abundance in the Spring was a seasonal event.

Chaetognatha

Chaetognaths occurred at more stations in Fall than in Spring, 95% and 79%, respectively. Absences occurred on the Spring cruise at nearshore stations, particularly in the Stevenson Entrance area. Average abundance was 2.2-2.3/10m^2/Station (log value) and did not vary seasonally.

Amphipoda

Amphipods occurred more often in the Fall than Spring, but the abundance remained at 2.2-2.3/$10m^2$/Station for both cruises. There was no apparent pattern of distribution except that the highest number of zero occurrences occurred in the Kiliuda Trough and Southern Albatross Bank areas.

Larvacea

The percent occurrence of larvaceans was nearly the same with no pattern of absences for both cruises. The average abundance per station was the same. However, greater numbers of animals (7/$10m^2$/Station) were encountered over Southern Albatross Bank than in other areas during Spring. The abundance on the Fall cruise was evenly distributed.

Pteropoda

There was an 84% occurrence of pteropods in the Fall compared to a 63% occurrence in Spring. However, there were slightly more animals per station in Spring (2.3/$10m^2$/Station) than Fall (2.1/$10m^2$/Station). Absences appeared randomly distributed over the sampling area for both cruises. But the southern Albatross Bank - Kiliuda Trough area supported higher abundances per station (approx. 3/$10m^2$/Station) than elsewhere (2/$10m^2$/Station).

Cirripedia nauplii and cypris developmental stages (Figures 35 and 36)

Cirripedia nauplii were most prominent during Spring based on percent occurrence and average abundance (Table 3). In general, the highest concentrations were found nearshore, but very low concentrations were also found nearshore in adjacent areas. Concentrations of 4/$10m^2$/Station were also found toward the outer edge of the shelf over Southern Albatross Bank. Cirripedia were much less abundant (1.5 compared to 3.3/$10m^2$/Station) in the Fall and occurred at 16% fewer stations.

Cirripedia cypris (a later developmental stage) was much more prominent in the Fall than Spring. There was a 70% occurrence in the Fall compared to a 26% occurrence in Spring. Abundance per station, however, remained nearly equal for the two cruises. In Spring most cirripedia cypris were located from Kaiugnak Bay seaward over Southern Albatross Bank. Cirripedia cypris were more evenly distributed over the shelf during the Fall cruise but with a noticeable absence of animals in the Kiliuda and Stevenson Trough areas.

Caution must be applied when interpreting data on these larval stages, especially during the Spring spawning period. For example, note the absence of nauplii in the outer Chiniak Trough - Northern Albatross Bank area. These stations were sampled earlier in the cruise than stations to the south. Higher concentrations of nauplii may have spread to early stations very soon after they were sampled. The few cypris caught during the Spring cruise further suggest we were trawling very near the initial spawning period when rapid changes in both occurrence and abundance of cirripedia larval stages occur.

However, the pattern for the Fall cruise (Figure 35, top) suggests that the middle and southern area of the shelf may be more productive as shown by the concentrations of nauplii caught in these areas and not to the north.

Annelida

Annelids occurred at more stations in Fall but were less abundant per station than in Spring. During both periods they were evenly distributed over the shelf.

Cladocera

Cladocera also occurred at more stations in Fall than Spring (35% versus 7%). The number of animals caught per station remained nearly equal for the two cruises. In Spring cladocerans only occurred over Southern Albatross Bank but this pattern changed by Fall when cladocerans mostly occurred at nearshore stations of the survey area.

Ostracoda

The percent occurrence and abundance per station of ostracods were nearly equal between cruises. Generally, higher abundances were found at the outer edge of the shelf during both cruises but no apparent pattern of distribution over the shelf was evident.

Isopoda

Isopods were more than twice as evident during the Fall than Spring. Abundance was also slightly higher during Fall (1.8 versus $1.6/10m^2$/Station). The pattern of isopod distribution was very different between Spring and Fall. During Spring isopods generally occurred northward from Northern Albatross Bank. In Fall most isopods were found to the south of Middle Albatross Bank.

Other Zooplankton Taxa

Ctenophores were more abundant in Fall than Spring. They occurred at less than 10% of the stations and were low in abundance. During the Fall cruise they were evenly distributed along the shelf but more prominent at the nearshore stations.

Gastropod larvae were found at 42% of the stations in Spring and not at all during Fall. There was no apparent pattern in their distribution.

Cumaceans also did not occur in Fall and they occurred at only 9% of the stations in Spring. However, their abundance at these stations averaged $4.8/10m^2$/Station.

Echinoderm larvae occurred in Fall but not Spring. Their low abundance in Fall suggests that peak spawning for the Echinodermata occurs sometime between the dates of our two cruises.

Other major taxa that were captured but never very much in evidence were the Siphonophora, Heteropoda, Mysidacea, and Thaliacea.

Euphausiacea

Euphausiids were very abundant near Kodiak Island in the area surveyed. Four species dominated: Thysanoessa inermis, Thysanoessa spinifera, Euphausia pacifica, and Thysanoessa longipes. Other species rarely caught were Stylocheiron sp., Tessarabrachion occulatus, and Thysanoessa raschii. Because euphausiids are important food sources for the marine mammals, fish, and birds of the area, contour plots of the four relatively abundant species are included (Figure 39 to 42) and discussed below. Also included are contour plots of euphausiid larvae and juveniles.

Euphausiacea developmental stages (Figures 37 and 38)

Euphausiid larvae and juveniles were less abundant and occurred at fewer stations in Spring than Fall. In the Spring the highest concentrations of larvae were found at nearshore stations. These stations were sampled later in the cruise but the concentrations caught early in the cruise at Marmot Flats and east of Northern Albatross Bank show that there was some earlier spawning. Juveniles were also found during the Spring cruise, but may be from last year's season (Ponomareva, 1963). Juveniles occurred at many stations in Spring but in very low abundance (.8/10m^2/ Station). By Fall both juvenile and larval euphausiids occurred throughout the area and both showed increased abundance.

Thysanoessa inermis (Figure 39)

Thysanoessa inermis occurred at more stations in Spring than Fall (58% versus 33%), but the average catch per station remained nearly equal. The distribution of T. inermis during both cruises was overdispersed. Areas of high concentrations of animals were similar for the two cruises with both nearshore and offshore concentrations.

Thysanoessa spinifera (Figure 40)

Thysanoessa spinifera was the second most abundant euphausiid species in the area. They occurred with an average abundance of 1.5/10m^2/Station. Both the average number and percent occurrence of T. spinifera were nearly equal for Spring and Fall. T. spinifera appeared to occupy the same areas as T. inermis - particularly the area near the edge of the shelf over Kiliuda Trough.

Euphausia pacifica (Figure 41)

Euphausia pacifica was present in very low numbers during Spring, and animals were mostly located along the outer edge of the Kodiak shelf. In Fall greater numbers were found over the shelf, particularly over the inner area of Northern Albatross Bank and Stevenson Trough.

Thysanoessa longipes (Figure 42)

Thysanoessa longipes occurred with equal frequency during the two cruises but was more abundant on the average during Fall. *T. longipes* appeared only as a fringe member of the shelf ecosystem and was found most abundant near the outer edges of the shelf in areas greater than 100 fm. This pattern was evident on both cruises.

In summary, it appears that euphausiids spawn as early as mid-March in the area of the Kodiak Shelf. This concurs with Ponomareva (1963) who found euphausiids in the Sea of Japan spawned in March. The larvae are probably those of *T. inermis* and *T. spinifera*. These are the two dominant euphausiid species on the shelf, and the larval distributions were roughly parallel to those of *T. inermis* and *T. spinifera* in Spring.

The average abundance of euphausiids found was approximately 50 individuals/ $10m^2$ of the two dominant species. This is similar to numbers reported by Frost and McCrone (1979) at Stations P and Q (50^oN, long. 145^oW and 51^oN, long. 137^oW, respectively). Frost and McCrone (1979) towed their nets from 500 m to the surface and the dominant euphausiid in their tows was *Euphausia pacifica*. The shallow waters of the Kodiak shelf appear to support a much more dense euphausiid population than the nearest oceanic area studied.

SHRIMP AND CRAB LARVAE

Several species of decapod crustaceans are of considerable economic or ecological importance in the Kodiak area (Table 5).

Population diversity

Representatives of the families Hippolytidae, Majidae, Pinnotheridae and Paguridae were the most frequently occurring decapods, with the Hippolytidae and Paguridae having the highest incidence of occurrence. Other less frequently occurring families were Crangonidae, Ateleyclidae, Cancridae, Lithodidae and Pandalidae.

Comparisons of crab (Reptantia) and shrimp (Natantia) abundance within samples indicate some localized concentrations of larvae exist. Figure 43 shows the offshore distributions of crab and shrimp larvae during Spring. The major part of a given sample appeared to be either Reptantia or Natantia larvae.

Species composition generally did not vary between study areas or between bays within the inshore study area. Table 6 lists important decapods and their occurrence in each of the study areas as determined by their presence or absence in all samples examined to date.

Temporal distribution

In general, densities of crab and shrimp larvae appeared lowest during the early winter and spring months, and increased through the summer, with the highest densities occurring during late June and July. It appears that larval abundance of both taxonomic groups (Reptantia and Natantia) coincides temporally.

Table 7 indicates the time of occurrence and stage of development of important decapods in the study areas as exhibited by their presence in samples.

Although March-April initiation of sampling was thought to be sufficiently early in the season to determine the time of larval release, this was not the situation for some species. *Chionoecetes bairdi* and some species of the family Crangonidae were present in stages 2 through megalops forms in the earliest (March-April) samples. No stage 1 *C. bairdi* were encountered in the early samples; however, they were present in late April samples. Other species such as *Cancer gracilis*, *C. magister*, and members of family Pinnotheridae were not encountered until after mid-April. A protracted larval release is suggested for most species because stage 1 larvae were encountered throughout the survey time period (March-August).

It appears that with certain species, there may be a temporal variation in the time of larvae release between the inshore and offshore study areas. For example, stage 1 Pinnotheridae occurred inshore as early as mid-April, whereas initial offshore occurrence was not until late June.

Spatial distribution

Most decapod species of principal interest were found in both study areas (inshore and offshore). Pandalus hypsinotus and P. platyceros were only encountered in the offshore and inshore study areas, respectively. Additionally, P. montagui tridens only occurred in samples collected from one of the bays within the inshore study area.

Initial examination of neuston samples indicates that megalops of Chionoecetes bairdi are highly mobile and can occur in the upper layers of the water column. This species was frequently encountered in neuston samples.

Diel sampling

Day-night samples indicate that species diversity varied by depth. This variability also appears to change with time. For example, during daylight hours in Izhut bay, the highest species diversity occurred in the depth range of 50-70 meters while during hours of darkness, the highest diversity occurred higher in the water column (i.e. 30-50 meters).

Decapod larvae abundance also changed with time and depth. During the day, the highest abundance occurred in deeper water layers (50-70 m) while at night, abundance increased in shallower zones (30-50 m).

Aliquot subsamples

Aliquot subsamples do not appear to provide the total diversity and relative abundance of species and life history stages. These subsamples only appear to indicate the presence of those species that are the most abundant within a given bulk sample.

VII. Discussion

From these preliminary results, it appears that we have in hand plankton samples adequate to describe the major seasonal features of plankton distribution in the Kodiak area with respect to hydrography, bathymetry and interspecies relationships. The analysis to date of the first two cruises shows that the area harbors a diverse plankton community, with complex relations between the measured parameters. More detailed interpretation of these data await processing of samples from the later cruises.

Although analysis of shrimp and crab larval data has not been completed, preliminary findings indicate that:

There appears to be no difference in species diversity between the inshore and offshore study areas; however, inshore abundance in various bays appears to be higher than levels present in the offshore study area. Whether this species diversity-abundance information indicates separate inshore-offshore stocks or a single overall population cannot be determined at this time. Investigations of larval transport mechanics may provide insight into decapod population dispersal in the Kodiak Island region. If inshore and offshore stocks are related, do offshore larval populations result from inshore concentrations dispersing seaward or, are inshore concentrations a result of shoreward decapod larval transport from offshore areas?

Series of repetitive sampling at 1 location indicated substantial variability in numbers of organisms and the dominance of one species group or another. There was a strong tendency for decapods within a sample to be mostly crab or shrimp. Samples obtained during diel sampling suggest that larval populations are not randomly distributed within an area, but rather, form concentrations or clumps that are predominantly one taxonomic group or another.

Several families formed the majority of decapod organisms in the samples examined to date. Although the study areas support commercial crab and shrimp fisheries, larvae of economically important species were encountered in low abundance. It is not known whether this low larval abundance reflects depressed stock conditions or results from low sampling density.

Three families of crab (Pinnotheridae, Paguridae, and Majidae) and two families of shrimp (Hippolytidae and Crangonidae) represent the most frequently occurring decapod larvae. The abundance of these larvae, relative to larvae of economically important decapods, differs from a comparative abundance of the adult forms. This may reflect high mortality rates during early life stages for the families mentioned above.

Survey data suggests a sequential occurrence of species in the study areas. Data from samples collected later in the year indicate that members of family Pinnotheridae and *Cancer gracilis* (Cancridae) replace organisms from families Paguridae, Hippolytidae, and Crangonidae in density and frequency of occurrence.

There is evidence to suggest that larval release of some decapods may occur earlier than mid-March. This early release may be a normal occurrence or a result from mild winter conditions accelerating egg development. Additionally, it appears that larval release of decapods may not occur during a limited time span, but rather may be protracted throughout the year.

VIII. Conclusions

From our study thus far the following tentative conclusions can be drawn with regard to the plankton community off Kodiak Island and our survey of it:

General

The study area contains a diverse plankton assemblage, with complex patterns of distribution.

Ichthyoplankton

Several taxa show high abundances in waters over troughs in the area. Capelin larvae in Spring, 1978, were concentrated over Kiliuda Trough, South Albatross Bank and northwest of the Trinity Islands. Pollock eggs also were more abundant in the general area from Kiliuda Trough to west of the Trinity Islands. Greenling (Hexagrammos Type I) were centered over Kiliuda Trough in the Fall, 1977, but were widely dispersed in the Spring, 1978. Atka mackerel larvae also were found mainly over Kiliuda Trough in the Fall, but during Spring were primarily over Northern and Middle Albatross Banks. Flathead sole eggs were found mainly over Kiliuda Trough during Spring.

Some early life history stages of fishes in Kodiak Island waters are neustonic. Examples are greenling (Hexagrammos Type I; H. stelleri); Atka mackerel; and certain sculpins (e.g. some Hemilepidotus sp.). Other taxa occur deeper in the water column, such as capelin, sand lance and some sculpins.

Invertebrate Zooplankton

There is a higher abundance of zooplankton on the Kodiak shelf in the Fall compared to early Spring.

The most abundant taxa in the area were cnidarians, pteropods, amphipods, chaetognaths, and larvaceans, and euphausiids. Copepods, as expected, were the most abundant group.

Siphonophores, heteropods, mysids, and thaliaceans were present but with very low occurrence.

All species of copepods were in the copepodid developmental stage during Fall.

Thysanoessa inermis and spinifera tended to occur in patches over the shelf.

Euphausia pacifica and Thysanoessa longipes are most abundant near the outer fringe of the Kodiak shelf.

Euphausiids probably start spawning in early March and continue throughout the summer and early fall.

Euphausiid juveniles from the previous year's season are found in early Spring.

Shrimp and Crab Larvae

Until final analysis of data has been completed, results are inconclusive. However, certain tentative conclusions can be made at this time:

Time of occurrence of decapod larvae concides between inshore and offshore areas for the Kodiak Island region.

Several families form the majority of the decapod larvae population.

Relative abundance of most decapods is a function of time. The highest densities of larvae usually occur during midsummer months.

Decapod larvae populations in both inshore and offshore study areas have the same basic species composition.

The sample aliquots may not provide adequate species representation within samples.

IX. Needs for further study

The overall patterns of seasonal occurrences of zooplankton of the Kodiak shelf are being derived from the present collections. Further studies on annual variations in distribution are needed before the patterns can be well understood. The present study was not designed to investigate small scale distributions on a horizontal or vertical basis. Such studies are important if the impact of such things as local spills of oil on zooplankton are to be evaluated properly. Comparisons of the shelf around Kodiak to the shelf elsewhere with respect to the early life history of species with broad distribution needs to be made in order to understand the relative importance of various shelf areas to these species.

Preliminary analysis of decapod larval sample data shows a need for further study with regard to: (1) decapod larvae transport mechanics, (2) stratification of larvae by depth, (3) localized concentrations or clumping behavior, (4) diel migration of larval decapods within the water column, and (5) early periods of larval release.

An intensive study of one particular bay system within the inshore study area would shed further light on the questions listed above as well as provide data useful in assessing the magnitude of larval decapod populations for the entire nearshore region.

X. Summary of January-March 1979 Quarter

Activities to date are on schedule with respect to the milestone chart (Table 8).

A. Field Activities

Offshore

a. The fifth quarterly offshore cruise was conducted aboard the FRS *Miller Freeman* from February 13 - March 11, 1979.

1. Field Party:

Name	Affiliation	Role
Kenneth Waldron	NWAFC	Chief Scientist
Ann Matarese	NWAFC	Biologist
Donald Fisk	NWAFC	Physical Science Technician
Martha Siemroth-Peters	NWAFC	Biological Technician
Gary Shigenaka	NWAFC	Biological Technician

2. Methods:
At each grid station a surface neuston tow was made for 10 minutes utilizing a Sameoto sampler to sample ichthyoneuston. A double-oblique bongo tow was next made from near bottom to the surface to sample ichthyo- and zooplankton. At selected stations a Tucker trawl was used to sample discrete strata. A CTD cast was made at each station. Sea-bed drifters were released at 16 locations.

3. Sample Collection Localities
The station plan is illustrated in Figure 5. A total of 88 regular grid stations was occupied.

4. Data Collected and Analyzed:

(a) Number of samples collected:

	89	neuston samples
	179	bongo samples (88 each 0.505 and 0.333 mm mesh)
	74	Tucker trawl samples
Total	339	

A total of 88 CTD measurements was taken and 768 sea-bed drifters were released.

(b) Number and types of analyses:

Samples collected during the Freeman cruise have been sent to the contractor for sorting.

b. Inshore

The 12th cruise of the R/V Commando was conducted by RU553 from March 1 through March 20, 1979. Details of that cruise will be reported by RU553. Aliquots of crab and shrimp larvae from samples collected by RU553 will be identified by RU551.

B. Laboratory Activities

1. Scientific group (all analyses except for those of crab and shrimp are conducted at the Seattle laboratory):

Name	Affiliation	Role
Jean Dunn	NWAFC	Co-principal investigator
Arthur Kendall	NWAFC	Co-principal investigator
Robert Wolotira	NWAFC*	Co-principal investigator
Langdon Quetin	NWAFC	Biological Oceanographer
John Bowerman	NWAFC*	Fisheries Biologist
Ann Matarese	NWAFC	Fisheries Biologist
Beverly Vinter	NWAFC	Ichthyoplankton Specialist
Jay Clark	NWAFC	Biological Technician
Don Fisk	NWAFC	Physical Science Technician
Eric Monk	NWAFC*	Biological Technician
Bernie Goiney	NWAFC	Biological Technician

* Kodiak Laboratory

2. Methods:

Fish eggs and larvae were identified by microscopic examination using standard procedures of larval fish taxonomy. Fish eggs and larvae were measured by means of a calibrated ocular micrometer.

Aliquots of zooplankton from the 0.333 mm mesh bongo net were identified by the sorting contractor to phylum, class, or order, as appropriate, except for euphausiids which were identified to species. Euphausiids from the Tucker trawl were also identified by the sorting contractor.

Crab and shrimp larvae were identified to species and life history stage.

3. Sample Collection Localities:

Ichthyoplankton samples presently being identified were collected during the fall 1978 cruise (R/V Wecoma 78-1). The station grid is shown in Figure 4.

Zooplankton data from this cruise have been received from the sorting contractor.

4. Data Analyzed:

a. Discoverer cruise (4DI78) - Spring 1978

The tape of the ichthyo- and zooplankton data and ancillary information from the spring 1978 cruise will be forwarded to OCSEAP shortly.

b. Miller Freeman cruise 78-2 - Summer 1978.

Identification of ichthyoplankton samples was completed. Station, ichthyo- and zooplankton data were entered into our data management system.

c. Wecoma cruise 78-1 - Fall 1978.

Identification of ichthyoplankton samples from this cruise has begun. Zooplankton have been sorted from aliquots from 98 bongo (0.333 mm mesh) samples and aliquots of euphausiids from 100 Tucker trawl samples have been identified.

d. Shrimp and crab larvae.

Through this quarter, the shrimp-crab portions of approximately 2500 aliquots have been shipped to the Kodiak Facility. Of these, 1968 have undergone detailed sorts to the lowest possible taxonomic-life history stage classification. Additionally, all crab and shrimp larvae were removed from 14 bulk samples (i.e. that portion of the plankton sample remaining after the removal of the 500-organism aliquot) so that an evaluation of levels of precision for the aliquot portion could be examined.

Species diversity comparisons between aliquots and bulk samples were also investigated. Four of the 14 above-mentioned bulk samples were sorted to lowest possible taxonomic levels.

Information recorded during the sorts and counts of aliquots and bulk samples included:

(1) total number of all organisms per bulk sample

(2) total number of decapods per bulk sample and aliquot

(3) numbers of crab and shrimp per species and life stage per bulk sample and aliquot.

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Table 1.--Number of plankton samples collected and other associated measurements made on OCSEAP cruises October 1977 - March 1979.

Cruise No.	Vessel	Cruise	Cruise Dates	Number Stations Occupied	Number of samples by gear type: Neuston 0.505	Bongo 0.505	Bongo 0.333	Tucker 0.505	IKMT	Number Samples Collected	CTD Casts	XBT Probes	Seabed Drifters Released
1	*Miller Freeman*	4MF77	31 Oct-14 Nov 1977	61	83	59	59	168	0	369	40	31	400
2	*Discoverer*	4DI78	28 Mar-20 Apr 1978	89	111	85	85	138	56	475	117	0	800
3	*Miller Freeman*	2MF78	19 Jun-9 July 1978	91	111	89	89	176	40	505	106	0	800
4	*Wecoma*	1WE78	25 Oct-17 Nov 1978	94	101	98	98	100	0	397	97	0	768
5	*Miller Freeman*	1MF79	13 Feb-11 Mar 1979	88	89	88	88	74	0	339	88	0	768

Table 2.--Vertebrate taxa collected at least five times in a stage-gear-net combination from the Fall 1977 and Spring 1978 plankton cruises off Kodiak Island.

Taxon	Stage	Fall 1977				Spring 1978			
		Neuston	Bongo	Tucker 1	Tucker 2	Neuston	Bongo	Tucker 1	Tucker 2
No fish present	n.a.					x			
unidentified	larva						x		x
unidentified A	egg					x			
Mallotus villosus	larva	x	x	x	x	x			
Leuroglossus schmidti	egg		x	x					
Leuroglossus schmidti	larva							x	
Protomyctophum thompsoni	larva		x	x					
Stenobrachius leucopsarus	larva						x	x	x
Stenobrachius leucopsarus	juvenile						x		
Theragra chalcogramma	egg	x	x			x	x	x	x
Theragra chalcogramma	larva						x	x	x
Hexagrammidae	larva					x			
Hexagrammos sp.	larva	x				x			
Hexagrammos D	larva	x							
Hexagrammos E	larva	x							
Hexagrammos I	larva	x				x	x	x	x
Hexagrammos stelleri	larva	x	x		x	x			
Pleurogrammos monopterygius	larva	x	x			x			
Cottidae	larva						x	x	x
Gymnocanthus A	larva						x	x	x
Hemilepidotus sp.	larva	x	x	x	x	x	x	x	x
Myoxocephalus B	larva						x	x	x
Myoxocephalus G	larva						x		x
Cyclopteridae	larva						x		x
Stichaeidae	larva						x	x	x
Chirolophis polyactocephalus	larva					x			
Lumpenus sagitta	larva						x	x	x
Lyconectes aleutensis	larva					x			x
Ammodytes hexapterus	larva					x	x	x	x
Pleuronectidae	egg					x	x	x	x
Atheresthes stomias	larva						x	x	x
Hippoglossoides elassodon	egg					x	x	x	x
Lepidopsetta bilineata	larva						x	x	x

Table 3.--Seasonal comparison of major invertebrate zooplankton from cruises 4MF77 (Fall) and 4DI78 (Spring). Occurrence is the number of stations at which a group was represented. Percent occurrence is based on 43 stations analyzed from each cruise. Average abundance is expressed as log $N/10m^2$/station.

		4MF77 (Fall)			4DI78 (Spring)		
Taxonomic Group	Stage	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)
Cnidaria		43	100	2.8	30	70	2.3
Hydrozoa siphonophora		-	-	-	1	2	2
Ctenophora		9	21	1.2	1	2	1
Annelida		26	61	1.7	10	23	2
Mollusca		0	-	-	2	5	2
Gastropoda	Larva	0	-	-	18	42	2.3
Heteropoda		0	-	-	1	2	1
Pteropoda		36	84	2.1	27	63	2.3
Cladocera		15	35	1.9	3	7	2
Cumacea		0			4	9	4.8
Ostracoda		20	47	2.0	18	42	2.1
Copepoda		43	100	4.2	43	100	4.3
Cirripedia	Nauplius	18	42	1.5	25	58	3.3
Cirripedia	Cypris	30	70	2.3	11	26	2.4
Mysidacea		3	7	1.3	-	-	-
Isopoda		17	40	1.8	7	16	1.6
Amphipoda		39	91	2.8	30	70	2
Echinodermata	Larva	8	19	1.0	-	-	-
Chaetognatha		41	95	2.3	34	79	2.2
Thaliacea		2	5	2.0			
Larvacea		40	93	2.9	38	88	2.9

Table 4.--Seasonal comparison of Euphausiacea from cruises 4MF77 (Fall) and 4DI78 (Spring). Occurrence is the number of stations at which a group was represented. Percent occurrence is based on 43 stations analyzed from each cruise. Average abundance is expressed as log N/10m^2/station.

		4MF77 (Fall)			4DI78 (Spring)		
Taxonomic Group	Stage	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log N/10m^2/Sta)	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log N/10m^2/Sta)
Euphausiacea	Larva	42	98	2.9	17	40	2.4
Euphausiacea	Juv.	43	100	2.8	31	72	.8
Euphausia pacifica	Adult	16	37	1.4	8	19	.1
Stylocheiron sp.	Adult	1	2	1.0	1/	-	-
Tessarabrachion oculatus	Adult	2	5	1.5	2	5	1
Thysanoessa inermis	Adult	14	33	1.7	25	58	1.5
T. longipes	Adult	5	12	1.2	6	14	.5
T. raschii	Adult	3	7	1.0	3	7	0
T. spinifera	Adult	15	35	1.4	16	37	1.6

1/ Occurred in bongo net tows but not at stations used for seasonal comparison

Table 5.--Decapod crustaceans of principal interest in the Kodiak Island region.

Species of Present or Potential Commercial Importance

Scientific name	Common name
Pandalopsis dispar	Sidestripe shrimp
Pandalus borealis	Pink shrimp
P. goniurus	Humpback shrimp
P. hypsinotus	Coonstripe shrimp
P. platyceros	Spot shrimp
P. stenolepis	- -
Paralithodes camtschatica	Red King crab
Cancer magister	Dungeness crab
Chionoecetes bairdi	Snow crab

Species (or Familes) of High Abundance or Potential Ecological Importance

Family or scientific name	Common name
Family Crangonidae	Sand shrimp
Family Hippolytidae	Hippolytid shrimp
Pandalus montagui tridens	- -
Family Paguridae	Hermit crab
Telmessus cheiragonus	Arthopod crab
Cancer gracilis	Cancer crab
Family Pinnotheridae	Pea crab

Table 6.--Occurrence (X) of larvae of crab and shrimp species of principal interest in inshore and offshore areas examined during plankton surveys of the Kodiak Island area, October, 1977 - August, 1978.[1/]

Shrimps	Inshore[2/]				Offshore
	Z	C	L	G	
Family Crangonidae	X		X	X	X
Family Hippolytidae	X	X	X	X	X
Pandalopsis dispar	X				X
Pandalus borealis	X	X	X	X	X
P. goniurus	X	X	X		X
P. hypsinotus					X
P. montagui tridens		X		X	
P. platyceros	X				
P. stenolepis	X		X	X	X
Crabs					
Paralithodes camtschatica	X	X	X	X	X
Family Paguridae	X	X	X	X	X
Telmessus cheiragonus	X	X		X	X
Cancer magister			X	X	X
Cancer gracilis			X	X	X
Family Pinnotheridae	X	X	X	X	X
Chionoecetes bairdi	X	X	X	X	X

1/ Inshore Surveys--March-August, 1978; Offshore Surveys--October-November, 1977; March-April, 1978; June-July,1978.

2/ Z = Izhut Bay
C = Chiniak-Kalsin Bay
L = Kiliuda Bay
G = Kaiugnak Bay

Table 7.--Time of occurrence of larval shrimp and crab by taxa and life history stage in inshore and offshore areas of Kodiak Island. Broken lines indicate the projected occurrence of species based on absence of life stages from samples. All stages are zoea unless otherwise indicated.

SPECIES OR FAMILY	INSHORE MONTH (J F M A M J J A S)	OFFSHORE MONTH (J F M A M J J A S)
Family Crangonidae	stages 1 - 5	stages 1 - juvenile
Family Hippolytidae	stages 1 - 5	stages 1 - 6
Pandalopsis dispar	stage 1 ?	stage 1
Pandalus borealis	stages 1 - 6	stages 1 - 5
Pandalus goniurus	stage 1 ?	? stage 5
Pandalus hypsinotus	not captured	stage 1?
Pandalus platyceros	stage 1 ?	not captured
Pandalus stenolepis	? stages 1 - juvenile ?	stages 1 - 5
Pandalus montagui tridens	? stage 1 ?	not captured
Paralithodes camtschatica	? stages 1 - 4 ?	stages 1 - glaucothe
Family Paguridae	stages 1 - glaucothe	stages 1 - glaucothe
Telmessus cheiragonus	? stages 1 - 4 ?	stages 1 - megalops
Cancer magister	stage 1	stages 1 - 2 ?
Cancer gracilis	stage 1	stages 1 - 2 ?
Family Pinnotheridae	stages 1 - 2 ?	stages 1 - 3 ?
Chionoecetes bairdi	? stages 1 - 2	? stages 1 - megalops

Table 8.--Major milestone or activity chart
for RU 551

MILESTONE CHART

↓ - Start

△ - Planned Completion Date

▲ - Actual Completion Date
(to be used on quarterly updates)

RU # 551 PI: Dunn, Kendall, Wolotira

Major Milestones: Reporting, and other significant contractual requirements; periods of field work; workshops; etc.

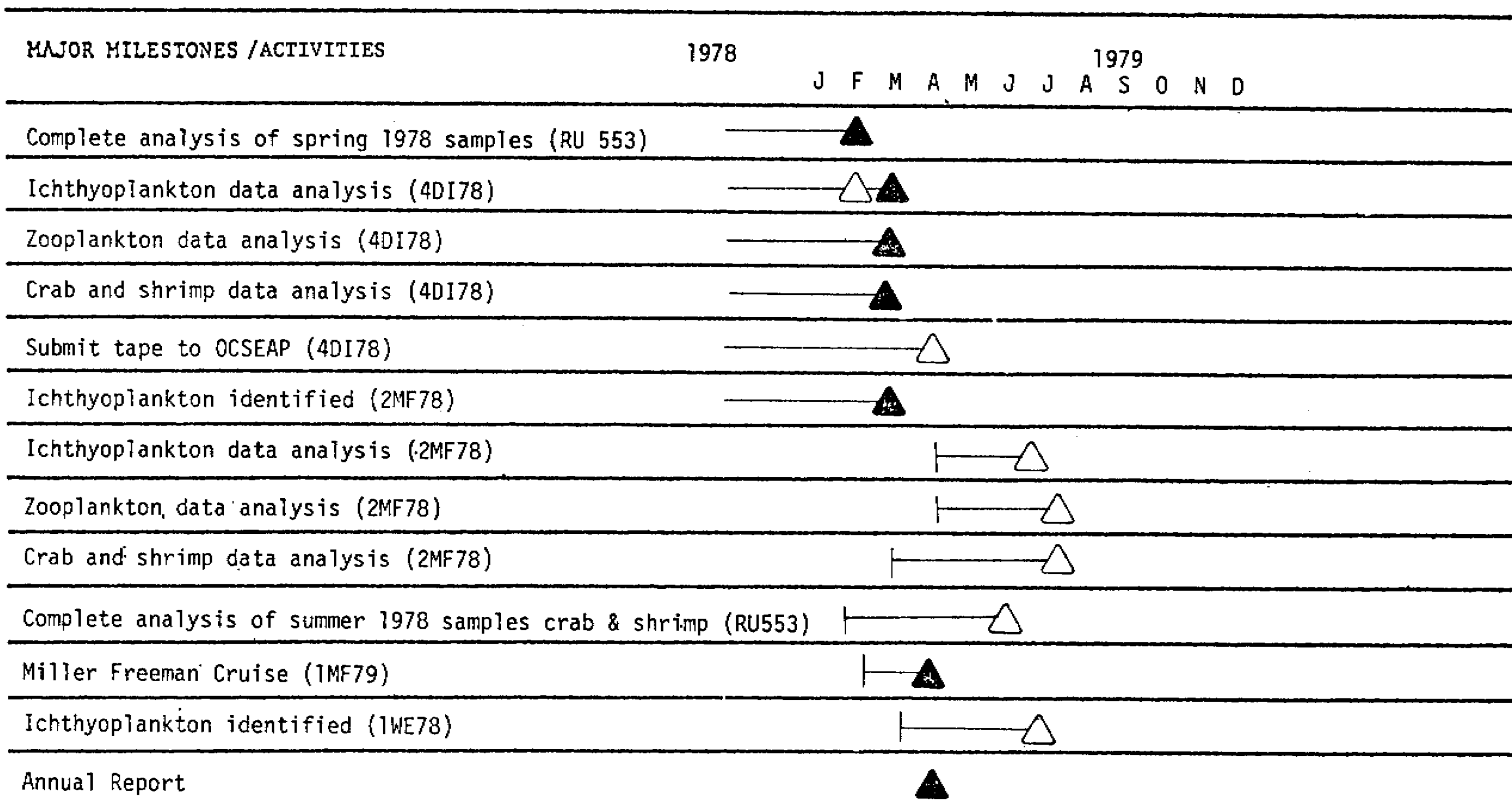

Table 8.(contd)--Major milestone or activity chart for RU 551

MILESTONE CHART

|- Start

△- Planned Completion Date

▲- Actual Completion Date (to be used on quarterly updates)

RU # 551 PI: Dunn, Kendall, Wolbtira

Major Milestones: Reporting, and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES/ACTIVITIES	1978	1979 J	F	M	A	M	J	J	A	S	O	N	D
Ichthyoplankton data analysis (1WE78)							|—	—	△				
Submit tape to OCSEAP (2MF78)							△						
Zooplankton data analysis (1WE78)					|—	—	—	△					
Crab and shrimp data analysis (1WE78)					|—	—	—	—	△				
Complete analysis fall 1978 crab & shrimp samples (RU553)					|—	—	—	—	△				
Submit tape to OCSEAP (1WE78)									△				
Ichthyoplankton identified (1MF79)								|—	—	—	△		
Ichthyoplankton data analysis (1MF79)											|—	—	△
Zooplankton data analysis (1MF79)										|—	—	—	△
Crab and shrimp data analysis (1WE78)									|—	—	—	—	△
Submit quarterly report (Synthesize first four cruises)											△		
Complete analysis winter 1979 crab & shrimp samples (RU553)											|—	—	△
Submit Tape to OCSEAP (1MF79)													△
Final Report													△

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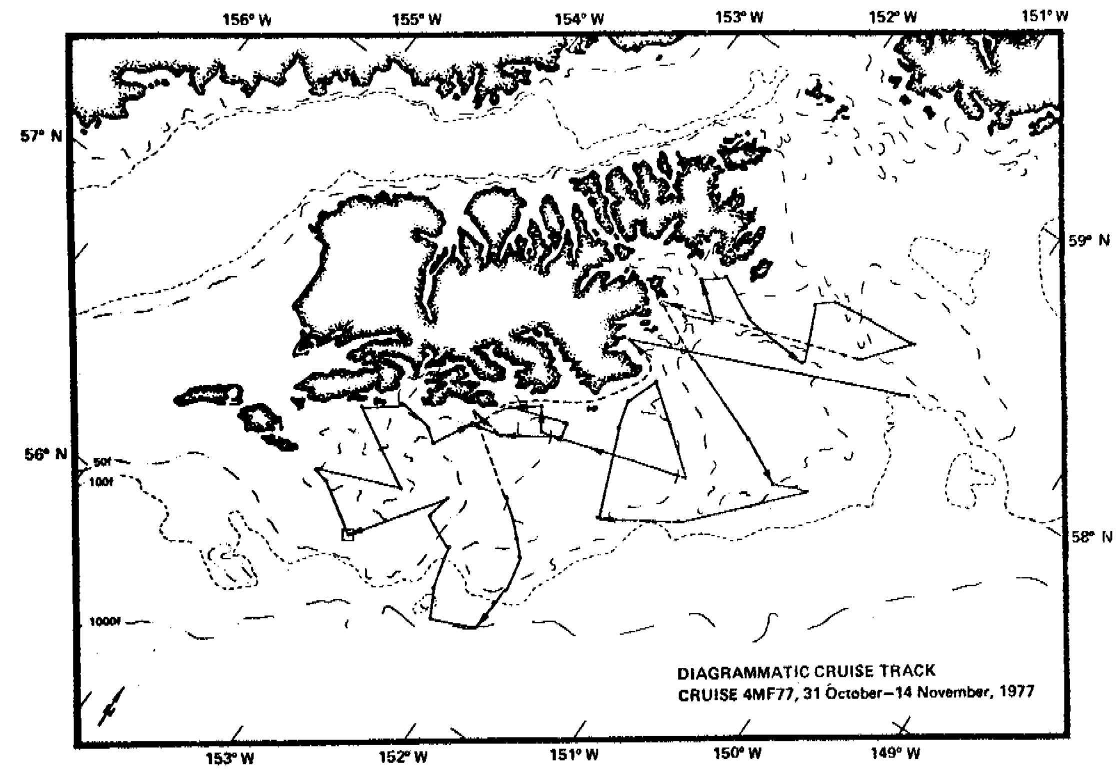


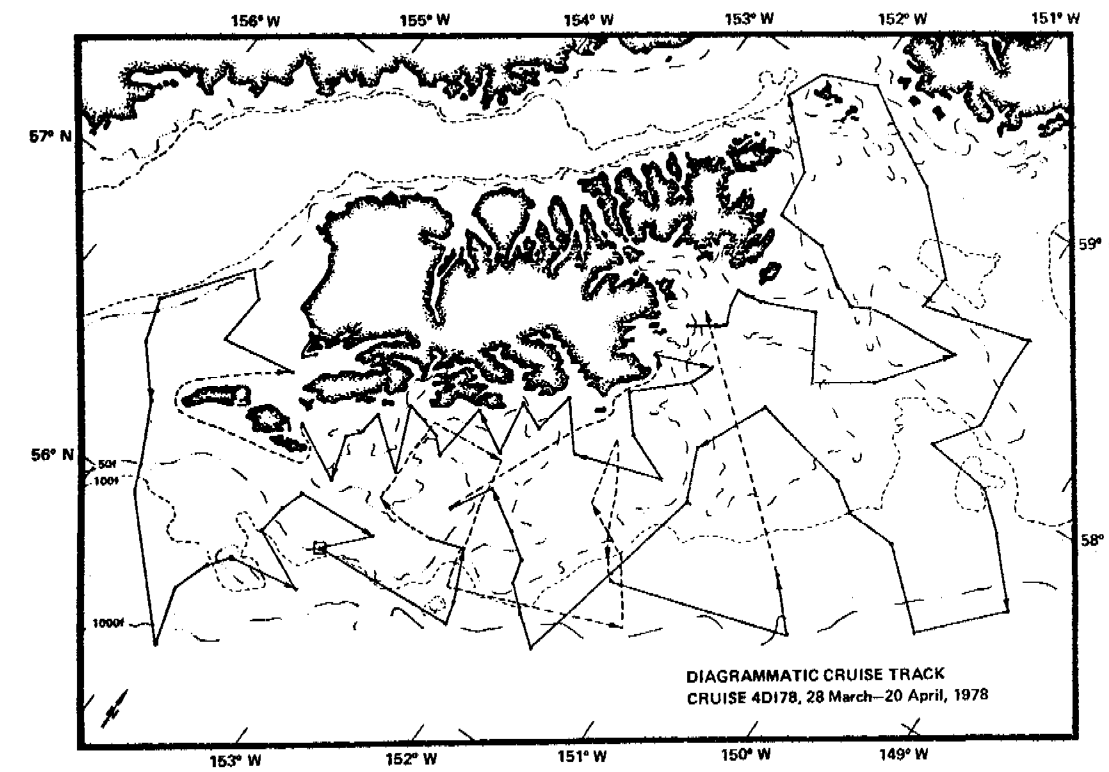
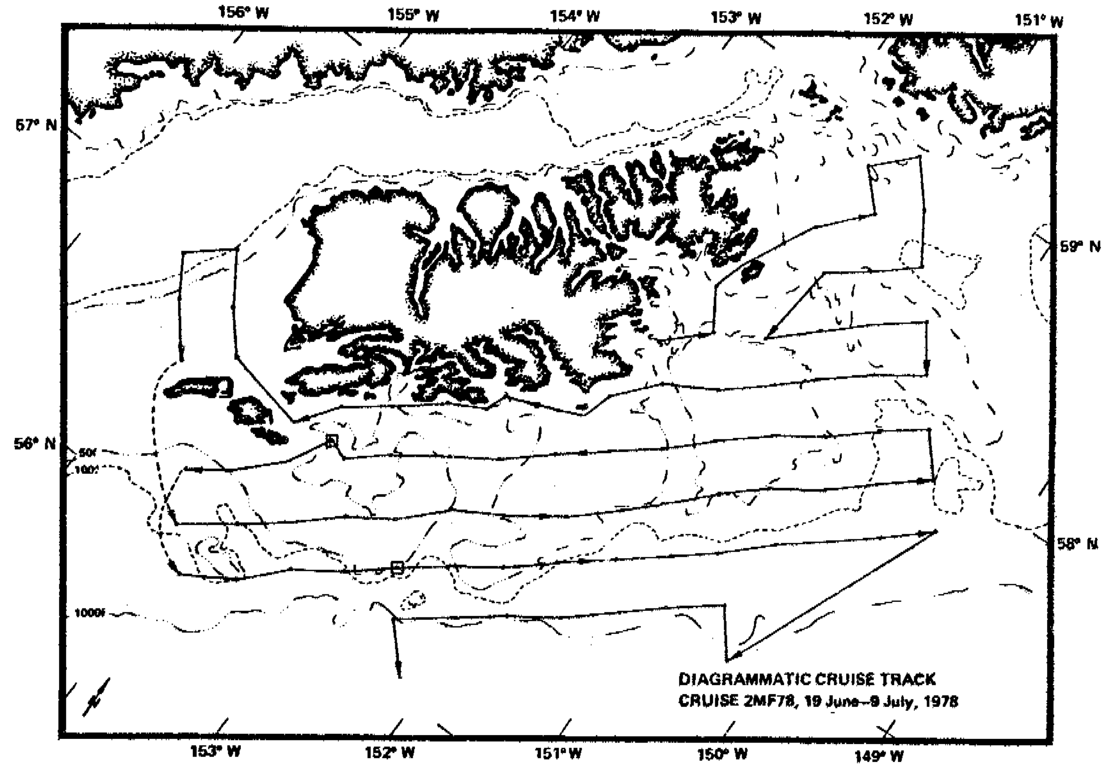


Figure 1.--Cruise track, Fall, 1977
Figure 2.--Cruise track, Spring, 1978



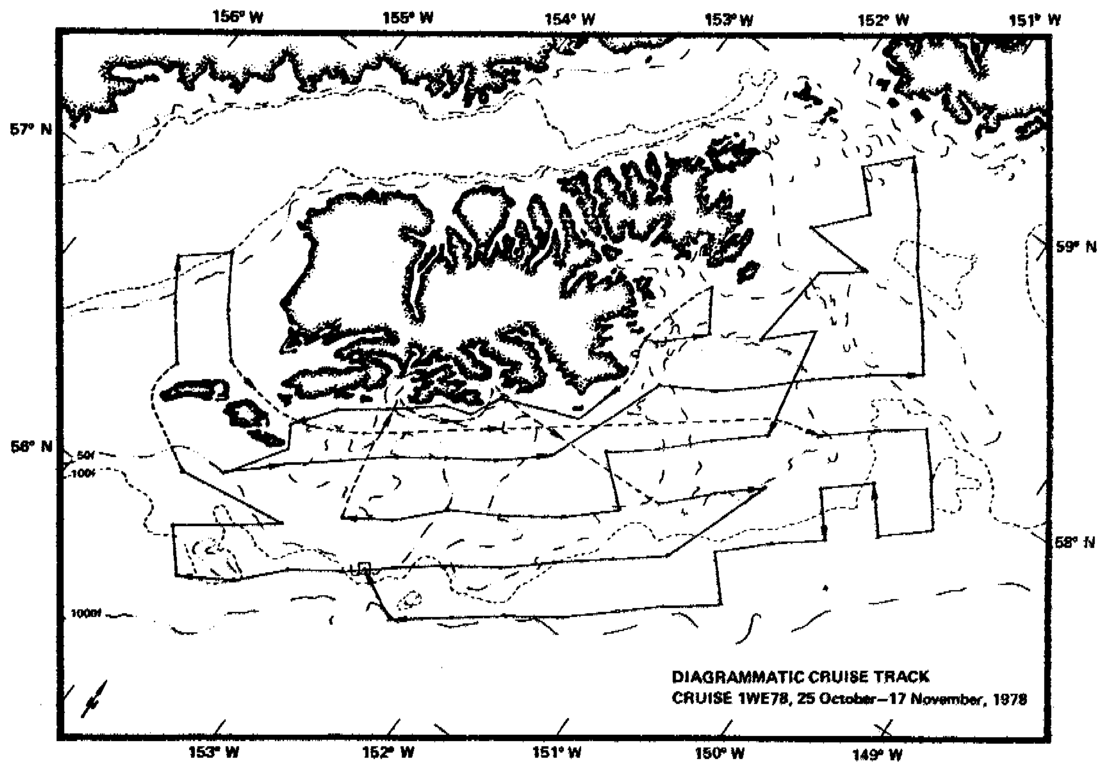
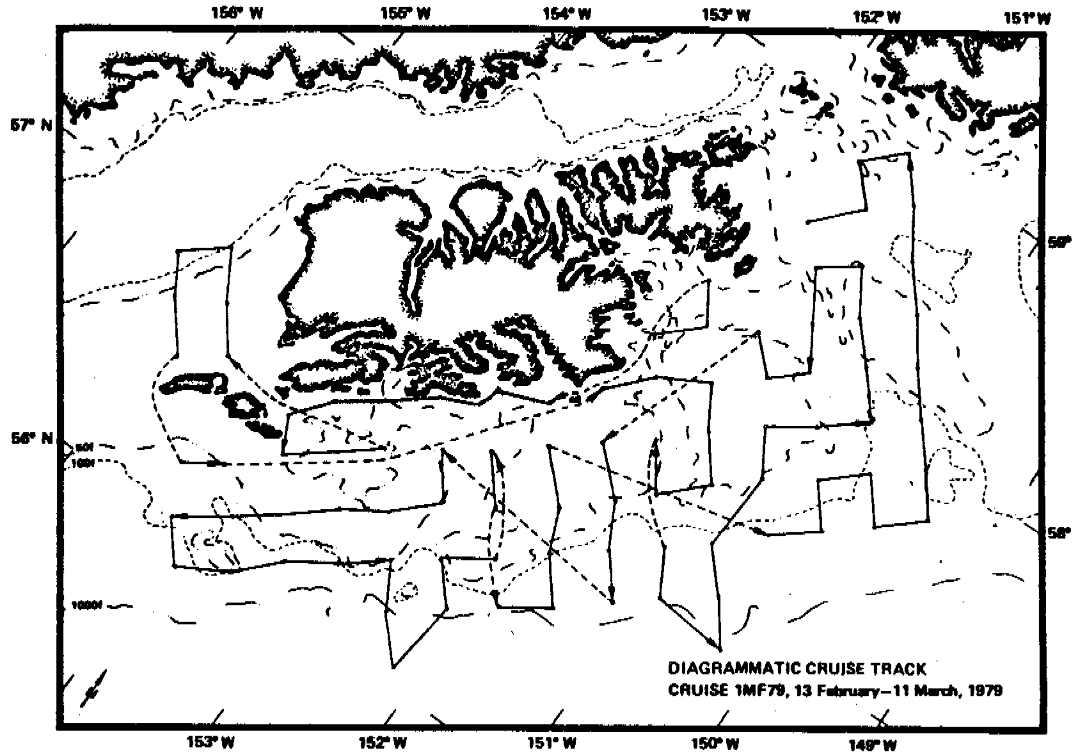


Figure 3.--Cruise track, Summer, 1978
Figure 4.--Cruise track, Fall, 1978



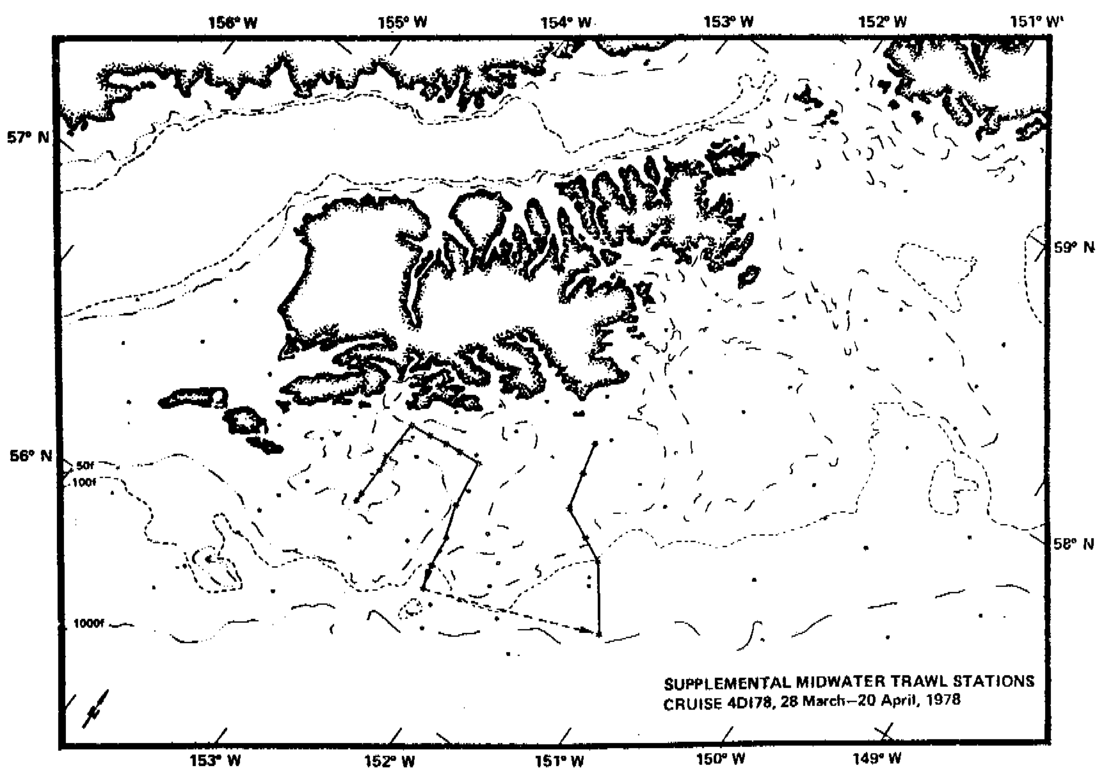
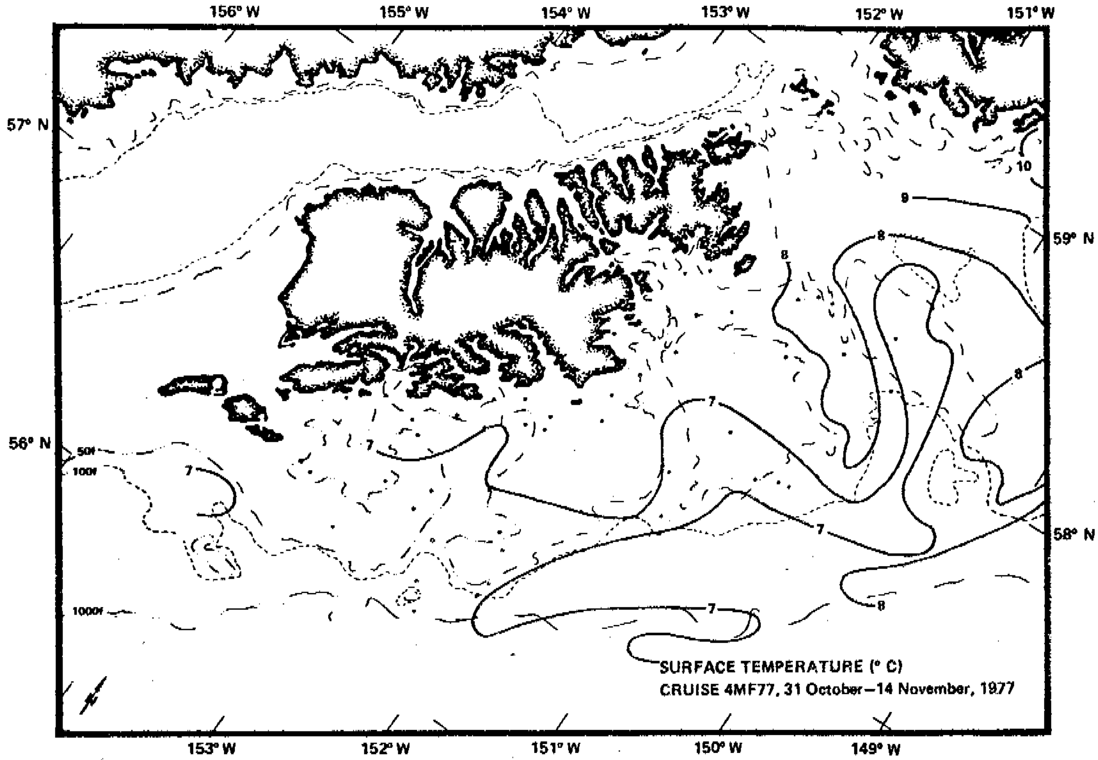


Figure 5.--Cruise track, Winter, 1979
Figure 6.--Supplemental midwater trawl stations, Spring, 1978



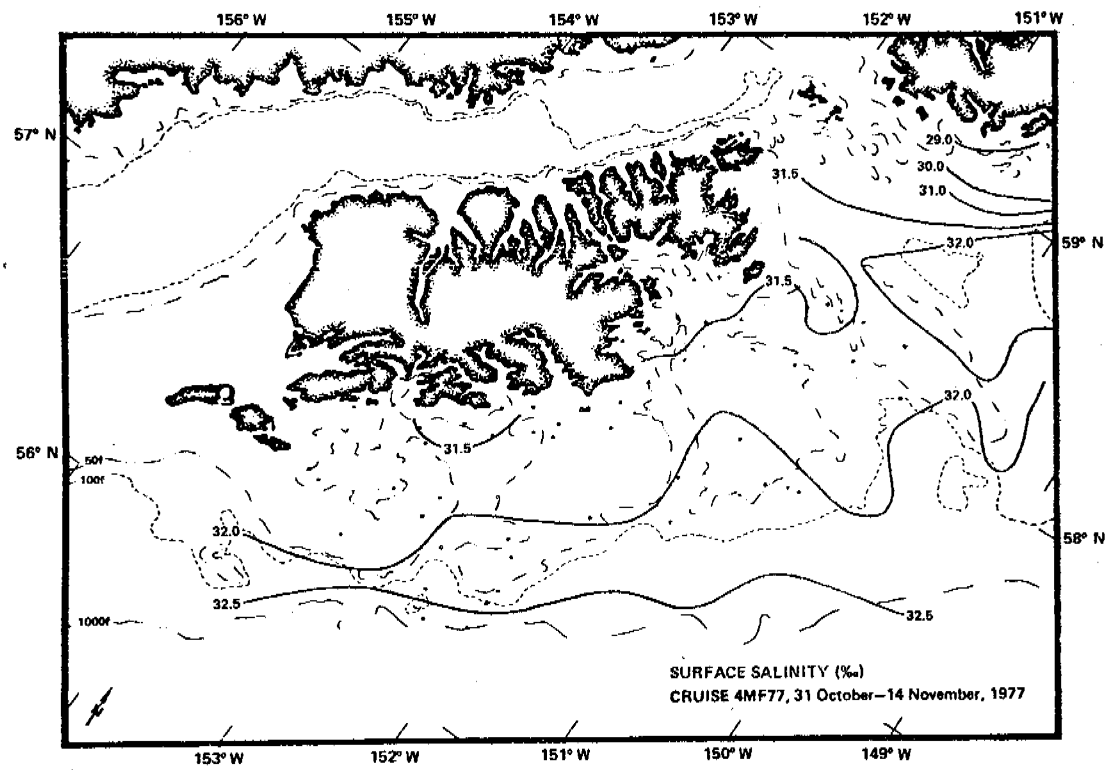
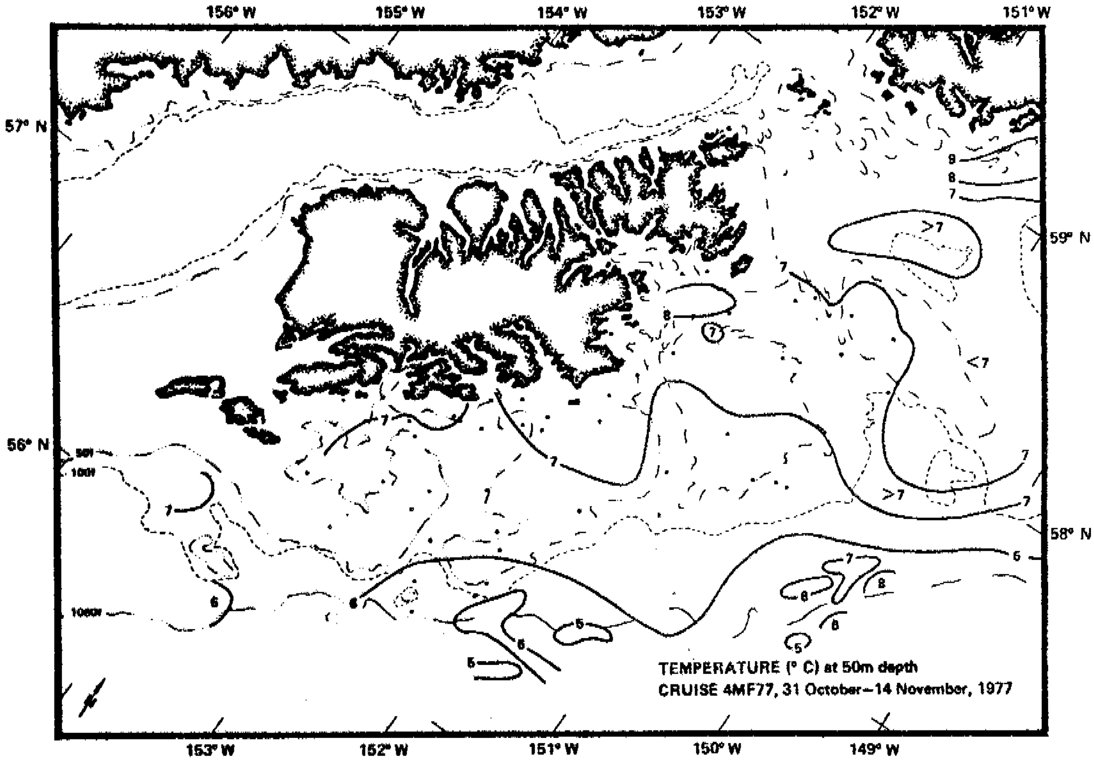


Figure 7.--Surface temperature (°C), Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 8.--Surface salinity (‰), Fall, 1977 (Data from Schumacher, et al., In Press.)



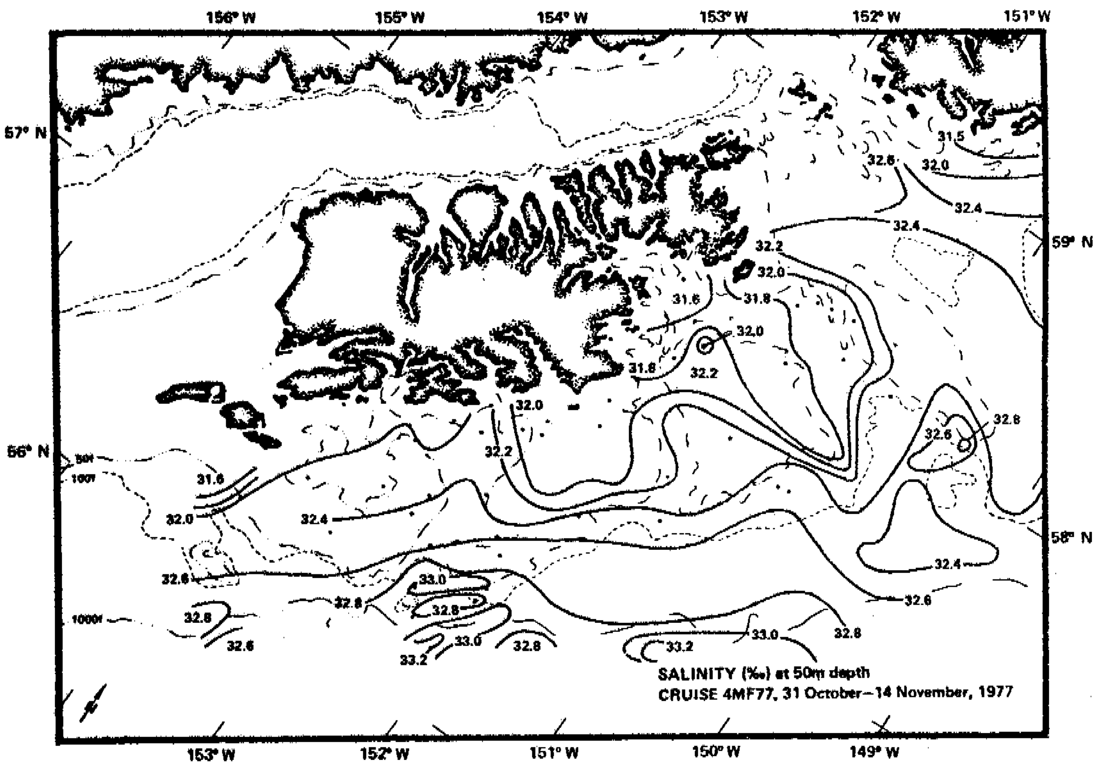
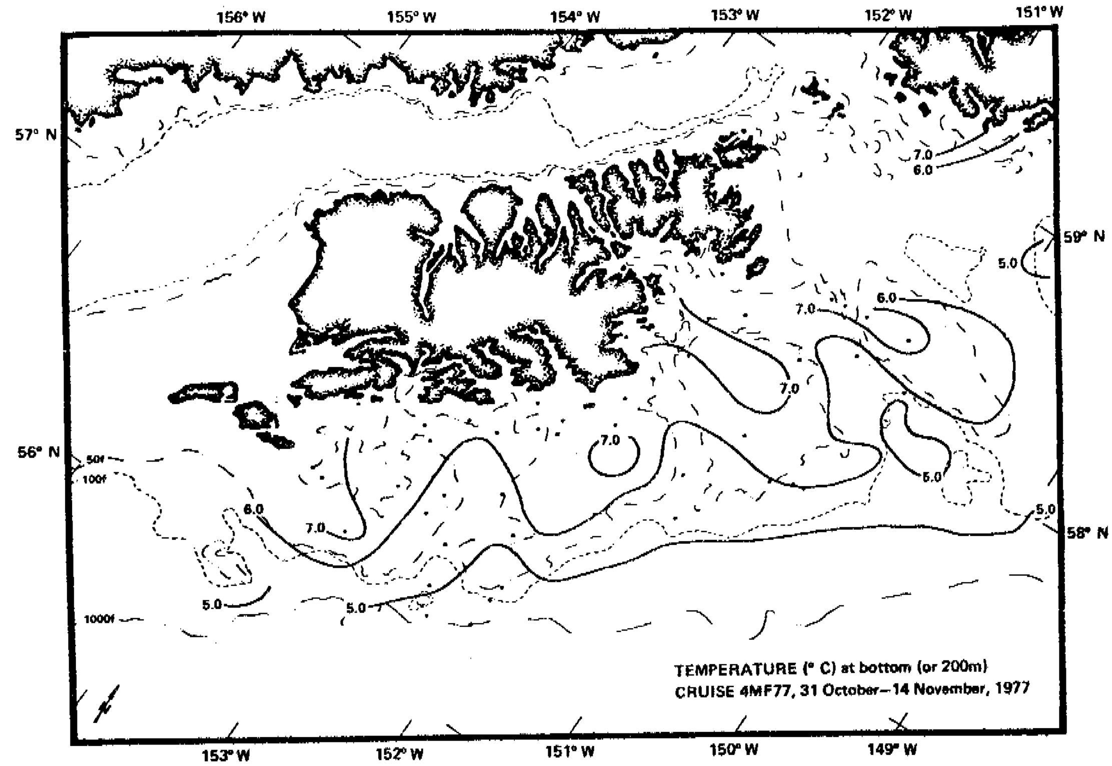


Figure 9.--Temperature (°C) at 50 m depth, Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 10.--Salinity (‰) at 50 m depth, Fall, 1977 (Data from Schumacher, et al., In Press.)



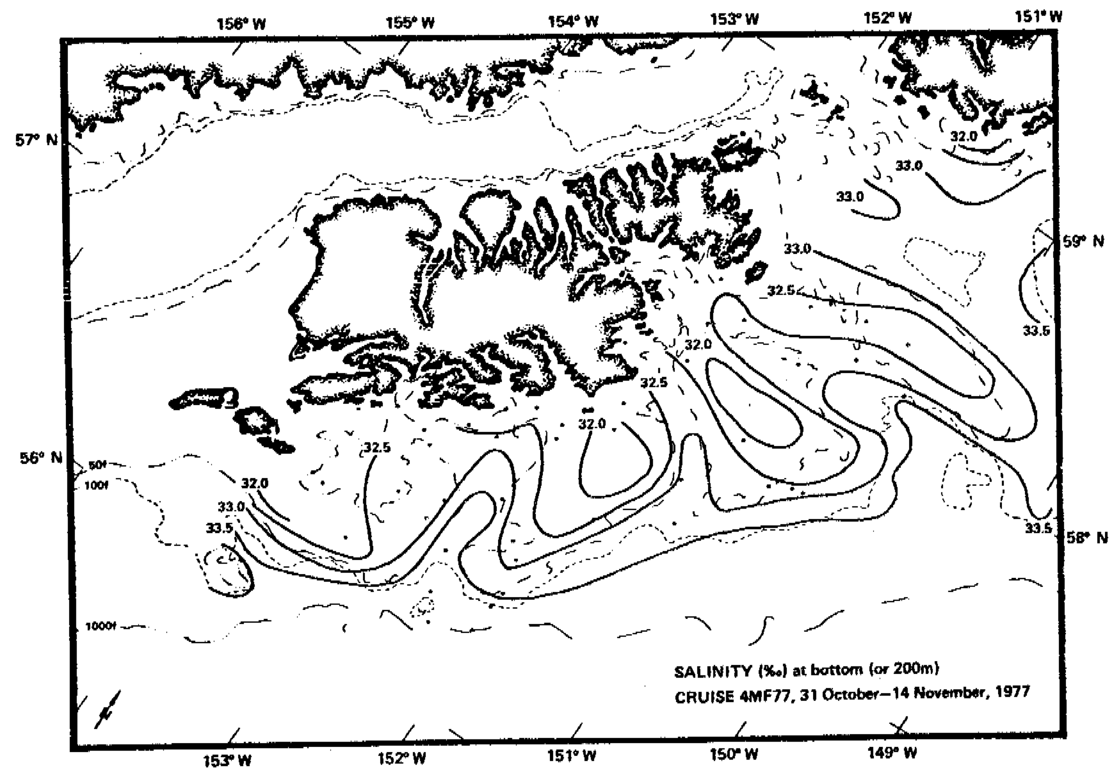
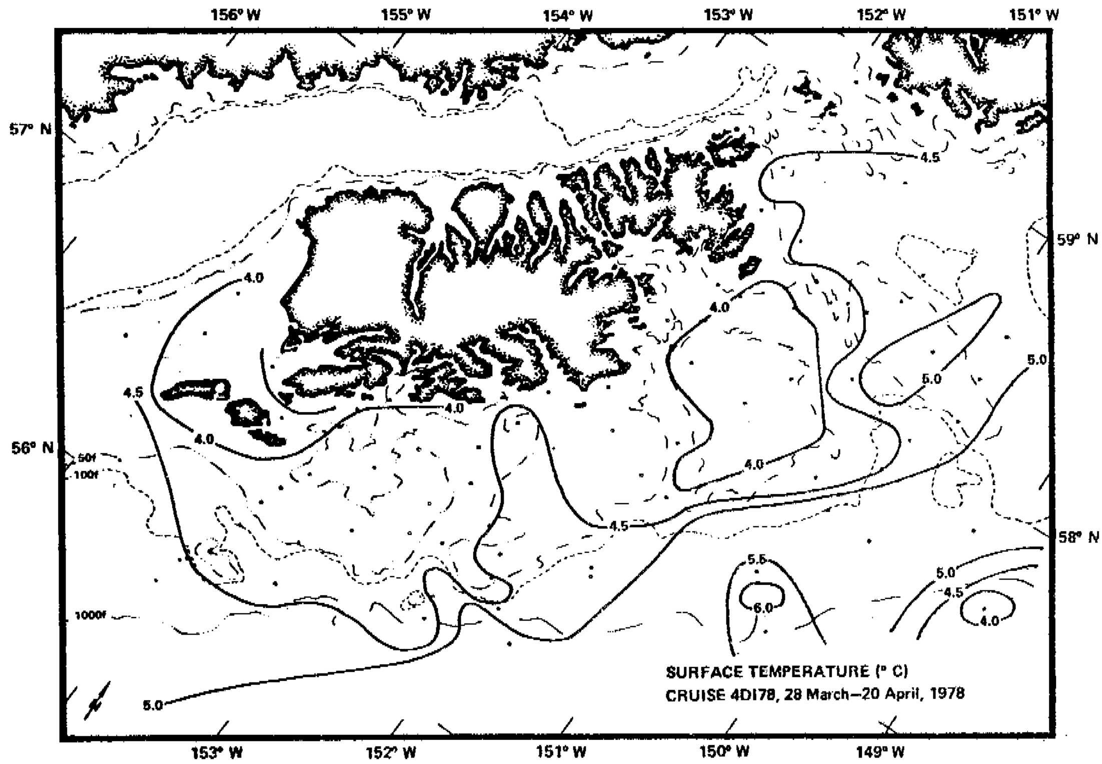


Figure 11.--Temperature (^{O}C) at bottom (or 200 m), Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 12.--Salinity (‰) at bottom (or 200 m), Fall, 1977 (Data from Schumacher, et al., In Press.)



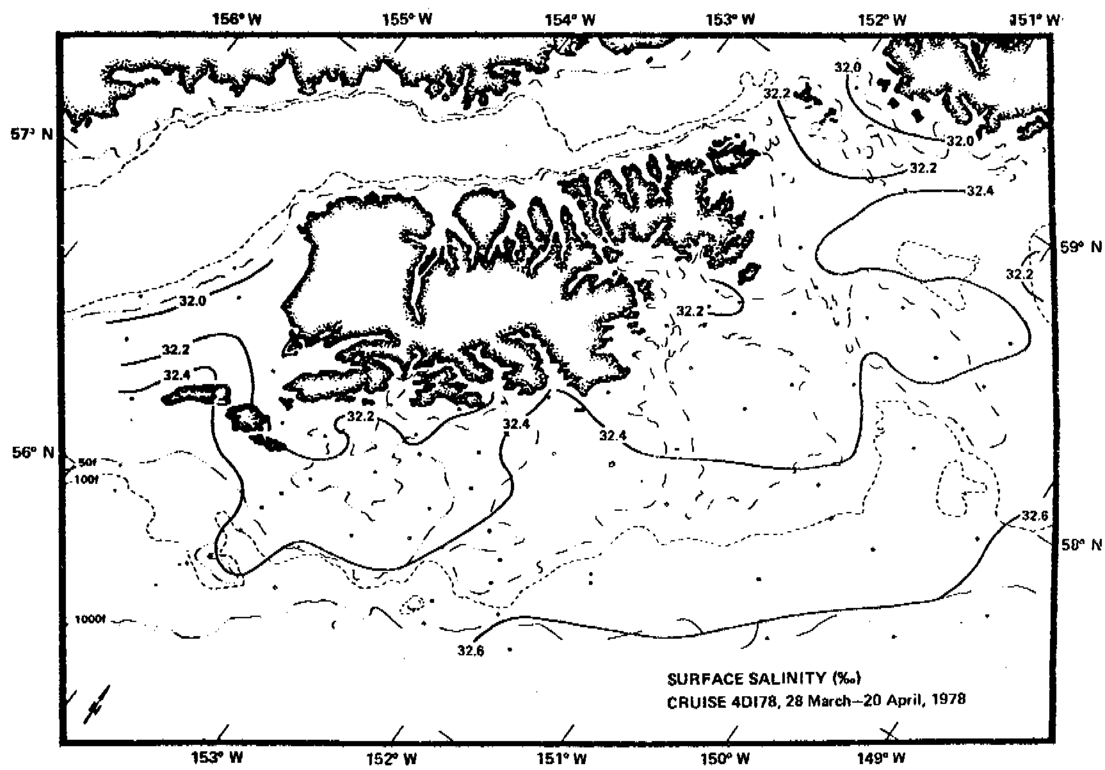
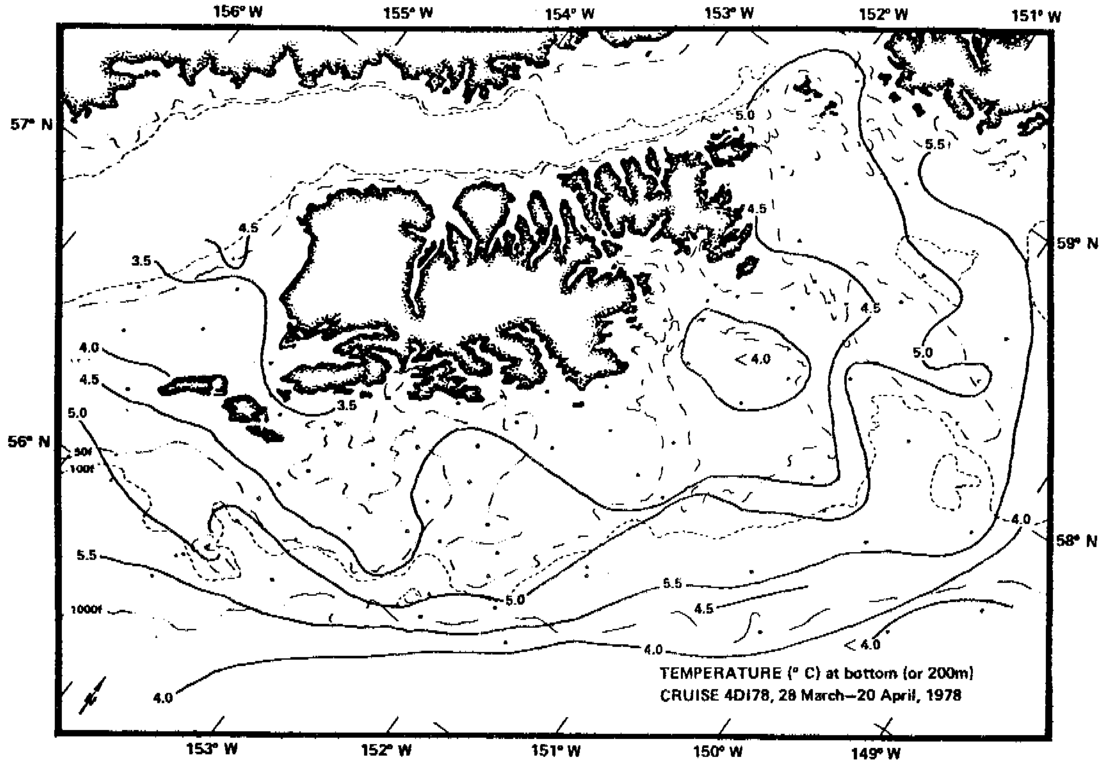


Figure 13.--Surface temperature (°C), Spring, 1978
Figure 14.--Surface salinity (‰), Spring 1978



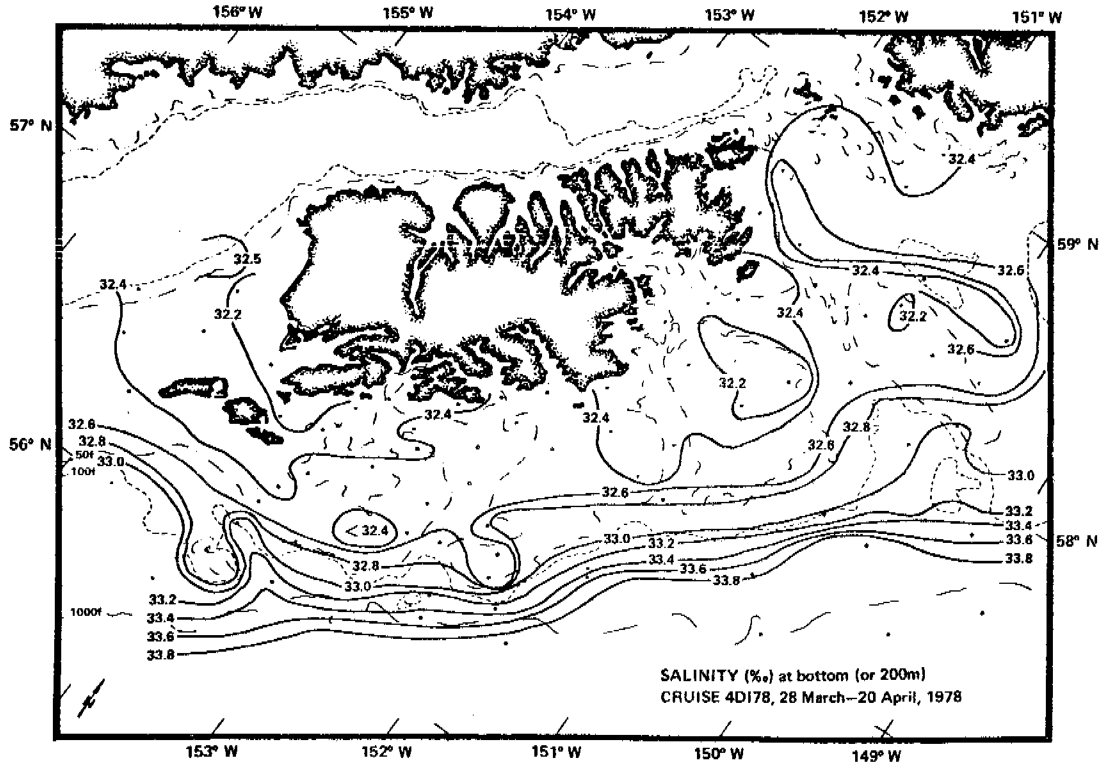


Figure 15.--Temperature (°C) at bottom (or 200 m), Spring, 1978
Figure 16.--Salinity (‰) at bottom (or 200 m), Spring, 1978

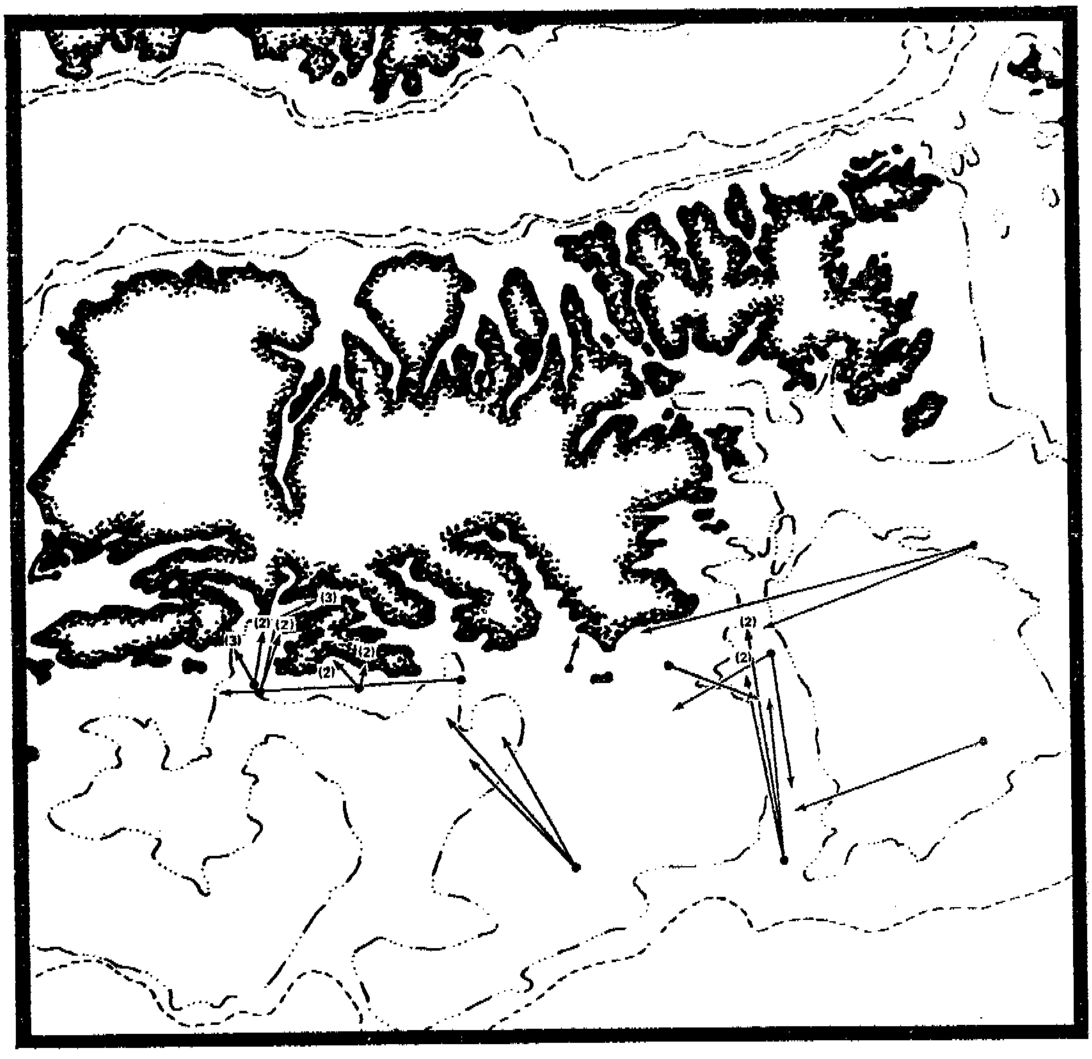


Figure 17.--Sea bed drifter recoveries from releases made in November, 1977 through November, 1978

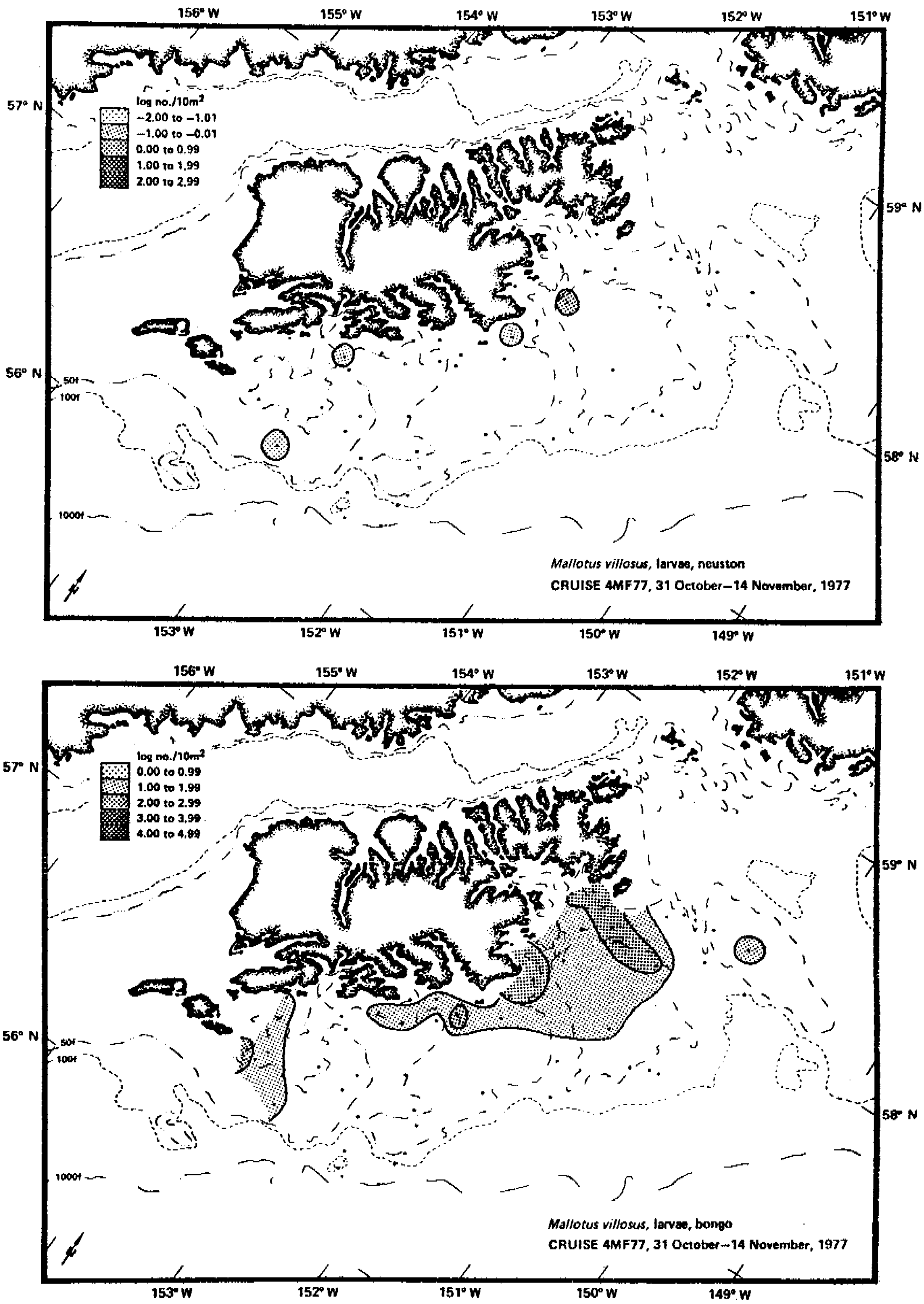


Figure 18.--Distribution and abundance of Mallotus villosus larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

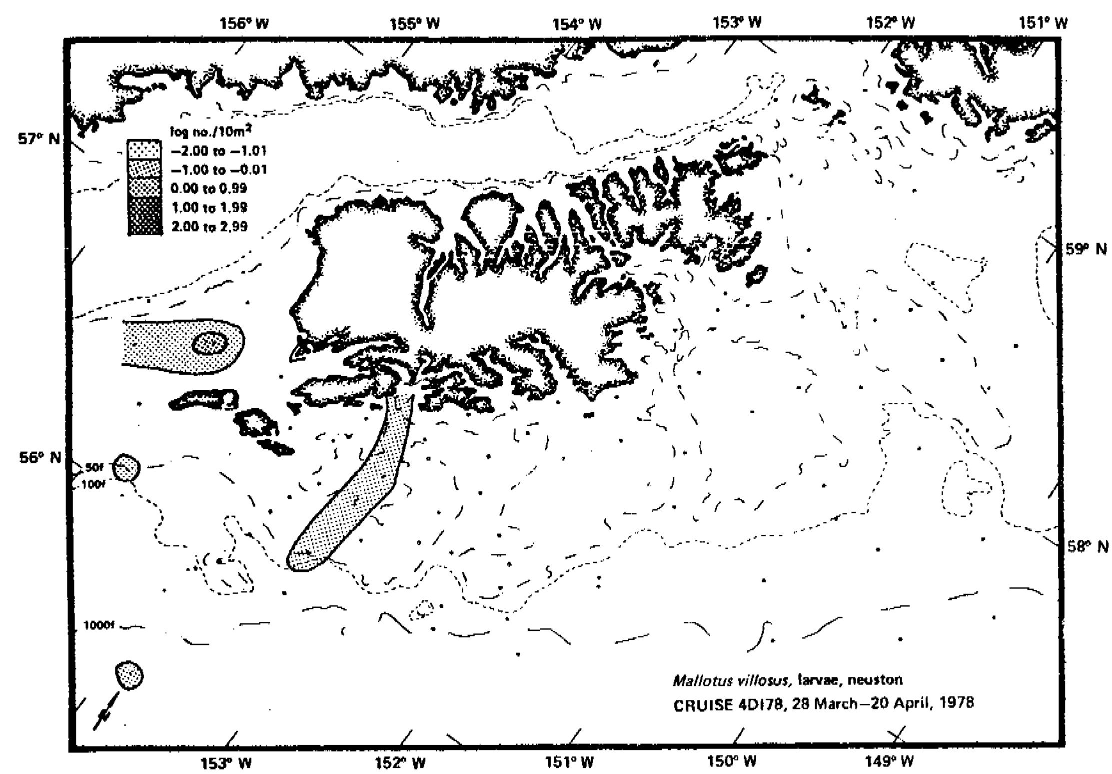


Figure 19.--Distribution and abundance of Mallotus villosus larvae in neuston tows from the Spring cruise.

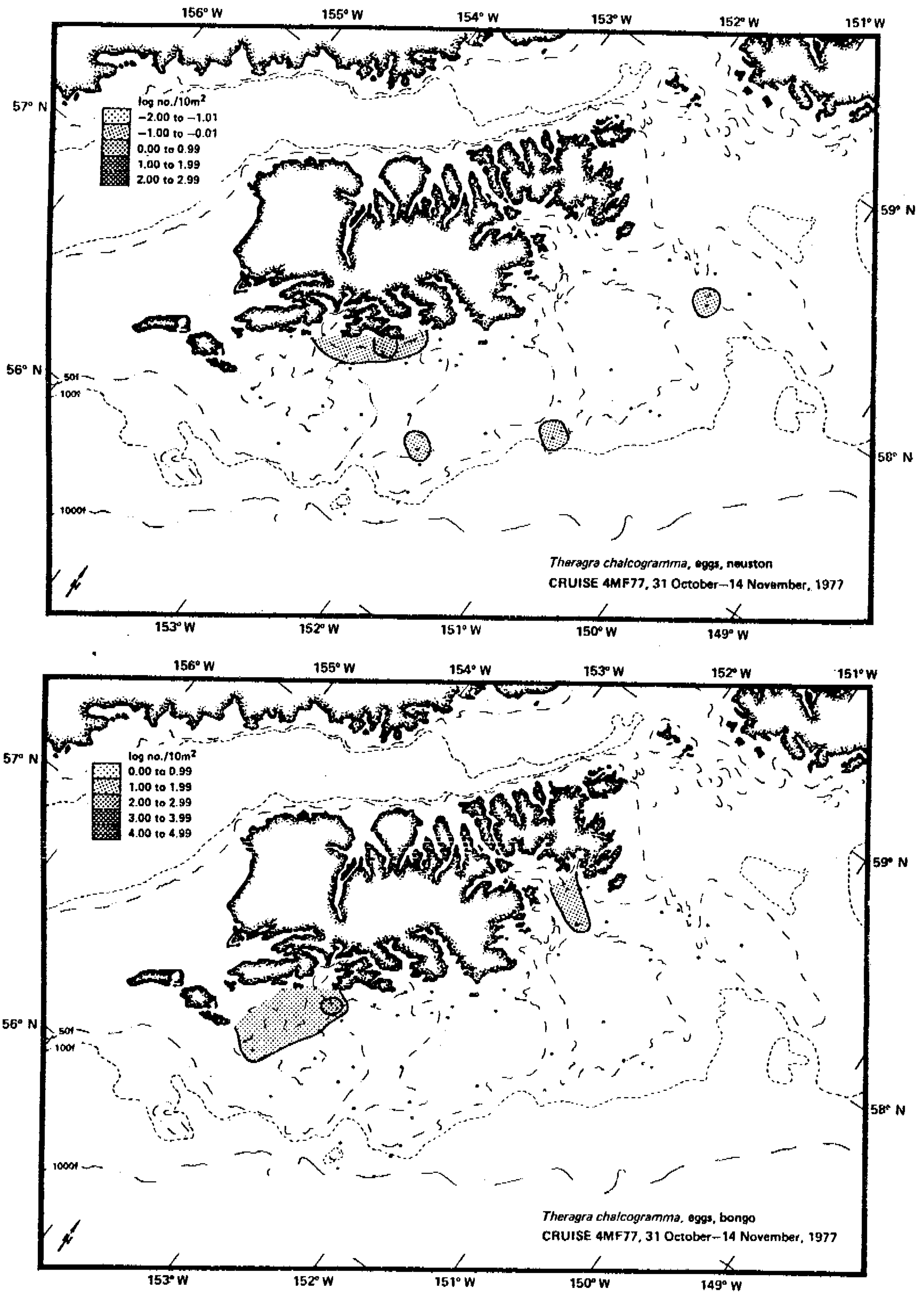


Figure 20.--Distribution and abundance of Theragra chalcogramma eggs in neuston (top) and bongo (bottom) tows from the Fall cruise.

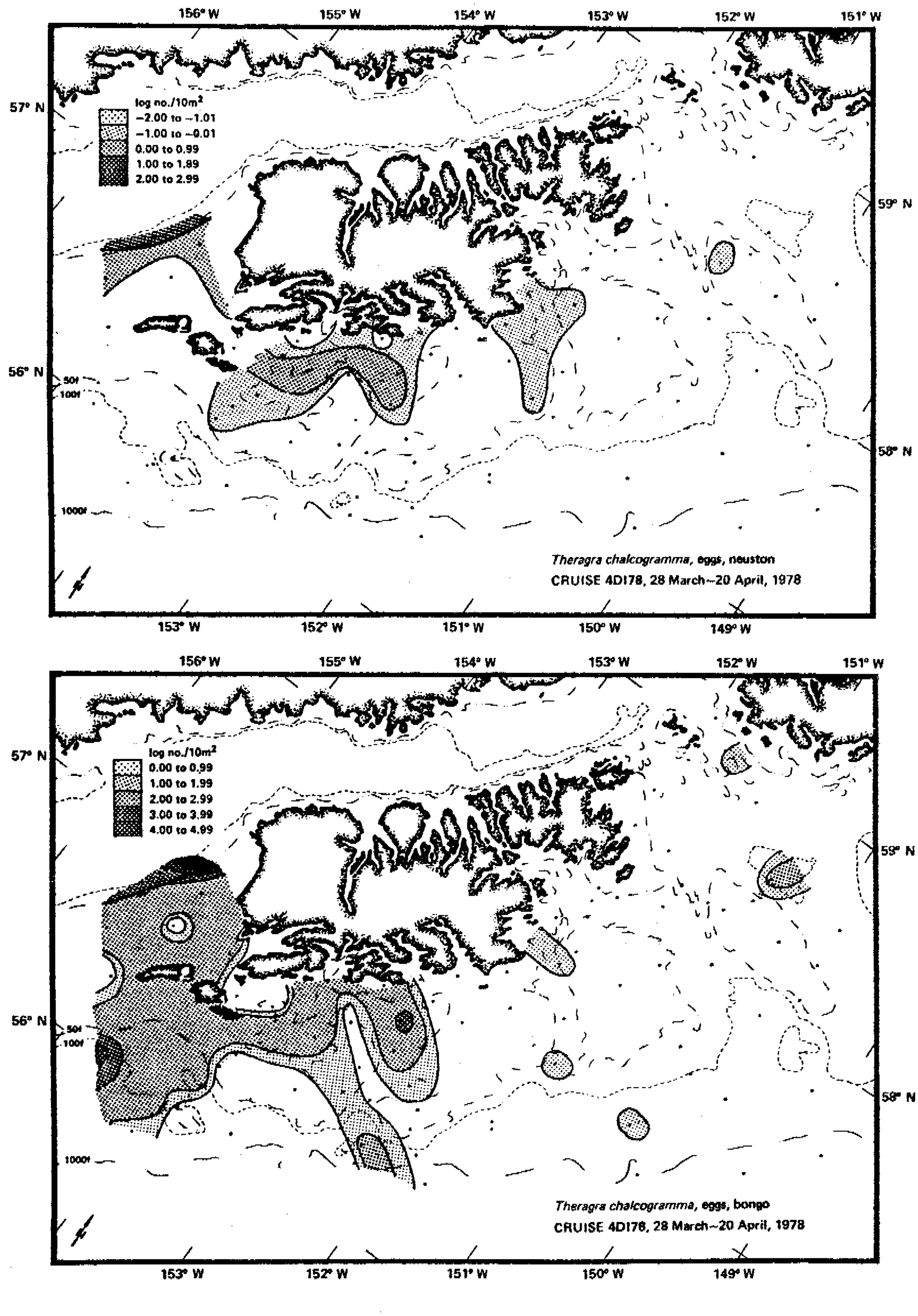


Figure 21.--Distribution and abundance of Theragra chalcogramma eggs in neuston (top) and bongo (bottom) tows from the Spring cruise.

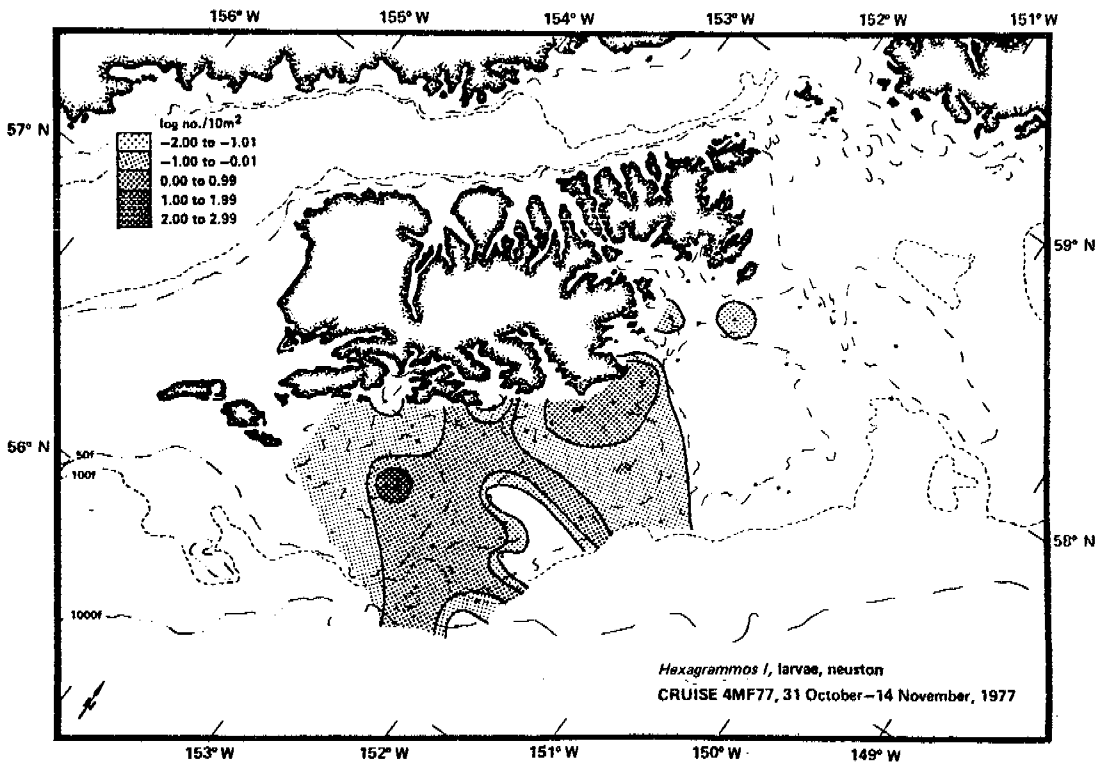
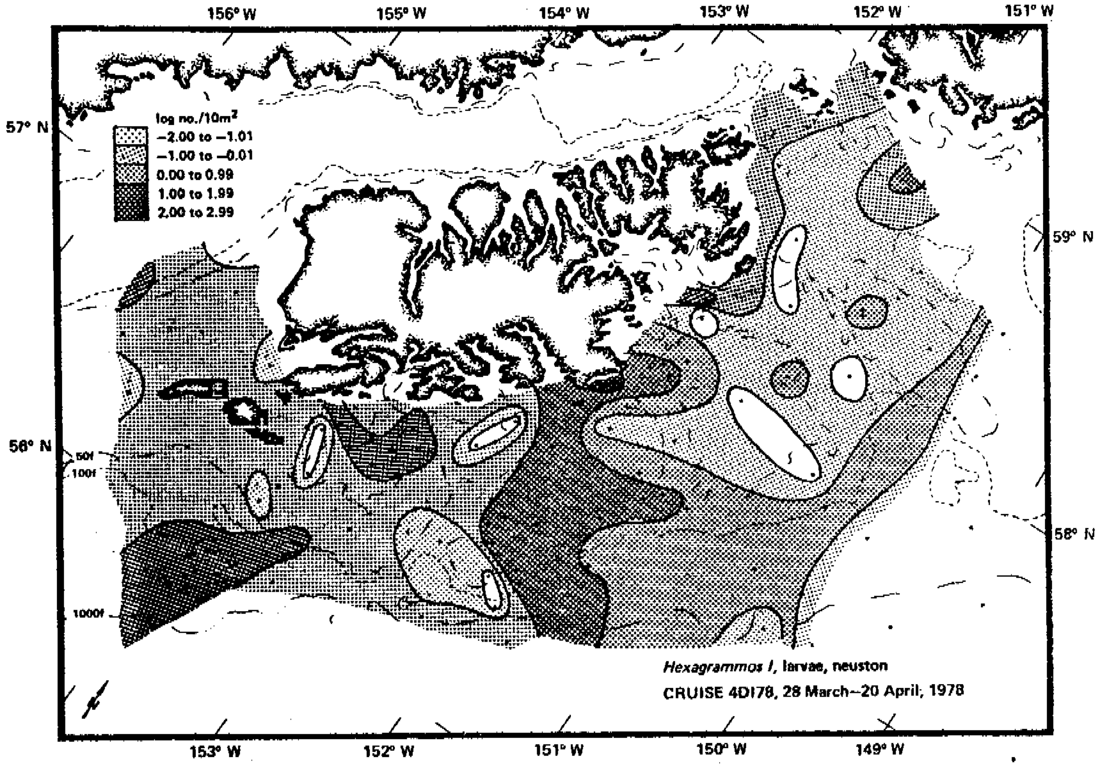


Figure 22 --Distribution and abundance of Hexagrammos I larvae in neuston tows from the Fall cruise.



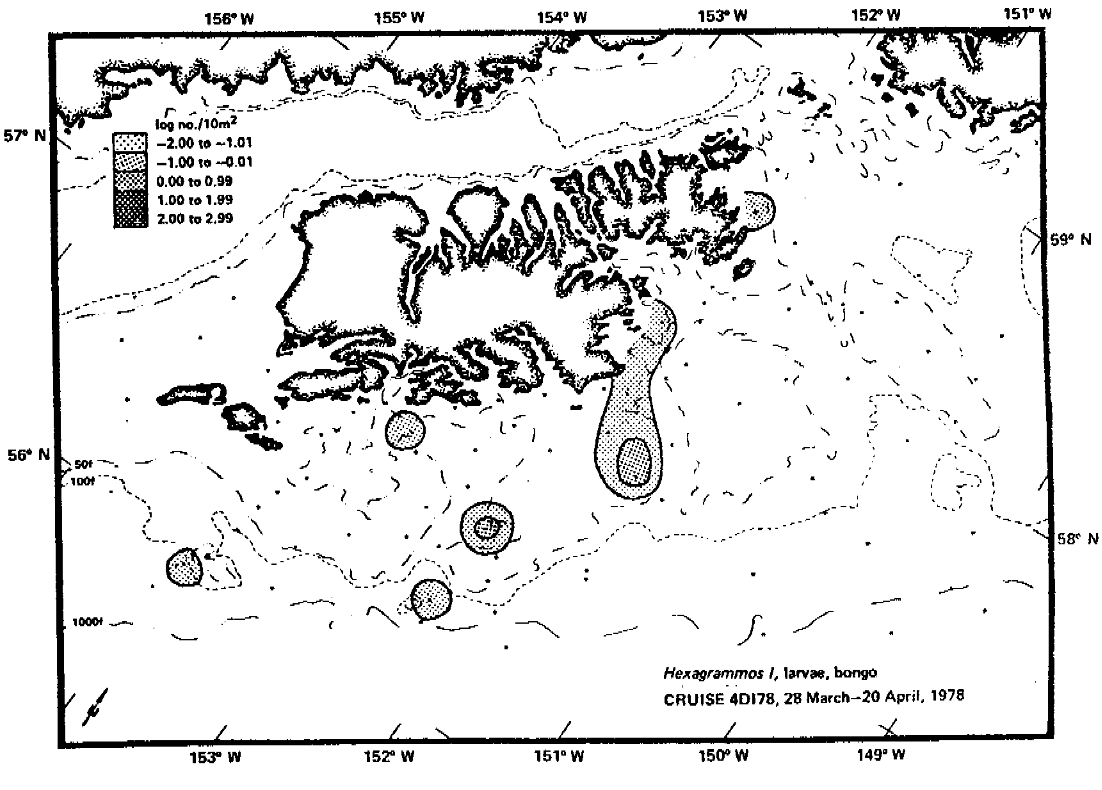


Figure 23.--Distribution and abundance of Hexagrammos I larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.

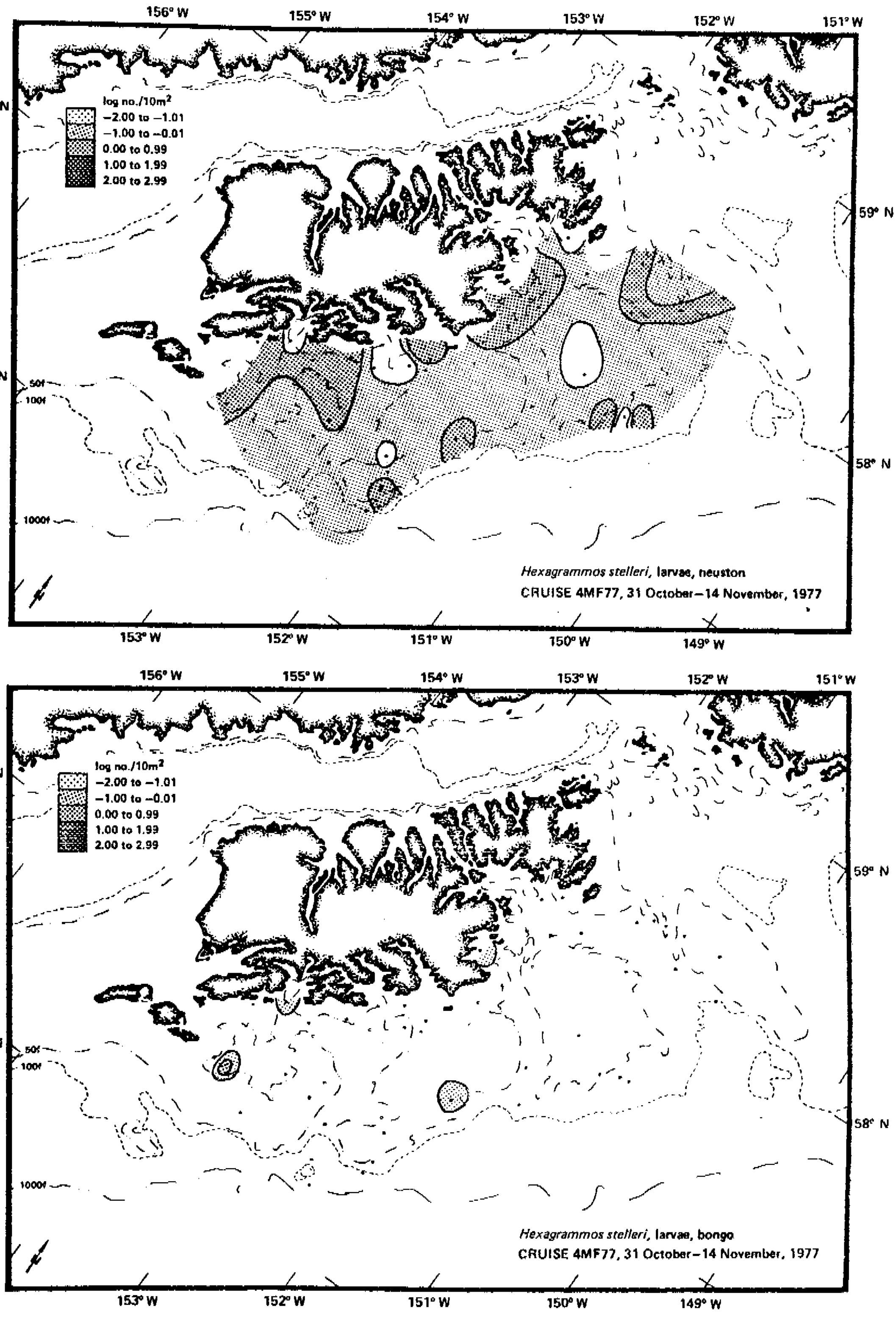


Figure 24.--Distribution and abundance of Hexagrammos stelleri larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

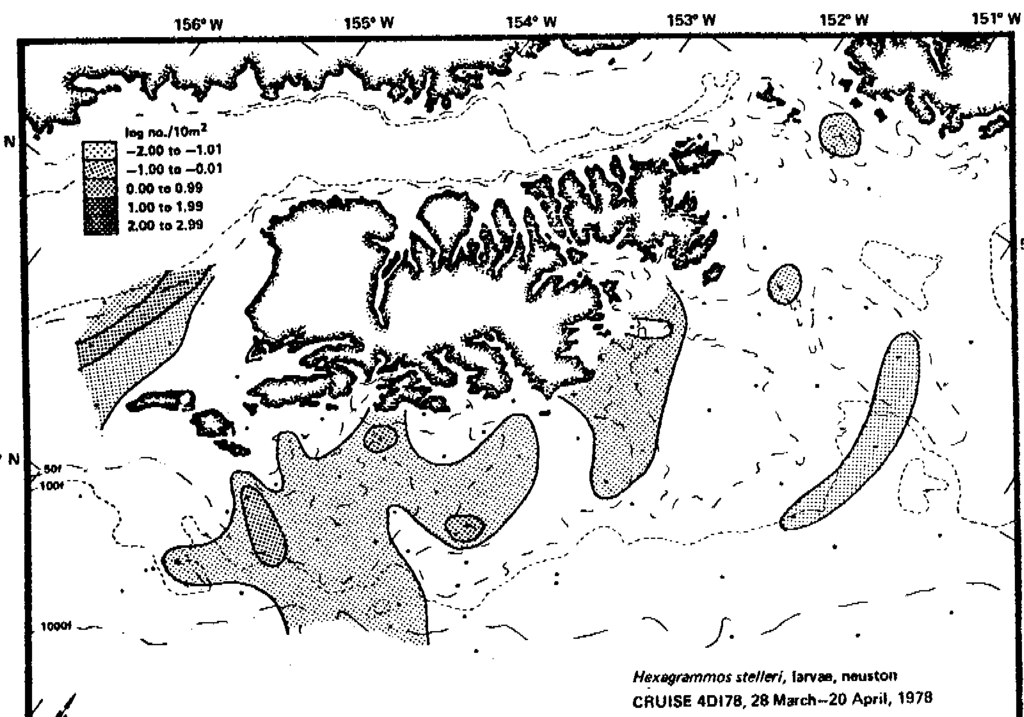
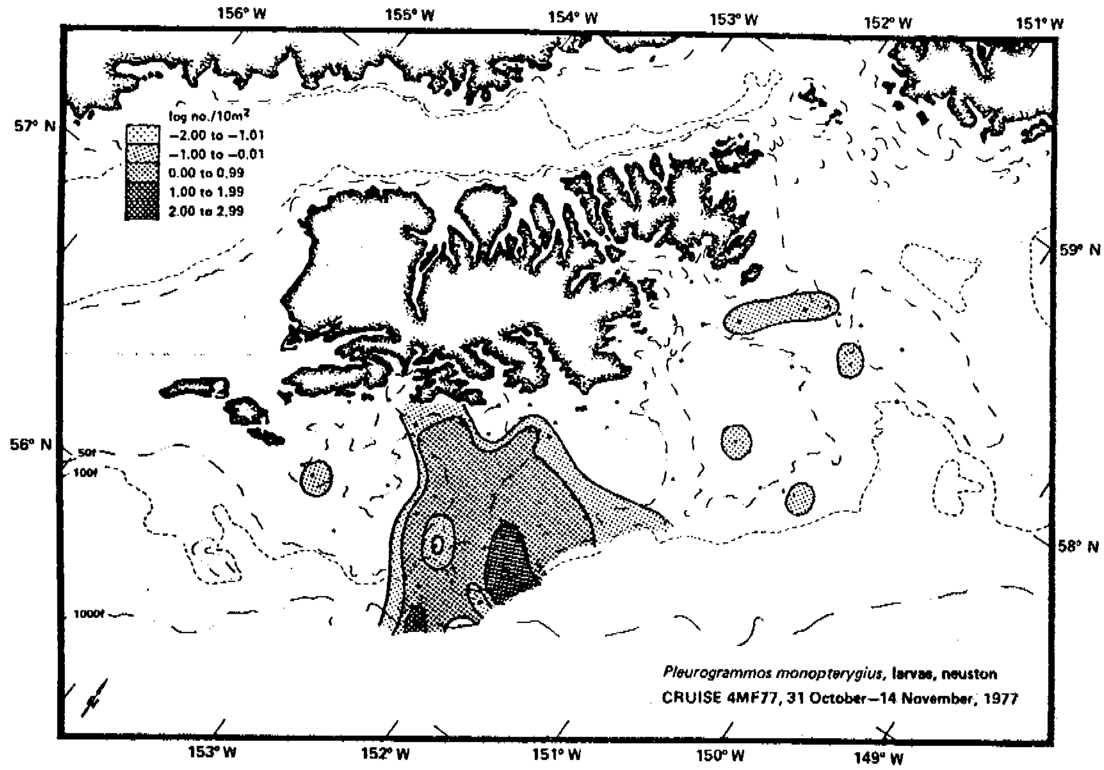


Figure 25.--Distribution and abundance of Hexagrammos stelleri larvae in neuston tows from the Spring cruise.



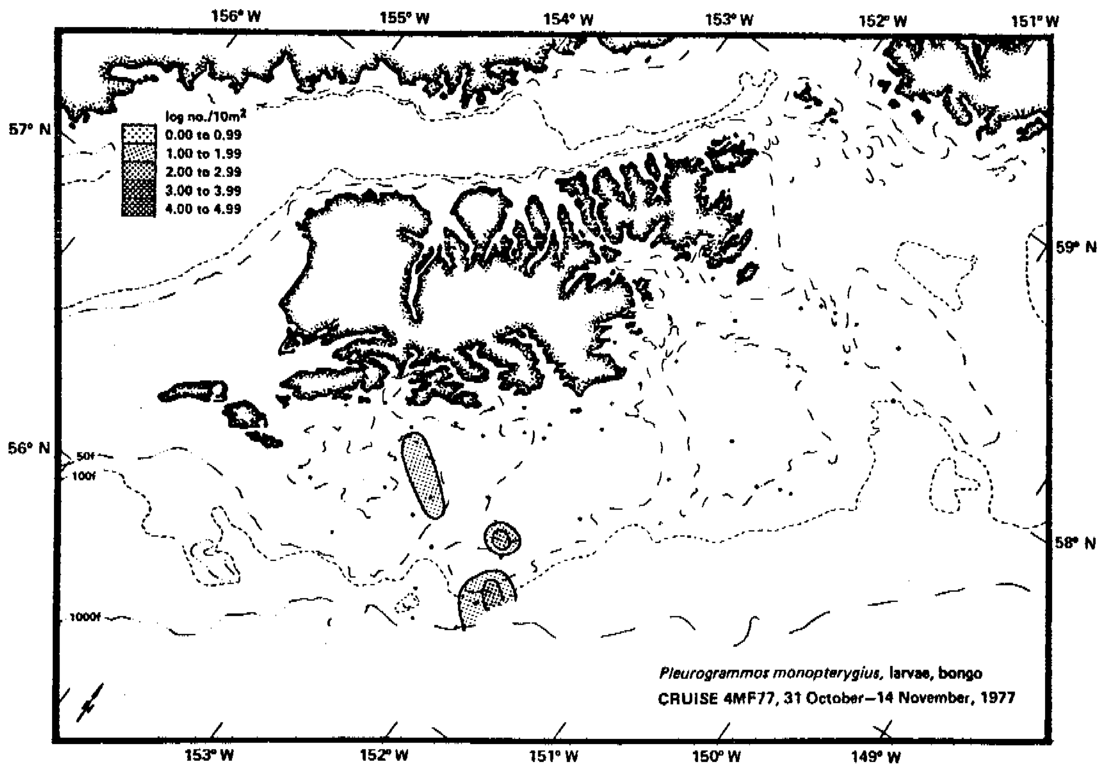


Figure 26.--Distribution and abundance of Pleurogrammos monopterygius larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

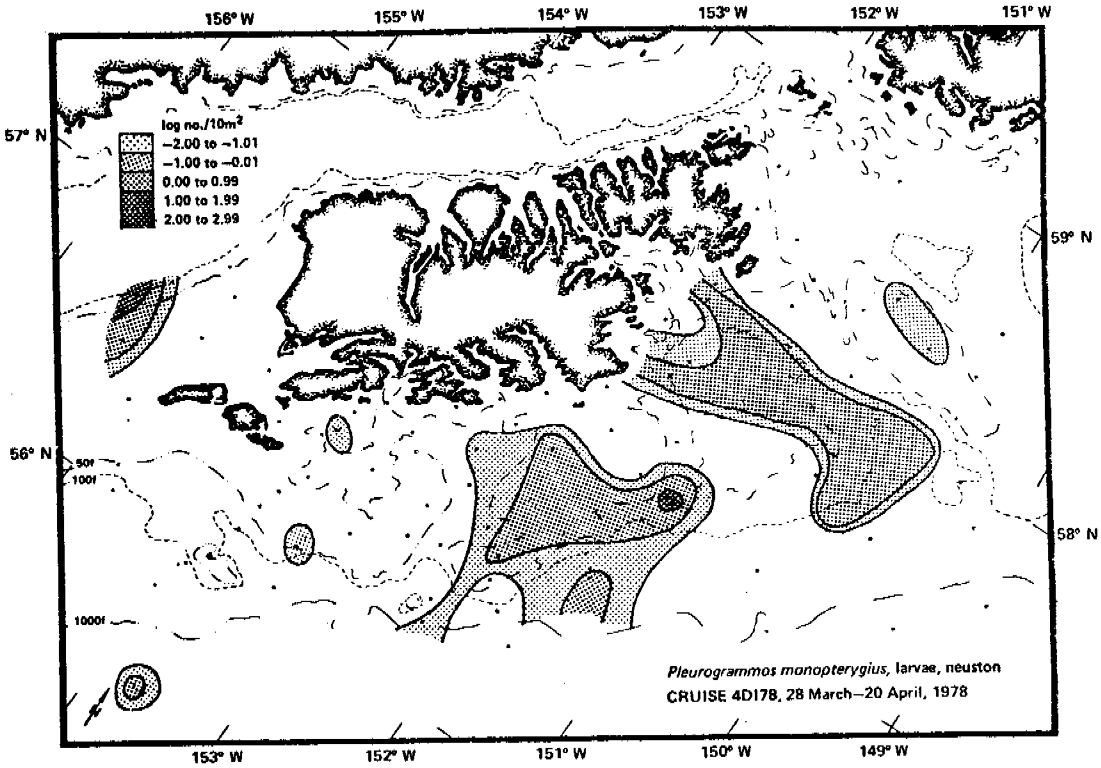


Figure 27.--Distribution and abundance of Pleurogrammos monopterygius larvae in the neuston net from the Spring cruise.

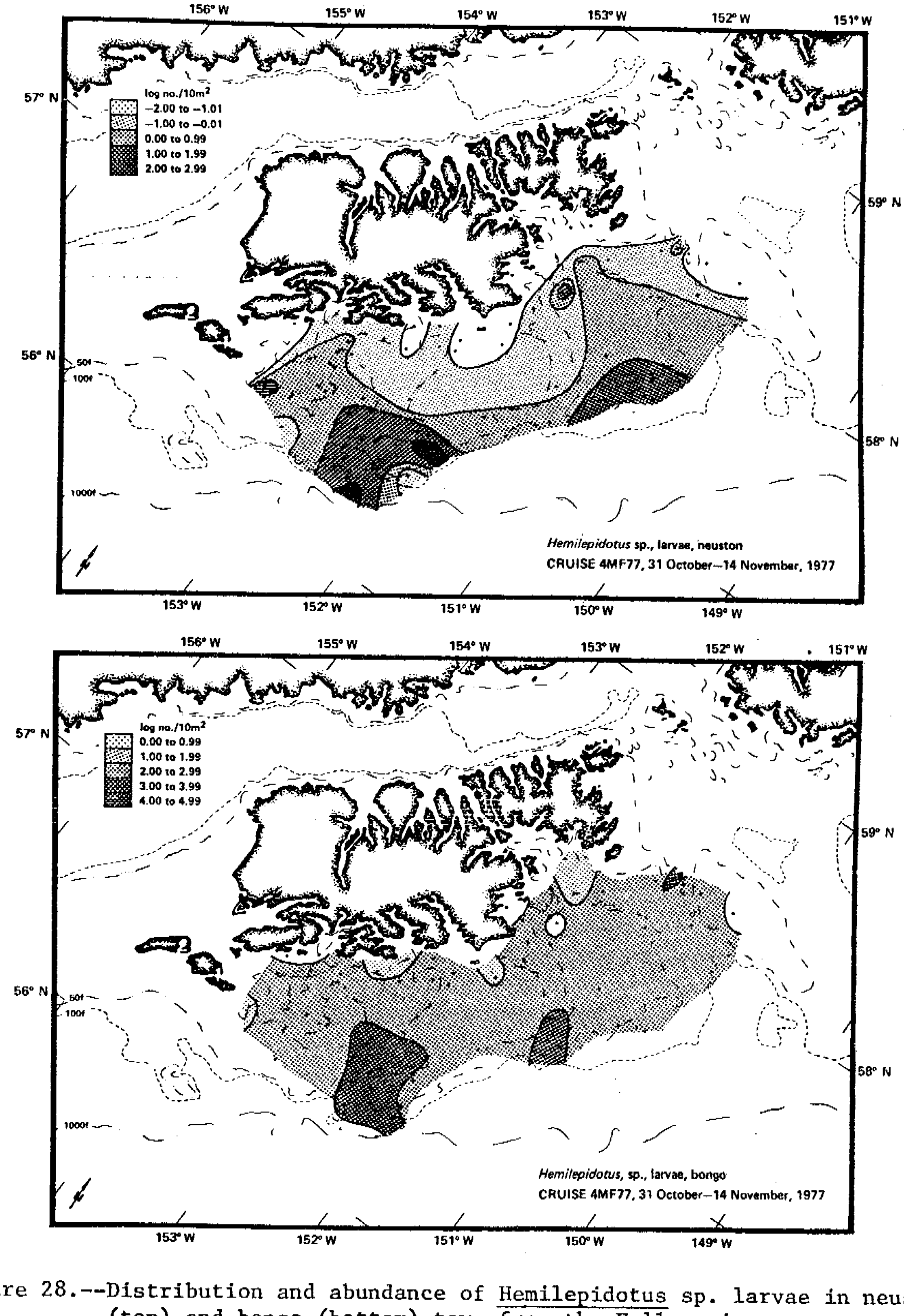


Figure 28.--Distribution and abundance of Hemilepidotus sp. larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

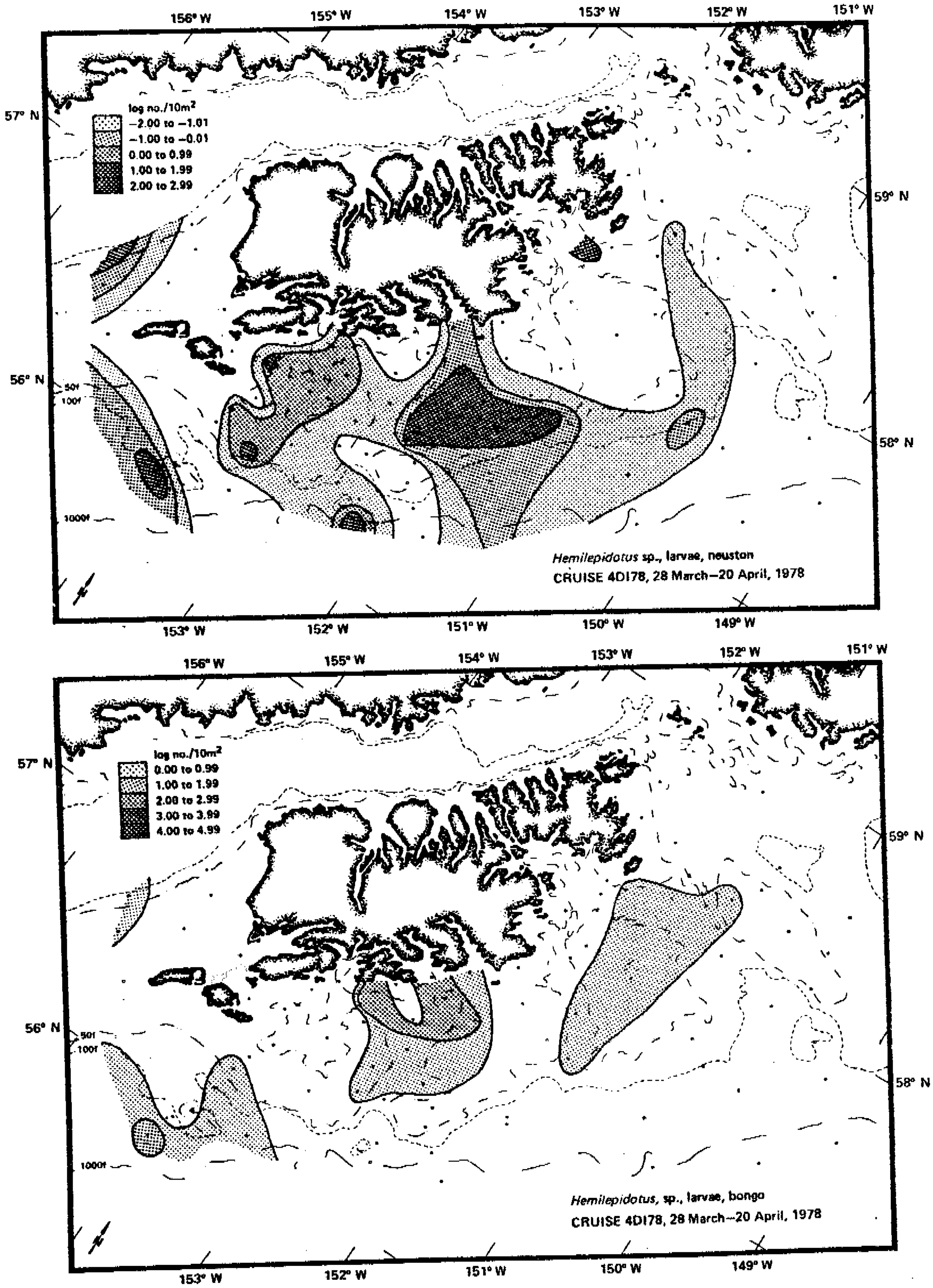


Figure 29.--Distribution and abundance of Hemilepidotus sp. larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.

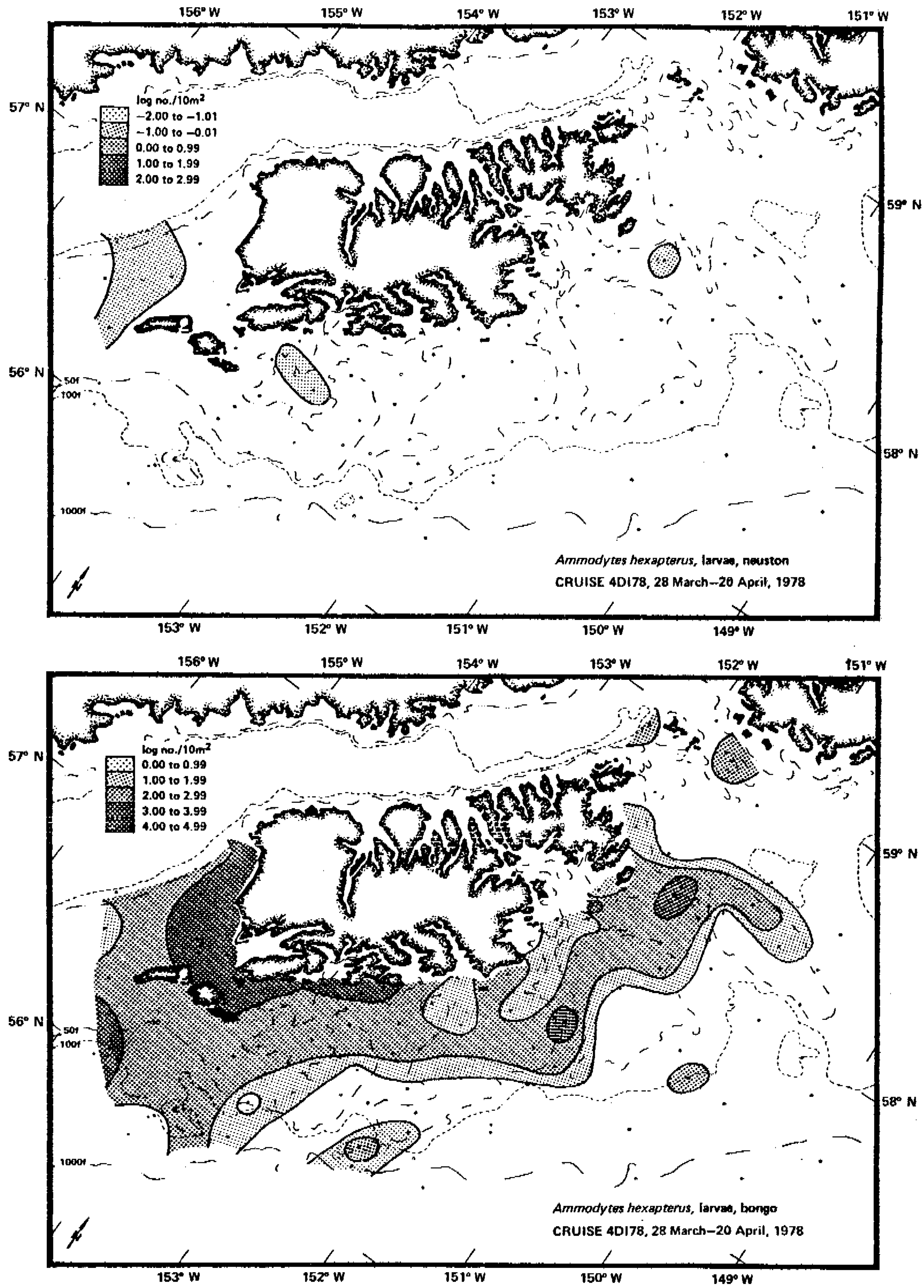
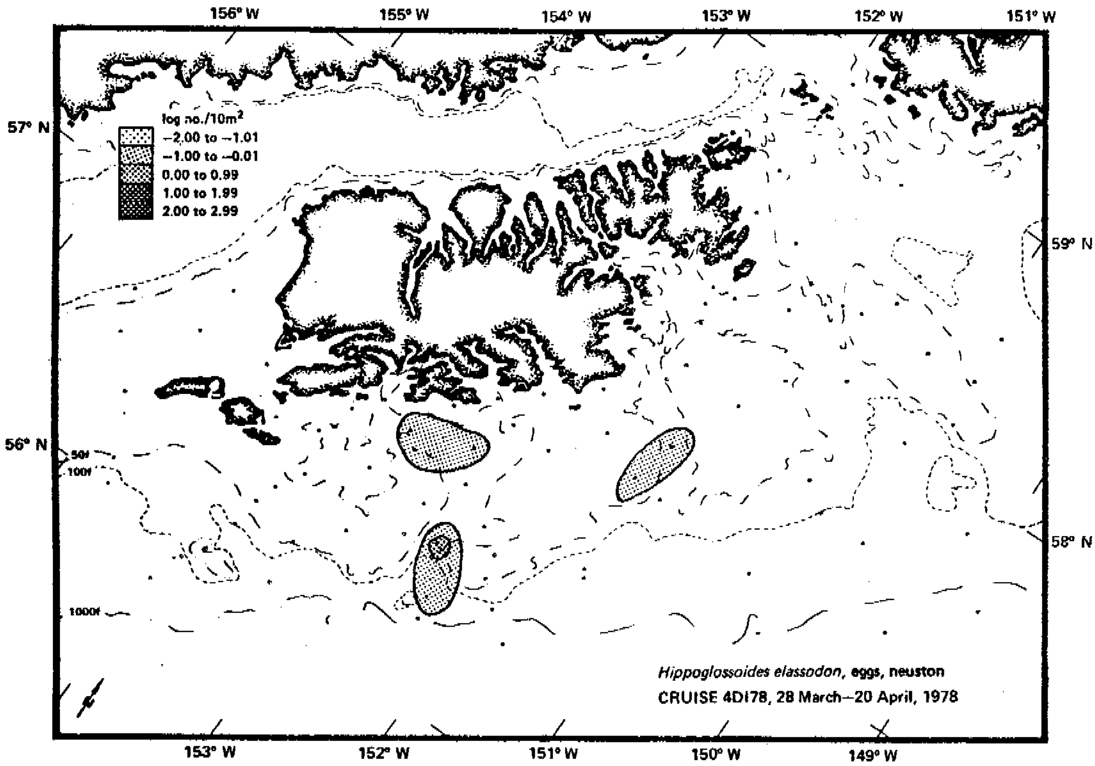


Figure 30.--Distribution and abundance of Ammodytes hexapterus larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.



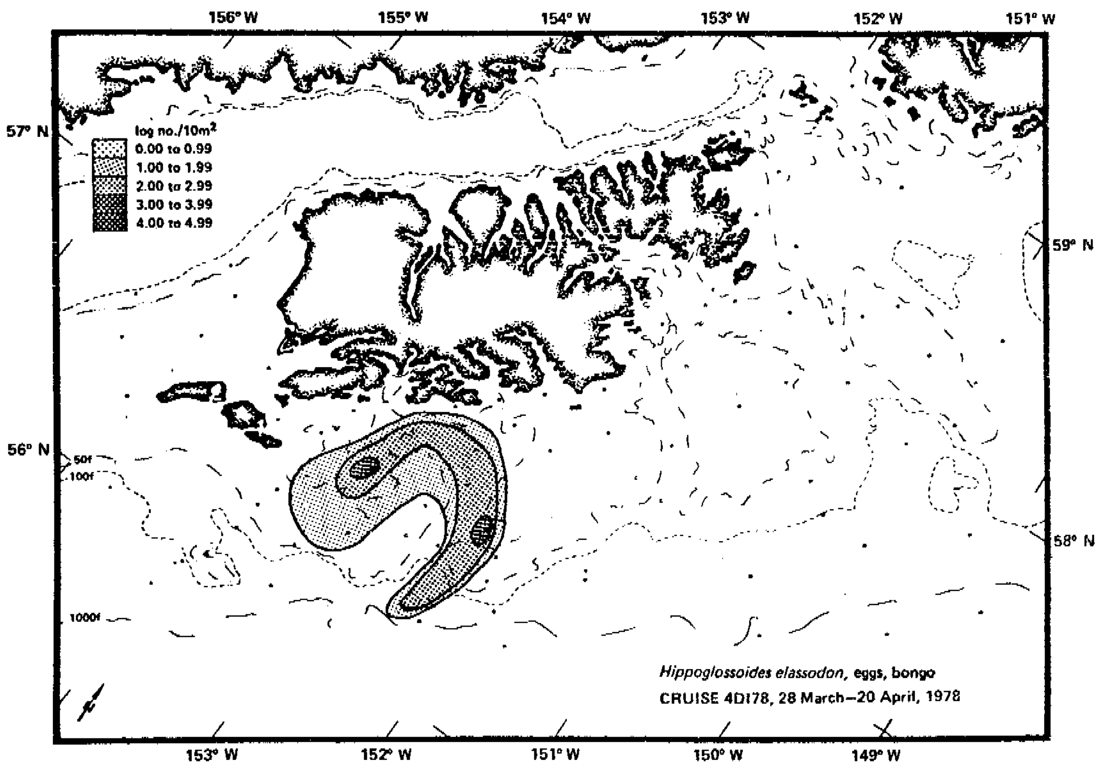


Figure 31.--Distribution and abundance of Hippoglossoides elassodon eggs in neuston (top) and bongo (bottom) tows from the Spring cruise.

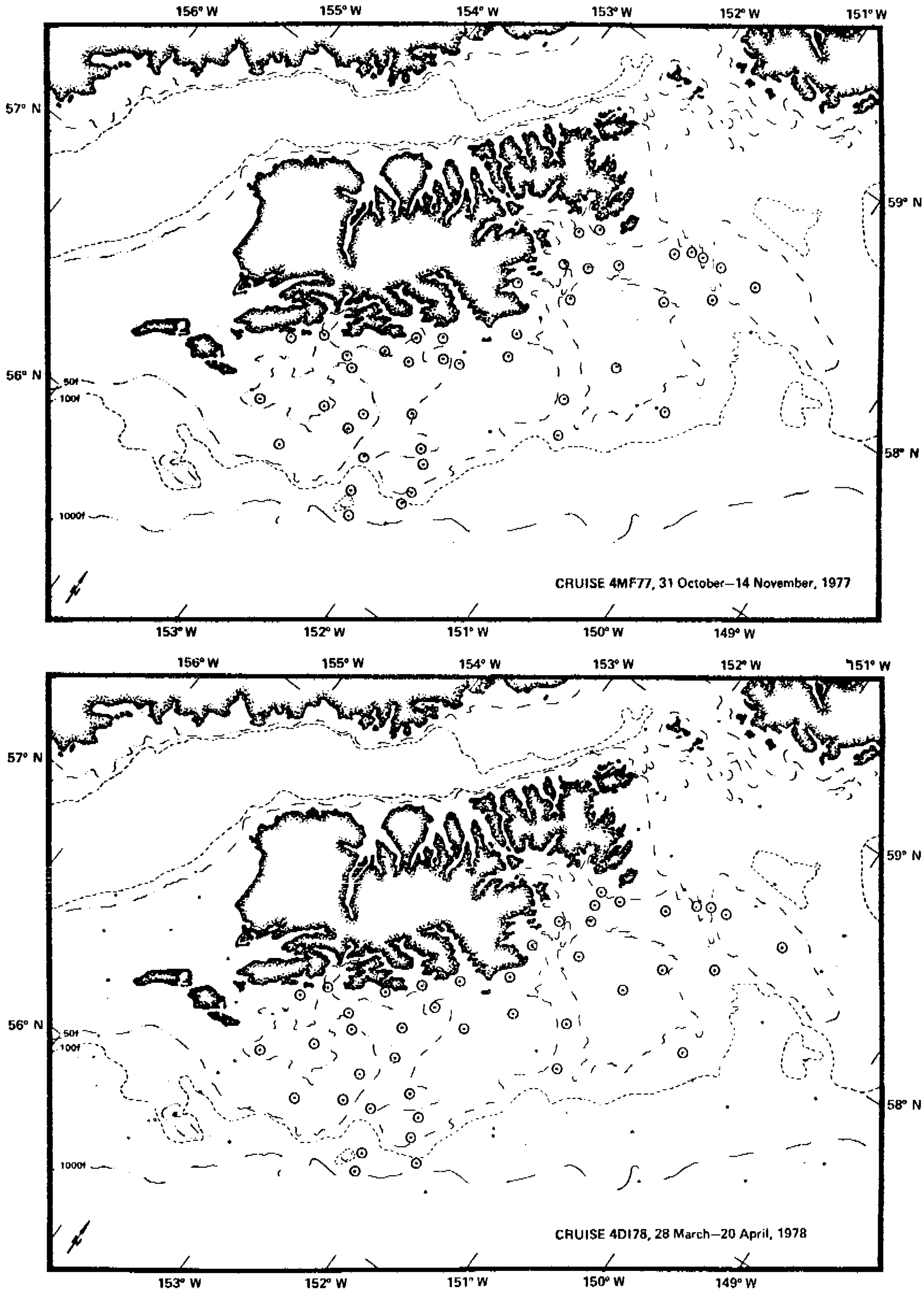


Figure 32.--Station locations used during the Fall (top) and Spring (bottom) to compare the seasonal occurrence and abundance of zooplankton (Tables 3 and 4) near Kodiak Island.

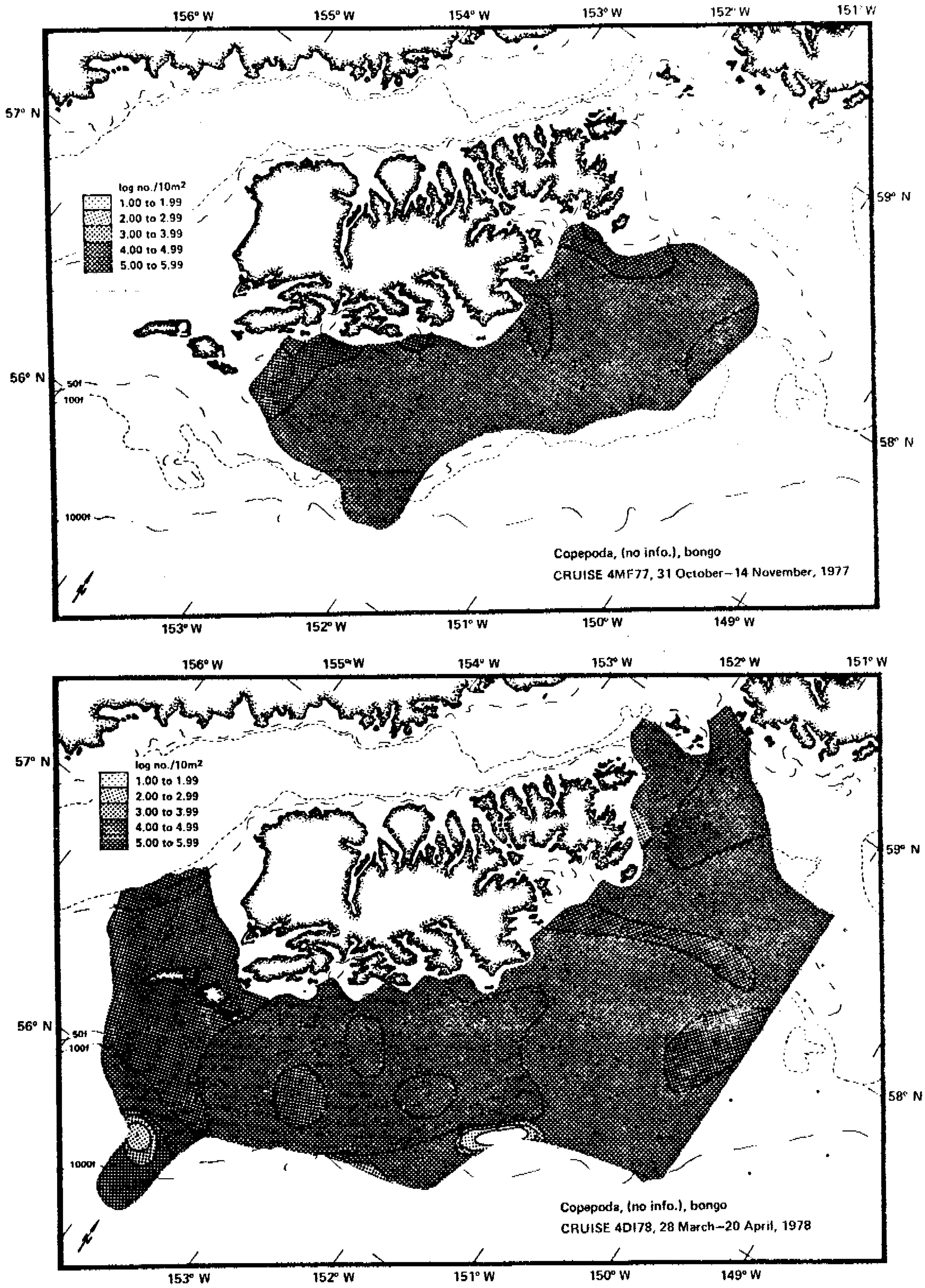


Figure 33 --Distribution and abundance of Copepoda during the Fall (top) and Spring (bottom) from bongo net samples.

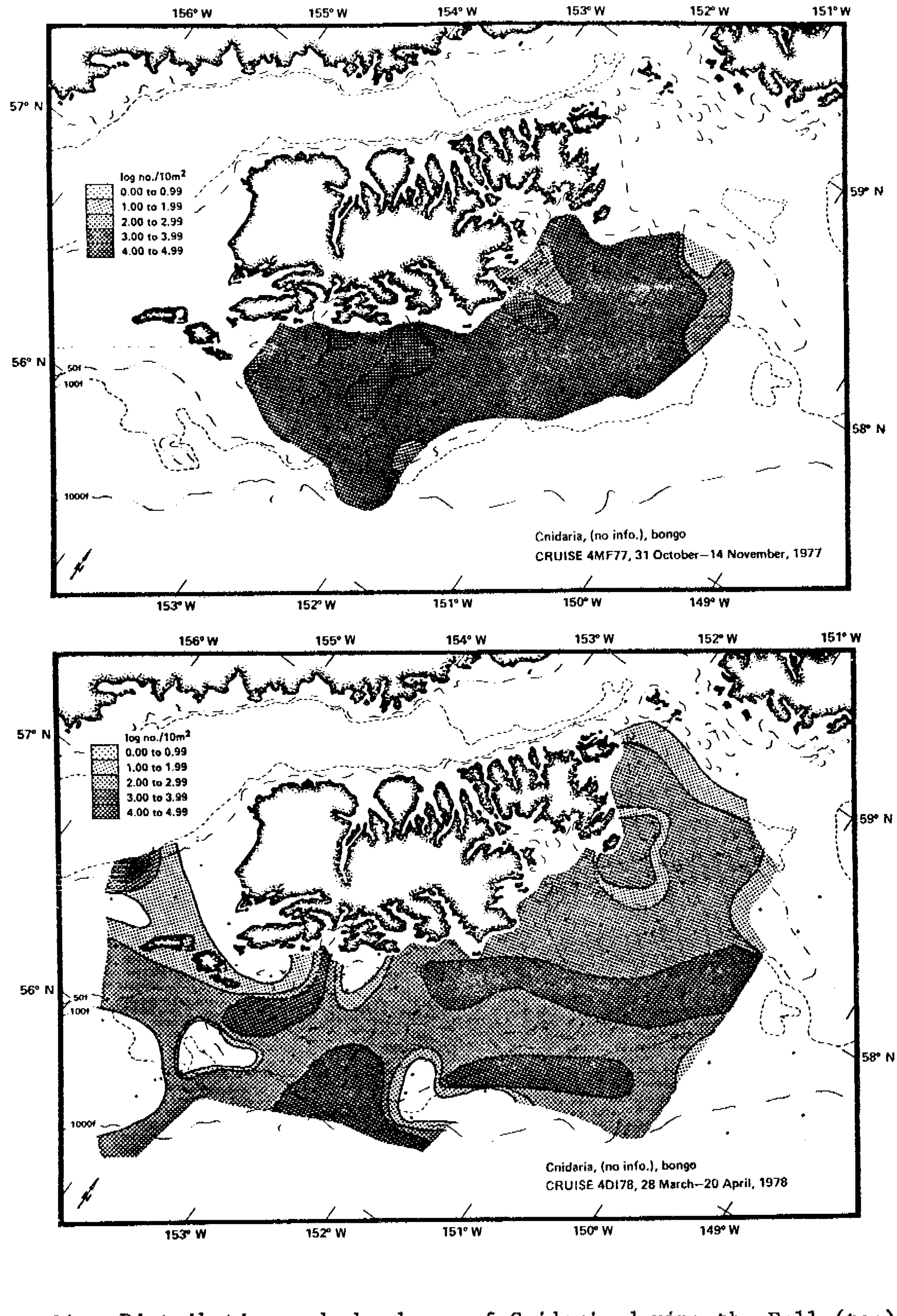


Figure 34.--Distribution and abundance of Cnidaria during the Fall (top) and Spring (bottom) from bongo net samples.

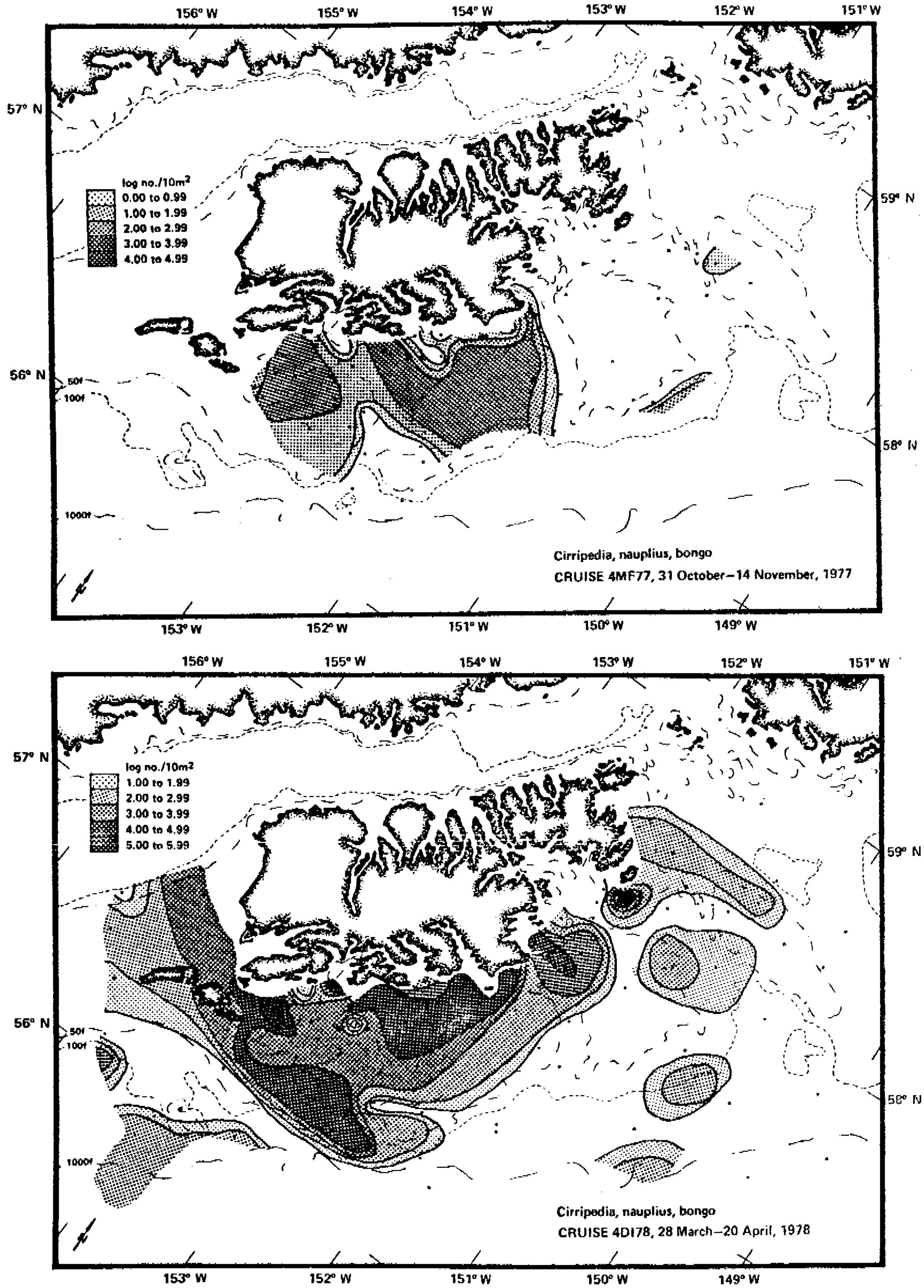


Figure 35.--Distribution and abundance of Cirripedia nauplii during the Fall (top) and Spring (bottom) from bongo net samples.

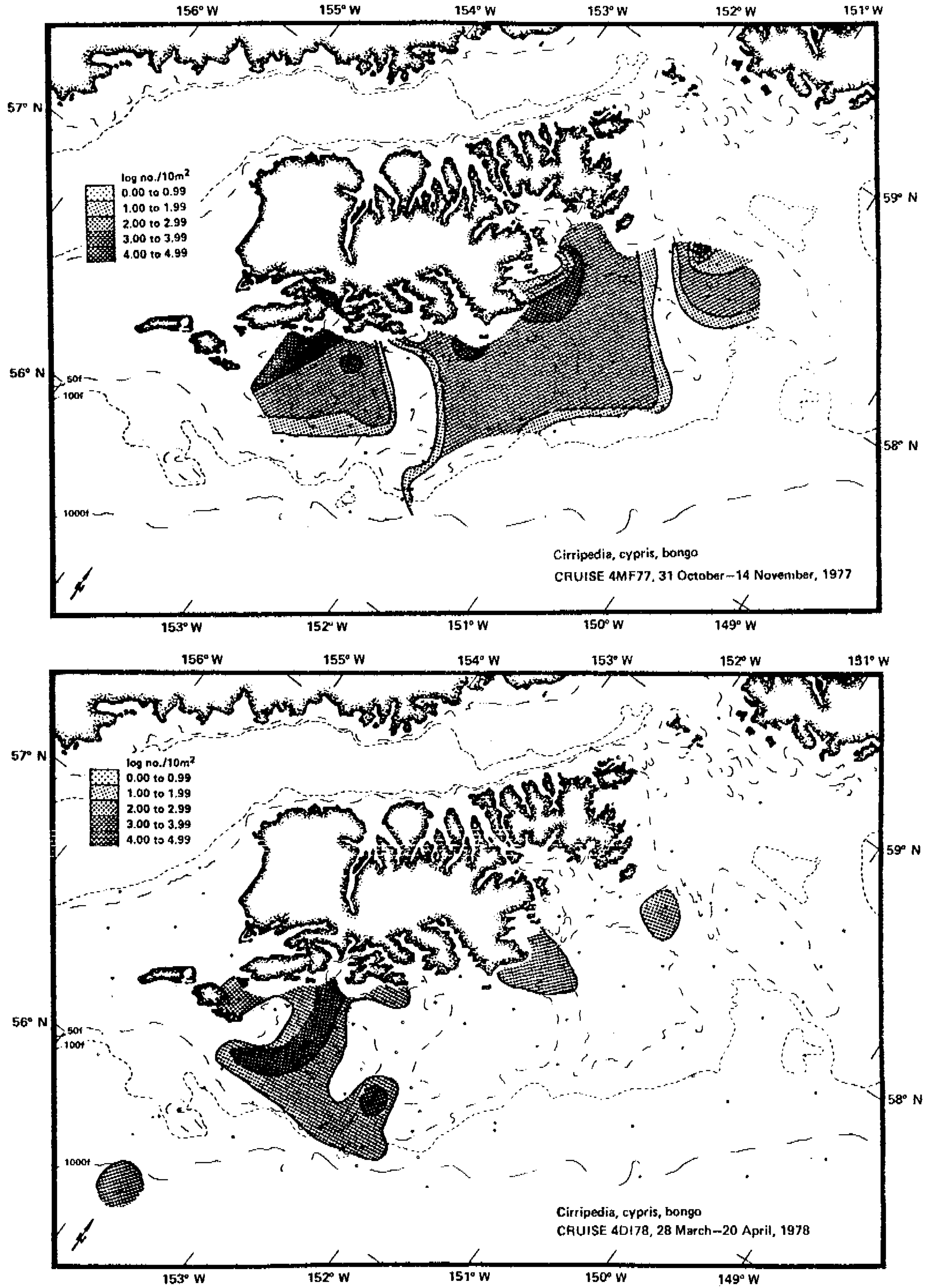


Figure 36.--Distribution and abundance of Cirripedia cypris during the Fall (top) and Spring (bottom) from bongo net samples.

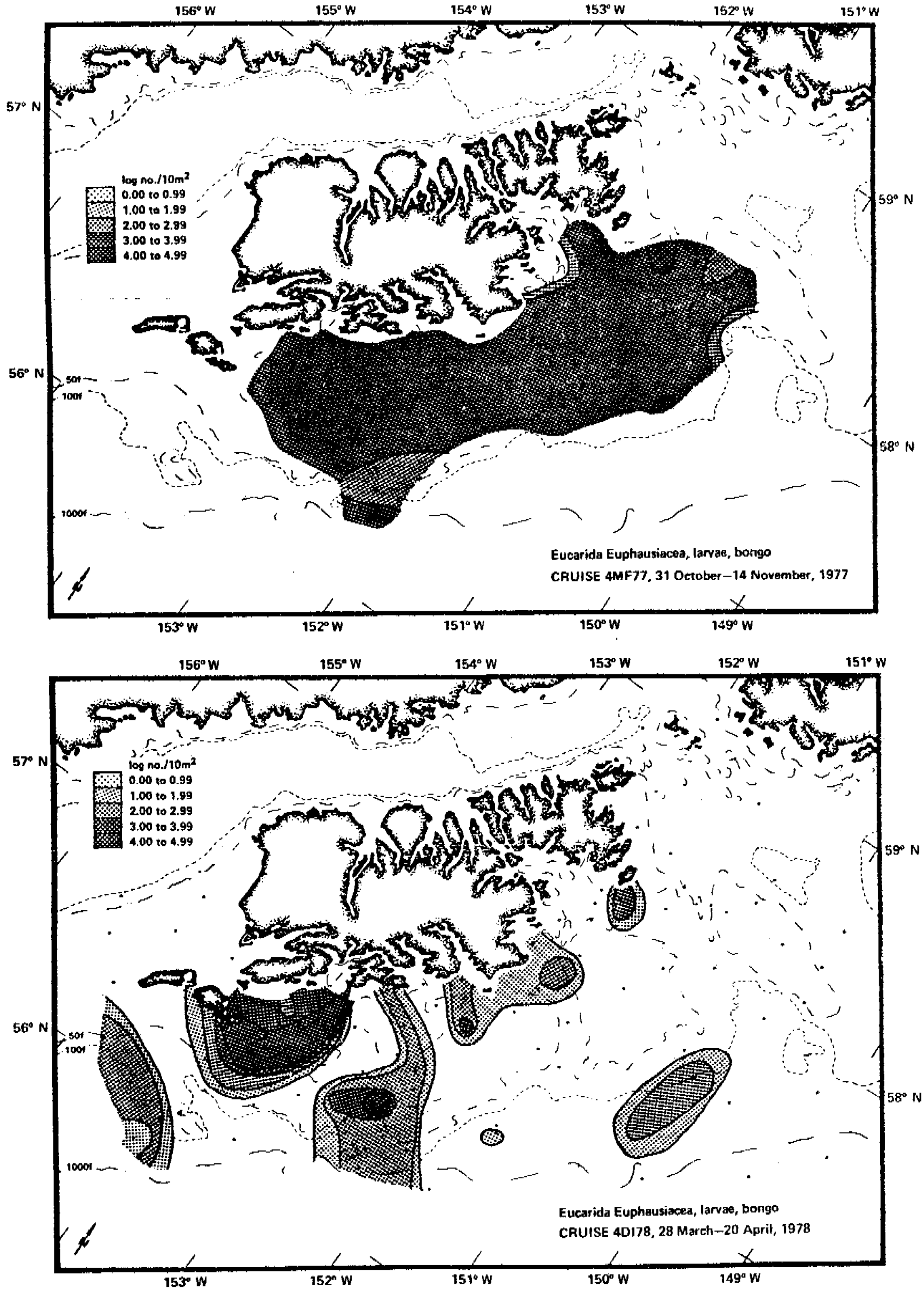


Figure 37.--Distribution and abundance of Euphausiacea larvae during the Fall (top) and Spring (bottom) from bongo net samples.

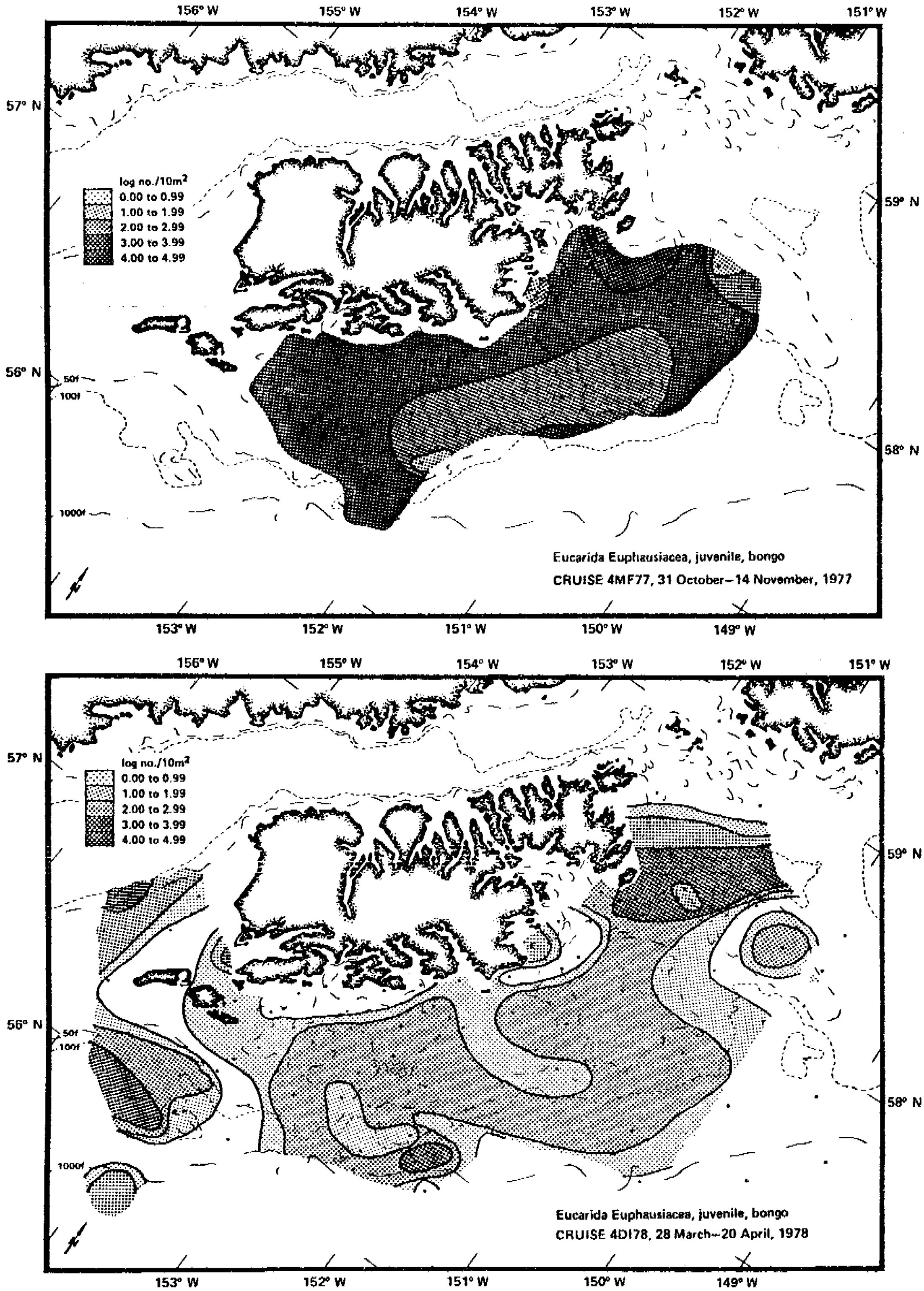


Figure 38.--Distribution and abundance of Euphausiacea juveniles during the Fall (top) and Spring (bottom) from bongo net samples.

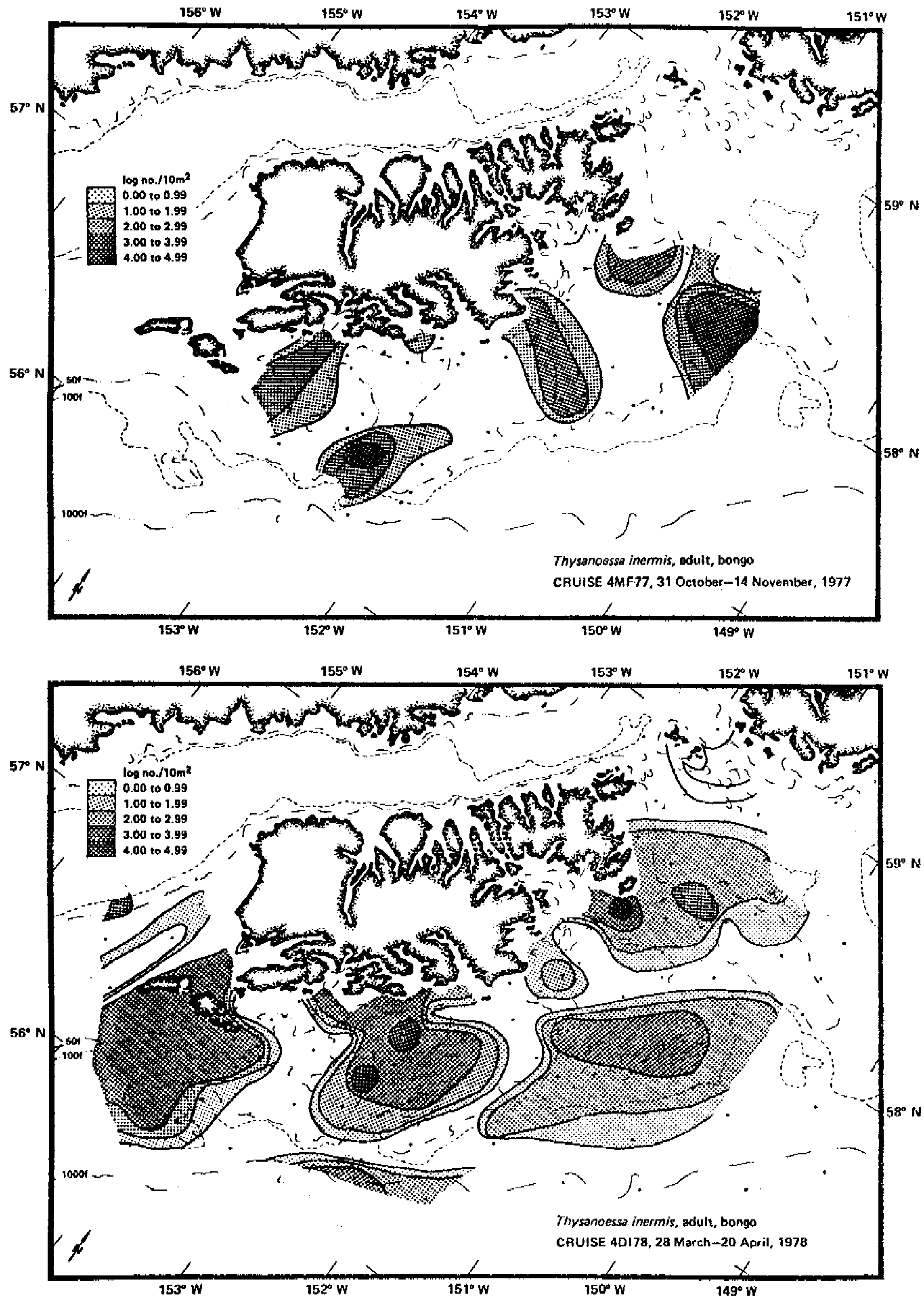


Figure 39.--Distribution and abundance of Thysanoessa inermis during the Fall (top) and Spring (bottom) from bongo net samples.

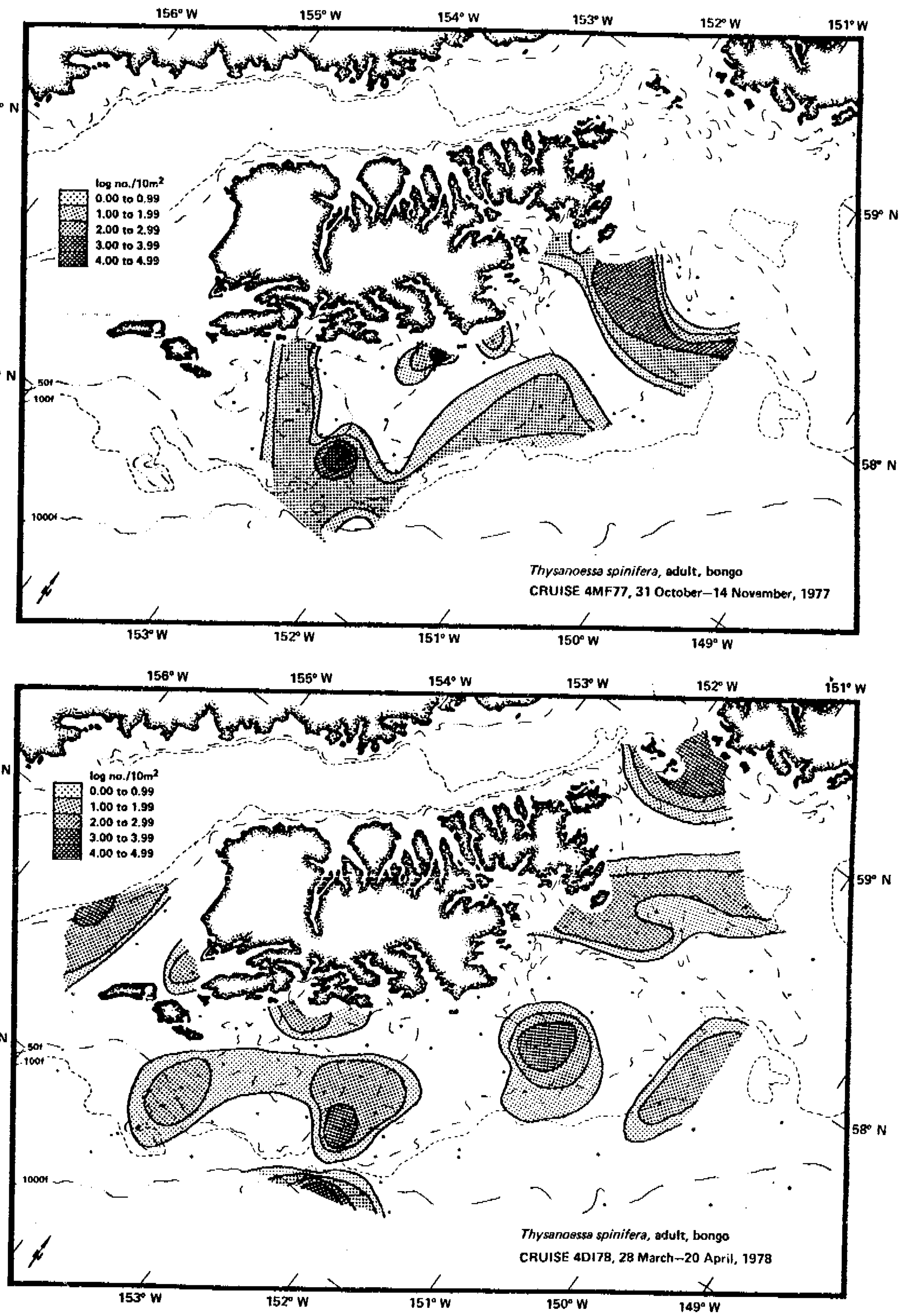


Figure 40.--Distribution and abundance of Thysanoessa spinifera during the Fall (top) and Spring (bottom) from bongo net samples.

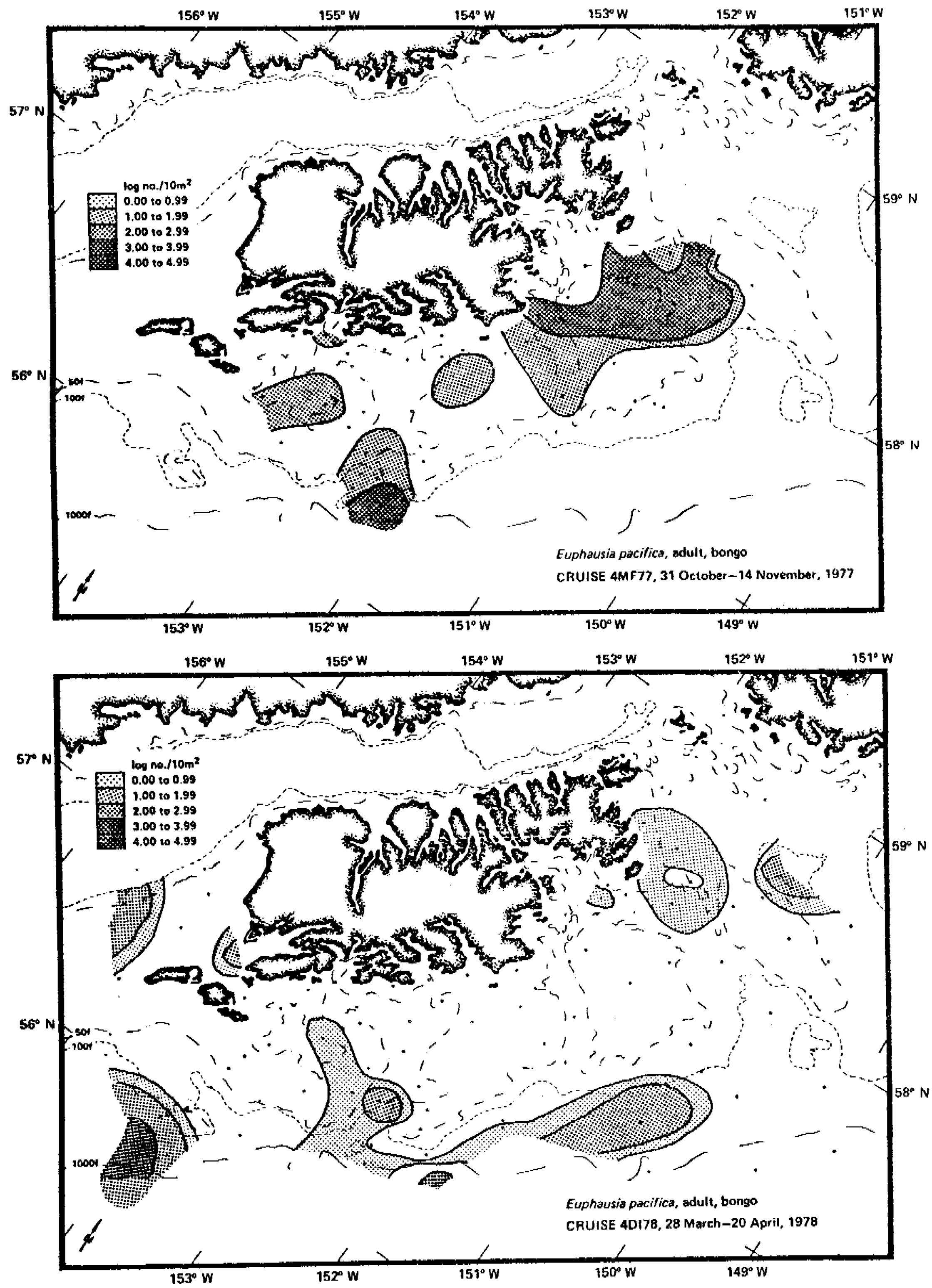


Figure 41.--Distribution and abundance of Euphausia pacifica during the Fall (top) and Spring (bottom) from bongo net samples.

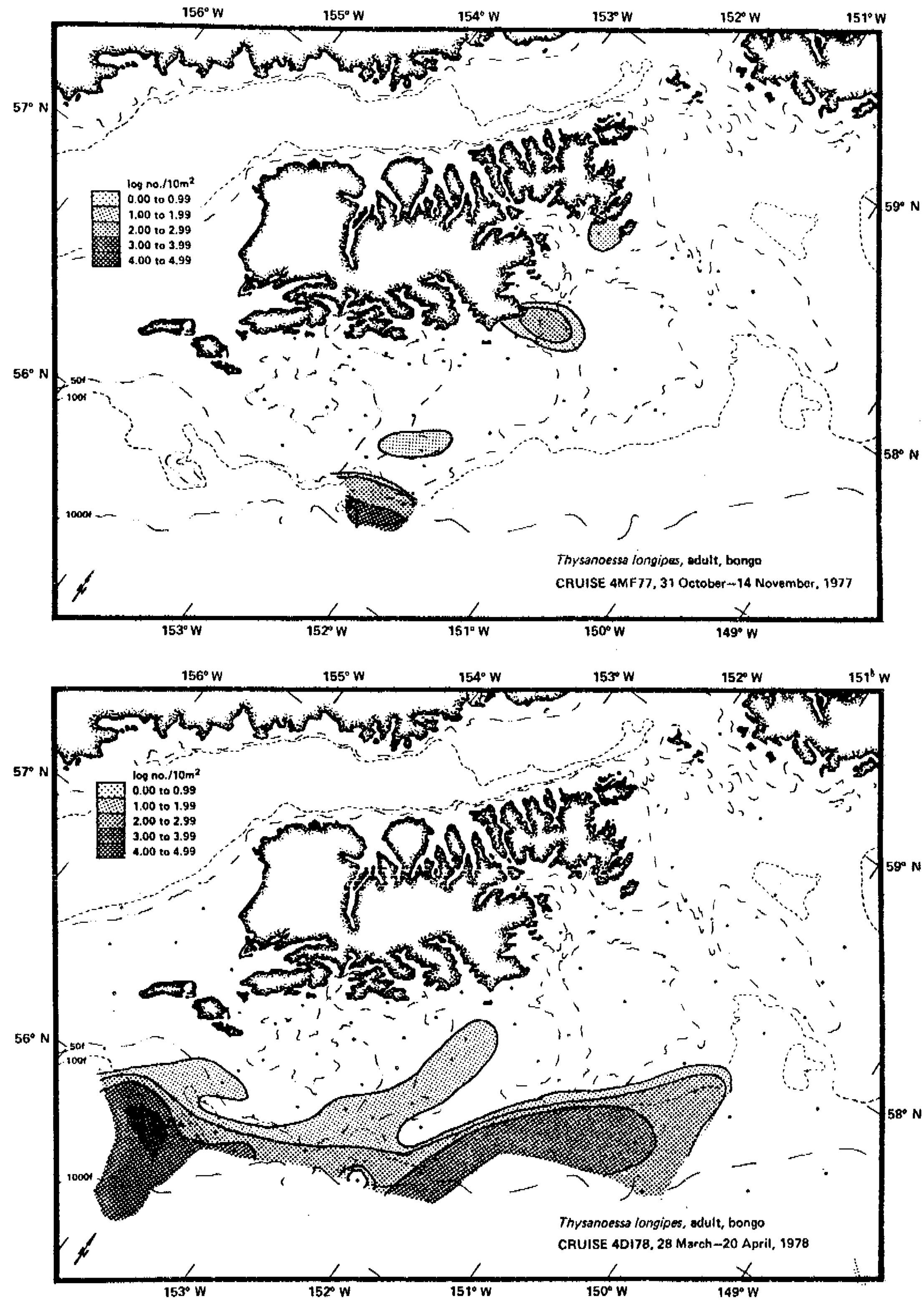


Figure 42.--Distribution and abundance of Thysanoessa longipes during the Fall (top) and Spring (bottom) from bongo net samples.

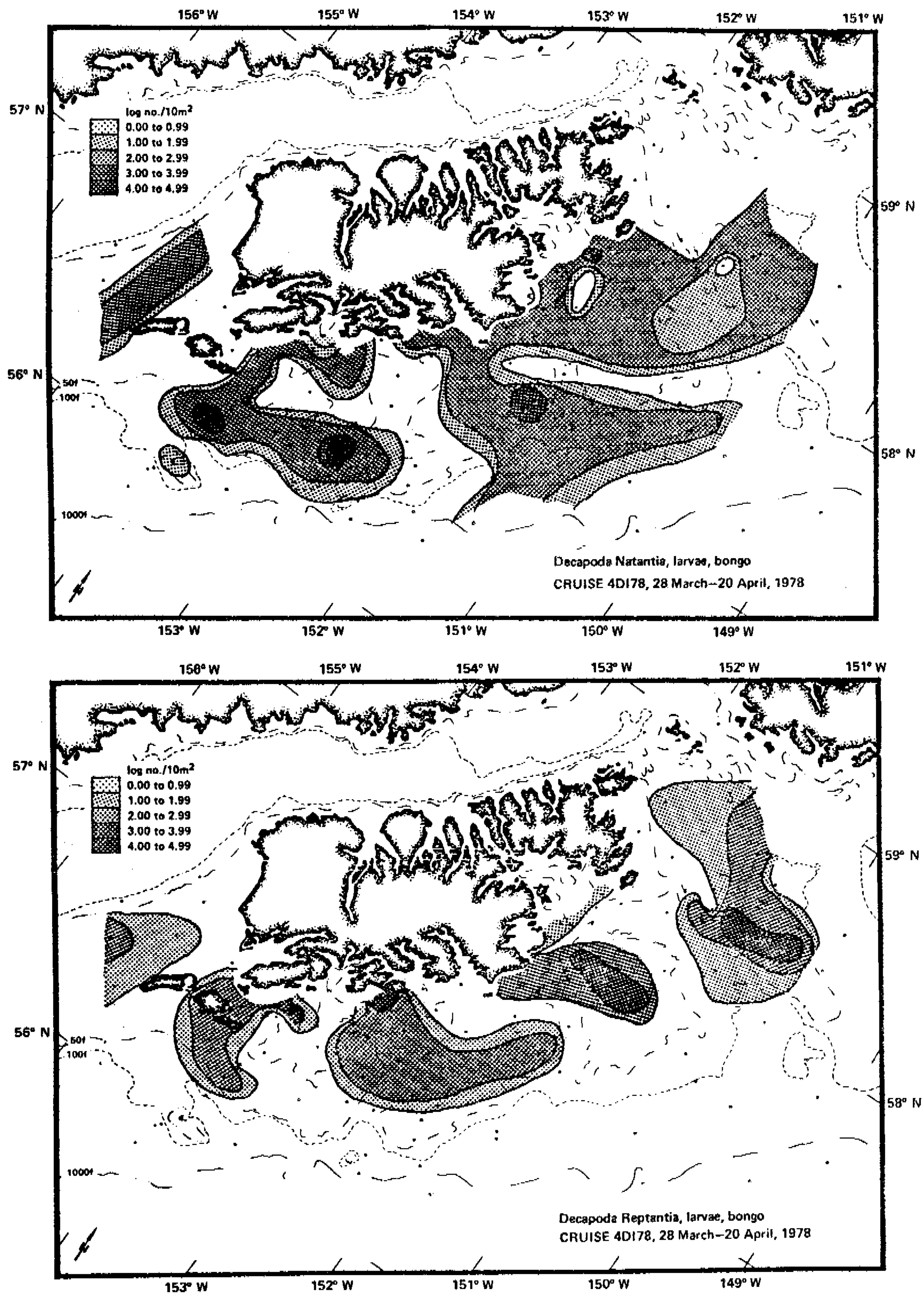


Figure 43.--Distribution and abundance of Decapoda Natantia larvae (top) and Decapoda Reptantia larvae (bottom) during the Spring from bongo net samples.

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FISHERIES RESEARCH INSTITUTE
College of Fisheries
University of Washington
Seattle, Washington 98195

SEASONAL COMPOSITION AND FOOD WEB RELATIONSHIPS OF MARINE ORGANISMS IN THE NEARSHORE ZONE OF KODIAK ISLAND--INCLUDING ICHTHYOPLANKTON, MEROPLANKTON (SHELLFISH), ZOOPLANKTON, AND FISH

by

Donald E. Rogers, Principal Investigator,
Douglas J. Rabin, Brenda J. Rogers,
Kathryn Garrison, and Mark Wangerin

ANNUAL REPORT

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Res. Unit: #553
Reporting Period: April 1, 1978 -
March 31, 1979

Approved

Submitted May 7, 1979

Associate Director
Fisheries Research Institute

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PART A: ICHTHYOPLANKTON

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

Objectives of this program are to provide information on the spatial and temporal relationships of zooplankton in four bays of the Kodiak Archipelago. The Fisheries Research Institute (FRI) is studying the ichthyoplankton and euphausiids, whereas the National Marine Fisheries Service (NMFS) is studying the decapod larvae.

Larval forms of species of both commercial and ecological significance feed and mature in marine waters of Kodiak and nearby islands. For many species these life processes are regulated by both local and natural abiotic and biotic phenomena such as changes in water characteristics and seasonal abundances of zooplankton food resources.

Management of the exploration for and production of offshore petroleum and gas reserves necessitates complementary management of those larval forms and life processes that may be adversely affected by industrial developments in contiguous waters. This study, in coordination with related and concurrent studies within the same area, is intented to create a basis for the required management.

II. INTRODUCTION

General Nature and Scope of Study

The general nature of this study relates to an examination of zooplankton populations in the nearshore waters of the Kodiak Archipelago. The scope of the study consisted of intensive spring and summer sampling followed by less intensive autumn and winter sampling. Gear types included a neuston sampler, bongo-arrayed plankton nets, a mechanical opening-closing Tucker trawl, and an epibenthic plankton sled. This array of sampling devices enabled both discrete and complete sampling of the water column. Sampling design, zooplankton sorting procedures, and laboratory analysis focused on the collection and identification of fish larvae, euphausiids, and other zooplankton taxa. A final report discussing all (12) cruise results will be submitted in September 1979.

Specific Objectives

The specific objectives of this study are to:

1) Describe seasonal composition, distribution, and relative abundance of major life stages of selected holo- and mero-plankton forms in four bays of the Kodiak Archipelago. Emphasis will be placed on planktonic stages of fishes and eupausiids (by FRI) and decapod larvae (by NMFS).
2) Determine seasonal development and succession of selected commercially and ecologically important fish and invertebrate species.
3) Correlate observed biological distributions with local hydrographic regimes and bathymetry.

Relevance to Problems of Petroleum Development

The development of petroleum in Kodiak's marine environment may directly or indirectly affect the life processes of animals. Under natural conditions most animals are constrained, or limited to, for example, the time of year they may reproduce, the area over which the young may be distributed, and/or the depth(s) at which the larvae may feed.

These constraints of time, space, and depth determine to a certain extent the mortality rate of larval forms of many fish species. It is also assumed that one of the problems of petroleum development is the potential introduction of a pollutant that may accentuate those natural constraints already in force.

This study addresses the seasonal composition, spatial and temporal distribution of fish larvae to define the natural environmental limitations. With this information, we should be able to recognize whether the developmental processes of a species are likely to be put under further constraint by an oil spill incident.

III. CURRENT STATE OF KNOWLEDGE

Aside from the 1978-79 Kodiak-OCS studies, very little descriptive literature exists for ichthyoplankton in the nearshore waters of Kodiak. A general reference to this information is made below. The pertinent data, however, will be incorporated with the discussion of our results.

The egg and larval development, abundance, and distribution of the Pacific halibut, *Hippoglossus stenolepis*, were examined from 1926-34 by Thompson and Van Cleve (1934). Their study included stations in areas east and southwest of Kodiak Island. Survey results indicated a relatively high concentration of late-stage halibut larvae in the Kodiak region.

Pacific ocean pearch, *Sebastes alutus*, larvae were sampled by Lisovenko (1964) in response to the (past) importance of this rockfish to Soviet commercial fisheries. In comparison to other Gulf of Alaska regions, he found a relatively high abundance of rockfish larvae over Kodiak's continental slope during the spring.

Salmon feeding studies were conducted in 1971 in Alitak and Kiliuda bays of Kodiak Island (Gosho 1977). In several instances fish larvae were found to be an important dietary component of outmigrating juvenile salmon. Unfortunately, no information was obtained on species composition of those larval fishes.

Ichthyoplankton research was carried out in the spring of 1972 over an extensive area of Kodiak shelf waters (Dunn and Naplin 1974). Walleye pollock, *Theragra chalcogramma*, eggs and larvae were dominant components of the April-May samples.

A composite study of juvenile and adult fishes in three Kodiak Island bays was conducted in 1976 (Harris and Hartt 1977). Large incidental catches of fish larvae were taken with gear types, e.g., beach seine and surface townet, designed to sample larger fishes. Larval forms of capelin, greenling, herring, ronquils, sandfish, sandlance, and pricklebacks, were reported from the inshore survey.

In comparison to the studies above, this program constitutes a much more comprehensive sampling of the abundance, spatial, and temporal characteristics of ichthyoplankton in Kodiak waters. In addition, this study has been complemented by concurrent offshore ichthyoplankton and inshore juvenile and adult fish sampling. Integration of this information should significantly enhance the knowledge of fish populations in this area.

IV. STUDY AREA

The study area includes the Izhut, Kalsin-Chiniak, Kiliuda, and Kaiugnak bays of the Kodiak Archipelago (Figs. 1, 2, and 3; Table A). These inshore waters are largely influenced by oceanic water conditions, mixed tides, and prevailing weather patterns. In addition, relatively deep troughs approach all bays and permit additional inflow and/or outflow of waters as dictated by oceanic and atmospheric conditions. Water temperatures range from approximately $1^{o}C$ to $15^{o}C$ and salinities up to 34 $^{o}/oo$, depending upon season, depth monitored, and degree of freshwater influence. Bottom substrates vary considerably and include both homogeneous and heterogeneous rock, sand, and mud bottom types. Depths at the selected sampling stations ranged from approximately 30 m to 170 m.

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

Zooplankton were collected from the 20.4 m University of Washington fisheries research vessel Commando. Each bay was sampled once every 2 weeks from late March through August 1978 and once in November 1978 and March 1979. A total of 12 cruises (five spring, five summer, one fall, and one winter) were completed (Table 1).

Station locations were linearly arranged along the main axis of each bay and in front of the respective headlands. Several of the seaward stations were in close proximity to those of the NMFS offshore survey (RU 551). Additional sample locations were added in May 1978 along the edges and inner reaches of Izhut and Kiliuda bays. The inshore sampling program included a total of 26 standard stations.

Capture techniques included the use of four types of gear (Table 2). A Sameoto neuston sampler collected fish eggs and larvae at the air-sea interface. Bongo-arrayed plankton nets sampled the water column from near bottom to the surface. The opening-closing mechanical Tucker trawl sampled discrete depths during light and dark periods, and the epibenthic plankton sled--a Tucker trawl mounted on skis--took discrete samples close to the sea floor. Field procedures generally followed MARMAP survey guidelines (Smith and Richardson 1977).

Samples were preserved with 50 ml of formaldehyde and buffered with 20 ml of saturated sodium borate solution. They were then inventoried and shipped to a commercial sorting center for separation and enumeration of specified zooplankton components (Table 3). Settled plankton volumes were determined for all samples following Kramer et al. (1972), and weighing procedures for euphausiids followed Weibe et al. (1975).

To integrate this program with the offshore ichthyoplankton research (RU 551), various degrees of homogeneity were incorporated into the sampling periods, station locations, gear-use procedures, and sorting options. Project leaders collaborated to insure agreement in the identification and/or typing of captured larval fishes. The closely spaced sample periods should permit descriptive accounts of the appearance, residence time, and growth of selected larval fish species in the inshore zooplankton community.

VI. RESULTS

Density and kinds of fish eggs and larvae caught during the spring and summer cruises are listed (Tables 4-35). These data will be discussed by life history stage - eggs and larvae; by gear type - neuston and bongo; and by bay - Izhut, Chiniak, Kiliuda, and Kaiugnak. Various elements of the tabularized results and discussion will treat stations 6, 7, and 8, in Izhut and Kiliuda bays separately from other stations within the respective bays because the initiation of sampling at those stations was delayed and they are located close to the margins and heads of the bays.

Station-group comparisons are based primarily on an examination of means of ichthyoplankton densities.

This report does not review results from Tucker trawl or epibenthic sled samples. Nor will there be an examination of other major zooplankton groups sorted from Bongo (333 μ) samples. These will be examined in the final report, along with a more integrated review of the findings of the present report.

Eggs from Neuston Samples

Izhut Bay. Samples were taken at five stations from April through August, and three additional stations were sampled from May through August for a total of 71 plankton hauls. Data from two hauls, station 7, cruise 9 and station 8, cruise 10, were missing; however, these egg densities were estimated, using methods from Snedecor and Cochran (1971), and then were used to calculate mean densities for stations and cruises.

Densities of fish eggs varied between stations and over time (Table 4). No eggs were caught during late March and no eggs were caught from March to May at two stations.

Egg densities were greater at the nearshore stations, 6-8, than at bay stations 1-5. High mean densities of eggs at stations 6-8 occurred in late June and again in early August, whereas mean egg density at stations

1-5 was greatest in late July. Densities decreased for both groups of stations in mid-August.

Unidentified pleuronectid eggs were most abundant in the catches from April to August (Table 5). Flathead sole eggs were second in mean abundance and occurred from late April to August. Species of other eggs included walleye pollock which occurred only during April and two demersal spawners, sandfish and greenling.

Chiniak Bay. Densities for fish eggs were determined from 50 hauls (Table 6). Eggs were found at all stations and during all cruises, except for one station in early April. Mean abundances for all stations fluctuated over the months sampled, but a substantial increase in eggs occurred in June-July. Egg densities remained relatively high through August.

Station 1 was located closest to shore and had the highest mean number of eggs for March-August. Stations 4 and 5 were located in the outermost part of the bay and had the lowest mean number of eggs.

As in Izhut Bay, unidentified pleuronectid eggs were most abundant and occurred in all spring and summer months (Table 7). Flathead sole eggs and walleye pollock eggs also occurred, but were not as abundant.

Kiliuda Bay. Fish eggs occurred in most of the 70 hauls taken from March-August (Table 8). One missing value was estimated with methods from Snedecor and Cochran (1971).

Mean abundances between the nearshore stations, 6-8, and the other stations, 1-5, were not appreciably different. For all stations, mean egg densities were low from April through early June, with a substantial increase in numbers in mid-June. Densities remained high through July and began to decrease in August.

Unidentified flatfish eggs were again most abundant in the plankton from March-August, and peak abundances occurred in June-July (Table 9). Walleye pollock eggs were second in abundance and were present from March-June. Flatfish eggs from flathead sole, Alaska plaice, and rex sole occurred in low abundance.

Kaiugnak Bay. Fish eggs were caught in all months except during May when egg densities were lowest (Table 10). Mean egg densities increased during June and early July and peaked in late July-early August. Overall, more eggs were found at the stations (1, 2) closest to the head of the bay.

Unidentified flatfish eggs occurred in all months sampled except May, and densities were greatest during late July (Table 11). Walleye pollock eggs were caught in April and June, but were absent in May catches. Flathead sole eggs occurred April-August and were the only eggs taken from the neuston during May.

Summary. More eggs were collected in Chiniak, stations 1-5, than from the same station group in any other bay.

Although the nearshore stations, 6-8, in Izhut Bay had substantially more eggs than stations 1-5, there was not a significant difference between stations 6-8 and 1-5 in Kiliuda Bay.

Unidentified pleuronectid eggs dominated the egg catches in all four bays and were present from April-August. Overall egg densities were low during the early spring for all bays. In June and July, egg densities increased in each bay primarily from large increases in unidentified flatfish eggs. Egg abundances remained high through late July and early August, with a slight decrease in numbers in most bays during late August.

Walleye pollock eggs also occurred in all bays and were found predominantly during April-June. Flathead sole eggs were also collected from each bay and were present during all months sampled, although no flathead sole eggs were taken in Kiliuda Bay after June.

Larvae from Neuston Samples.

Izhut Bay. Fish larvae were caught in 55 of the 69 hauls taken from March-August (Table 12). Two missing values were estimated by methods in Snedecor and Cochran (1971), and the numbers were used in the following discussion.

Mean densities of larvae varied between stations, with more larvae caught at stations 6-8 than at 1-5. The mean density was highest during late July, although only three of the eight stations contained larvae. Station 8 yielded the greatest mean number of larvae per station.

Approximately 19 different species and types from 12 families were identified (Tables 13 and 36). The preponderant larval fish were smelts which occurred from June-August. Two greenling species, *Hexagrammos* type I and whitespotted greenling, were relatively abundant in the neuston samples and occurred from March-June. Ronquils were less abundant but were present in every month sampled, except March. Juvenile pink salmon were caught during April and May.

Chiniak Bay. Larval fish were present in 76% of the April-August hauls and densities were low; e.g., no larvae were caught at several stations (Table 14). Densities increased in May primarily because of *Hexagrammos* type I which was most abundant in May and present until July (Table 15). Larval fish densities decreased during June and again increased in July from the appearance of larval smelts. Densities remained high through August with the appearance of two other greenling species--types D and E. Ronquils were present in low abundance from May-August. Eight other larval fish species, including juvenile pink salmon occurred, but were not as abundant.

Kiliuda Bay. Fish larvae occurred in 55 of the 70 hauls. One sample could not be taken but the missing value was estimated. Kiliuda Bay had a greater number of species, types, and families than the other bays (Table 36).

No significant difference in mean densities was apparent between station groups 6-8 and 1-5, and numbers of larvae were greatest during March-May (Table 16). Lyconectes aleutensis, dwarf wrymouth, was the most abundant larval fish and occurred only in March-April (Table 17). Hexagrammos type I and members of the family Stichaeidae were also abundant during this time. Other larvae occurring in early spring were Myoxocephalus types A and B, whitespotted greenling, sandlance, and rock sole. Abundances of these species decreased in May-June. Larval fish densities increased in late June-July when smelts appeared in the samples.

Kaiugnak Bay. Two-thirds of the hauls in March-August contained fish larvae (Table 18). Two main peaks in mean density were apparent. The first occurred in late April and species contributing to this abundance were Hexagrammos type I, Myoxocephalus types A and B, and whitespotted greenling (Table 19). Abundance of these larvae decreased in May and June, but densities were relatively high again in late June-July primarily because of the presence of smelt and ronquil larvae. Other species abundant at this time included sand sole and unidentified rockfish. Densities decreased in August when larvae present included smelts and Hexagrammos types D and E.

Summary. Smelt were the most abundant larval fish caught in the neuston from all four bays; however, they were only present from June-August. They comprised 79% of the larvae caught in Izhut Bay, 47% in Kaiugnak Bay, 13% in Kiliuda Bay, and 7% in Chiniak Bay.

Greenlings were also important components in the neuston samples. Three greenling types, Hexagrammos types I, D, and E and whitespotted greenling were caught. Although specific identification of the greenling types I, D, and E, cannot yet be made, it is relatively certain that these types include the kelp, masked and rock greenlings.

Hexagrammos type I occurred in all four bays and was the second most abundant larval fish caught in the neuston. It occurred from late March to June and was most abundant in late April-May. Whitespotted greenling, also occurred in all four bays, but only during March and April. The remaining greenlings, types D and E, occurred in most of the bays but were caught only during July and August. Greenlings as a family comprised 83% of the neuston larvae in Chiniak Bay, 39% in Kaiugnak Bay, 24% in Kiliuda Bay, and 14% in Izhut Bay.

More larval fish were caught in Izhut Bay than in any other bay. Kiliuda Bay, however, contained the greatest number of species, types, and families. Fish larvae from the neuston in each bay appeared on a seasonal basis. Hexagrammos type I, whitespotted greenling, Myoxocephalus types A and B, and dwarf wrymouth were preponderant in the surface plankton from late March to late May. In June, densities of fish larvae dropped to the lowest values, then increased in July-August due to the appearance of large numbers of smelts. Hexagrammos types D and E also occurred at this time and ronquils contributed to catches in all months sampled.

Eggs from Bongo Samples (Fig. 4).

Izhut Bay. Fish eggs occurred in Izhut Bay bongo samples from mid-April through August (Table 20). Mean egg abundance peaked at stations 6-8 in late June and at stations 1-5 in late July. Stations 6-8 had significantly more eggs than stations more distant from shore. Flatfish eggs were the preponderant type from May through August (Table 21). Walleye pollock and flathead sole eggs were less abundant but occurred in the plankton in 7 and 8 of the 10 cruises, respectively.

Chiniak Bay. Fish eggs occurred in all 10 cruises in Chiniak Bay with a major peak in abundance in early July (Table 22). The station closest to shore had both the greatest station total and mean abundance. Flatfish eggs were most abundant and occurred throughout the spring and summer with a seasonal peak in July (Table 23). Walleye pollock eggs occurred from April through July and flathead sole eggs from April through August, with peaks in abundance for both species occurring in early May.

Kiliuda Bay. Fish eggs were caught from April through August in Kiliuda Bay (Table 24). Peaks in mean abundance occurred in mid-July at both groups of stations. As in Izhut Bay, stations 6-8 contained a greater mean number of eggs than stations 1-5. Pleuronectid eggs were preponderant in all cruises (Table 25). Walleye pollock eggs occurred from April through early July with the greatest mean number present in late April.

Kaiugnak Bay. In Kaiugnak Bay fish eggs were present from April through August (Table 26). Seasonal peaks of abundance occurred in mid-July and early August, and stations in the central and head portions of the bay contained the greatest mean totals of eggs. Pleuronectid eggs were slightly less abundant than walleye pollock eggs in early April whereas flatfish eggs were most abundant later. A relatively large number of flathead sole eggs appeared in a single cruise in late April (Table 27).

Larvae from Bongo Samples (Fig. 5).

Izhut Bay. Larval fishes occurred in all cruises and in 70 of the 71 samples from Izhut Bay (Table 28). Peaks in abundance occurred in late June and again in August, whereas the relative abundance of larvae from late March through early June remained relatively constant for stations 1-5. In this bay as in Chiniak and Kiliuda bays smelt larvae were primarily responsible for a marked increse in the mean density of fish larvae in late June and early July. The inner and marginal bay stations 1, 6, and 7, contained the highest densities while stations 2 and 3 had the lowest. A temporary dip in abundance occurred in late July at all stations and no larvae were caught in cruise 8, station 5.

Smelt larvae in this and the other three bays clearly outnumbered all other larval fish taxa in mean abundance (Table 29). Their spawning period began in early to mid-June in all bays, with a peak in larval abundance in the first half of July. Ronquil and sand lance larvae were second and third in abundance, respectively.

Other larval forms of species of relative importance that ranked among the top 15 in abundance included sand sole, rock sole, (great) sculpin types, walleye pollock and rockfishes.

Chiniak Bay. In Chiniak Bay larval fish were present at all stations during all cruises (Table 30). As in Izhut Bay, mean abundance remained relatively low until smelt larvae appeared in mid-June. Peak mean abundance occurred in early July, and the station furthest inside the bay had significantly more larvae than the remaining stations. Species of relative importance and among the most abundant in Chiniak Bay were smelts, sand lance, rock sole, pricklebacks, sand sole, flathead sole, rockfish and cod (Table 31). Of these, rock sole were present in the greatest number of cruises.

Kiliuda Bay. In Kiliuda Bay larval fishes occurred during all cruises and at all stations (Table 32). As in Chiniak Bay lowest mean densities occurred in May and early June followed by peaks in abundance in mid-July and August. Mean abundance for stations 1-5 was approximately half of that found at marginal stations 6-8. Larval fish species of importance that occurred in relative abundance were smelts, pricklebacks, sand lance, rock sole, walleye pollock, sand sole, and *Myoxocephalus* types (Table 33). As with those species mentioned for Izhut and Chiniak bays, particular patterns of seasonality and periods of relative abundance can be noted. The principle example is the synchronous disappearance of sand lance larvae in early June and the appearance of smelt larvae in late June (Figs 6 and 7).

Kaiugnak Bay. In Kaiugnak Bay fish larvae were found in all cruises and in 49 of 50 station-samples (Table 34). A minor peak in spring abundance occurred in late April with the higher summer densities occurring in late August. Minimum mean larval fish densities were in early June. Mean densities for stations 1, 2, 3 and 5 were relatively similar to one another and low when compared to station 4. Commercially and economically important fishes for which larval forms were relatively abundant were smelts, sand lance, rock sole, pricklebacks, sand sole, Pacific cod, and flathead sole (Table 35). These fishes, excluding the Pacific cod, occurred in at least half of the cruise periods.

Environmental Data

Salinity and temperature data were compiled for the various cruises, bays and depths (Tables 39-42). Ranges in mean temperatures for all bays and all cruises were 3.5-12.3°C at 1 meter depth, 3.4-9.7 at 25 m, 3.5-8.7 at 50 m, and 3.5-7.6°C at 100 m. Ranges in mean salinities for all bays and all cruises were 30.5-34.3 at 1 m, 33.5-34.4 at 25 m, 33.6-34.4 at

50 m, and 33.5-34.5 at 100 m. A slight cooling trend appeared in late August at the surface in three bays and in deeper water in Kaiugnak Bay.

VII. DISCUSSION

Several fish taxa used the nearshore regime as a nursery area for various segments of the spring and summer sampling periods. In general, cod fish, sand lance, pricklebacks, *Myoxocephalus* spp., rock sole, and *Hexagrammos* type I larvae were the primary spring spawners. Smelts, yellowfin sole, sand sole, and *Hexagrammos* types D and E were the most important species of the summer ichthyoplankton populations. Ronquil larvae were relatively abundant during the spring and summer periods.

Smelt larvae were clearly preponderant in the summer samples. Their abundance remained relatively high in relationship to other species, when sampling was recessed in August. Other species, such as rock sole, *Myoxocephalus* spp., and sand lance and pricklebacks were both reaching a size for transformation to existence in their juvenile habitat and/or occuring in relatively fewer numbers by early summer. Relationships between fish length, time, and abundance will be discussed in the final report.

Fish larvae were distributed throughout the nearshore zone while patterns of distribution within and between bays varied. In many but not all cases larval densities were higher for stations closest to shore. Analysis of distribution by family, genera, and species (versus cruise and station) has not yet been completed. This is intended for the final report, along with an analysis of their vertical distributions in Izhut and Kiliuda bays.

Several references were made to the occurrence and abundance of eggs of the family Pleuronectidae and larvae of the families Osmeridae, Cottidae (types I and L), and the genus *Myoxocephalus* (types A and B). These families and generic types could not be identified at a lower taxonomic level. However, listed below are the genera and species they most likely represent.

Many pleuronectid eggs are extremely difficult to identify to genus (or species) except when fully developed. We consider captured flatfish eggs to be composed of one or more of the following species: butter sole, yellowfin sole, english sole, starry flounder and/or sand sole. Yellowfin sole, starry flounder and sand sole probably accounted for the majority of eggs found. Rock sole eggs are demersal and adhesive and are not included among the planktonic pleuronectid eggs.

Osmerid larvae are also difficult to identify to a sub-family level. Capelin probably accounted for the majority of the smelt larvae, but other possible species include surf smelt, eulachon, and longfin smelt.

Cottidae type I is presently considered to contain the sculpin genera *Icelinus* and *Icelus*. Cottidae type L may be composed of larvae from the genera *Artedius*, *Clinocottus* and/or *Oligocottus*.

Myoxocephalus types A and B may represent two or more of the 4(?) local species within the genus. The great sculpin is the most abundant and ecologically important of the group and probably composes the greatest part of the type A group.

Larvae of many fish species did not appear in density tables 29, 31, 33, and 35, but did occur in relatively low numbers in at least one of the bays (Table 37). Several of these species occurred in relatively low numbers in all four bays. The most notable is the yellowfin sole. Adults are caught in relatively large numbers in bottom trawls in Kodiak Island bays (Blackburn 1978; Harris and Hartt 1977). However, the larvae were not found to be proportionately abundant. Rockfish larvae were also caught in low numbers in all four bays, as were juveniles/adults by investigators of RUs 485 and 552.

Species considered commercially and/or economically important and which did not appear in the bongo and neuston plankton samples, included Pacific herring, *Clupea harengus pallasi*, sablefish, *Anoplopoma fimbria*, sandfish, *Trichodon trichodon*, and arrowtooth flounder, *Atheresthes stomias*. We suspect that one or more factors were responsible for their absence. Foremost is that they did not spawn or have larvae in the study area. Secondly, their larvae may be large enough or close enough to the bottom to avoid the nets. Finally, their appearance in the plankton may not occur except in the fall and winter periods.

VIII. SUMMARY - CONCLUSIONS

Ichthyoplankton in four bays of the Kodiak Archipelago were sampled from late March through August, 1978. Larval fishes and fish eggs from bongo and neuston plankton samples were identified to the lowest taxonomic level possible; 20 families, 49 genera, and 31 species were identified.

Planktonic fish eggs and larvae were present during all cruise periods and in all bays in both surface and sub-surface samples. Seasonal trends in abundance of taxa of commercial and ecological importance were also evident. These taxa included cod fish, (great) sculpins, greenlings, sand lance, pricklebacks and flatfish. Most notable, perhaps, were the large numbers of flatfish eggs and smelt larvae present in the late spring and summer months.

Several aspects of the sampling will be reported in the final report. These include an examination of the epibenthic (sled) samples, vertical distributions, and variation in day and night catches in both neuston and tucker trawl samples.

From the data presented in this report, it is apparent that OCS development activities may interact with the early life history stages of many fishes of the nearshore zone. Species in the neuston are, of course, more susceptable to floating pollutants. Diel migrations to the surface at night of larval fishes normally found at depth could further complicate such an interaction. Many of those stations closest to shore had relatively higher mean densities of fish eggs and larvae and are subject to possible pooling effects of pollutants along or close to the shore and in small bays. Most of the larval fish species reviewed had distinct seasonal occurrences and may only be indirectly affected by the possible effects of petroleum developments in alternate seasonal periods.

IX. NEEDS FOR FURTHER STUDY

This will be discussed subsequent to the May 1979 Kodiak synthesis meeting.

X. SUMMARY OF JANUARY-MARCH QUARTER

A. Ship or laboratory activities

1. Ship or field trip schedule

   a. Dates: March 4-16, 1979
   b. Name of vessel: R/V COMMANDO

2. Scientific party

   a. Names: Doug Rabin; Biff Bermingham
   b. Affiliation: Fisheries Research Institute, Univ. Washington
   c. Roles: Project leader; Cruise leader, respectively

3. Methods

   a. Field sampling: Refer to methods section of this report
   b. Laboratory analysis: Refer to methods section of this report

4. Sample localities: refer to methods section of this report

5. Data collected or analyzed
   a. Number and types of samples: See Table 43.
   b. Number and types of analysis: completed identification of fish eggs and larvae from November 1978 cruise.

XI. AUXILIARY MATERIAL

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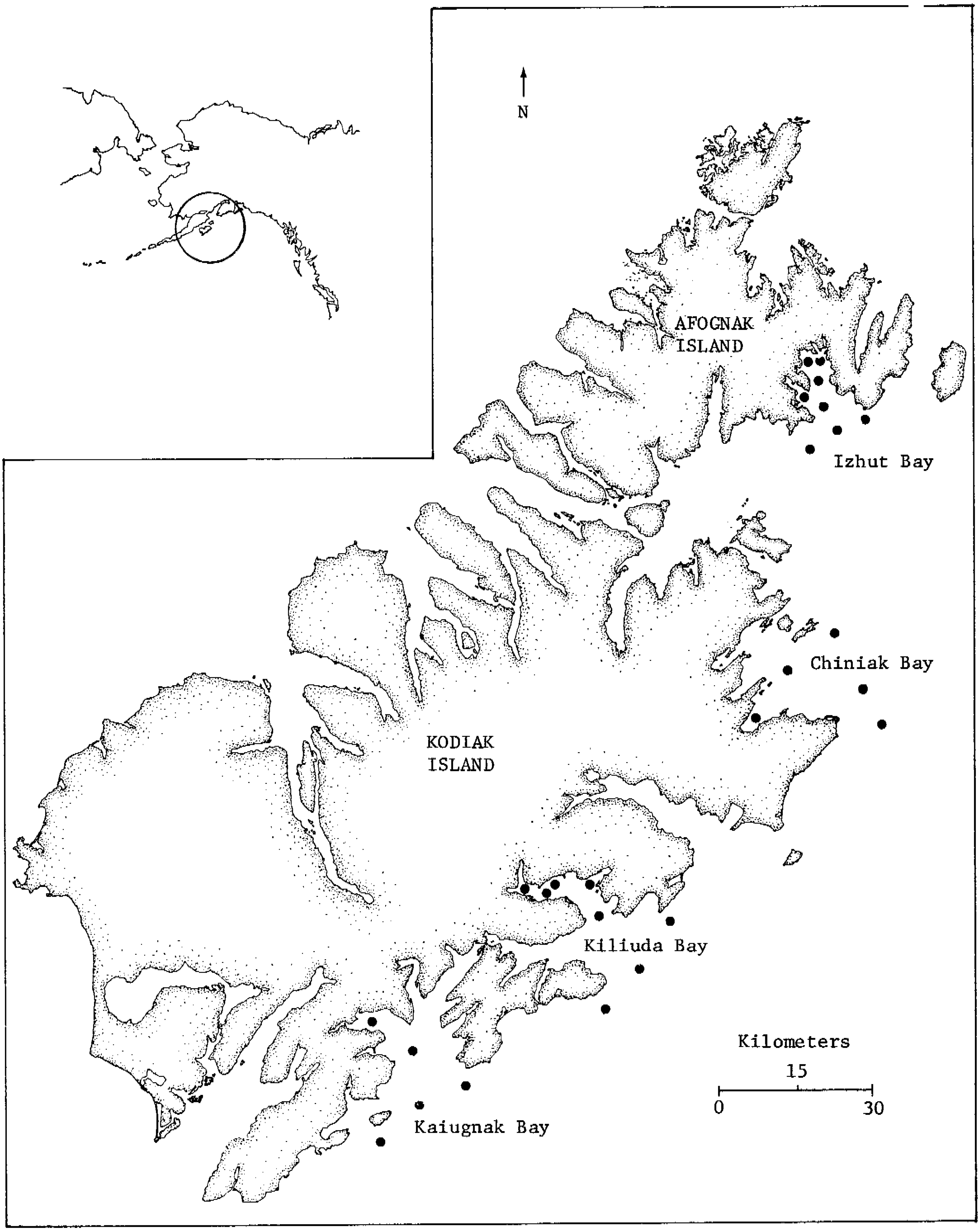

Fig. 1. Locations of bays and stations, Kodiak Archipelago nearshore zooplankton research, 1978.

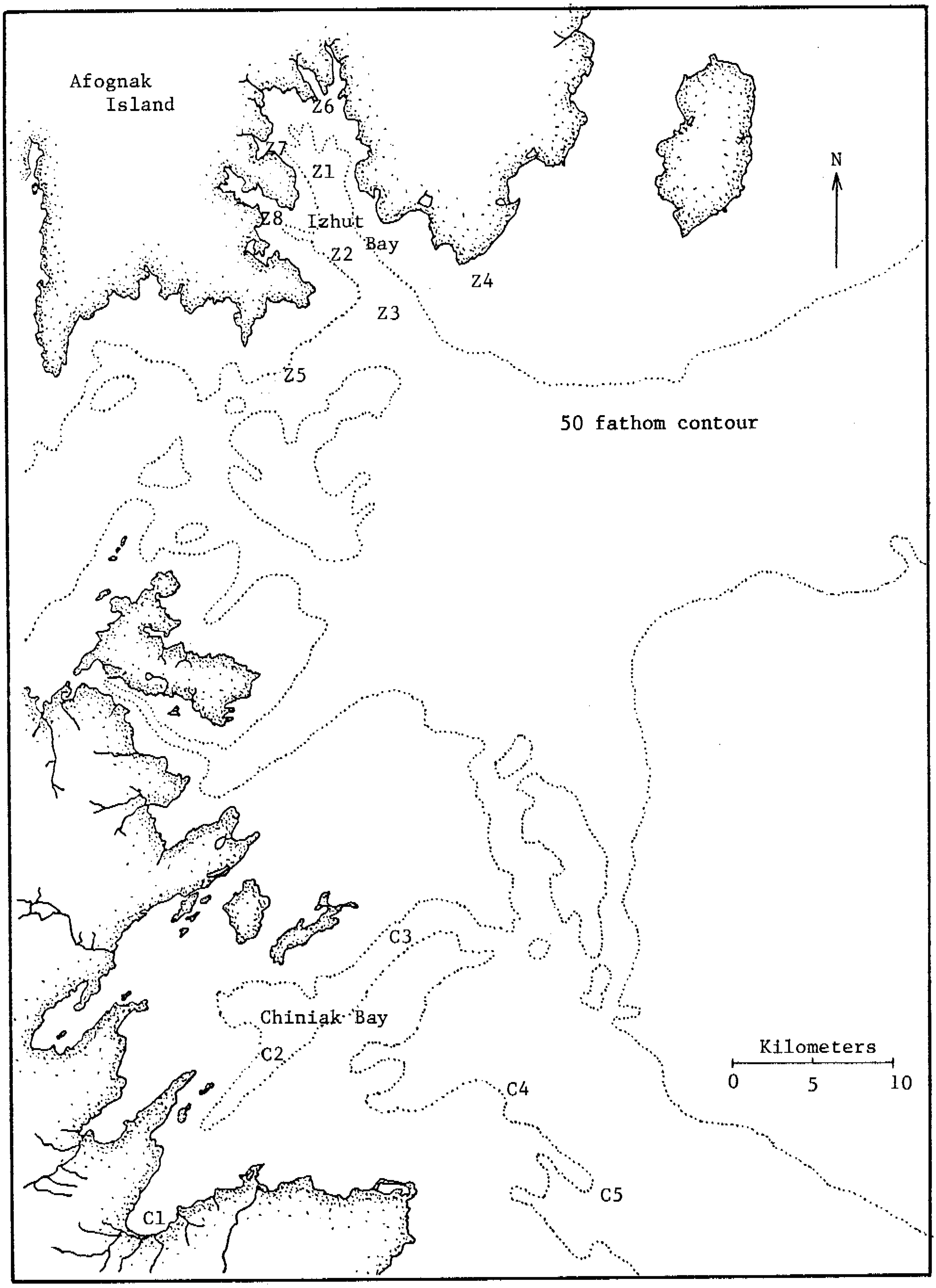

Fig. 2 . Station locations for Kodiak Island nearshore zooplankton research, 1978.

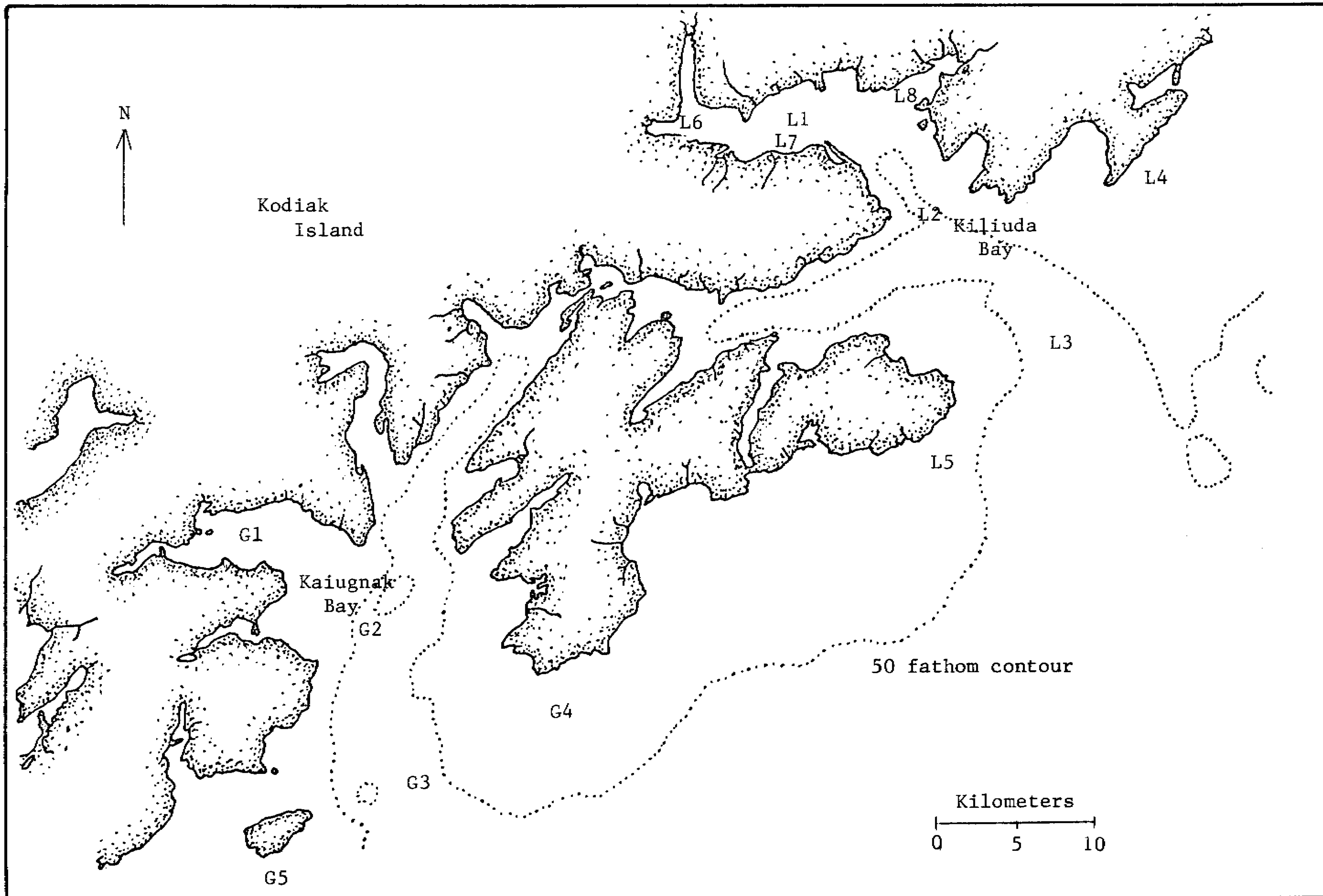

Fig. 3. Station locations for Kodiak Island nearshore zooplankton research, 1978.

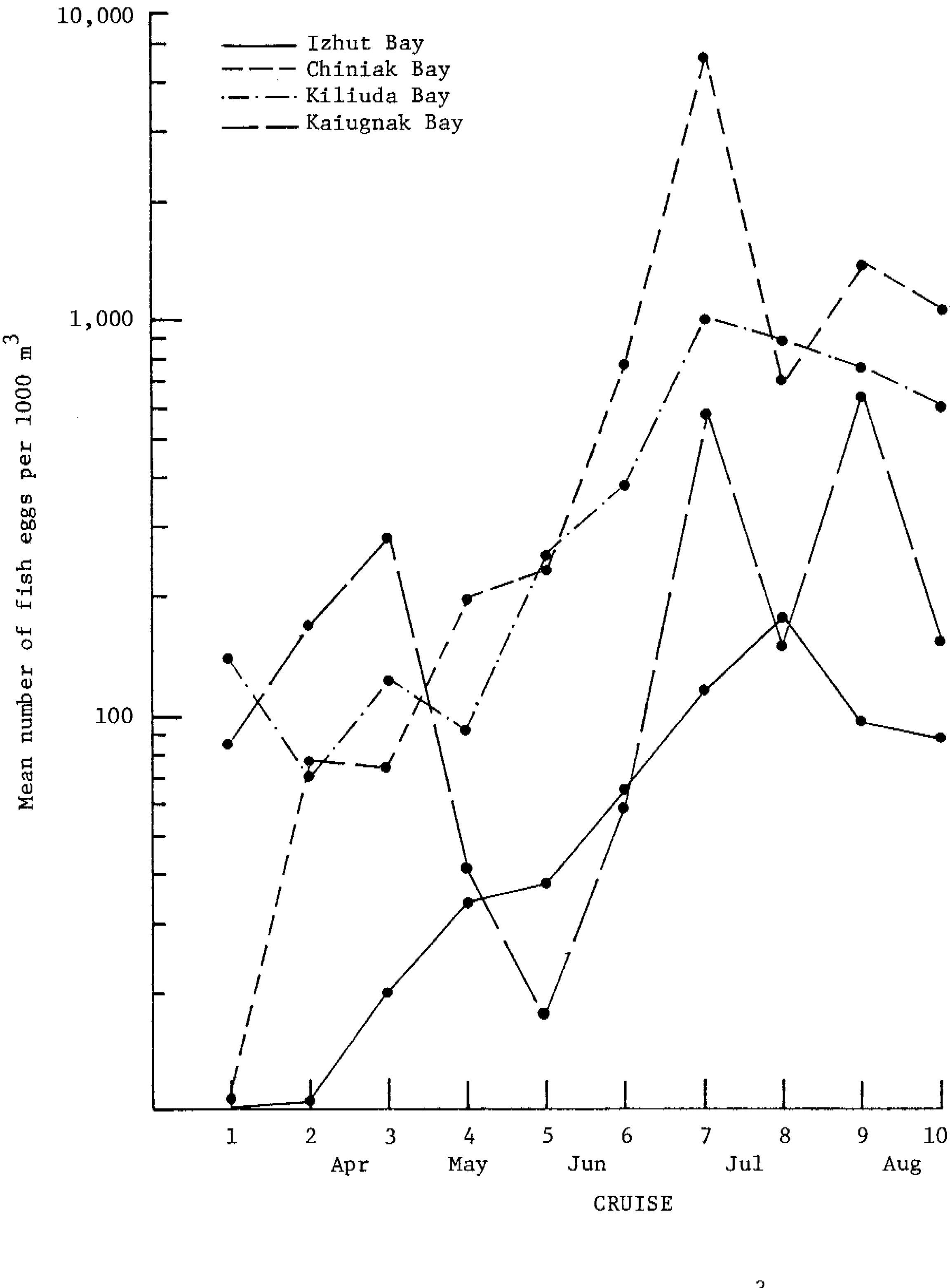

Fig. 4. Mean number of fish eggs per 1000 m^3 from bongo (505μ) samples, stations 1-5, by bay and cruise, Kodiak Archipelago, Alaska, 1978.

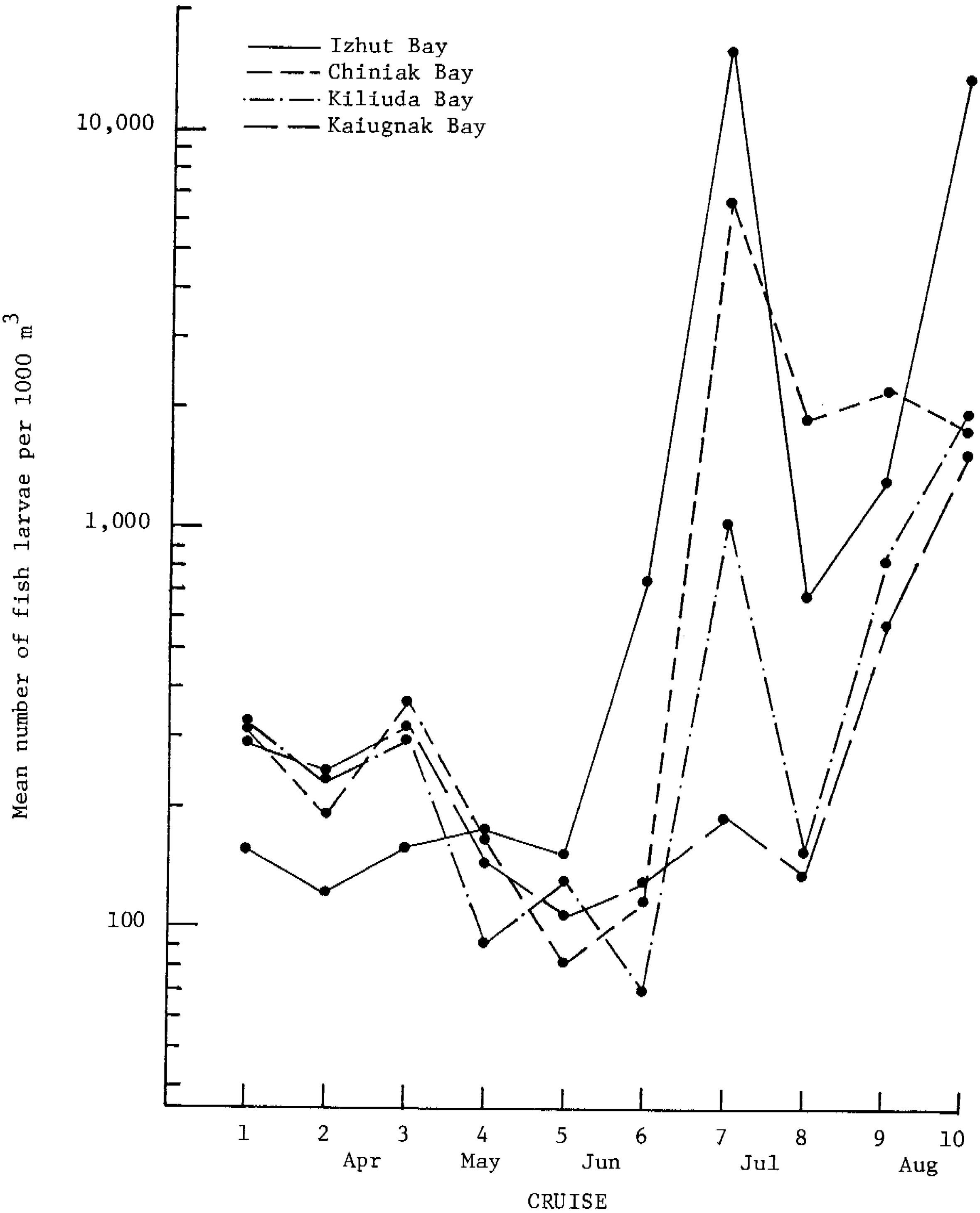

Fig. 5. Mean number of fish larvae per 1000 m^3 from bongo (505μ) samples, stations 1-5, by bay and cruise, Kodiak Archipelago, Alaska, 1978.

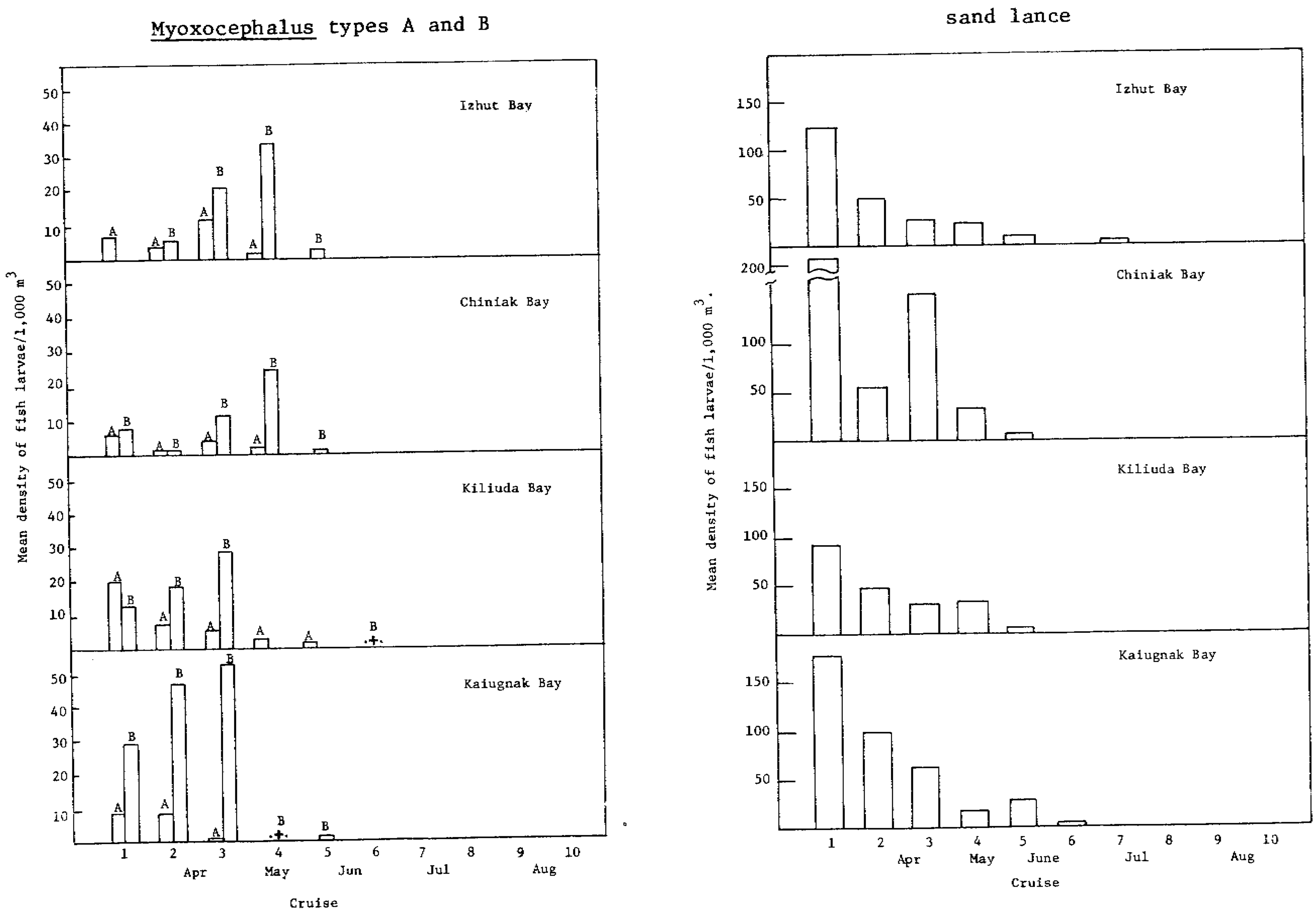

Fig. 6. Seasonal occurrence and mean density of *Myoxocephalus* types A and B and sand lance larvae in four bays of the Kodiak Archipelago, Alaska, 1978.

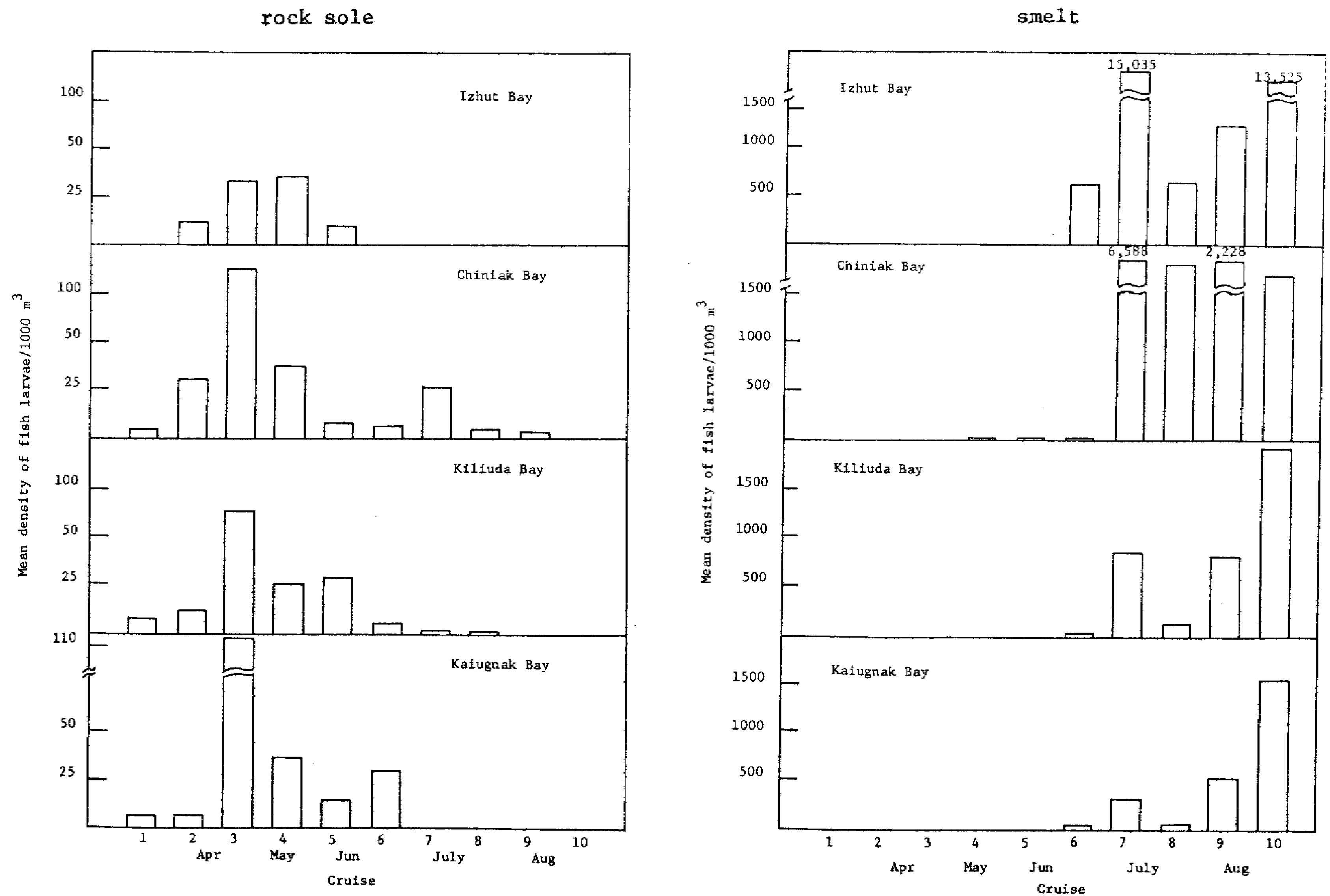

Fig. 7. Seasonal occurrence and mean density of rock sole and smelt larvae in four bays of the Kodiak Archipelago, Alaska, 1978.

Table A. Station locations for Kodiak Island nearshore zooplankton research, 1978-79.

Bay	Station	Latitude		Longitude		Gear used*
Izhut	Z1	58	13	152	17	N,B
	Z2 (day-night)	58	10	152	14	N,B,T,S
	Z3	58	06	152	10	N,B,S
	Z4	58	08	152	03	N,B
	Z5	58	05	152	18	N,B
	Z6**	58	15	152	16	N,B
	Z7**	58	13	152	18	N,B
	Z8**	58	11	152	20	N,B
Kalsin-Chiniak	C1	57	37	152	25	N,B
	C2	57	41	152	19	N,B,S
	C3	57	44	152	14	N,B,S
	C4	57	42	152	04	N,B
	C5	57	38	151	55	N,B
Kiliuda	L1	57	19	153	02	N,B
	L2 (day-night)	57	16	152	55	N,B,T,S
	L3	57	12	152	45	N,B,S
	L4	57	16	152	37	N,B
	L5	57	36	152	54	N,B
	L6**	57	20	153	09	N,B
	L7**	57	18	153	06	N,B
	L8**	57	20	152	55	N,B
Kaiugnak	G1	57	04	153	36	N,B
	G2	57	01	153	29	N,B,S
	G3	56	56	153	27	N,B,S
	G4	56	58	153	14	N,B
	G5	56	52	153	35	N,B

*N = neuston, B = bongo, T = Tucker trawl, S = epibenthic sled

**Stations added 5/78

Table 1. Frequency of gear use by bay, station, and cruise for inshore zooplankton research, Kodiak Archipelago, Alaska, 1978-79.[1, 2]

Gear		Neuston (505μ)	Bongo (505μ & 333μ)	Tucker (505μ)	Tucker (3 mm)	Epibenthic sled (505μ)
Bay/Station						
Izhut	1	I-XII	I-XII			
	2	"	"	II-XII	II-X	II-X
	2 (night)	II-XII		II-XII	II-X	
	3	I-XII	I-XII			II-VI
	4	"	"			
	5	"	"			I
	6	IV-XII	IV-XII			
	7	"	"			
	8	"	"			
Chiniak	1	I-XII	I-XII			I
	2	"	"			I-X
	3	"	"			I-V
	4	"	"			
	5	I-X	I-X			

Cruise-month reference

Cruise	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Month	Mar '78	Apr		May		Jun	Jul		Aug		Nov	Mar '79

[1]All stations were occupied during daylight hours except when noted.

[2]Gear use per cruise was limited to one sample per gear type, station, depth interval (and time of day when appropriate).

Table 1. Frequency of gear use by bay, station, and cruise for inshore zooplankton research Kodiak Archipelago, Alaska, 1978-79.[1], [2] - continued.

Gear		Neuston (505μ)	Bongo (505μ & 333μ)	Tucker (505μ)	Tucker (3 mm)	Epibenthic sled (505μ)
Bay/Station						
Kiliuda	1	I-XII	I-XII			I
	2	"	"	I-XII	I-X	II-X
	2 (night)	"	I-XII	I-XII	I-X	
	3	"	"			II-V
	4	"	"			
	5	"	"			
	6	IV-XII*	IV-XII			
	7	IV-XII°	"			
	8	IV-XII+	"			
Kaiugnak	1	I-XII	I-XII			
	2	"	"			II-X
	3	"	"			II-V
	4	"	"			
	5	"	"			

Time-scale reference

Cruise	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Month	Mar '78	Apr		May		Jun	Jul		Aug		Nov	Mar '79

*Except cruise VI.
° " " IX.
\+ " " X.

[1] All stations were occupied during daylight hours except when noted.

[2] Gear use per cruise was limited to one sample per gear type, station, depth interval (and time of day when appropriate).

Table 2. Gear and gear-use characteristics for inshore zooplankton research, Kodiak Archipelago, Alaska, 1978-79.

Gear type	Opening (m^2)	Mesh (μ)	Tow characteristics	Duration (minutes)	Vessel speed (knots)
Neuston	.14 (= .3 m x .5 m)	505	Horizontal-surface	10	2-2.5
*Bongo	.28 (.6 m dia.)	505 & 333	Double oblique - near bottom to surface	10-25	2-2.5
*Tucker (with opening-closing mechanism)	1 (with 45° side-wire angle)	505	Horizontal at 10, 30, 50, 70, 90 meters	5 per depth	2-2.5
*Tucker	1	505 & 3000	Double oblique - 90 m to surface	10-25	2-2.5 (4 for larger mesh)
Epibenthic sled (with opening-closing mechanism)	1	505	Horizontal-bottom	10	2-2.5

*Rate of descent: 50 m of wire/min with 30 second hold at maximum depth. Rate of ascent: 20 m of wire/min.

*Procedure conducted once during daylight and repeated after dusk.

Table 3. Zooplankton sorting design, by gear type, for inshore zooplankton research, Kodiak Archipelago, Alaska, 1978-79.

Sampling device (mesh size)	Sorted component(s)	Total number or organisms removed or percent of sample sorted
Neuston (505µ)	- fish eggs and larvae	100%
Bongo (505µ	- fish eggs and larvae - adult euphausiids[1]	100% 175-225
Bongo (333µ)	- major taxa including fish eggs and larvae, crab and shrimp larvae, euphausiids, amphipods, copepods, and chaetognaths	500≃700
Tucker trawl (505µ)	- fish eggs and larvae - crab and shrimp larvae - adult euphausiids[1]	100% from 500≃700 organism-aliquot 175-225
Tucker trawl (3 mm)	- fish larvae	100% of those > 20 mm
Epibenthic sled (505µ)	- fish eggs and larvae - crab & shrimp larvae	100% from 500≃700 organism-aliquot

[1]Adult euphausiids were removed from Bongo (505µ) samples taken at stations 1 and 3 for all bays and all cruises and from Tucker (505µ) samples taken in Kiliuda Bay during both day and night sampling from depths 10 m and 30 m.

Adult euphausiids were identified, their lengths measured and wet weights taken by the sorting agency.

Table 4. Density of fish eggs per 1000 m^3 from neuston (505μ) samples, by cruise and station, Izhut Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	6	7	8	$\bar{X}$ (1-5)	$\bar{X}$ (6-8)
1	Mar 29-Apr 8	0	0	0	0	0	-	-	-	0	
2	Apr 10-Apr 17	0	1074	0	0	9	-	-	-	217	
3	Apr 21-May 1	333	14	0	0	15	-	-	-	72	
4	May 3-May 28	140	18	8223	95	64	409	386	0	1708	265
5	May 31-Jun 6	3121	313	0	143	71	3845	8000	18000	730	9948
6	Jun 14-Jun 26	14215	2636	195	360	3525	67647	43368	43238	4186	51418
7	Jun 28-Jul 18	21999	31	754	21	679	53238	29647	187253	4697	90046
8	Jul 21-Jul 29	92617	3940	714	33	525	31875	54564	30533	19566	38991
9	Aug 1-Aug 9	20865	6122	204	40	9055	45484	(28970)	641600	7257	238685
10	Aug 15-Aug 21	13167	323	587	541	774	5579	11489	(144785)	3078	53951
	$\bar{X}$ (1-10)	16646	1447	1068	123	1472					
	$\bar{X}$ (4-10)	23732	1912	1525	176	2099	29725	25203	152201		

( ) = estimate; no sample taken.

Table 5. Kinds and mean numbers per 1000 m^3 of fish eggs from neuston (505μ) samples, Izhut Bay, Kodiak Archipelago, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Pleuronectidae		.	2	25	131	4177	21543	36670	26755	103292	4578
Hippoglossoides elassodon		.	.	3	992	4	297	22	77	19	10
Theragra chalcogramma		.	215	.	.	.	.	.	.	.	.
Unidentified		.	.	44	18	2	53	12	18	0	49
Trichodon trichodon		.	.	.	26	.	4	.	.	.	.
Hexagrammidae		.	.	.	.	.	.	.	.	27	.
Glyptocephalus zachirus		.	.	.	.	4	.	.	.	.	.

Table 6. Density of fish eggs per 1000 m^3 from neuston (505μ) samples, by cruise and station, Chiniak Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations					$\bar{X}$ (1-5)
		1	2	3	4	5	
1	Mar 29-Apr 8	23	42	10	0	13	18
2	Apr 10-Apr 17	2414	265	68	457	180	677
3	Apr 21-May 1	21*	29	47	129	222	90
4	May 3-May 28	160	454	579	387	4500	1216
5	May 31-Jun 6	38	179	889	804	81	398
6	Jun 14-Jun 26	10250	12617	2445	2548	1500	5872
7	Jun 28-Jul 18	166909	40604	18310	8109	589	46904
8	Jul 21-Jul 29	16522	91784	77511	180	510	37301
9	Aug 1-Aug 9	33216	10278	6312	590	2821	10643
10	Aug 15-Aug 21	335673	5088	329	262	2796	68830
	$\bar{X}$ (1-10)	56523	16134	10650	1347	1321	

* not identified.

Table 7. Kinds and mean numbers per 1,000 m^3 of fish eggs from neuston(505μ) samples, Chiniak Bay, Kodiak Archipelago, 1978.

Taxa	Month Cruise	Apr 1	 2	 3	May 4	Jun 5	 6	Jul 7	 8	Aug 9	 10
Pleuronectidae		13	636	11	87	363	5777	46861	37296	10566	68808
Hippoglossoides elassodon		.	.	54	1109	35	20	29	5	72	21
Unidentified		.	.	.	7	.	71	15	.	.	.
Theragra chalcogramma		4	41	20	13	.	3	.	.	5	.

Table 8. Density of fish eggs per 1000 m^3 from neuston (505μ) samples, by cruise and station, Kiliuda Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	6	7	8	$\bar{X}$ (1-5)	$\bar{X}$ (6-8)
1	Mar 29-Apr 8	686	1896	466	226	167	-	-	-	688	
2	Apr 10-Apr 17	2276	1387	30	86	396	-	-	-	835	
3	Apr 21-May 1	1468	151	84	387	341	-	-	-	486	
4	May 3-May 28	27	784	20	1384	1056	12	0	239	654	84
5	May 31-Jun 6	0	422	417	86	95	0	4796	571	204	1789
6	Jun 14-Jun 26	1029	21389	184	22700	15056	(6320)	128	48340	12072	18263
7	Jun 28-Jul 18	4447	42000	7578	10949	18244	21	1211	30591	15844	10608
8	Jul 21-Jul 29	13853	17705	13943	29192	15436	342	5105	47821	18026	17756
9	Aug 1-Aug 9	27765	14227	24800	7656	4891	1667	1339	8512	15868	3839
10	Aug 15-Aug 21	25182	3521	1702	7000	7395	1432	822	9065	8960	3773
	$\bar{X}$ (1-10)	7673	10348	4922	7967	6308					
	$\bar{X}$ (4-10)	10329	14293	6949	11281	8882	1399	1914	20734		

( ) = estimate; no sample taken.

Table 9. Kinds and mean numbers per 1000 m^3 of fish eggs from neuston (505μ) samples, Kiliuda Bay, Kodiak Archipelago, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Pleuronectidae		38	812	417	410	782	15431	14380	17925	11357	7015
<u>Theragra chalcogramma</u>		286	17	38	17	.	20	.	.	.	.
<u>Hippoglossoides elassodon</u>		2	6	20	8	10	96	.	.	.	.
Unidentified		20	.	6	5	4	.	.	.	.	.
<u>Pleuronectes quadrituberculatus</u>		.	.	5	.	.	.	.	.	.	.
<u>Glyptocephalus zachirus</u>		.	.	.	.	2	.	.	.	.	.

Table 10. Density of fish eggs per 1000 m^3 from neuston (505μ) samples, by cruise and station, Kaiugnak Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	$\bar{X}$ (1-5)
1	Mar 29-Apr 8	907	523	1449	678	28	717
2	Apr 10-Apr 17	95	5137	913	32	2193	1674
3	Apr 21-May 1	1846	1553	257	143	1077	975
4	May 3-May 28	0	17	56	0	0	15
5	May 31-Jun 6	113	52	122	68	60	83
6	Jun 14-Jun 26	235	3235	1000	83	590	1029
7	Jun 28-Jul 18	7160	969	886	1179	56	2050
8	Jul 21-Jul 29	37489	43539	2405	29	583	16809
9	Aug 1-Aug 9	9156	39170	776	4828	5880	11962
10	Aug 15-Aug 21	1848	3920	1440	151	1567	1785
	$\bar{X}$ (1-10)	5885	9812	930	719	1203	

Table 11. Kinds and mean numbers per 1000 m^3 of fish eggs from neuston (505μ) samples, Kaiugnak Bay, Kodiak Archipelago, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Pleuronectidae		207	875	602	.	15	912	1631	16788	11945	1785
Theragra chalcogramma		503	771	118	.	5	.	.	.	.	.
Unidentified		2	13	36	.	20	.	419	.	.	.
Hippoglossoides elassodon		5	15	219	15	42	116	.	21	17	.

APPENDIX 4.4.28. SHELL LENGTH (MM) DATA FOR *CLINOCARDIUM NUTTALLII* FROM GLACIER SPIT, CHINITNA BAY

6 April 1977				30 July 1977					Frequency	
+3.6'	+2.5'	+0.9'	-1.2'	+3.6'	+2.5'	+0.9'	-1.2'	Size Class	4/6/77	7/30/77
2.0	1.6	9.2	1.9	9.6	1.8	8.7	9.6	1-3	62	16
1.5	2.1	2.5	2.6	2.3	11.5	2.3	3.4	4-6	0	2
2.0	2.4	10.8	2.1	27.1	39.9	2.3	7.4	7-9	1	4
1.9	2.8	2.0	2.0		27.9	5.8	3.4	10-12	1	5
1.7		2.1	2.1		31.3	1.6	2.2	13-15	0	1
		1.8	2.2		33.6	2.2	11.8	16-18	0	0
		1.9	1.9			4.0	12.6	19-21	0	0
		2.0	1.9			2.1	12.7	22-24	0	0
		2.0	2.0			1.9	14.0	25-27	0	2
		2.0	1.5			2.2	10.9	28-30	0	0
		1.8	1.6			2.0	1.9	31-33	0	2
		2.0	2.2			2.0	2.3	34-36	0	0
		1.8	2.2			47.2		37-39	0	1
		1.6	2.4					40-42	0	0
		1.8	1.8					43-45	0	0
		1.9	2.2					46-48	0	1
		1.8	2.5							
		2.2	1.8							
		2.3	3.0							
		2.1	2.2							
		1.8	2.4							
		1.6	2.5							
		2.0	1.9							
		1.9	1.9							
		1.7								
		2.2								
		2.1								
		1.8								
		1.7								
		2.4								
		2.3								

	6 April 1977	30 July 1977
$\bar{x}$	2.25	10.63
s	1.46	12.25
n	64	34

APPENDIX 4.4.29. SHELL LENGTH AND WEIGHT MEASUREMENTS FOR *CLINOCARDIUM NUTTALLII* AT GLACIER SPIT, CHINITNA BAY

+3.6'			+2.5'			+0.9'			-1.2'		
Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)	Shell Length (mm)	Whole Wet Weight (g)	Wet Tissue Weight (g)
6 April 1977											
2.0	0.005	-	1.6	0.002	-	9.2	0.1	-	1.9	0.004	-
			2.1	0.01	-				1.9	0.004	-
			2.4	0.01	-						
			2.8	0.01	-						
30 July 1977											
9.6	0.18	-	1.8	0.005	-	8.7	0.15	-	2.2	0.005	-
2.3	0.01	-	11.5	0.34	-	2.0	0.005	-	11.8	0.44	-
27.1	3.70	0.96	39.9	9.83	3.0	47.2	25.50	9.73	1.9	0.005	-
			27.9	3.32	1.30				2.3	0.005	-
			31.3	7.01	2.23				-	2.10	-
			33.6	7.79	2.49						

Wet tissue weight:whole wet weight ratio = 0.34

APPENDIX 4.4.30. SHELL LENGTH (MM) DATA FOR <u>PSEUDOPYTHINA</u> SP. FROM GLACIER SPIT, CHINITNA BAY

6 April 1977						30 July 1977					
+3.6'	+2.5'	+0.9'	-1.2'	Size Class	Number	+3.6'	+2.5'	+0.9'	-1.2'	Size Class	Number
1.5	3.6	1.9	3.8	1.0-1.9	8	12.9	11.9	2.5	3.3	1.0-1.9	0
1.7	1.9	2.1	4.9	2.0-2.9	16	11.2	2.7	2.3	3.5	2.0-2.9	11
2.5	3.4	2.1	2.0	3.0-3.9	13	2.7	3.0	4.2	3.8	3.0-3.9	12
2.4	4.7	2.0	3.3	4.0-4.9	10	4.4	4.3	3.3	4.4	4.0-4.9	10
4.1	3.7	2.9	4.0	5.0-5.9	0	2.9	4.2	2.4	4.6	5.0-5.9	1
3.5	4.2	3.4		6.0-6.9	0	2.9	6.1	4.3	3.9	6.0-6.9	2
3.4	2.6	2.7		7.0-7.9	0	3.3	3.6	4.0	5.4	7.0-7.9	0
2.9	3.7	4.7		8.0-8.9	0		11.7	4.0	3.7	8.0-8.9	1
1.8	2.4	3.8		9.0-9.9	0		6.7	3.8	2.0	9.0-9.9	1
	2.7	3.0		10.0-10.9	0			9.2	10.0	10.0-10.9	1
	11.9	1.7		11.0-11.9	1			4.5	2.1	11.0-11.9	3
	1.8	2.0		12.0-12.9	0			2.1		12.0-12.9	1
	4.1	2.0		13.0-13.9	0			3.1		13.0-13.9	0
	4.2	2.8		14.0-14.9	0			16.2		14.0-14.9	0
	2.2	4.3						2.0		15.0-15.9	0
	1.6	3.4						3.7		16.0-16.9	1
		3.2						8.9			
		4.4									

	6 April 1977	30 July 1977
$\bar{x}$	3.18	5.04
s	1.60	3.37
n	48	44

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ANNUAL REPORT

Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System

James E. Blackburn

Peter B. Jackson

Alaska Department of Fish & Game

P.O. Box 686

Kodiak, Alaska 99615

March 31, 1979

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INTRODUCTION

General Nature and Scope of Study

This study is in part a survey of the nearshore finfish and commercial crab resources and food habits of lower Cook Inlet. The study is to evaluate impact of oil development in the final report. Field collections and available data are to be drawn upon as source material. Field collections were collected primarily in the northern half of Kamishak Bay with some effort in Kachemak Bay in April and October of 1978. This study is only one of a coordinated set of studies of several aspects of the Cook Inlet system which include bird, mammal, benthic invertebrate, plankton and several other studies by OCSEAP investigators.

At the present time field collections are completed, key punching is completed and initial computer runs of data have been completed. Mapped information on fisheries is partially complete. This progress report presents only a few generalities which could be drawn from the data.

Specific Objectives

1. Determine the feeding habits of principal life stages of dominant pelagic and demersal fish and provide an initial description of their role in the food web.

2. Describe the distribution and relative abundance of pelagic and demersal fish and their seasonal changes.

3. Identify areas of unusual abundance or of apparent importance to fish, especially commercially important species.

4. Review all past information on the fisheries in lower Cook Inlet including commercial and sports catch statistics in order to determine the past and future trends in the importance of these species and to define the geographical and seasonal locations of fishing areas.

5. Define the geographical locations and seasonal use of spawning areas to the highest resolution possible.

6. Identify the geographical and seasonal locations of important prey.

7. Describe and evaluate the potential for impact on commercial, potentially commercial, and sports fisheries by OCS oil and gas explorations, development, and production based on the findings of the above six objectives plus existing information on the sensitivity of various life stages of these species, and geographical areas of potential risk.

Relevance to Problems of Petroleum Development

Oil exploration in the Cook Inlet lease area constitutes a potential for environmental degradation and it is a legal requirement of the leasing agency, Bureau of Land Management (BLM), to consider this potential as a part of the cost of leasing. This study was funded by BLM as a part of the program to satisfy their requirements.

Study of the living marine resources of Cook Inlet is an especially pertinent portion of the pre-lease studies as the livelihood of the vast majority of the people of this area is based upon the harvest of renewable resources.

Acknowledgements

The personnel of the OCSEAP Juneau Project Office contributed considerably to the planning and execution of this study, especially George Lapiene and Paul Becker. All vessel support and field camp support was arranged by them.

The employees that conducted the sampling did a fine job and they were Jay Field, crew leader, Jim Sicina, Dan Locke, Robert Sanderlin, Harry Dodge and Tom Bledsoe. Ms. Karen Anderson conducted all the food habits analysis and Bill Johnson created the computer routines to analyse the data.

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office.

CURRENT STATE OF KNOWLEDGE

In the lower Cook Inlet area previous survey type data on marine resources is largely lacking. The National Marine Fisheries Service (NMFS) has conducted approximately 85 otter trawl hauls in Cook Inlet during 1958, 1961 and 1963, however, they were rigged for shrimp or crab and operated only between mid-July and late September. Various fisheries have existed in the inlet for some time and information based on these fisheries has been accumulating. The salmon fishery is conducted in summer, throughout the inlet, with local concentrations of effort and fish. The herring fishery has been active in Kachemak Bay, Kamishak Bay and in the vicinity of the Forelands. Rounsefell (1929) documented this fishery in Kachemak Bay in the early part of the century, however, due to fluctuations in price and stocks, this has not been a continuous fishery.

Halibut have been fished in Kachemak Bay, Kamishak Bay and to some extent around Kalgen Island. The International Pacific Halibut Commission conducted 26 otter trawl hauls in July of 1974 and 1976 in the mouth of Kachemak Bay as part of their work to index rearing stocks. The trawl shrimp fishery has been active but restricted to Kachemak Bay. Shrimp research has included fishery documentation and since 1971, trawl surveys have been conducted in May to index stock abundance (Davis 1976a).

The king and tanner crab fisheries have been active in Kachemak Bay and in the central inlet southeast of Augustine Island. In 1974, a pot index program for king and tanner crab abundance was initiated in Kachemak Bay and in 1975 the program was expanded to the Kamishak Bay area (Davis 1975, 1976b). Other fisheries include Dungeness crab and pot shrimp (those caught by pot as opposed to trawl) which are largely restricted to Kachemak Bay. Sport fisheries include king salmon and razor clam, which are largely restricted to the east side of the inlet between Anchor Point and the Forelands.

A compilation of existing information on the Cook Inlet fisheries was prepared by the Alaska Department of Fish and Game under a program funded by the Federal Coastal Zone Management Program Development Funds (ADF&G 1976). This work included a written narrative and a portfolio of mapped data. The narrative included characterizations of each fishery and tabularizations of statistical data. Historical catch, effort, economic value, and escapement statistics were included. The map section included distribution mappings for all significant finfish and shellfish species, major fishing areas for all commercial species, critical salmon and shellfish spawning areas by species, where known, and shellfish rearing areas by species, where known.

A study of the effects of oil on biological resources was funded by the State of Alaska as a result of public concern over Alaska's 28th Oil and Gas Lease Sale of subtidal land in Kachemak Bay. These studies included the fishery resources, birds, coastal morphology, circulation and a synthesis of the impact of oil on the Kachemak Bay environment (Trasky et. al. 1977).

The studies initiated in 1976 under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) were hastily assembled and were faced with a paucity of data concerning what to expect. The scope was broad: as much of the inlet as could be physically covered efficiently. Sampling was conducted with beach seines and surface tow nets from the east Forelands to Port Graham on the east side of the inlet and from Amakdedori Beach to Chinitna Bay (with a few samples further north) on the west side of the inlet. Surveys were repeated monthly during June through September of 1976. An otter trawl was successfully used in the central portion of the inlet during June, July, August, September 1976 and March 1977. A power purse seine and gill nets were used to study pelagic fish during July, August and September 1976. A number of conclusions resulted from this study as did some questions (Blackburn, 1978).

Since this project was initiated the lease area has been expanded into Shelikof Straits. Information on resources in Shelikof Straits is quite limited. Ronholt et. al. (1978) have gathered together the results of all past NMFS trawl surveys in the north Pacific area, including those conducted in Shelikof Straits and lower Cook Inlet. From this report general species abundance can be obtained but distributional features within Shelikof are not clear.

Commercial fishery catch statistics for Shelikof and lower Cook Inlet are being assembled from ADF&G information and these data will be presented in the final report. Certain highlights are clear. Tanner crab catches are concentrated around Cape Douglas, in Kachemak Bay, in Viekoda Bay-Kupreanof Strait and in the south of Shelikof. King crab catches are similarly concentrated but around Cape Douglas they are further north. Dungeness crab catches are greatest in outer Kachemak Bay and along both shorelines of Shelikof Strait. Shrimp fisheries have been most active in Kachemak Bay, Kukak Bay, Uganik Bay, Uyak Bay, Wide Bay and Puale Bay. Herring are known to spawn in virtually every bay on the west side of the Kodiak archipelago, in Kukak Bay, Kamishak Bay, Kachemak Bay and near the Forelands, where fisheries exist. Salmon use virtually every river and stream in the area, catches are widely distributed and the entire area is used by migrating fish. The expanding bottomfish fishery is catching walleye pollock and fewer Pacific cod in central Shelikof at very high catch rates from a relatively large, dense aggregation of these fish. Catch rates of 1000 to 5000 lbs. per hour have been documented. Further information will be presented in the final report.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

The field collections for this study were made in part of Kachemak Bay and northern Kamishak Bay. The work in Kachemak Bay was conducted continuously from May through September. Collections were made with beach seine, try net, gill net, trammel net, and surface tow net. These are described in detail below. Temperature and salinity were measured with a Yellow Springs Instrument Co. Model 33 Temperature/Salinity meter.

The field crew consisted of four people who were housed in camp facilities in Cottonwood Bay during May through September. During April and November they stayed in Homer and the Kasitsna Bay field station respectively. Two outboard skiffs, one 17 ft. (5 m) and one 21 ft. (6.4 m) in length were continuously used for sampling and the M/V HUMDINGER was irregularly available for tow net and try net sampling beginning in May.

Beach Seine

The beach seine was constructed as shown in Figure 1. Approximately 50 ft. (15 m) of rope was attached to each end with one small anchor. The net was set in an arc such that each end of the net was usually within 10 ft. (3 m) of the beach and the net was immediately retrieved. Sampling stations were informally selected on suitable beaches so as to evenly cover the study area. Once stations were selected, they were visited on each successive cruise.

Try Net

The try net was a standard 20 ft. (6.1 m) try net purchased from McNeir Net and Supply Co. It had a 22 ft. (7 m) foot rope, a 20 ft. (6.1 m) was made with 1-1/2" (38 mm) #18 bag and was dipped in green gard. Otter boards were 15: X 30" (38 cm x 76 cm). It was equipped with a tickler of 3/8" (9.5 mm) chain which was slightly shorter than the footrope so that it preceeded the footrope when the net was in operation. It was pulled at about 3.5 kph so that about 0.6 km were covered in one tow. The net was considered to open about 5.3 m horizontally and 0.7 m vertically so that one tow covered about 3200 m^2. Sampling stations were selected in the field.

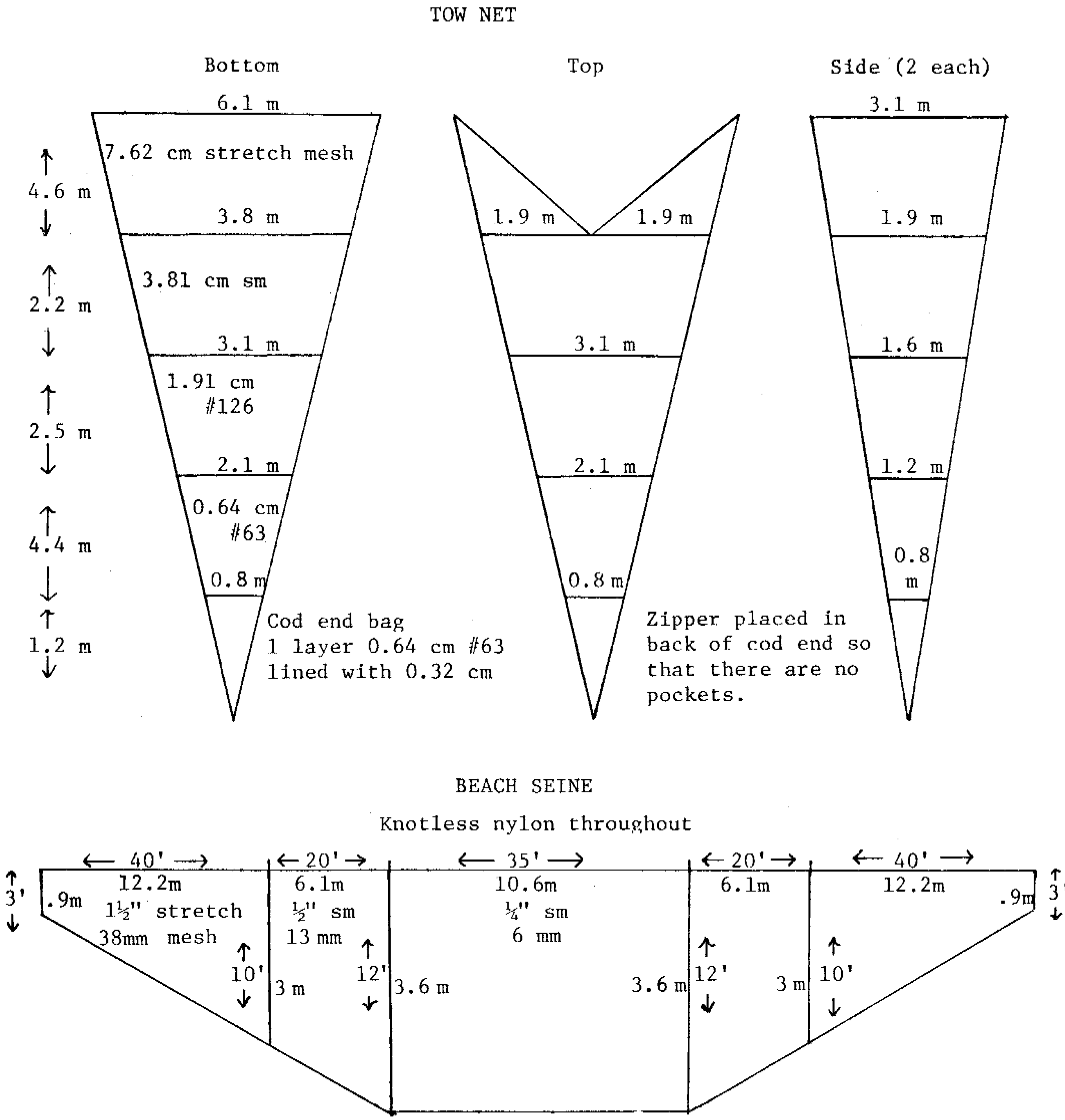

Figure 1 . Specifications of the tow net and beach seine, diagrammatic.

Gill Nets

Gill nets were 6 ft. (1.8 mm) deep and 100 ft. (30.4 m) long and each consisted of 25 ft. (7.6 m) long panels of 1", 1-1/2", 2" and 2-1/2" (25 mm, 38 mm, 51 mm and 64 mm) stretch mesh knotted nylon. The nets were hung to float, were anchored in the immediate vicinity of beach seine stations and retrieved after about a one hour soak.

Trammel Nets

The trammel nets were constructed of three adjacent panels (two outer and one inner) each 150 ft. (45.7 m) by 6 ft. (1.8 m). The two outer panels were made with 20" (0.5 m) stretch mesh of #9 twine 8 mesh deep by 168 mesh long. The single inner panel was 2" (51 mm) stretch mesh of #139 twine, 68 mesh deep by 2016 mesh long. All panels were white knotted nylon. The lead line was 75 lb. lead core rope and the floatline was 1/2" (13 mm) poly foam core line.

The trammel nets were hung to sink and were fished on the bottom. A single net was anchored in the immediate vicinity of a beach seine station and was retrieved after approximately a one hour soak.

Tow Net

The tow net was constructed as illustrated in Figure 1. It was held open vertically by spreader bars of 2" (51 mm) galvanized water pipe and was held open horizontally by a towing vessel on each side. It opened approximately 10 ft. (3 m) vertically and 20 ft. (6.1 m) horizontally when fishing. It was towed at the surface between a skiff and the charter vessel on approximately 100 ft. (30.4 m) of line for 10 minutes at approximately 3.5 kph so that about 0.6 km were covered in one tow. Sampling stations were informally selected to cover the study area.

Sample Handling

Immediately after capture, catches were sorted to species when possible, counted, weighed and recorded. Life history stage was recorded when it was possible to determine and for some species the catches were sorted by life history stage, i.e. adult, juvenile and larval. The stomach was removed from large fish after they were weighed, measured and the data recorded. Small fish were preserved whole for food habits analysis and lengths of these were not taken in the field. Lengths were recorded from a large portion of the fish that were not used for food habits analysis.

Maturity state of adult fish was recorded when they were opened for stomach removal and in some cases samples of fish were opened expressly to determine maturity state. When sex products were observed to flow freely from fish this was recorded. Due to the lack of knowledge of the appearance of the gonads before and after spawning for the many species handled, the maturity state observations are considered of value only when freely flowing sex products were observed.

Food Habits Analysis

Specimens for food habits analysis were selected from those captured using the list of priorities and maximum number per cruise shown in Table 1 . The total time available for food identification was allotted by cruise and as many specimens were examined as time allowed. During the sample analysis the project was extended and due to State of Alaska employment rules, the time available could not be extended without an extended delay, hence available time was less for analysis of later cruises.

Table 1. Priority list for selection of specimens for food habits analysis.

PRIORITY		Maximum number analyzed per cruise
1	Sandlance	25
2	Herring	25
3	Dolly Varden	25
4	Chum Salmon Fry	25
5	Chinook Salmon Fry	15
6	Red Salmon Fry	15
7	Coho Salmon Fry	15
8	Pink Salmon Fry	15
9	Whitespotted Greenling Juvenile	15
10	Whitespotted Greenling Adult	10
11	Masked Greenling Juvenile	15
12	Masked Greenling Adult	10
13	Capelin	20
14	Eulachon	5
15	Longfin Smelt	10
16	Great Sculpin	20
17	Yellowfin Sole	10
18	Starry Flounder	10
19	Rock Sole	10
20	Staghorn Sculpin	10
21	Pollock	10
22	Pacific Cod	10

Table 24. Density of fish eggs per 1000 m^3 from bongo (505μ) samples, by cruise and station, Kiliuda Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	6	7	8	$\bar{X}$ (1-5)	$\bar{X}$ (6-8)
1	Mar 29-Apr 8	480	58	34	0	138	-	-	-	142	
2	Apr 10-Apr 17	132	122	11	4	81	-	-	-	70	
3	Apr 21-May 1	131	56	38	207	192	-	-	-	125	
4	May 3-May 28	16	230	19	68	126	100	29	418	92	182
5	May 31-Jun 6	51	326	206	650	45	969	161	1760	256	963
6	Jun 14-Jun 26	54	489	49	865	449	3333	1245	4307	381	2962
7	Jun 28-Jul 18	2148	680	419	771	1130	2734	3681	4494	1030	3636
8	Jul 21-Jul 29	1884	1368	173	768	237	2557	3093	2084	886	2578
9	Aug 1-Aug 9	1437	1030	527	485	338	1736	3161	4142	763	3013
10	Aug 15-Aug 21	472	1389	63	663	425	1518	1700	2058	602	1759
	$\bar{X}$ (1-10)	680	575	375	448	316					
	$\bar{X}$ (4-10)	866	787	524	610	393	1850	1867	2752		

Table 25. Kinds and mean numbers per 1000 m^3 of fish eggs from bongo (505μ) samples, Kiliuda Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Pleuronectidae		114	57	83	125	519	1348	2006	1521	1605	1035
<u>Theragra chalcogramma</u>		28	12	40	1	3	1	1	.	.	.
Unidentified		.	1	1	.	.	.	.	.	2	1
<u>Hippoglossoides elassodon</u>		.	.	1	.	.	.	.	.	.	.
<u>Glyptocephalus zachirus</u>		.	.	.	+	.	.	.	.	.	.

$< .5$ egg/1000 m^3

Table 26. Density of fish eggs per 1000 m^3 from bongo (505μ) samples, by cruise and station, Kaiugnak Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	$\bar{X}$ (1-5)
1	Mar 29-Apr 8	45	211	64	90	19	86
2	Apr 10-Apr 17	36	329	72	7	394	168
3	Apr 21-May 1	203	631	104	74	404	283
4	May 3-May 28	0	172	5	34	0	42
5	May 31-Jun 6	0	26	2	39	12	16
6	Jun 14-Jun 26	11	47	52	15	168	59
7	Jun 28-Jul 18	2648	132	14	135	7	587
8	Jul 21-Jul 29	78	286	278	52	50	149
9	Aug 1-Aug 9	807	438	28	1510	460	649
10	Aug 15-Aug 21	421	64	72	21	211	158
	$\bar{X}$ (1-10)	425	234	69	198	172	

Table 27. Kinds and mean numbers per 1000 m^3 of fish eggs from bongo (505μ) samples, Kaiugnak Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Pleuronectidae		23	73	90	41	5	59	587	149	649	157
Theragra chalcogramma		62	89	79	+	5	.	.	.	.	.
Hippoglossoides elassodon		1	3	107	.	5	.	.	.	.	.
Unidentified		.	3	8	.	1	.	.	.	.	.
Glyptocephalus zachirus		.	.	.	1	+	.	.	.	.	.

+ = < .5 egg/1,000 m^3.

Table 28. Density of larval fish per 1000 m^3 from bongo (505μ) samples, by cruise and station, Izhut Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	6	7	8	$\bar{X}$ (1-5)	$\bar{X}$ (6-8)
1	Mar 29-Apr 8	172	243	31	55	268	-	-	-	154	-
2	Apr 10-Apr 17	221	151	54	116	71	-	-	-	123	-
3	Apr 21-May 1	275	262	78	127	50	-	-	-	158	-
4	May 3-May 28	91	87	149	296	255	217	307	417	176	314
5	May 31-Jun 6	155	117	86	187	219	379	111	199	153	230
6	Jun 14-Jun 26	1644	1882	52	128	11	4449	3197	534	743	2727
7	Jun 28-Jul 18	47867	5359	3858	14038	5719	88806	58975	22227	16112	56669
8	Jul 21-Jul 29	1147	648	408	1278	0	2239	1384	4878	696	2834
9	Aug 1-Aug 9	4127	1769	72	246	503	7277	17167	13752	1343	12732
10	Aug 15-Aug 21	48567	864	3114	7561	7864	27922	8252	3673	13594	13282
	$\bar{X}$ (1-10)	10427	1138	790	2403	1496	-	-	-		
	$\bar{X}$ (4-10)	14800	1532	1106	3391	2082	18756	12770	6526		

Table 29. Kinds and mean numbers per 1000 m^3 of 15 most abundant fish larvae from bongo (505μ) samples, Izhut Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month	Apr			May	Jun		Jul		Aug	
	Cruise	1	2	3	4	5	6	7	8	9	10
Osmeridae		.	.	.	.	.	1339	30519	1459	5478	13323
Bathymasteridae		.	.	+	27	85	69	91	4	25	3
Ammodytes hexapterus		121	49	26	13	2	.	1	.	.	.
Cottidae type L		.	1	1	2	9	15	99	8	33	17
Psettichthys melanostictus		.	.	.	.	6	20	27	7	36	88
Cottidae Type I		10	13	18	9	12	10	42	1	3	.
Lepidopsetta bilineata		.	12	33	50	14	8	.	.	.	.
Icelinus spp.		.	.	.	1	5	2	17	3	27	25
Myoxocephalus type B		.	6	22	22	2	.	.	.	.	.
Lumpenus medius		1	1	1	29	8	1	.	.	.	.
Cyclopteridae		.	1	7	11	4	2	12	2	1	1
Theragra chalcogramma		.	16	14	4	.	.	.	.	.	.
Anoplarchus spp.		.	.	3	8	9	6	2	.	.	.
Myoxocephalus type A		7	4	12	5	+	.	.	.	.	.
Sebastes spp.		.	.	.	2	1	2	2	2	4	13

+ = <.5 larvae/1000 m^3

Table 30. Density of larval fish per 1000 m^3 from bongo (505μ) samples, by cruise and station, Chiniak Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	$\bar{X}$ (1-5)
1	Mar 29-Apr 8	1382	30	75	56	41	317
2	Apr 10-Apr 17	745	87	92	19	27	194
3	Apr 21-May 1	1054	335	183	293	25	378
4	May 3-May 28	249	147	254	73	109	166
5	May 31-Jun 6	77	47	173	30	79	81
6	Jun 14-Jun 26	318	64	48	113	50	119
7	Jun 28-Jul 18	27685	4767	883	170	30	6707
8	Jul 21-Jul 29	5259	2881	677	400	424	1928
9	Aug 1-Aug 9	8442	2496	209	118	153	2284
10	Aug 15-Aug 21	7119	784	451	486	163	1801
	$\bar{X}$ (1-10)	5233	1164	305	176	110	

Table 31. Kinds and mean numbers per 1000 m^3 of 15 most abundant fish larvae from bongo (505μ) samples, Chiniak Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month / Cruise	Apr 1	2	3	May 4	Jun 5	6	Jul 7	8	Aug 9	10
Osmeridae		.	.	.	1	1	16	6588	1831	2228	1709
Ammodytes hexapterus		217	57	153	29	1	.	.	.	.	.
Lepidopsetta bilineata		3	31	87	37	9	6	26	5	3	.
Lumpenus medius		44	50	51	12	1	3	.	1	.	.
Bathymasteridae		.	.	.	10	28	17	17	7	13	30
Cottidae type L		.	2	1	1	+	3	13	26	11	8
Psettichthys melanostictus		.	.	.	.	2	2	18	14	8	19
Lumpenus maculatus		20	28	10	3	1	.	.	.	.	.
Unidentified		1	1	7	.	3	49	.	.	1	1
Myoxocephalus type B		8	1	11	25	1	.	.	.	.	.
Hippoglossoides elassodon		.	.	.	5	2	1	14	8	1	+
Cottidae type I		.	2	7	2	8	7	4	1	.	1
Gadidae		.	.	14	15	1	.	.	.	.	+
Sebastes spp.		.	.	.	.	.	5	9	1	4	10
Theragra chalcogramma		2	10	15	.	1	.	.	1	.	.

+ = <.5 larvae/1000 m^3

Table 32. Density of larval fish per 1000 m^3 from bongo (505μ) samples, by cruise and station, Kiliuda Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	6	7	8	$\bar{X}$ (1-5)	$\bar{X}$ (6-8)
1	Mar 29-Apr 8	269	386	77	74	872	-	-	-	336	-
2	Apr 10-Apr 17	178	115	15	107	761	-	-	-	235	-
3	Apr 21-May 1	169	963	67	137	154	-	-	-	298	-
4	May 3-May 28	179	90	2	55	135	98	199	80	92	126
5	May 31-Jun 6	21	193	106	73	277	54	21	63	134	46
6	Jun 14-Jun 26	42	74	47	129	58	30	111	370	70	170
7	Jun 28-Jul 18	444	1759	615	1840	587	278	892	1601	1049	924
8	Jul 21-Jul 29	101	369	89	125	112	206	158	437	159	267
9	Aug 1-Aug 9	155	597	487	2066	919	70	114	686	845	290
10	Aug 15-Aug 21	1708	3697	1120	564	2793	392	2711	11937	1976	5013
	$\bar{X}$ (1-10)	327	824	263	517	667					
	$\bar{X}$ (4-10)	379	968	352	693	697	1128	762	2168		

Table 33. Kinds and mean numbers per 1000 m^3 of 15 most abundant fish larvae from bongo (505μ) samples, Kiliuda Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month / Cruise	Apr 1	Apr 2	Apr 3	May 4	Jun 5	Jun 6	Jul 7	Jul 8	Aug 9	Aug 10
Osmeridae		.	.	.	.	.	25	889	155	592	3069
Lumpenus medius		135	79	37	5	1	1	.	.	.	.
Ammodytes hexapterus		92	45	31	24	2	.	.	.	.	.
Lepidopsetta bilineata		8	11	63	26	21	8	+	2	.	.
Theragra chalcogramma		2	5	102	.	.	.	.	.	.	.
Psettichthys melanostictus		.	.	.	1	5	20	24	8	7	7
Bathymasteridae		.	.	6	11	14	7	7	6	12	3
Myoxocephalus type B		13	18	30	.	.	+	.	.	.	.
Cottidae type L		4	.	.	2	8	13	13	4	4	11
Lumpenus maculatus		9	26	6	.	.	.	+	.	.	.
Isopsetta isolepis		.	.	.	.	+	1	34	3	2	.
Lumpenus sagitta		26	12	.	1	.	.	.	.	.	.
Cyclopteridae		1	6	4	3	9	7	1	3	1	1
Cottidae type I		4	8	5	2	6	4	6	.	.	.
Myoxocephalus type A		19	7	6	2	1	.	.	.	.	.

+ = <.5 larvae/1000 m^3

Table 34. Density of larval fish per 1000 m^3 from bongo (505μ) samples, by cruise and station, Kaiugnak Bay, Kodiak Archipelago, Alaska, 1978.

Cruise	Date	Stations 1	2	3	4	5	$\bar{X}$ (1-5)
1	Mar 29-Apr 8	132	238	89	714	286	292
2	Apr 10-Apr 17	209	168	108	143	601	246
3	Apr 21-May 1	395	376	237	358	234	320
4	May 3-May 28	24	77	65	417	145	146
5	May 31-Jun 6	17	117	47	233	130	109
6	Jun 14-Jun 26	124	23	76	230	204	131
7	Jun 28-Jul 18	0	191	208	444	114	191
8	Jul 21-Jul 29	155	115	46	161	205	136
9	Aug 1-Aug 9	436	139	126	1963	291	591
10	Aug 15-Aug 21	298	468	954	5389	857	1593
	$\bar{X}$ (1-10)	179	191	196	1005	307	

Table 35. Kinds and mean numbers per 1000 m^3 of 15 most abundant fish larvae from bongo (505μ) samples, Kaiugnak Bay, Kodiak Archipelago, Alaska, 1978.

Taxa	Month / Cruise	Apr 1	Apr 2	Apr 3	May 4	Jun 5	Jun 6	Jul 7	Jul 8	Aug 9	Aug 10
Osmeridae		.	.	.	.	.	46	114	68	547	1551
Ammodytes hexapterus		175	96	63	15	5	3	.	.	.	.
Lepidopsetta bilineata		7	7	111	36	15	30	.	.	.	.
Bathymasteridae		.	.	5	75	53	8	16	4	7	1
Myoxocephalus type B		29	47	53	+	2	.	.	.	.	.
Cottidae type L		.	1	.	.	1	17	6	15	8	20
Lumpenus maculatus		13	34	7	1	.	.	.	.	.	1
Psettichthys melanostictus		.	.	.	.	1	1	24	11	8	4
Gadus macrocephalus		.	.	33	.	.	.	.	.	.	.
Cottidae type I		11	1	5	4	7	3	.	1	.	.
Lumpenus medius		11	12	3	.	2	1	.	1	.	.
Isopsetta isolepis		.	.	.	.	.	.	16	7	4	1
Gymnocanthus spp.		14	8	2	2	1	.	.	.	.	.
Gadidae		3	.	17	2	1	1	.	1	.	.
Hippoglossoides elassodon		.	.	1	.	1	3	9	2	4	4

+ = <.5 larvae/1000 m^3

Table 36. Neuston caught larval fishes not found among the 15 most abundant taxa, by bay, Kodiak Archipelago near-shore zooplankton research, March-August, 1978.*

Taxa	Izhut	Chiniak	Kiliuda	Kaiugnak
Oncorhynchus gorbuscha			+	-
Mallotus villosus	-	-	+	-
Gadidae	-	-	+	+
Theragra chalcogramma	-	-	+	-
Gasterosteus aculeatus	+			+
Scorpaenidae			+	
Sebastes spp.	-	+	+	-
Hexagrammidae	+		+	-
Hexagrammos type E	+		+	
Cottidae	+	-	+	+
Artedius type 1	+	-	-	-
Blepsias spp.	-	-	-	+
Hemilepidotus jordani	-		+	-
Leptocottus armatus	+			+
Radulinus asprellus	+	-	-	-
Cottidae type I		-	-	+
Cottidae type L		-	+	
Agonidae	-	-	+	-
Cyclopteridae	+	+	-	-
Stichaeidae	-	-		+
Chirolophis spp.	+	-	+	-
Lyconectes aleutensis	+	-		
Pleuronectidae	-	-	+	-
Hippoglossoides elassodon	+	-	-	-
Isopsetta isolepis	-	-	+	-
Lepidopsetta bilineata	-	-		+
Limanda aspera	-	-	+	-
Platichthys stellatus	-	-	-	+

*Some of the species listed above may occur among the 15 most abundant taxa in 1-3 bays. Therefore,

(+) = not among 15 most abundant.
(-) = not found in bay.
Blank = among 15 most abundant taxa.

Table 37. Bongo caught larval fishes not found among the 15 most abundant taxa, by bay, Kodiak Archipelago near-shore zooplankton research, March-August, 1978.*

Taxa	Z	C	L	G
Bathylagidae	-	+	-	-
Mallotus villosus (juvenile)	+	-	+	-
Myctophidae	+	+	+	+
Gadidae	+		+	
Gadus macrocephalus	+	-	-	
Microgadus proximus	-	+	-	+
Theragra chalcogramma				+
Lycodes spp.	+	-	-	+
Scorpaenidae	+	+	+	+
Sebastes spp.			+	+
Sebastolobus spp.	+	+	+	-
Hexagrammos stelleri	+	+	-	-
Hexagrammos type D	-	-	+	-
Hexagrammos type I	+	+	+	+
Ophiodon elongatus	-	+	-	-
Cottidae	+	+	+	+
Artedius type 1	+	+	+	+
Artedius type 2	+	+	+	-
Clinocottus spp.	+	+	+	-
Cottus spp.	-	-	+	-
Dasycottus setiger	+	+	+	+
Enophrys spp.	+	-	+	
Gymnocanthus spp.	+	+	+	-
Hemilepidotus spp.	-	+	+	+
Hemilepidotus hemilepidotus	+	+	-	+
Hemilepidotus jordani	+	-	+	-
Icelinus spp.		+	+	+
Leptocottus armatus	+	+	+	-
Malacocottus spp.	+	+	-	+
Myoxocephalus type A		+		+
Psychrolutes type	-	-	+	-
Radulinus asprellus	+	+	+	+
Triglops spp.	-	+	-	+
Cottidae type 2	-	-	+	-
Agonidae	+	+	+	+
Cyclopteridae		+		+
Ptilichthys goodei	-	+	-	+
Stichaeidae	+	+	+	+
Anoplarchus spp.		+	+	+
Chirolophis spp.	+	-	+	+

Table 37. Bongo caught larval fishes not found among the 15 most abundant taxa, by bay, Kodiak Archipelogo near-shore zooplankton research, March-August, 1978.* - Continued.

Taxa	Z	C	L	G
Lumpenella longirostris	+	+	+	+
Lumpenus maculatus	+			
Lumpenus sagitta	+	+		+
Poroclinus rothrocki	-	-	-	+
Stichaeus punctatus	+	-	-	+
Lyconectes aleutensis	+	+	+	+
Delolepis gigantea	-	-	+	-
Pholidae	+	+	+	+
Pleuronectidae	-	+	+	+
Glyptocephalus zachirus	-	-	-	+
Hippoglossoides elassodon	+		+	
Hippoglossus stenolepis	-	-	-	+
Isopsetta isolepis	+	+		
Limanda aspera	+	+	+	+
Platichthus stellatus	-	-	+	-

*Some of the species listed above may occur among the 15 most abundant taxa in 1-3 bays. Therefore,

(+) = not among 15 most abundant.
(-) = not found in bay.
Blank = among 15 most abundant taxa.

Table 38. List of scientific and common names for larval fishes and fish eggs captured with bongo and neuston nets, Kodiak Archipelago, Alaska, March-August, 1978.

Salmonidae - trouts
- Oncorhynchus gorbuscha - pink salmon

Osmeridae - smelts
- Mallotus villosus - capelin

Bathylagidae - deep sea smelts

Myctophidae - lantern fishes

Gadidae - codfishes
- Gadus macrocephalus - Pacific cod
- Microgadus proximus - Pacific tomcod
- Theragra chalcogramma - walleye pollock

Zoarcidae - eelpouts
- Lycodes spp.

Bathymasteridae - ronquils

Gasterosteidae - sticklebacks
- Gasterosteus aculeatus - threespine stickleback

Cyclopteridae - lumpfishes and snailfishes

Trichodontidae - sandfishes
- Trichodon trichodon - Pacific sandfish

Stichaeidae - pricklebacks
- Anoplarchus spp.
- Chirolophis spp.
- Lumpenella longirostris - longsnout prickleback
- Lumpenus maculatus - daubed shanny
- Lumpenus medius - stout eelblenny
- Lumpenus sagitta - snake prickleback
- Poroclinus rothrocki - whitebarred prickleback
- Stichaeus punctatus - Arctic shanny

Pholidae - gunnels

Ptilichthyidae - quillfishes
- Ptilichthys goodei - quillfish

Cryptacanthodidae - wrymouths
- Delolepis gigantea - giant wrymouth
- Lyconectes aleutensis - dwarf wrymouth

Table 38. List of scientific and common names for larval fishes and fish eggs captured with bongo and neuston nets, Kodiak Archipelago, Alaska, March-August, 1978. - Continued.

Ammodytidae - sand lances
- *Ammodytes hexapterus* - Pacific sand lance

Scorpaenidae - scorpionfishes
- *Sebastes* spp.
- *Sebastolobus* spp.

Hexagrammidae - greenlings
- *Hexagrammos stelleri* - whitespotted greenling
- *Ophiodon elongatus* - lingcod
- *Hexagrammos* type D
- *Hexagrammos* type E
- *Hexagrammos* type I

Cottidae - sculpins
- *Artedius* type 1
- *Artedius* type 2
- *Blepsias* spp.
- *Clinocottus* spp.
- *Cottus* spp.
- *Dasycottus setiger* - spinyhead sculpin
- *Enophrys* spp.
- *Gymnocanthus* spp.
- *Hemilepidotus* spp.
- *Hemilepidotus hemilepidotus* - red Irish lord
- *Hemilepidotus jordani* - yellow Irish lord
- *Icelinus* spp.
- *Leptocottus armatus* - Pacific staghorn sculpin
- *Malacocottus* (?)
- *Myoxocephalus* type A
- *Myoxocephalus* type B
- *Nautichthys* spp.
- *Psychrolutes* (?)
- *Radulinus asprellus* - slimp sculpin
- *Rhamphocottus richardsoni* - grunt sculpin
- *Triglops* spp.
- Cottidae type 1
- Cottidae type 2
- Cottidae type I
- Cottidae type L

Agonidae - poachers

Table 38. List of scientific and common names for larval fishes and fish eggs captured with bongo and neuston nets, Kodiak Archipelago, Alaska, March-August, 1978. - Continued.

Pleuronectidae

- Glyptocephalus zachirus - rex sole
- Hippoglossoides elassodon - flathead sole
- Hippoglossus stenolepis - Pacific halibut
- Isopsetta bilineata - rock sole
- Limanda aspera - yellowfin sole
- Platichthys stellatus - starry flounder
- Pleuronectes quadrituberculatus - Alaska plaice
- Psettichthys melanostictus - sand sole

Table 39. Mean temperature and salinity data at depth for Izhut Bay, Kodiak Archipelago, Alaska, March-August, 1978.

Date	Cruise	Depth 1M °C	1M o/oo*	1M N	25M °C	25M o/oo	25M N	50M °C	50M o/oo	50M N	100M °C	100M o/oo	100M N	Range °C	Range o/oo
3/29-4/8	I	3.9	34.3	5	4.2	34.3	5	3.9	34.3	5	3.8	34.3	4	3.8-4.2	34.3
4/10-4/17	II	4.4	34.2	5	4.3	34.3	5	4.2	34.3	5	4.2	34.3	4	4.2-4.2	34.2-34.3
4/21-5/1	III	5.2	33.9	5	4.6	34.1	5	4.6	34.1	5	4.5	34.2	4	4.5-5.2	33.9-34.2
5/3-5/28	IV	5.9	31.6	8	4.8	34.0	8	4.8	34.0	5	4.6	34.1	4	4.6-5.9	31.6-34.1
5/31-6/6	V	6.3	33.3	8	5.5	34.1	8	5.5	34.2	5	5.3	34.2	4	5.3-6.3	33.3-34.2
6/14-6/24	VI	8.3	33.4	8	6.5	33.9	8	6.2	34.0	5	5.8	34.0	4	5.8-8.3	33.4-34.0
6/28-7/18	VII	8.7	33.5	8	7.2	33.7	8	7.0	33.8	5	6.8	33.9	3	6.8-8.7	33.5-33.9
7/21-7/29	VIII	9.7	33.2	8	7.6	33.6	8	7.3	33.8	5	6.8	33.9	4	6.8-9.7	33.2-33.9
8/1-8/9	IX	11.4	33.4	8	7.9	33.7	8	7.5	33.7	5	7.0	33.8	4	7.0-11.4	33.4-33.8
8/15-8/21	X	10.8	33.4	8	8.9	33.7	8	8.4	33.7	5	7.2	33.9	4	7.2-10.8	33.4-33.9
Range °C		3.9-11.4			4.2-8.9			3.9-8.4			3.8-7.2				
o/oo			31.6-34.3			33.6-34.3			33.7-34.3			33.8-34.3			

*Each value =mean for all stations in bay
N = number of observations.

Table 40. Mean temperature and salinity data at depth for Chiniak Bay, Kodiak Archipelago, Alaska, April-August, 1978.

Date	Cruise	Depth 1M			25M			50M			100M			Range		
		°C*	o/oo*	N	°C	o/oo	N	°C	o/oo	N	°C	o/oo	N	°C	o/oo	N
3/29-4/8	I	3.5	34.0	5	3.5	34.4	5	3.5	34.3	4	3.6	34.5	4	3.5-3.6	34.0-34.5	
4/10-4/17	II	4.5	33.8	5	3.9	34.1	5	3.9	34.1	4	3.8	34.1	4	3.8-4.5	33.8-34.1	
4/21-5/1	III	4.3	34.1	5	4.0	34.3	5	4.1	34.3	4	4.0	34.3	4	4.0-4.3	34.1-34.3	
5/3-5/28	IV	5.2	33.2	5	4.5	34.1	5	4.4	34.2	4	4.3	34.3	4	4.3-5.2	33.2-34.3	
5/31-6/6	V	6.8	32.1	5	5.6	34.0	5	5.5	34.0	4	5.3	34.1	4	5.3-6.8	32.0-34.1	
6/14-6/24	VI	7.1	33.5	5	5.9	34.0	5	5.8	34.0	4	5.4	34.2	4	5.4-7.1	33.5-34.2	
6/28-7/18	VII	9.2	33.2	5	7.3	33.7	5	6.9	33.8	4	6.5	33.8	4	6.5-9.2	33.2-33.8	
7/21-7/29	VIII	9.0	33.1	5	7.7	33.6	5	7.3	33.8	4	6.9	33.9	4	6.9-9.0	33.1-33.9	
8/1-8/9	IX	10.5	33.4	5	8.3	33.6	5	7.4	33.8	4	6.7	33.9	4	6.7-10.5	33.4-33.9	
8/15-8/21	X	11.3	33.3	5	9.3	33.6	5	8.7	33.6	4	7.1	33.8	4	7.1-11.3	33.3-33.8	
Range °C		3.5-11.3			3.5-9.3			3.5-8.7			3.6-7.1					
o/oo			32.1-34.1			33.6-34.4			33.6-34.3			33.8-34.5				

*Each value = mean for all stations in bay.
N = number of observations.

Table 41. Mean temperature and salinity data at depth for Kiliuda Bay, Kodiak Archipelago, Alaska, April-August, 1978.

Date	Cruise	Depth 1M			25M			50M			100M			Range	
		°C*	o/oo *	N	°C	o/oo	N	°C	o/oo	N	°C	o/oo	N	°C	o/oo
3/29-4/8	I	3.6	33.7	5	3.4	34.4	5	3.5	34.4	5	3.5	34.4	2	3.4-3.6	33.7-34.4
4/10-4/17	II	4.5	33.9	5	3.8	34.2	5	3.8	34.3	5	4.0	34.4	1	3.8-4.5	33.9-34.4
4/21-5/1	III	4.7	33.9	5	4.2	34.3	5	4.0	34.3	4	4.1	34.5	1	4.0-4.7	33.9-34.5
5/3-5/28	IV	6.8	31.2	8	5.4	33.7	8	5.1	34.1	4	4.7	34.2	3	4.7-6.8	31.2-34.1
5/31-6/6	V	7.4	31.4	8	5.7	33.8	8	5.4	33.9	5	5.6	34.1	2	5.6-7.4	31.4-34.1
6/14-6/24	VI	8.2	31.4	8	5.8	33.8	8	5.7	34.2	5	5.4	34.3	3	5.4-8.2	31.4-34.3
6/28-7/18	VII	9.7	30.7	8	7.7	33.7	8	6.7	33.8	5	5.7	34.0	2	5.7-9.7	30.7-34.0
7/21-7/29	VIII	10.6	31.4	8	8.2	33.5	8	7.2	33.7	5	7.0	33.8	1	7.0-10.6	31.4-33.8
8/1-8/9	IX	12.6	30.5	8	8.6	33.5	8	7.4	33.8	5	6.9	34.1	1	6.9-12.6	30.5-34.1
8/15-8/21	X	10.9	32.9	8	8.5	33.6	8	7.5	33.8	5	7.6	33.9	1	7.6-10.9	32.9-33.9
Range °C		3.6-10.9			3.4-8.6			3.5-7.5			3.5-7.6				
o/oo			30.5-33.9			33.5-34.4			33.7-34.4			33.8-34.5			

*Each value = mean for all stations in bay
N = number of observations.

Table 42. Mean temperature and salinity data at depth for Kaiugnak Bay, Kodiak Archipelago, Alaska, April-August, 1978.

Date	Cruise	Depth 1M °C*	1M o/oo*	1M N	25M °C	25M o/oo	25M N	50M °C	50M o/oo	50M N	100M °C	100M o/oo	100M N	Range °C	Range o/oo
3/29-4/8	I	3.7	34.1	5	3.5	34.2	5	3.5	34.3	4	3.5	34.5	2	3.5-3.7	34.1-34.3
4/10-4/17	II	4.2	34.0	5	3.9	34.2	5	3.8	34.2	3	4.1	34.3	2	3.8-4.2	34.0-34.3
4/21-5/1	III	4.6	33.8	5	4.5	34.1	5	4.3	34.2	3	4.3	33.8	2	4.3-4.6	33.8-34.2
5/3-5/28	IV	6.6	32.5	5	5.0	34.0	5	4.8	34.0	4	4.8	34.1	3	4.8-6.6	32.5-34.1
5/31-6/6	V	6.9	33.1	5	5.8	33.9	5	5.6	33.9	3	5.2	34.0	2	5.2-6.9	33.1-34.0
6/14-6/24	VI	6.6	33.4	5	5.8	34.0	5	5.6	34.1	3	5.6	34.2	2	5.6-6.6	33.4-34.2
6/28-7/18	VII	9.5	32.6	5	8.8	33.6	5	7.8	33.9	3	6.4	34.1	2	6.4-9.5	32.6-34.1
7/21-7/29	VIII	11.3	32.7	5	8.5	33.6	5	7.8	33.7	3	6.8	33.9	2	6.8-11.3	32.7-33.9
8/1-8/9	IX	12.3	33.0	5	9.7	33.5	5	8.4	33.6	3	7.3	33.8	2	7.3-12.3	33.0-33.8
8/15-8/21	X	9.4	33.5	5	8.0	33.8	5	7.6	33.8	3	7.2	33.5	2	7.2-9.4	33.5-33.8
Range °C		3.7-12.3			3.5-9.7			3.5-8.4			3.5-7.3				
o/oo			32.5-34.1			33.5-34.2			33.6-34.3			33.5-34.5			

*Each value - mean for all stations in bay.
N = number of observations.

Table 43. Number of zooplankton samples collected by bay and gear type, Kodiak Island, Alaska, 1979.

Cruise 01* - <u>Commando</u> 3/4/79 - 3/16/79 RU 553

	Neuston	Bongo		Tucker				
		505μ	333μ	505μ		3 mm		Epibenthic sled
Bay				Day	Night	Day	Night	
Izhut	8	8	8	6	6	–	–	–
Kalsin-Chiniak	4	4	4	–	–	–	–	–
Kiliuda	8	8	8	6	6	–	–	–
Kaiugnak	5	5	5	–	–	–	–	–
Total	25	25	25	12	12			

Cruise total 99

Scientific party: Doug Rabin, Project Leader, FRI

Biff Bermingham, Cruise leader, FRI

*Cruise 01 for inshore zooplankton work in CY 1979.

PART B: FOOD HABITS

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

The objectives of this study are to determine the food habits of several nearshore fish species with respect to season, area, habitat, and life history stage. These data may then be used, after oil production is underway in the Kodiak area, to detect disruptions in the food webs of the fish that may be caused by petroleum contaminants.

II. INTRODUCTION

General Nature and Scope of Study

Exploitation of oil in the lease areas east of Kodiak Island introduces potential hazards to the marine environment, especially in the vicinity of Kodiak Island. The productive waters surrounding Kodiak now support a sizable fishing industry, which could be damaged by an oil industry. The fish living in the bays and fjords of the island are especially vulnerable to an oil spill since they would probably suffer a greater exposure to the oil than would fish living in the open waters offshore.

The food web of a fish species could be disturbed by an oil spill if it caused the depletion or contamination of critical prey types. This could, in turn, result in the depletion of fish stocks in an area or in the contamination of fish with petroleum hydrocarbons. This study will greatly increase our knowledge about the food habits and trophic relationships of the inshore fish of Kodiak Island. The baseline information will be used, if oil production is initiated in the area, to quantitatively assess the effects of oil on the feeding relationships of the inshore fish.

Specific Objectives

Our objectives are to determine the food habits of several nearshore pelagic and demersal fish species with respect to season, area, habitat, and life history stage.

III. CURRENT STATE OF KNOWLEDGE

Gosho (1977) studied the feeding habits of pink salmon juveniles from stomachs taken during the summer of 1971 in Alitak and Kiliuda bays. He also collected data (unpublished) on the feeding habits of juvenile greenling and chum salmon which were caught along with the pinks. Harris and Hartt (1977) examined stomachs from 18 species of fish caught by four types of gear (townet, herring trawl, beach seine, trynet), in Kaiugnak, Alitak, and Ugak bays during late May to mid-September of 1976. Hunter (1979) studied the food habits of 12 species of demersal fish taken offshore near Kodiak Island during July 1977. Information from some of his sampling may be applied to our onshore work since six of the species that he examined occur frequently inshore.

IV. STUDY AREA

The Kodiak Archipelago is located in the western Gulf of Alaska, southeast of the Alaska Peninsula. It is composed of many islands, 16 of which have an area greater than 18 km^2; Kodiak Island (9,293 km^2) and Afognak Island (1,813 km^2) are the largest. Mountains rise sharply from the ocean floor to elevations of over 1,200 m. The coastline is intricately carved by deep, narrow bays and fjords, and most of the shoreline is composed of rocky bluffs and narrow beaches. The continental shelf, which is about 120 km wide, and the nearshore waters of the archipelago are among the most productive in the world and support commercial fisheries for halibut, salmon, and crab.

There is a strong marine influence on the climate, resulting in cloudy skies, moderately heavy annual precipitation, and mild temperatures for the latitude of the islands. The average maximum air temperature during the summer is about 15°C and the average minimum temperature during the winter is about -5°C (AEIDC 1975). Ice does form in the more protected inlets during the winter months, and surface water temperatures of 1°C are not uncommon. Daylight ranges from 8.25 hr at the winter solstice to 22.50 hr at the summer solstice.

Our study areas include Izhut, Kalsin, Kiliuda, and Kaiugnak bays. They are located on the east side of Afognak and Kodiak islands and represent most of the nearshore habitats of that area. Izhut Bay, which is located on Afognak Island, opens southward to the Gulf. It is 15 km long and is fringed by many protected inlets and lagoons. The mean depth at midbay is about 135 m and depths of over 200 m are found at the mouth. Izhut Bay has a fairly irregular bottom. The surrounding terrain has a moderate to low relief, and peaks reach just over 600 m. Lower-lying hills predominate at the head. Sitka spruce is the most obvious form of vegetation and some of this has been logged.

Kalsin Bay is only 11 km long and opens to the northeast into Chiniak Bay. Numerous small islands are located near the mouth. Kalsin Bay has a mean depth at midbay of about 50 m. The peaks are larger around Kalsin than around Izhut, but like Izhut, the bay head is less mountainous. Sedimentary rock predominates. Due to glaciation, there is an absence of Sitka spruce, and the principal vegetation consists of Sitka alder and willow, the latter often occurring in dense thickets in depressions such as stream basins.

Kiliuda Bay is our longest bay, reaching inland approximately 24 km. It is exposed to the southeast near the northern end of Sitkalidak Strait and has a few protected arms, bays, and small lagoons. The mean depth at midbay is about 70 m and there is a fairly irregular bottom. A sill is located off Coxcomb Point, thus making Kiliuda a true fjord. The surrounding hillsides and mountains are steep and are composed primarily of sedimentary rock with a small amount of volcanic rock. The vegetation is much like that in Kalsin Bay, but it also has some areas of moist tundra.

Kaiugnak Bay is about 15 km long and has two large protected lagoons, Kiavak and Kaiugnak. It opens to the southeast at the southern end of Sitkalidak Strait. The bottom is irregular and the mean depth at midbay is about 80 m; however, the lagoons are quite shallow. Steep hillsides and mountains with vegetation much like those in Kalsin Bay predominate.

V. SOURCES, METHODS, AND RATIONAL OF DATA COLLECTION

The stomachs were collected off the R/V COMMANDO during April, May, June, July, August, November (1978), and March (1979). Our stomach sampling followed the fish sampling planned by RU #552 (Alaska Department of Fish and Game, ADF&G). As the fish were landed, they were first sorted to species. The field crew next selected specimens according to species and size; the emphasis was on both the most abundant species and on the economically important fish. Larger fish were measured and dissected in the field. Gonads were examined for level of maturity, then the stomachs were removed and placed in a Whirlpak bag along with 10% formalin. Smaller fish were preserved whole.

In the laboratory, the stomach contents of each large fish were blotted dry and then weighed to the nearest .01 g. The contents were next sorted into the lowest possible taxonomic categories, and each group was then counted and weighed to the nearest .001 g.

If the fish were small, lengths were taken for each fish in a group and then an average length was recorded. Stomach contents were pooled and the contents from the pooled stomachs were treated as above. Average numbers and weights of prey items were then calculated.

The data were stratified by species of predator, life history stage, area, month, and habitat, which will allow us to examine the effect of each variable on the feeding habits of the more frequently sampled fish. For each prey type, the mean number and weight per stomach and its frequency of occurrence within a sample were calculated.

These data will elucidate the major food web characteristics for the more abundant fish species, and thereby provide some insight into the trophic interactions between species.

VI. RESULTS

During 7 months of sampling, we collected stomachs from nearly 14,000 fish (Table 1). Approximately 40 species were sampled and more than 500 stomachs were collected from each of 12 species. These data are from shipboard logs and will be modified after all the stomachs have been processed and recounted in the lab. Because the types of food eaten by a fish may be dependent on its habitat, the numbers of stomachs examined are presented by bay, gear, and life history stage in Table 2.

The stomach contents in mean weight and numbers for June and July are presented by fish species, month, and life history stage in Tables 3-23. The mean stomach fullness for each sample is also indicated on these tables. Stomach fullness was rated on a scale of 1-7 where 1 indicated an empty stomach and 7 a distended one. For each of the 12 most frequently sampled species of fish, the average percent composition of major prey types by weight and number are shown in Figs. 1-7. We originally planned to use IRI values (Pinkas et al. 1971) to designate the relative importance of each prey type to the diet of a sample of fish. However, since we pooled stomachs within several of the samples so that we could process more stomachs, data on the number of stomachs in which a type of prey (frequency of occurrence) occurred was lost. Since this statistic is part of the IRI formula, we decided for this report to drop IRI values and instead to rank prey types in order of importance by weight and number, and to average these two rankings for an estimate of the overall importance of each prey type in a sample.

These data will be compared with data for April and May, which were submitted in the quarterly report for the period ending December 31, 1978. Two changes must be made, however, on the April-May tables. Weights were reported to the mg when they were actually mg x 10. For this report, the June-July weights are in mg. In addition, empty stomachs in a sample were not used to compute mean contents per stomach during April-May, whereas the total number of stomachs was used in June-July. We feel that the latter method more accurately reflects the degree of feeding by each species and that such data will be easier to use for modeling the Kodiak nearshore ecosystem.

Salmonidae

Pink Salmon

More types of prey were found in stomachs of pink salmon juveniles in June-July than in April-May, but in all 4 months, harpacticoid and/or calanoid copepods were the most important foods by weight and number (Table 3). The contribution of harpacticoids to the total weight of the pink juvenile diet decreased steadily from a high 77% in April to 7% in July whereas the contribution of the larger calanoids steadily increased from 2% in April to 41% of the total weight in July. Harpacticoids were the most important food in April-May, calanoids and harpacticoids were equally important in June and calanoids were the most important food in July. This shift to a larger prey may be a result of the juveniles growing from a mean length of 35 mm in April to 70 mm in July.

Over all 4 months, harpacticoids followed by calanoids and then gammarid amphipods were the most important foods in both numbers and weight (Fig. 1).

Only two adult pink salmon were sampled that had food in their stomachs. These were caught in July and their stomachs contained only fish.

Chum Salmon

During April, only four chum juveniles were sampled and insects were their most important food (83% of the total weight of the stomach contents). Sample sizes were larger between May and July and ranged from 76 to 367 stomachs. Harpacticoids were the most important foods during May and June but during July, both harpacticoids, because of their numbers (73% of the total number) and gammarid amphipods, because of their weight (81% of the total weight) ranked first (Table 4).

Over the four months, harpacticoids contributed more than 50% of the total number of organisms eaten by the chums while harpacticoids, gammarid amphipods, and insects each accounted for approximately 25% of the weight of the diet (Fig. 1).

Coho Salmon

Few coho have been sampled: only 15 juveniles in May, 3 in July, and 6 in June. Calanoid and harpacticoid copepods ranked first and second in importance during May and harpacticoids ranked first in July (Table 5). The coho in June relied most heavily on Oxyrhyncha (spider crab) larvae and then on gammarid amphipods and teleosts (fish).

Osmeridae

Capelin

Among the 33 capelin sampled in June, calanoid copepods comprised nearly 100%, by weight and number, of their diet (Table 5).

Ammodytidae

Sand Lance

The sand lance depend to a great extent on small, pelagic organisms for their food, much like the pink and chum juveniles. In April-July and for both juveniles and adults, calanoid copepods were the most important food (Fig. 1). Gammarid amphipods contributed 44% by weight to the diet of the juveniles in April and barnacle (cirripede) larvae were as important as calanoids to adults in July (Table 6). Other occasionally high-ranking organisms were pandalid shrimp, harpacticoids, the cladoceran *Podon* and unidentified eggs.

Gadidae

Pacific Cod

Caridean shrimp, especially *Pandalus borealis* was the major food of adult cod (average length of about 450 mm) and was also important but to a lesser degree to the smaller juveniles (average length of about 200 mm). Among the adults, shrimp formed 60-87% by weight of the total diet between May and July and among juveniles, shrimp formed 19-59% by weight of the diet between April and July (Table 7). Gammarid amphipods, because of their numbers, ranked high in the diet of the juveniles during April, May, and July and fish, because of their weight, ranked high during April-June.

During July, fish ranked low in the diets of the juveniles because of the low numbers consumed, even though they amounted to 45% of the total weight of the stomach contents.

In general, caridean shrimp were the major food of adult cod while gammarid amphipods were most important by number and shrimp and fish were most important by weight to the juveniles (Fig. 2).

Walleye Pollock

Juvenile pollock fed the most heavily on small prey such as chaetognaths (in May) and calanoid copepods. Also important were unidentified crustacea and crustacean larvae in June and euphausids and shrimp in July (Table 8). During May and July, pollock adults fed most often on shrimp and euphausids. Also in May, fish constituted 55% of the total weight of the adult stomach contents.

Hexagrammidae

Rock Greenling

The rock greenling ate a wide variety of primarily benthic foods (Table 9). Gammarid amphipods, and polychaetes in April and May, numerically prevailed in the diet of the juveniles while clam (pelecypod) siphons prevailed by weight in May and June. Even though few fish were eaten in May, they contributed 27% of the total weight of the diet and in July, decapods and hydrozoans, while low in numbers, contributed about 50% of the total weight of the diet of the juveniles.

Fish eggs contributed high numbers to the adult rock greenling diet during April, May, and July. Gammarids were also important numerically during May, June, and July. In all 4 months, brachyuran crabs were most important by weight and in May, fish composed 20% by weight of the diet.

The rock greenling juveniles ate large numbers of gammarid amphipods while the adults ate large numbers of eggs and secondarily, gammarid amphipods (Fig. 3). No one food greatly outweighed the rest. The most important organisms by weight in the juvenile diet were polychaete worms and these accounted for less that 25% of the weight of the total diet. Similarly, brachyuran crabs, which were most important in terms of weight to the adults, contributed less than 25% to the total weight of the diet.

Whitespotted Greenling

In May, miscellaneous decapods (including shrimp) were the most important food of the juvenile whitespotted greenling and these were followed by polychaetes and gammarid amphipods. However, in June and July, fish (including fish eggs in July) were the primary foods (Table 10). Of secondary importance during June were gammarids and polychaetes. Harpacticoids contributed 41% of the total number and brachyuran crabs contributed 22% of the total weight of the diet in July.

Caridean shrimp were the primary food of the adults in May followed by gammarid amphipods. However, in June, shrimp, crab, and fish all ranked first. Crabs were the most important food in July followed by fish and caprellid amphipods. Fish eggs in June and July constituted more than 50% of the diet by number; however, their weights were very low.

Over all 3 months, fish, brachyuran crabs and caridean shrimp contributed by weight 24, 20, and 19%, respectively, to the diet of the juveniles (Fig. 3). Harpacticoids and gammarids contributed 16 and 20% to the total numbers of prey in the diet. Fish (17%), crabs (25%), and shrimp (31%) also dominated the biomass of the adult whitespotted greenling diet while gammarid amphipods and eggs dominated in numbers (26 and 42%, respectively).

Masked Greenling

Gammarid and polychaetes were the most important foods to juvenile masked greenling in April, and in addition, harpacticoids contributed 41% of the number of organisms eaten. During May through July, gammarid amphipods were the primary food, ranging from 38% to 57% of the total biomass. In July, the juveniles also consumed large numbers of harpacticoids (Table 11).

The adults fed predominantly on gammarid amphipods in each of the 4 months. In addition, during April, 26% of the diet by weight was clam siphons and eggs were 27% by number.

In general, gammarids were the most important food for both juveniles and adults (Fig. 4). In the juvenile diet, polychaetes ranked high by weight and harpacticoids ranked high by weight and harpacticoids ranked high by numbr. Gammarids dominated the adult diet in terms of numbers, but in terms of weight, polychaetes, crab, and clam siphons closely followed gammarids in importance.

Kelp Greenling

Between April and July, only 13 juvenile and adult kelp greenling stomachs were taken. The six adult stomachs from May contained primarily fish eggs, gammarid amphipods, and caridean shrimp while the four taken in June and July contained mainly gammarids, brachyuran crabs, fish, and clam siphons (Table 12). The primary foods of the two juveniles taken in June were pagurid crabs and fish.

Cottidae

Yellow Irish Lord

Except for one time in 3 months (May-July), shrimp and brachyuran crabs ranked first or second in the yellow Irish lord diet. Fish, and these were primarily cottids, formed 59% by weight of the adult diet in July (Table 13). Fish were also relatively important to juveniles and adults in June.

Over all 3 months, shrimp formed 65% and 53% of the weight of juvenile and adult diets, respectively (Fig. 5). Brachyuran crabs and then gammarid amphipods (because of their large numbers) were of secondary importance to the juveniles. Fish (26% of the weight) and crabs (16% of the number and 12% of the weight) were of secondary importance to the adults.

Red Irish Lord

Only seven stomachs were sampled: two from adults in June and five from adults in July (Table 14). During June, fish constituted most of the diet and during July, crabs were the most important food.

Myoxocephalus spp.

Three species of *Myoxocephalus* probably occur in the Kodiak area, the most common of which is *M. polyacanthocephalus*, the great sculpin. Shipboard identification was somewhat difficult and was probably not always correct. For this reason, we have pooled the stomach data from all *Myoxocephalus* spp.

In all four months, gammarid amphipods numerically dominated (51-83% of the total numbers of prey consumed each month) the diet of the juveniles, whereas fish and brachyuran crab dominated by weight (Fig. 5). In May, fish and crab were each about 45% of the total weight of the diet. During April and July, fish composed about 50% of the weight of the diet and in June, crabs were about 50% of the total weight of the diet (Table 15).

Fish were by far the most important food of the adults, ranging from 66% of the total weight of the stomach contents in July to 91% in June. Crab, in each month (May-July) ranked second and in May and June, shrimp were also important numerically.

Trichodontidae

Sandfish

Only adult sandfish were sampled between May and July. The 12 stomachs that were taken in May contained mostly euphausids (65% of the total number) and fish (87% of the total weight). The one stomach taken in June contained only brachyura megalops and unidentified crustacea (Table 16). In July, the stomach contents were dominated by fish (70% by number and 97% by weight). Fairly large numbers of euphausids were also present.

Stichaeidae

Snake Prickleback

The snake prickleback primarily fed upon benthic organisms. One juvenile stomach containing food was taken in May and it contained polychaetes, gammarids and bivalve siphons. One taken in June contained mainly polychaetes, then gammarids and ostracods. Gammarid amphipods were the most important food in July (Table 17) followed by fish eggs.

Among adults, those taken in June fed mostly on polychaetes (41% of the total weight) and fish eggs (90% of the total number and 33% of the weight) while those sampled in July contained mostly gammarids (97% of the total number and 73% of the weight).

Pholidae

Crescent Gunnel

The primary foods of adult crescent gunnel sampled in May-June were benthic while those of the juveniles were both benthic and pelagic. Gammarid amphipods, which are usually benthic, were the most important food for both juveniles and adults with the exception of two juveniles in July which fed mostly on epibenthic harpacticoid copepods (Table 18). Also important to the juveniles were polychaetes in April, harpacticoids and isopods in June, and calanoids in July. Polychaetes were relatively important to the adults in May (39% of the weight) and ostracods were as important as gammarids in July (62% of the number and 22% of the weight).

Pleuronectidae

Flathead Sole

Juveniles and especially adult flathead sole fed heavily on caridean shrimp (Fig. 6) and the most frequently consumed species of shrimp was *Pandalus borealis*. Only in April, when the juveniles were about one-half the size (80 mm) of those from other months, were shrimp unimportant. Instead, during April, 64% of the biomass of the diet was composed of polychaetes while nemertean worms ranked second in importance. No juveniles were sampled in May but in June, mysids and euphausids were major contributors to the diet (Table 19). Among adults, however, shrimp composed 51-86% of the numbers and 84-94% of the weight of the diet each month.

Rock Sole

The rock sole ate a wide variety of polychaete worms (Table 20). In all 4 months, polychaetes ranked first and occasionally second in the diet of both juveniles and adults. The rock sole also snipped many clam siphons --siphons ranked first in the diet of the juveniles during April and second in May and June. They were also consumed in fairly large numbers by juveniles in May and by adults each month. Gammarid amphipods contributed a large proportion of the numbers of food items eaten by juveniles during May-July and by adults in May. Fish, which were not consumed by the juveniles to any great extent, contributed 22-50% by weight of the adult diet each month.

In general, rock sole juveniles ate primarily clam siphons (37% by number) and polychaetes (43% by weight), while adults ate primarily polychaetes, eggs, and fish (Fig. 7).

Yellowfin Sole

Yellowfin sole ate a wide variety of foods but no organism dominated the diet in both numbers and weight (Fig. 7). Juveniles ate greater numbers of clam siphons in May, June, and July than any other food, but in April, they consumed even more unidentified eggs than clam siphons. Polychaetes were important in either numbers or weight each month and cottids contributed 29% by weight in May and fish, 40% by weight in July (Table 21).

Adults fed primarily on polychaetes (34% by number and 67% by weight) in April. However, in no other instance did one food dominate in both numbers and weight. During May, polychaetes were 41% by number, but only 8% by weight of the total diet. Clam siphons were relatively important in terms of numbers in April, May, and July. During May, June, and July, shrimp were 20% or more of the total weight of the diet and in June, fish were 20% of the total weight of the adult diet.

Pacific Halibut

Few halibut were sampled, but the 27 juvenile stomachs that were taken during April and June yielded primarily shrimp and the 10 stomachs taken in July contained primarily fish (Table 22). The six adult stomachs taken in June and July contained mostly fish by weight and in June, there were also large numbers of shrimp.

Anoplopomatidae

Sablefish

The 25 sablefish stomachs examined in June contained 95% fish by weight and 60% euphausids by number (Table 23).

VII. DISCUSSION

The preceding section presented the diet of each species of fish sampled during June and July. The data were stratified by month and life history stage of each predator but not by bay or gear type. In addition, family was the lowest taxon used to categorize the food organisms. Information on the prey to genus or species will be presented after all the stomachs have been processed and the data will be analyzed by gear type, bay, and perhaps length of the more frequently sampled species of fish.

The percent composition of food of the 12 most commonly sampled species of fish, averaged over April-July, are presented in Figs. 8 and 9. Data from juveniles (and adult sand lance) are presented in Fig. 8 and data from adults are shown in Fig. 9.

Three species fed predominantly on small, planktonic organisms: the sand lance (both juveniles and adults) and pink and chum salmon juveniles. All three species were caught primarily by beach seine and a few by townet. Sand lance fed mostly on calanoid copepods, while chum salmon fed more on harpacticoid copepods than calanoids. The pink juveniles ate more harpacticoids than did the chum salmon but they also consumed large amounts of calanoid copepods. All three species ate some gammarid amphipods (which are not pelagic) but the chum juveniles consumed the most (about 20% of the total weight of the diet). This was due to the large amount of gammarids eaten during July.

None of the greenling, juveniles, or adults seemed to specialize in any one type of food. Both juvenile and adult masked greenling depended more on gammarid amphipods than did the rock or whitespotted greenlings, but the juvenile masked greenling ate more polychaetes than did the adults. The rock greenling juveniles ate more gammarids and polychaetes than other types of food, but the adult diet shifted more to crabs. Shrimp, crab, and fish formed the bulk of both the juvenile and adult whitespotted greenling diet.

Yellowfin sole ate a fairly generalized diet with the adults tending toward polychaetes and shrimp and the juveniles toward polychaetes, crab, and fish. The rock sole juveniles fed mostly on polychaetes and the adults fed mostly on fish and polychaetes. Adult flathead sole and Pacific cod diets were amazingly similar with a very high proportion of shrimp and a few crab and fish in the diet. The juveniles also ate large amounts of shrimp, but other food such as polychaetes in the juvenile flathead diet and fish in the juvenile cod diet were also fairly important.

The yellow Irish lord also consumed large numbers of shrimp but in addition, fish were fairly important to the adults. The diet of the adult Myoxocephalus, more than any other fish, was almost entirely of fish. The juveniles also consumed mostly fish, but they also ate large amounts of crab and about 10% of the diet was gammarid amphipods.

VIII. CONCLUSIONS

The objectives of our research are to determine the food habits of several nearshore fish species of Kodiak Island with respect to location, season, habitat, and life history stage. This report discusses food habits primarily in terms of season (spring and early summer) and life history stage.

Among the 12 most frequently sampled species of fish, zooplankton was consumed mostly by sand lance, chum and pink juveniles. Gammarid amphipods were important in terms of weight to masked greenling, rock greenling juveniles, and chum salmon juveniles. Polychaetes were important to masked greenling juveniles, rock greenling juveniles, yellowfin sole, and rock sole. Two species appeared to be shrimp specialists: flathead sole and Pacific cod (especially the adults). A large proportion of the yellow Irish lord diet was shrimp, but the adult diet also consisted nearly 30% by weight of fish. Shrimp were also important to the whitespotted greenling. Rock greenling adults, whitespotted greenling, Myoxocephalus juveniles, and yellowfin sole juveniles ate more crab than the other fish species. Only the adult

Myoxocephalus specialized by eating fish. Others, rock sole adults, cod juveniles, and *Myoxocephalus* juveniles ate sizable amounts of fish along with the other foods in their diets.

The greenling all appeared to eat a wide variety of foods as did the yellowfin and rock soles. In contrast, sand lance, chum and pink salmon juveniles fed mostly on calanoids, harpacticoids and gammarids, and harpacticoids, respectively. Flathead sole and Pacific cod adults fed primarily on shrimp, and yellow Irish lord adults ate shrimp, fish, and crab in descending order of importance. The *Myoxocephalus* adults were fish specialists. The juveniles of the last four species had more varied diets than the adults, but even so, shrimp was still the most important food to juveniles of the flathead sole, cod, and yellow Irish lord and fish was the most important food to *Myoxocephalus* juveniles.

IX. NEEDS FOR FURTHER STUDY

Not applicable at this time.

X. SUMMARY OF JANUARY-MARCH QUARTER

A. Ship or Laboratory Activities
  1. Ship or Field Trip Schedule
    a. Dates: March 3-18, 1979
    b. Name of Vessel: R/V COMMANDO (Chartered)

  2. Scientific Party
    a. Names: Mr. Mark Wangerin and Mr. Chris Wilson
    b. Affiliation: Fisheries Research Institute, University of Washington
    c. Role: Fish samplers

  3. Methods: Same as described in this annual report and in previous quarterly reports

  4. Sample localities: See RU #552 for sampling sites

  5. Data collected or analyzed
    a. Number and Types of Samples: Stomachs from 971 fish were collected in March from about 23 species of fish.
    b. Number and Types of Analysis: Data from the first 4 months of sampling (April-July) have been analyzed for mean numbers, weights, and IRI values of each prey type per stomach. The data are grouped by species and life history stage of predator and month. Data from August have been keypunched and will be analyzed in the same way.

XI. AUXILIARY MATERIAL

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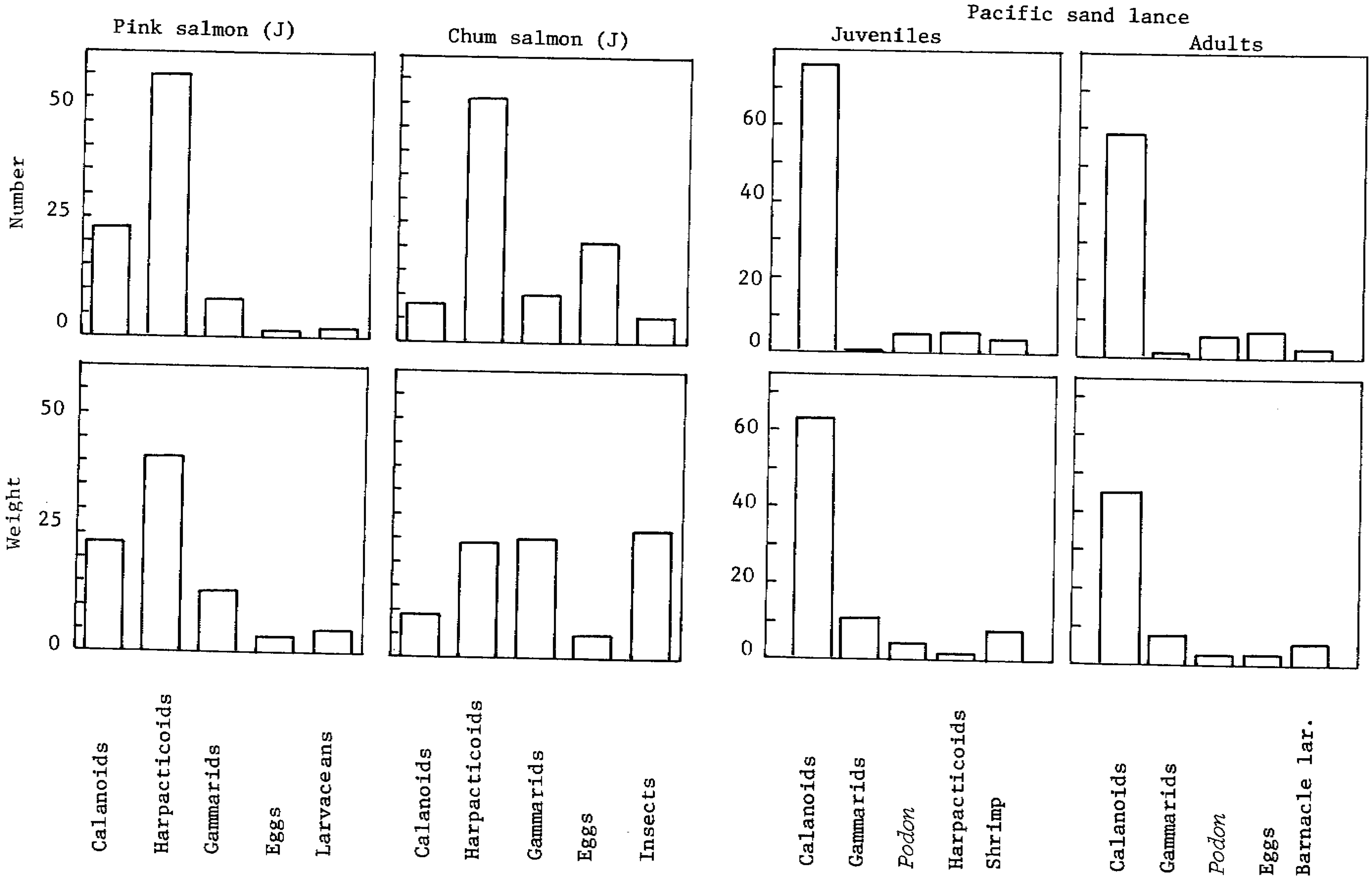

Fig. 1. Percentage composition of major food items in pink and chum salmon and Pacific sand lance. Samples primarily from beach seine hauls during May-July, 1978. (J = juvenile.)

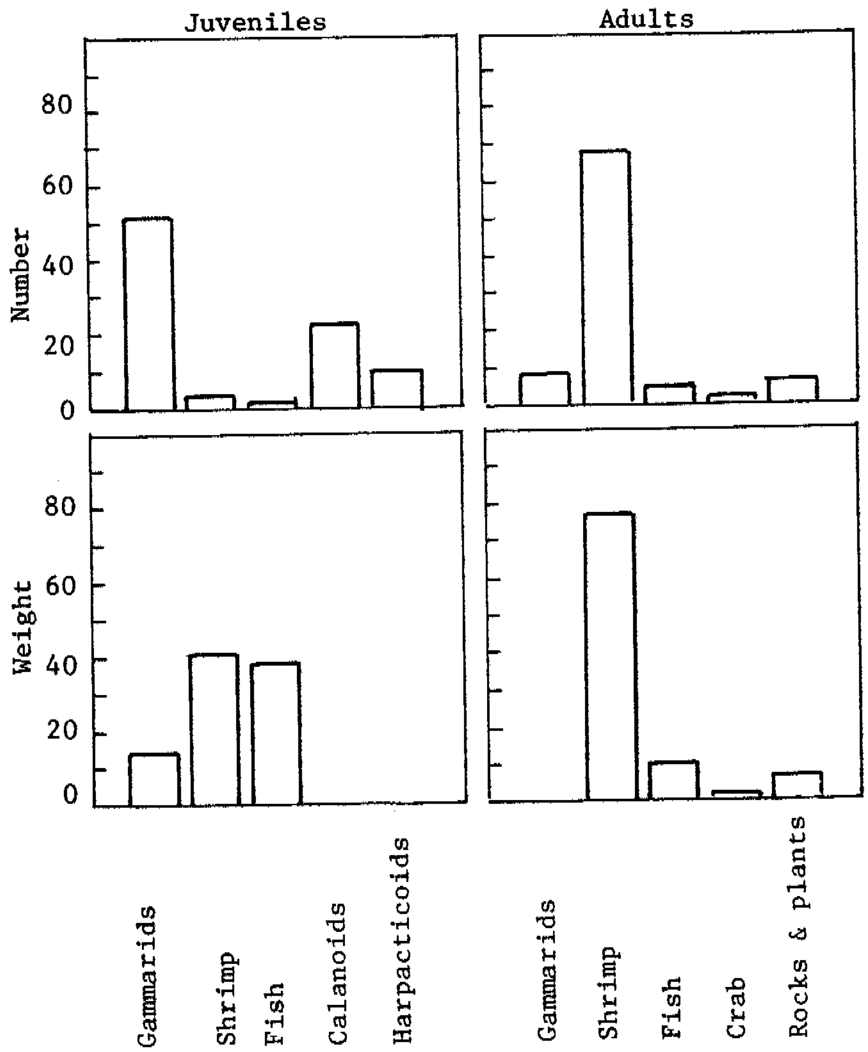

Fig. 2. Percentage composition of the major food items in Pacific cod. Juveniles from all gear and adults from otter trawls, primarily during June to July.

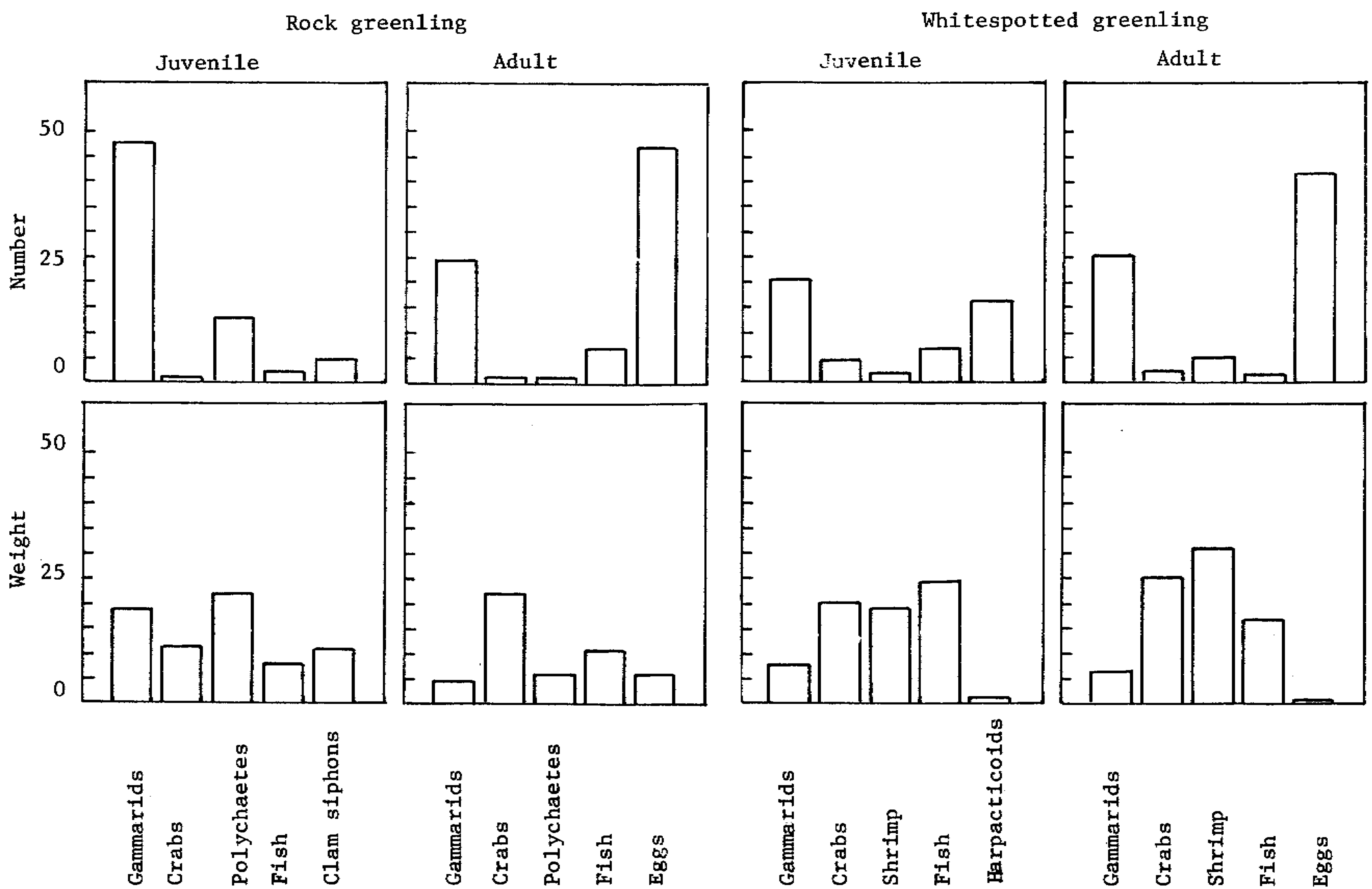

Fig. 3. Percentage composition of major food items in rock and whitespotted greenling. Samples primarily from May to July. Rock greenling from beach seine and trammel nets and whitespotted from all gears except townet.

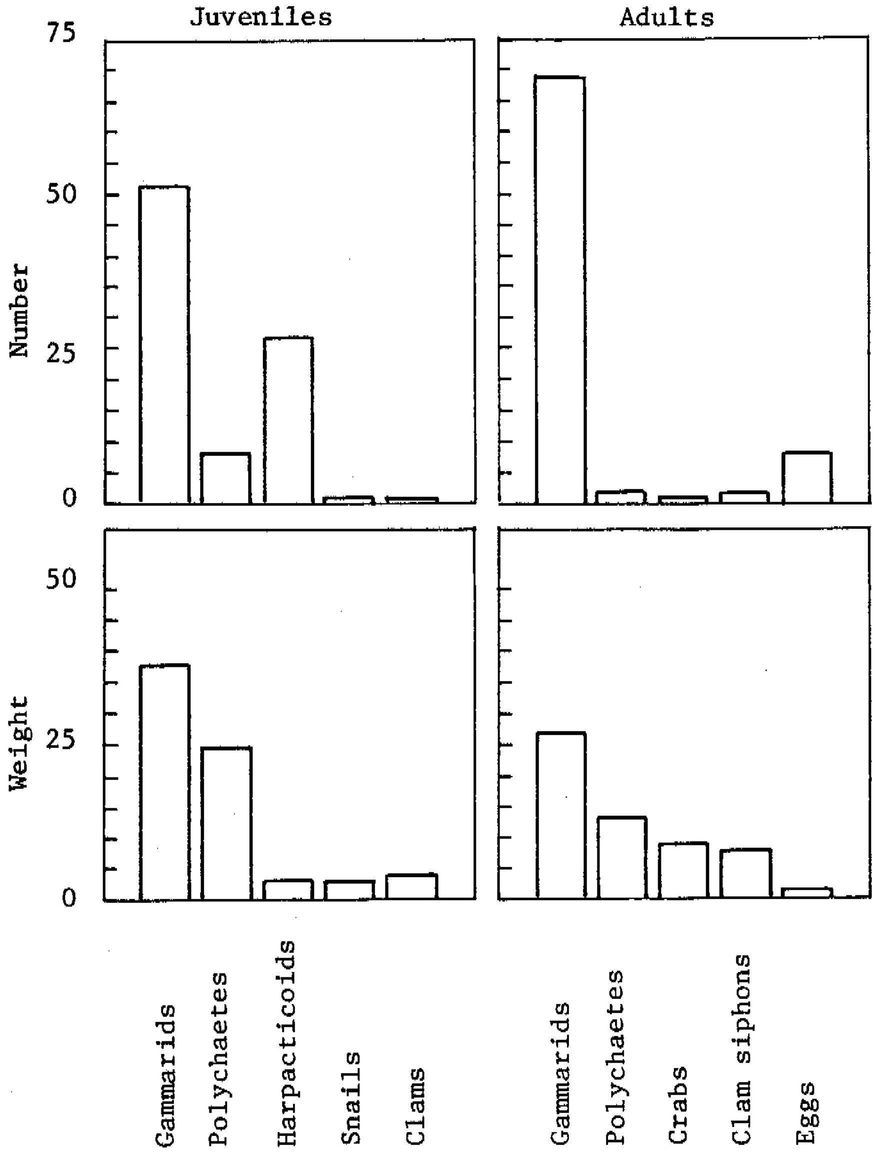

Fig. 4. Percentage composition of the major food items in masked greenling. Samples primarily from beach seine and trammel nets during May to July.

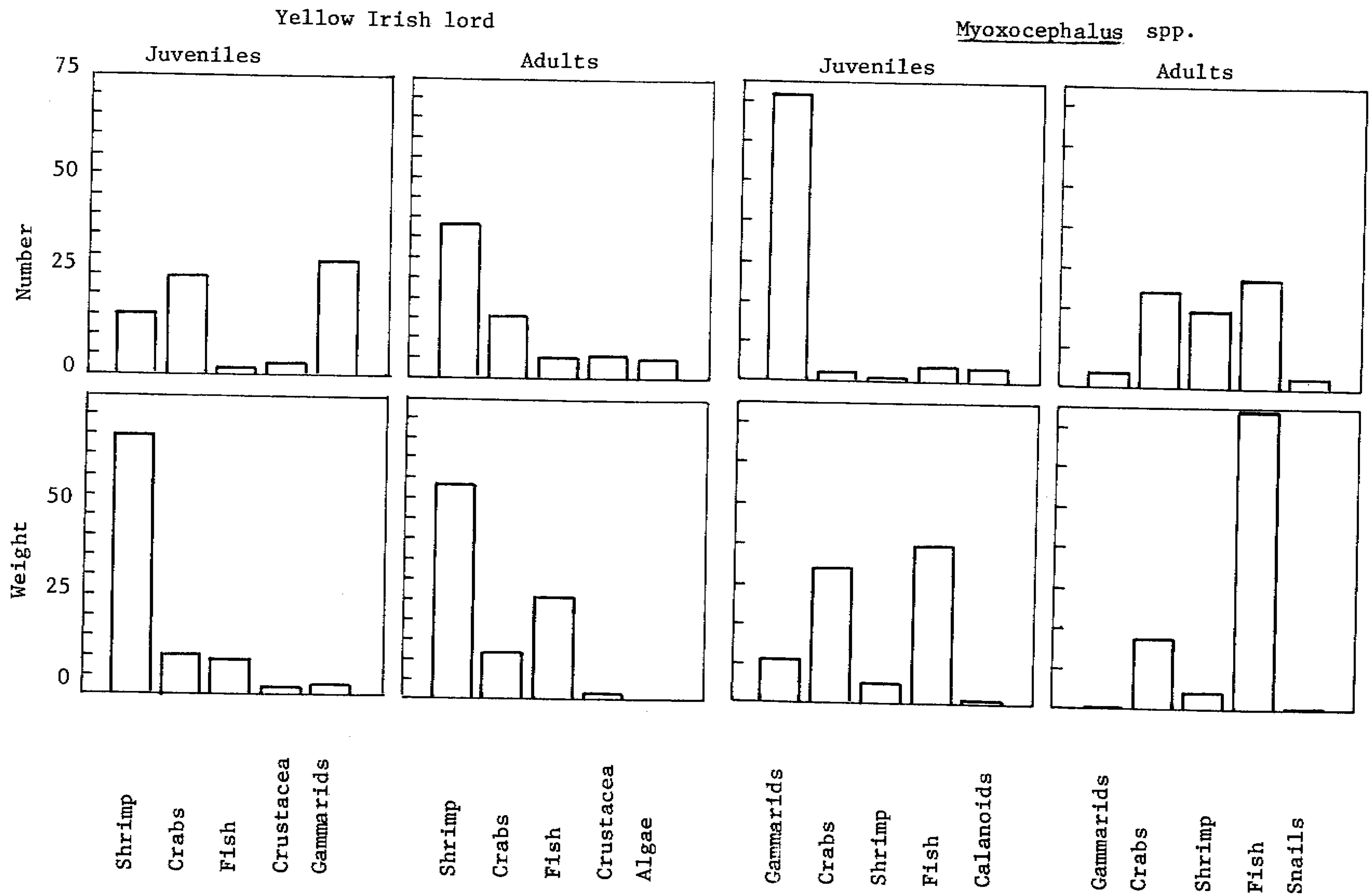

Fig. 5. Percentage composition of major food items in yellow Irish lord and *Myoxocephalus*. Yellow Irish lord primarily from trynet and otter trawl (Izhut and Kiliuda), whereas juvenile *Myoxocephalus* are primarily from beach seine and adults from all gear except townet.

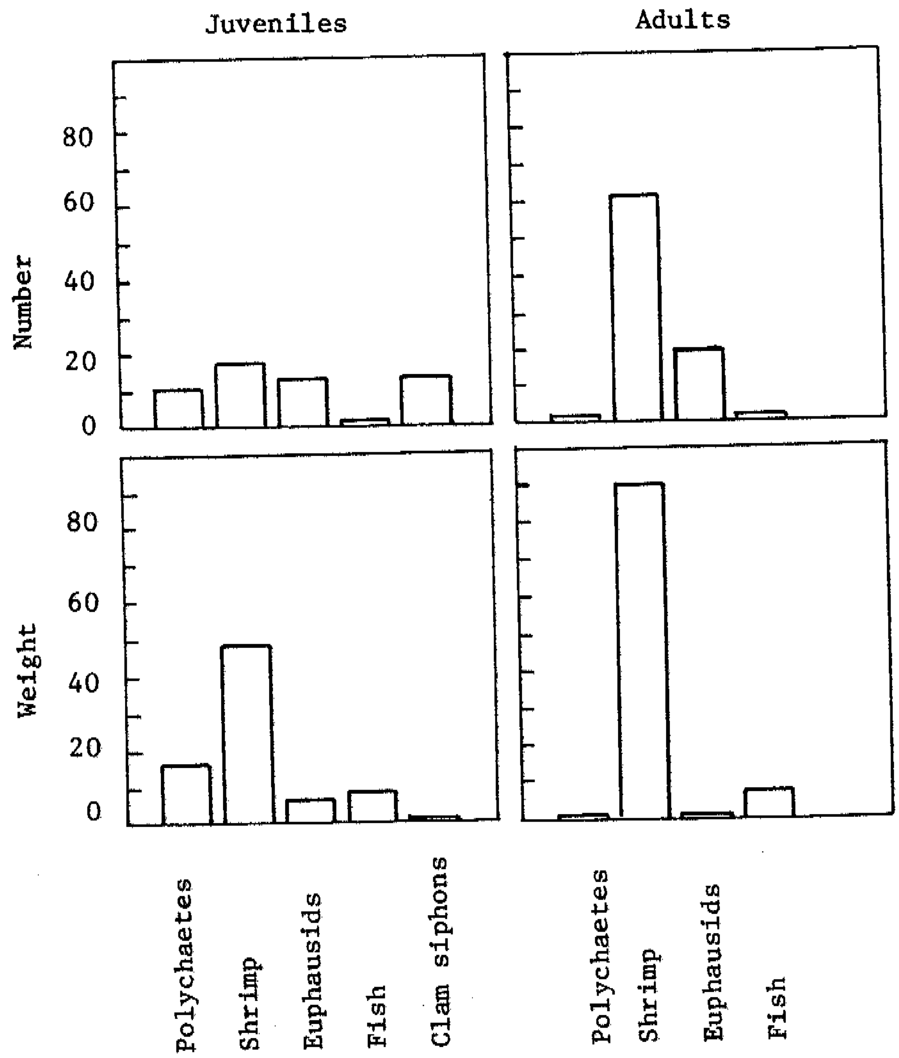

Fig. 6. Percentage composition of major food items in flathead sole during May to July. Juveniles from trynet and otter trawl and adults primarily from otter trawl in Izhut and Kiliuda bays.

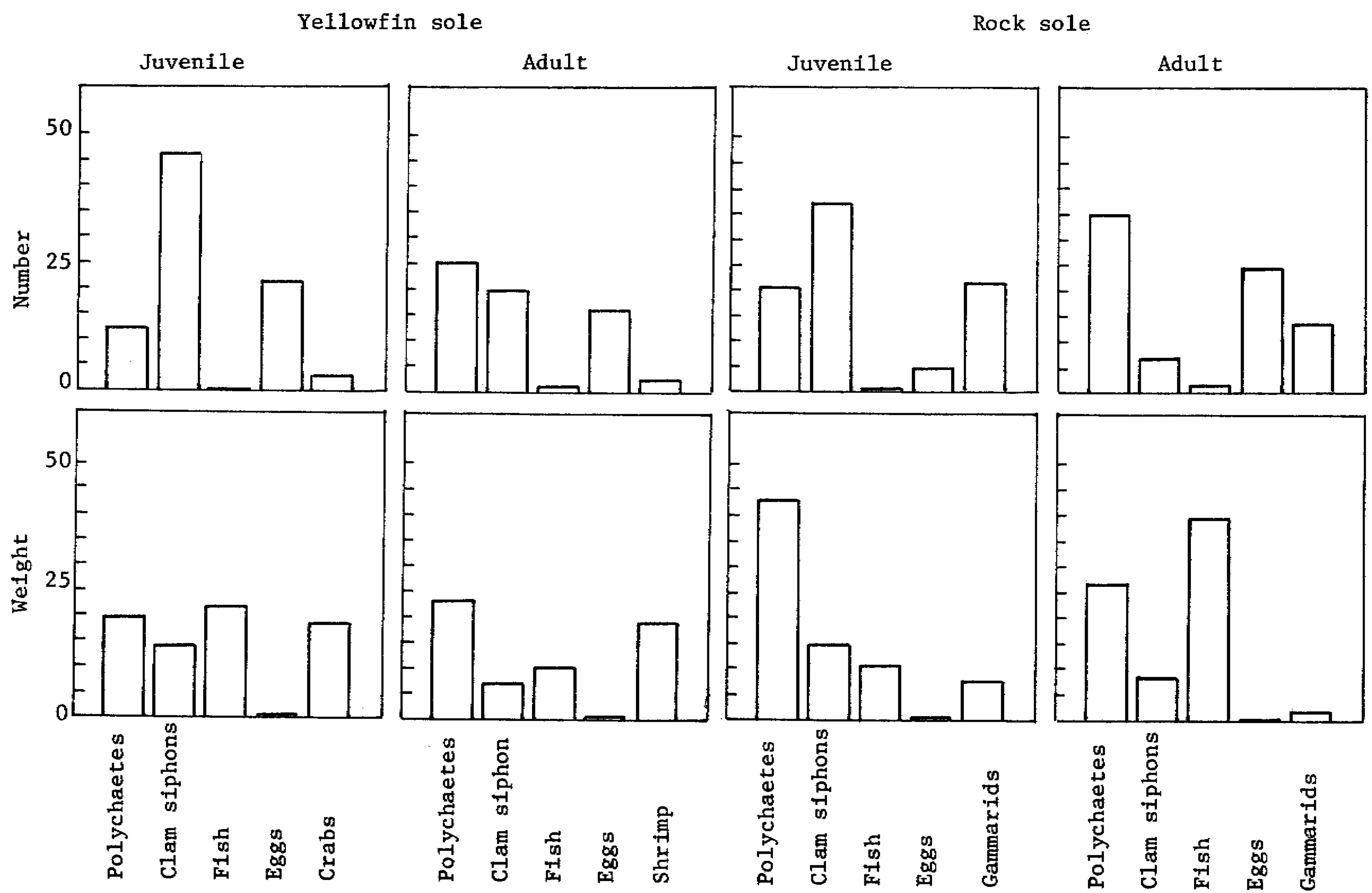

Fig. 7. Percentage composition of major food items in yellowfin and rock sole during April to July. Samples primarily from trynets.

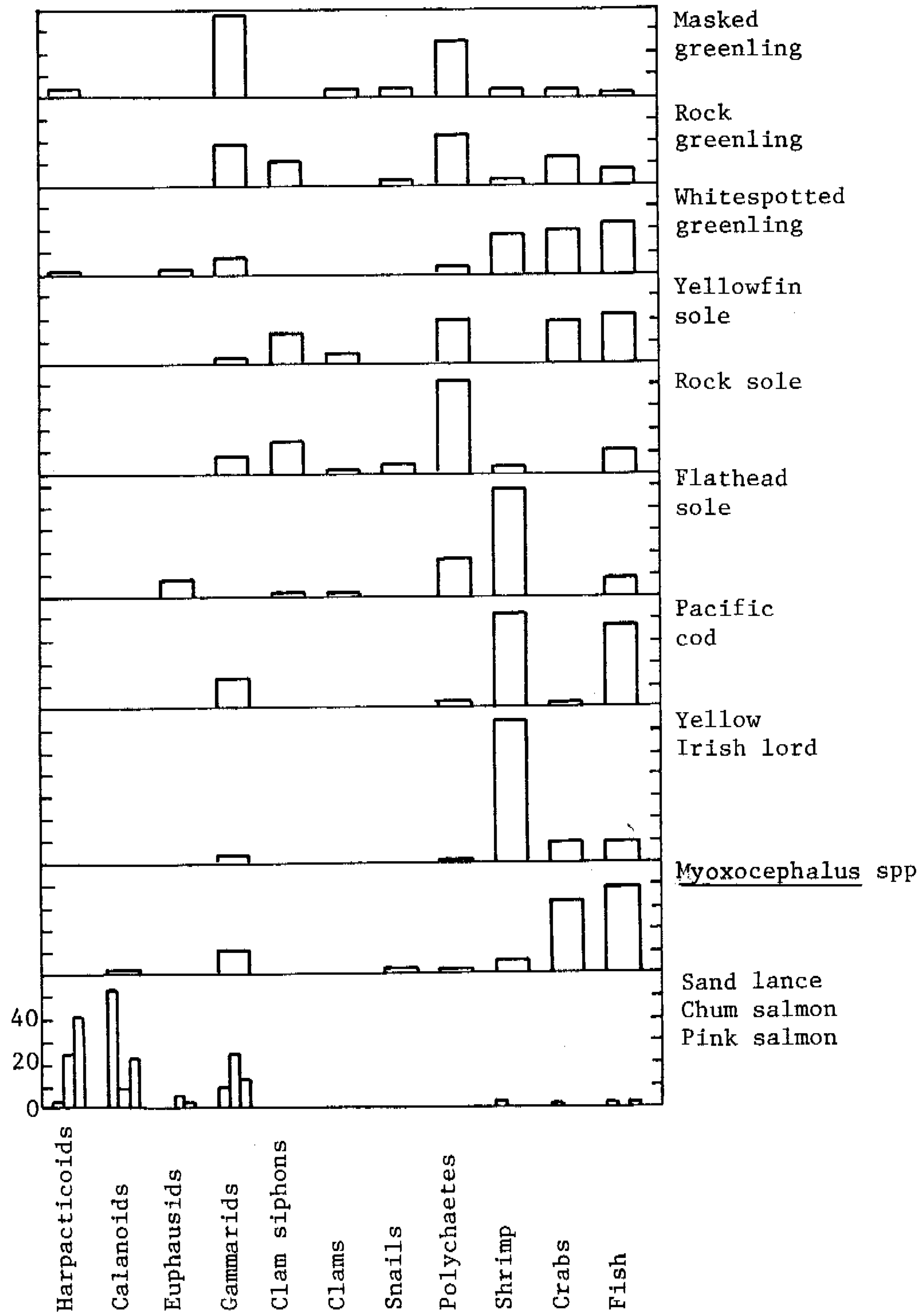

Fig. 8. Percentage composition by weight of major food items in the stomachs of juvenile fish. Composition for sand lance (juveniles and adults), chum salmon, and pink salmon from left to right, respectively.

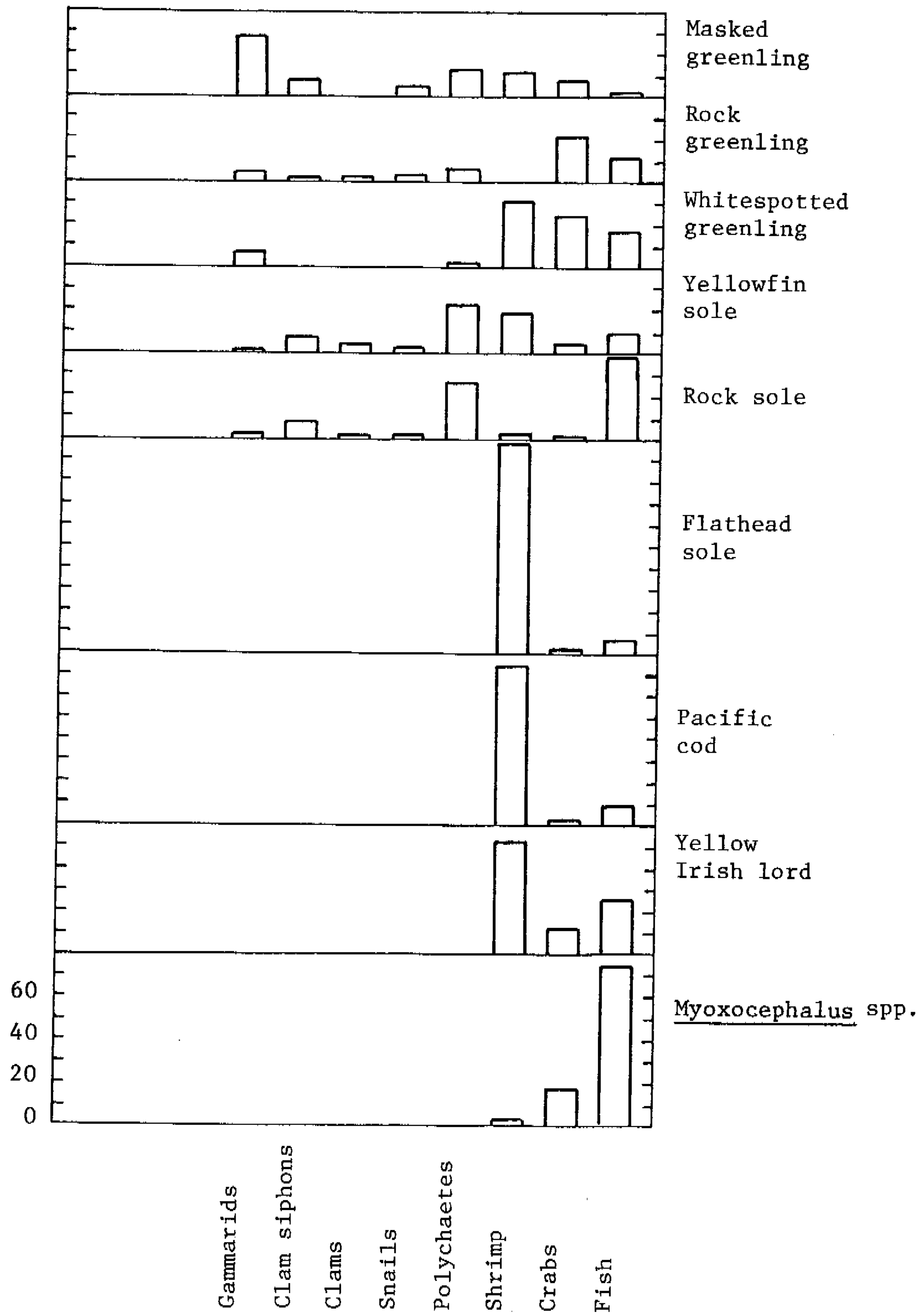

Fig. 9. Percentage composition by weight of major food items in stomachs of adult fish.

Table 1. The number of fish stomachs sampled by species and month, April-November, 1978 and March, 1979.

	April	May	June	July	August	November	March	Total
Rock sole	229	530	673	384	285	417	275	2,793
Yellowfin sole	25	381	601	249	297	267	225	2,045
Flathead sole	18	209	366	183	179	184	113	1,252
Starry flounder	3					4		7
Arrowtooth flounder	1	41						42
Butter sole		12						12
Alaska plaice	1					2		3
Pacific halibut	4		26	20				50
Rock greenling	6	78	240	177	169	105	27	802
Masked greenling	69	108	124	258	254	180	15	1,008
Whitespotted greenling		49	112	176	284	68	21	710
Kelp greenling		6	5	2	7	6	1	26
Unidentified greenling		3	4	6	5			18
Myoxocephalus spp.	13	84	81	97	153	158	70	656
Oligocottus sp.	1							1
Staghorn sculpin		1						1
Gymnocanthus spp.	1	7					14	22
Buffalo sculpin		2					1	3
Silverspotted sculpin	7						3	10
Yellow Irish lord	1	100	155	99	113	41	33	542
Red Irish lord			3	10	9	2		24
Pink salmon	22	220	414	150	42		1	849
Chum salmon	4	200	337	74		1	1	617
Silver salmon		15	4					19
Dolly Varden	13							13
Pacific sand lance	26	197	217	155	291	80	26	992
Eulachon						4	33	37
Capelin		1	31			1		33
Sandfish		13	1	28	42	2	6	92
Snake prickleback		2	17	40	11		4	74
Crescent gunnel		20	16	17	64	1	4	222
Penpoint gunnel					2			2
Blennioids	2							2
Daubed shanny		1						1
Shortfin eelpout						1		1
Pacific cod	21	84	97	159	121	80	32	594
Walleye pollock		81	55	47	78	62	44	367
Tomcod					9	23	21	53
Sablefish			25		35	13		73
Searcher		1						1
Prowfish				1				1
Black rockfish					4			4
Lingcod					12	5	1	18
Total	467	2,446	3,603	2,332	2,467	1,706	971	13,992

Table 2. The number of stomachs examined by bay, gear, and life history stage for the period April-July, 1978. (J = juvenile, A = adult).

Species	Bay	Gear									
		Seine		Try		Trammel		Otter trawl		Townet	
		J	A	J	A	J	A	J	A	J	A
Rock sole	Izhut	6	5	261	305	6	31	61	49		
	Kalsin	11	11	282	173	1	40				
	Kiliuda	44	9	254	104	3	53	9	49		
	Kaiugnak	3		53	4		6				
Yellowfin sole	Izhut			71	59		1	27	93		
	Kalsin		1	291	286		11				
	Kiliuda			212	102		4	9	99		
	Kaiugnak			66	20						
Flathead sole	Izhut			181	7			82	82		
	Kalsin			138	9						
	Kiliuda			97	9			95	71		
	Kaiugnak			17							
Pacific halibut	Izhut			1		1		22	8		
	Kalsin			3	1						
	Kiliuda							12	1		
Rock greenling	Izhut	7	12			15	102			1	
	Kalsin	4				9	75				
	Kiliuda		7			8	83				
	Kaiugnak	12	16			5	134				
Whitespotted greenling	Izhut	8	6	2	8		21		5		
	Kalsin	2	6	7	13	2	20				
	Kiliuda	41	7	3	14	4	68	4	54		
	Kaiugnak	18	1	2	3	2	14				
Masked greenling	Izhut	74	30				69			2	
	Kalsin	2	12				49				
	Kiliuda	59	49	1	4	12	157		2		
	Kaiugnak	19	18		5	1	83				

Table 2. The number of stomachs examined by bay, gear, and lift history stage for the period April-July, 1978. (J = juvenile, A = adult). - Continued.

		Gear									
		Seine		Try		Trammel		Otter trawl		Townet	
Species	Bay	J	A	J	A	J	A	J	A	J	A
Kelp greenling	Izhut	2					3		1		
	Kiliuda						2				
	Kaiugnak						5				
<u>Myoxocephalus</u> spp.	Izhut	21	2	6	4	1		1	19		
	Kalsin	29	7		1	1	7			1	
	Kiliuda	27	17	9	7	2	12	2	58		
	Kaiugnak	23	2	3	2						
Yellow Irish lord	Izhut	2		20	5			14	54		
	Kalsin	1		4	2						
	Kiliuda			33	35		2	66	102		
	Kaiugnak			10	8		2				
Red Irish lord	Izhut						3				
	Kiliuda						2				
	Kaiugnak						3				
Pacific cod	Izhut	2		3		5		26	60		
	Kalsin			5		8	1				
	Kiliuda	39		26		32		41	59	9	
	Kaiugnak	23		2		1					
Walleye pollock	Izhut	1		2		1		30	3		
	Kalsin			34	2						
	Kiliuda			8				103	28		
Pacific sand lance	Izhut	67	113								
	Kalsin	12	3								
	Kiliuda	118	124							31	
	Kaiugnak	32	77								

Table 2. The number of stomachs examined by bay, gear, and life history stage for the period April-July, 1978. (J = juvenile, A = adult) - Continued.

		Gear									
		Seine		Try		Trammel		Otter trawl		Townet	
Species	Bay	J	A	J	A	J	A	J	A	J	A
Sandfish	Izhut				1			1	15		
	Kiliuda				1				23		
Capelin	Izhut								4	20	
	Kalsin	1			4						
	Kiliuda							1	4		3
Pink salmon	Izhut	177								24	
	Kalsin	164								41	
	Kiliuda	150	4							44	
	Kaiugnak	134	2								
Chum salmon	Izhut	18									
	Kalsin	108								41	
	Kiliuda	342								57	
	Kaiugnak	81									
Snake prickleback	Izhut				1				14		
	Kalsin			1							
	Kiliuda			1					1		
	Kaiugnak	1	1								
Crescent gunnel	Izhut	6	10								
	Kalsin	5	7								
	Kiliuda		2								
	Kaiugnak		3	3							

Table 3. The average number and weight (mg) of prey items per pink salmon stomach. (T = trace, J = juvenile, P = pooled*).

	Pink salmon (*Oncorhynchus gorbuscha*)					
	June (J)		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight
Mollusca						
Gastropoda			0.6	0.8		
Gastropod larvae	T	T	0.1	0.2		
Arthropoda						
Crustacea zoea	T	T	0.1	T		
Copepoda	1.3	0.2				
Calanoida	14.0	11.2	124.1	24.2		
Harpacticoida	18.0	10.9	32.3	4.2		
Cladocera	T	T	28.1	1.9		
Ostracoda	T	T				
Cirripedia larvae	0.3	T	17.8	2.2		
Mysidacea	0.1	0.5	0.3	0.1		
Cumacea	2.9	0.9	0.6	9.0		
Isopoda			T	T		
Sphaeromatidae			T	T		
Idoteidae			T	T		
Amphipoda						
Capellidea			4.0	0.2		
Gammaridea	1.0	1.4	4.8	4.8		
Corophiidae	T	T	T	T		
Hyperiidea			0.1	T		
Euphausiacea	T	3.5	0.6	0.5		
Decapod zoea	0.1	0.1	0.2	T		
Anomura						
Paguridae	T	T	T	T		
Brachyura						
Oxyrhyncha			0.1	0.3		
Insecta	0.2	0.2	0.1	T		
Diptera	0.2	0.5	1.7	2.7		
Diptera larvae	0.1	0.1	0.1	0.1		
Chironomid larvae			T	T		
Chironomid pupae	T	T				
Chordata						
Urochordata						
Larvacea			0.9	2.1		
Vertebrata						
Teleostei	T	0.1			2.2	2,653
Unidentified	1.1	4.1	10.8	1.1		
Total number stomachs	371		119		6	
Number empty stomachs	P		P		4	
Mean stomach fullness	4.2		3.8		2.2	
Mean length (mm)	49.0		68.4		506.3	

* In tables 3-27, P indicates that at least some of the stomachs within a month and life history stage were pooled, but not necessarily that all of them were.

Table 4. The average number and weight (mg) of prey items per chum salmon stomach. (T = trace, J = juvenile, P = pooled).

	Chum salmon (*Oncorhynchus keta*)			
	June (J)		July (J)	
	Number	Weight	Number	Weight
Ectoprocta			T	T
Mollusca				
Pelecypoda	T	T		
Gastropoda	T	T		
Annelida				
Polychaeta			T	T
Nereidae	T	T		
Arthropoda				
Crustacea				
Copepoda				
Calanoida	9.9	11.0	1.4	0.3
Cyclopoida	0.4	0.1	2.3	0.4
Harpacticoida	37.6	13.4	248	20.7
Cladocera	T	T		
Ostracoda			T	T
Cirripede larvae	0.4	0.2	1.9	0.3
Cumacea	6.1	5.5	1.3	1.0
Isopoda	T	T	0.1	0.1
Idoteidae	T	T		
Sphaeromatidae	T	T		
Amphipoda				
Gammaridea	5.8	6.4	81.9	115
Amphithoidae	0.2	0.2		
Corophiidae			T	T
Hyperiidea			0.1	T
Euphausiacea	0.2	19.0		
Decapod zoea	0.2	T		
Carides			T	T
Caridea larvae	T	0.1		
Insecta	0.5	1.0	0.1	0.1
Diptera	0.6	2.2	2.1	4.3
Diptera larvae	T	T	1.0	0.4
Chironomidae larvae	T	T	0.2	0.1
Coleoptera	T	T		
Homoptera	T	T		
Hymenoptera	T	T		
Chordata				
Vertebrata				
Teleostei	0.3	9.3		
Teleost eggs	0.7	0.1		
Teleost larvae	T	4.8		
Clupeidae	T	2.2		
Cottidae	T	0.3		
Pholidae	T	0.6		
Unidentified	1.5	1.4		
Total number stomachs	367		76	
Number empty stomachs	P		P	
Mean fullness	4.4		3.8	
Mean length (mm)	78.7		57.8	

Table 5. The average number and weight (mg) of prey items per coho salmon and capelin stomach. (T = trace, J = juvenile, P = pooled).

	Coho salmon (*Oncorhynchus kisutch*)				Capelin (*Mallotus villosus*)	
	June (J)		July (J)		June	
	Number	Weight	Number	Weight	Number	Weight
Annelida						
Polychaeta	0.3	1.7				
Phyllodocidae			0.3	2.0		
Arthropoda						
Crustacea					0.1	0.5
Copepoda						
Calanoida					37.2	203
Harpacticoida			13.7	2.3		
Cumacea			2.3	1.0		
Amphipoda						
Gammaridea	2.2	23.8				
Decapod zoea					0.3	0.2
Anomura						
Paguridae	0.8	4.5				
Brachyura						
Oxyrhyncha zoea	3.0	31.7				
Insecta	0.2	2.5				
Diptera			0.7	1.7		
Chordata						
Vertebrata						
Teleostei	0.3	115				
Unidentified	0.2	22.5				
Total number stomachs	6		3		33	
Number empty stomachs	P		1		P	
Mean fullness	4.2		2.0		2.9	
Mean length (mm)	123.3		96.3		127.2	

Table 6. The average number and weight (mg) of prey items per sand lance stomach. (T = trace, J = juvenile, P = pooled).

	Sand lance (*Ammodytes hexapterus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Annelida								
Polychaeta			T	T				
Polychaete larva							1.5	0.2
Mollusca								
Gastropoda	0.3	0.3	T	T				
Gastropod veliger			T	T	0.2	T	0.2	T
Pelecypod veliger					4.6	0.1	0.1	T
Arthropoda								
Crustacea zoea			T	T	T	T	2.6	0.7
Crustacea nauplius					0.8	T		
Cladocera					14.2	0.9	107	11.8
Ostracoda			T	T				
Copepoda								
Calanoida	56.1	55.5	109	54.3	37.1	3.3	138	16.5
Cyclopoida			6.0	0.5				
Harpacticoida	16.9	3.3	32.5	6.2	1.2	0.1	T	T
Cirripedia			T	T				
Cirripede larvae	0.5	T	0.1	T	2.7	0.1	148	16.3
Mysidacea			T	0.2	T	T		
Cumacea			0.1	0.2				
Isopoda								
Sphaeromatidae			0.1	0.1				
Amphipoda								
Gammaridea	0.4	0.1	0.6	0.3	T	T	0.1	T
Amphithoidae			10.4	39.0				
Euphausiacea			T	0.5				
Decapoda								
Decapod zoea			T	T	0.1	T	0.6	T
Caridea			T	0.1				
Caridea zoea			T	T				
Insecta								
Chironomid pupa							T	T
Chordata								
Vertebrata								
Teleostei			T	T				
Teleost larva							0.3	1.2
Teleost egg							24.7	3.4
Unidentified			46.5	15.7	0.2	0.1	T	48.7
Total number stomachs	28		173		111		43	
Number empty stomachs	P		P		P		P	
Mean fullness	4.8		3.5		2.9		3.2	
Mean length (mm)	99.2		121.3		80.6		129.4	

Table 7. The average number and weight (mg) of prey items per Pacific cod stomach. (T = trace, J = juvenile, P = pooled).

	Pacific cod (*Gadus macrocephalus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Phaeophyta			T	519	T	1.7		
Angiosperma								
Potamogetonaceae					T	1.2		
Porifera							0.1	1,322
Annelida								
Polychaeta	T	0.1			T	4.4		
Nereidae					T	4.9		
Mollusca								
Gastropoda			T	348	T	T	0.2	203
Lacunidae					0.1	0.4		
Pelecypoda			T	6.1	T	0.3	0.1	54.2
Pelecypod siphons					0.1	0.3		
Arthropoda								
Crustacea	1.2	89.9	0.1	120	0.1	24.3	0.2	58.8
Copepoda								
Calanoida	9.8	1.3			9.3	1.1		
Cyclopoida					T	T		
Harpacticoida	0.4	0.2			16.1	3.9		
Caligoida					T	T		
Cladocera					2.2	0.2		
Ostrocoda	T	T			T	T		
Cirripedia larvae					0.7	0.1		
Mysidacea	0.1	3.3			T	0.1		
Isopoda					T	T		
Valvifera								
Idoteidae					0.1	24.4		
Flabellifera								
Sphaeromatidae					0.2	7.8	0.4	37.1
Amphipoda								
Gammaridea	1.8	29.9	T	T	10.8	77.3	2.1	4.3
Corophiidae					T	0.1		
Caprellidea					2.8	30.4		
Euphausiacea	0.1	0.3	0.1	T	0.2	1.6		
Decapod	T	154	T	29.2				
Carides	0.2	50.2	0.3	472			0.5	1,585
Crangonidae	T	18.5	T	13.5	T	15.1	0.1	79.3
Hippolytidae	0.1	38.6			T	4.9		
Pandalidae	0.7	1,848	2.4	8,238	0.2	281	3.5	14,972
Anonura								
Paguridae			0.1	155	T	16.0	0.1	45.6
Brachyura	0.2	105						
Oxyrhyncha			0.1	100	T	0.8		
Majidae			0.1	250	0.1	6.7		
Chordata								
Vertebrata								
Teleostei	0.1	257	0.3	1,156	0.2	106		
Ammodytidae					T	53.7	0.1	144
Bathymasteridae							0.1	466
Clupeidae	0.1	840	T	237	T	260		
Cottidae			T	153				
Osmeridae			T	204				
Pleuronectidae							0.1	900
Salmonidae			T	.179				
Unidentified	0.1	645	0.7	2,234	0.5	5.1	0.2	476
Total number stomachs	51		43		126		18	
Number empty stomachs	8		9		P		0	
Mean fullness	4.0		4.2		4.0		4.6	
Mean length (mm)	247.7		416.6		152.2		467.9	

Table 8. The average number and weight (mg) of prey items per walleye pollock stomach. (T = trace, J = juvenile, P = pooled.)

	Walleye pollock (*Theragra chalcogramma*)					
	June (J)		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight
Annelida						
Polychaeta	0.1	13.4				
Arthropoda						
Crustacea	13.8	220	2.8	25.6	0.4	6.4
Crustacea zoea	12.4	14.1				
Crustacea megalops	3.4	16.0				
Copepoda						
Calanoida	161	185	38.2	189	0.1	0.8
Caligoida	T	T				
Nebaliacea	T	T				
Mysidacea	25.9	28.2	17.2	85.7		
Cumacea	0.5	3.9	27.1	14.4		
Amphipoda						
Gammaridea	1.4	12.6	0.5	1.6		
Hyperiidea	T	T	0.1	0.7		
Euphausiacea	0.3	30.1	6.6	658	9.6	929
Decapod zoea	T	T	5.1	3.2		
Decapod megalops	T	0.2				
Carides	T	10.1	2.6	161	0.3	1,239
Carides larvae	T	T	2.4	8.3		
Crangonidae			T	28.2		
Pandalidae	T	68.7	T	18.0	3.1	1,556
Anomura						
Paguridae	0.2	0.4	0.2	1.3		
Brachyura	T	0.4				
Oxyrhyncha						
Majidae			0.1	0.2		
Chordata						
Teleostei	T	0.1	0.1	135	0.1	151
Teleost larvae	T	0.1				
Ammodytidae	T	2.7	T	34.0		
Perciformes			T	3.1		
Total number of stomachs	83		37		9	
Number empty stomachs	P		1		0	
Mean fullness	4.3		5.5		4.9	
Mean length (mm)	173.0		191.8		553.3	

Table 9. The average number and weight (mg) of prey items per rock greenling stomach. (T = trace, J = juvenile, P = pooled).

	Rock greenling (*Hexagrammos lagocephalus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta			T	6.7			T	0.2
Ulotrichales			T	3.6			0.1	0.4
Rhodophyta	T	0.9	0.1	25.0			0.4	14.3
Phaeophyta	T	5.4	0.2	306	0.1	0.8	0.1	154
Desmarestiaceae			T	24.2				
Cnidarea			T	0.4				
Anthozoa							T	12.2
Metridiidae			T	9.5				
Hydrozoa			T	0.3	T	149	0.1	102
Nemertinea	0.1	0.7	T	6.2				
Ectoproct			T	0.7			T	T
Mollusca			0.4	133			0.4	171
Amphineura								
Polyplacophora			0.5	78.0	0.5	20.0	0.2	119
Gastropoda	0.1	2.2	1.0	47.7	T	0.7	0.6	21.0
Prosobranchia								
Acmaeidae	1.1	20.5	T	2.1			T	0.3
Lacunidae	6.2	48.8	10.8	590	1.6	21.6	4.3	82.2
Littorinidae	0.1	5.2	T	1.8			1.2	30.2
Naticidae							T	0.5
Trichotropididae							T	0.8
Trochidae			T	2.4				
Velutinidae			T	T			0.1	19.0
Opisthobranchia								
Tectibranchia								
Aglajidae			T	1.2				
Bullidae			T	14.9				
Nudibranchia								
Doridae			0.1	30.7			1.1	61.8
Tritonidae							T	3.2
Pelecypoda	T	T	0.6	96.2	0.1	0.3	0.5	72.3
Pelecypod siphons	4.8	324	4.2	887	0.1	3.1	0.6	192
Mytilidae			T	0.4			T	0.5
Cephalopoda			T	0.9				
Octopoda			T	26.7				
Echiuroidea			T	T				
Annelida								
Polychaeta	1.8	192	1.2	124	0.3	4.6	0.4	151
Ampharetidae			T	0.3				
Flabelligeridae			T	3.5			T	8.4
Glyceridae			T	3.3			T	3.2
Goniadidae							T	0.5
Lumbrineridae			T	0.1				
Nereidae			0.1	24.1	T	3.1	0.1	3.1
Opheliidae			0.2	2.5				
Owenidae	0.4	3.3						
Polynoidae			T	6.7				
Sabellaridae			0.1	0.8				
Serpulidae	0.5	6.1	0.2	1.6	T	0.1	0.1	0.8
Arthropoda								
Pyncnogonida							T	T
Crustacea			0.2	8.9	0.1	4.2	0.1	67.8
Copepoda								
Harpacticoida	1.9	0.2			9.8	3.9		
Cirripedia	T	0.6	0.1	2.9	0.4	2.1	0.5	11.4
Mysidacea			T	0.3			T	0.3
Cumacea							T	0.1
Isopoda			T	0.4			T	0.1
Idoteidae	T	3.6	0.6	85.3	0.1	6.9	0.8	123
Sphaeromatidae			4.3	258	1.4	43.4	2.7	1.7

Table 9. The average number and weight (mg) of prey items per rock greenling stomach. (T = trace, J = juvenile, P = pooled). - Continued.

	Rock greenling (*Hexagrammos lagocephalus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Amphipoda								
Caprellidea	0.4	2.4	16.6	154	0.4	2.8	3.3	36.0
Gammaridea	23.7	303	27.1	278	30.2	154	58.5	280
Amphithoidae			0.1	7.1			0.1	9.8
Corophiidae	1.5	4.3	0.1	0.3	0.3	1.0	T	T
Eusiridae			0.2	2.1				
Hyperiidea			T	T				
Euphausiacea			T	0.2			T	2.7
Decapoda	0.4	20.9	0.3	309	0.2	134	1.2	174
Decapoda megalops	0.3	2.9	T	1.8				
Carides	0.1	10.8	0.1	21.0			0.2	6.1
Crangonidae	T	5.6	T	1.5			T	0.5
Hippolytidae	0.1	32.3	0.3	73.6			1.0	45.5
Pandalidae	T	0.7	T	3.0			0.3	12.1
Anomura			T	0.2				
Lithodidae	T	0.6	T	0.2			T	8.6
Paguridae	0.2	82.7	0.4	358	0.1	6.8	0.1	100
Brachyura megalops	T	0.8	0.2	4.4				
Oxyrhyncha	0.1	29.1	0.3	32.3			0.2	9.7
Majidae	T	46.9	1.1	326	T	10.3	0.4	389
Brachyrhyncha								
Atelecyclidae	0.1	124	T	1,333			0.3	666
Cancridae	0.1	38.3	0.1	146	T	3.5	0.2	97.7
Insecta								
Diptera larvae			0.2	0.6	T	T		
Chironomid larvae					2.6	0.3	0.1	0.1
Echinodermata								
Asteroidea								
Asteriidae							T	0.1
Holothuroidea			T	0.1				
Chordata								
Urochordata								
Ascidacea			T	85.2			T	6.9
Vertebrata								
Teleostei	0.2	69.0	0.7	404	T	5.3	0.4	930
Teleost larvae			T	2.3			T	0.4
Teleost egg	3.1	2.1	39.8	105	0.3	0.2	72.2	316
Ammodytidae							0.1	143
Cottidae			T	4.9			T	22.6
Cottid larva			T	0.6				
Cyclopteridae							T	132
Hexagrammidae							T	84.3
Perciformes			T	11.3			T	22.7
Pholid larvae			T	T			T	87.6
Unidentified	2.8	13.7	24.7	765	1.3	46.9	15.4	777
Total number stomachs	30		201		20		157	
Number empty stomachs	0		3		0		P	
Mean fullness	4.8		5.2		4.8		5.0	
Mean length (mm)	193.0		320.6		144.4		313.5	

Table 10. The average number and weight (mg) of prey items per whitespotted greenling stomach. (T = trace, J = juvenile, P = pooled).

	Whitespotted greenling (*Hexagrammos stelleri*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta			T	1.6			0.1	35.8
Ulotrichales			0.1	3.2			T	14.1
Phaeophyta			T	3.8			T	6.6
Desmarestiaceae			T	3.6				
Rhodophyta			0.2	19.2			T	4.6
Angiosperma								
Potamogetonaceae			T	2.7			0.2	54.8
Cnidarea			T	0.3				
Hydrozoa							T	39.9
Nemertinea			T	0.1				
Ectoprocta							T	T
Mollusca								
Amphineura								
Polyphacophora							T	9.5
Gastropoda	0.1	0.8	T	43.3	0.2	0.3	T	20.7
Lacunidae							0.3	2.5
Littorinidae							T	0.2
Trichotropidae			0.3	1.5				
Pelecypoda	0.1	2.3	T	0.2			0.1	7.8
Pelecypod siphons	1.4	9.5	0.1	3.1	T	0.1	T	71.3
Mytilidae			T	T			T	T
Cephalopoda							T	0.4
Octopoda			T	T				
Echiuroidea							0.1	39.5
Annelida								
Polychaeta	0.7	53.9	0.3	1,898	T	0.3	0.7	46.3
Flabelligeridae							T	2.7
Glyceridae			T	20.3			T	0.1
Opheliidae	1.4	16.1						
Pectinariidae					T	T	T	0.8
Nephtyidae							T	12.4
Nereidae			T	17.3	T	T	T	3.6
Sabellidae			T	1.7				
Syllidae			T	136				
Arthropoda								
Pyncnogonida			T	0.3				
Crustacea	0.7	16.1	0.2	119	T	3.1	T	319
Ostracoda					T	T		
Copepoda					1.3	0.3		
Calanoida					12.8	2.5		
Harpacticoida					65.4	6.5	1.3	0.1
Cirripedia	0.4	1.8			0.6	11.7	0.1	1.9
Mysidacea	1.1	65.7	0.2	21.7	0.3	11.1	0.9	6.7
Cumacea	0.1	0.1	0.1	1.1	T	T	0.9	1.8
Isopoda							T	0.2
Idoteidae			T	10.4	T	T		
Sphaeromatidae	0.3	7.4	0.1	4.3	0.4	1.2	1.1	55.9
Amphipoda								
Caprellidea	0.3	2.5	4.5	42.2	0.6	1.9	16.2	209
Gammaridea	6.2	38.4	4.7	90.5	14.8	31.6	11.0	127
Corophiidae					0.9	1.6	T	T
Euphausiacea					T	7.2		

Table 10. The average number and weight (mg) of prey items per whitespotted greenling stomach. (T = trace, J = juvenile, P = pooled). - Cont.

	Whitespotted greenling (*Hexagrammos stelleri*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Decapoda	0.1	2.4	0.7	292			0.3	460
Decapod megalops	0.9	6.9	T	0.5	T	0.3		
Carides			0.4	264	T	6.2	0.3	190
Crangonidae	0.3	60.7	0.1	95			0.2	73.1
Hippolytidae			T	9.3	T	0.2	0.2	15.4
Pandalidae	0.2	5.1	0.4	1,031	T	1.7	0.6	267
Anomura larva			T	0.1				
Albuneidae			T	2.5				
Paguridae			0.1	66.4			0.1	47.5
Lithodidae							0.5	11.3
Brachyura	0.2	2.1	0.1	8.6	0.1	43.7	0.6	119
Oxyrhyncha			0.2	238	T	0.6	0.2	184
Majidae	0.4	14.6	0.4	97.5			1.0	243
Brachyrhyncha								
Atelecyclidae			0.2	720			0.2	1,576
Cancridae			T	110			0.1	87.0
Insecta					T	T	T	6.7
Diptera larva					0.1	0.1	T	T
Echinodermata								
Holothuroidea			T	20.0				
Teleostei	0.6	162	0.3	470	0.2	16.9	0.8	552
Teleost egg					61.2	38.7	35.8	180
Teleost larva	0.1	3.1	0.1	5.9				
Ammodytidae			0.1	65.5			T	29.5
Cottidae	0.3	88.6	0.1	15.9			0.1	62.3
Cottid larvae			0.1	4.9			T	0.7
Hexagrammid	0.1	8.9					T	113
Pleuronectidae	0.2	58.9					T	2.1
Scorpaeniformes	0.6	224	T	369			T	13.8
Stichaeidae							0.4	161
Unidentified	5.5	18.8	49.0	188	1.4	6.9	15.1	161
Total number stomachs	14		96		67		110	
Number empty stomachs	2		4		P		6	
Mean fullness	4.2		4.6		3.7		4.8	
Mean length	167		263		99.4		261.7	

Table 11. The average number and weight (mg) of prey items per masked greenling stomach. (T = trace, J = juvenile, P = pooled.

	Masked greenling (*Hexagrammos octogrammus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta			0.1	1.9			T	0.4
Ulotrichales			0.1	3.9				
Ulvaceae							T	0.5
Rhodophyta	0.1	T	0.1	3.1			T	0.3
Phaeophyta			T	0.9			0.1	1.3
Angiosperma								
Potamogetonaceae			T	0.2			T	0.3
Cnidarea								
Anthozoa			T	3.4			T	T
Hydrozoa							T	0.6
Nemertinea							T	0.7
Ectoprocta							T	0.1
Mollusca			T	31.5			T	6.6
Amphineura								
Polyplacophora			T	0.2			0.1	2.5
Gastropoda	T	T	1.1	2.7	0.6	7.6	0.4	9.1
Prosobranchia								
Lacunidae	0.4	4.6	4.5	32.6			1.2	13.8
Lamillaridae							0.1	0.2
Littorinidae			T	1.3			T	0.6
Pyramidellidae							T	0.1
Trochidae			T	0.2			T	0.2
Turritellidae			T	T				
Opisthobranchia								
Tectibranchia								
Bullidae							T	0.1
Nudibranchia								
Doridae			T	3.8			0.1	2.3
Pelecypoda	T	0.3	0.1	2.8			0.1	0.1
Pelecypoda siphons	1.2	73.4	1.0	66.8			0.5	46.6
Mytilidae			T	0.1			T	0.7
Tellinidae			T	T				
Cephalopoda							T	3.0
Octopoda			T	45.3			T	4.0
Echiuroidea			T	10.7				
Annelida								
Polychaeta	1.0	24.7	1.9	114	0.1	3.4	0.9	120
Ampharetidae			0.1	2.5				
Capitellidae			T	0.2				
Flabelligeridae			T	4.3			T	3.6
Glyceridae	T	0.2	T	6.0				
Goniadidae			T	2.2			T	0.3
Lumbrineridae			T	3.0			T	0.2
Maldanidae			T	1.4				
Nereidae			0.1	16.4			0.1	20.9
Opheliidae			T	0.6				
Oweniidae	0.4	6.3	0.3	2.5				
Pectinariidae	0.1	2.7	T	0.2			T	1.5
Phyllodocidae	T	0.1	T	T			0.1	1.8
Polynoidae							T	0.1
Sabellidae			T	0.2				
Serpulidae	0.6	3.3	0.8	11.5	T	0.2	T	2.1
Spionidae							T	0.2

Table 11. The average number and weight (mg) of prey items per masked greenling stomach. (T = trace, J = juvenile, P = pooled. Continued.

	Masked greenling (*Hexagrammos octogrammus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Terebellidae			0.1	1.5			T	0.9
Arthropoda								
Crustacea			T	6.0			T	2.5
Copepoda								
Calanoida					0.5	0.2	T	T
Cyclopoida					0.1	T		
Harpacticoida	6.0	1.2	T	T	51.7	9.7	0.2	T
Caligoida			T	0.1				
Cladocera					0.5	0.3	T	T
Ostracoda					5.1	0.9	T	T
Cirripedia	0.8	1.6	0.1	1.6			0.1	0.2
Cirripede larvae					0.2	T		
Nebaliacea			T	0.3				
Mysidacea	T	1.8	T	1.4			T	0.4
Cumacea	0.2	0.5	0.2	1.4			T	T
Tanaidacea							T	T
Isopoda			T	0.9			0.2	1.6
Idoteidae			0.1	23.1			0.1	13.9
Limnoridae							T	0.1
Munnidae			T	T				
Sphaeromatidae	0.3	8.6	1.3	56.0			1.4	36.1
Amphipoda								
Gammaridea	67.7	190	71.7	381	37.7	44.2	77.9	397
Amphithoidae			0.1	4.6				
Corophiidae	0.2	0.3	0.7	2.0			0.3	0.4
Gammaridae			T	1.0				
Caprellidea	0.8	4.6	4.3	50.0	0.2	0.6	13.5	121
Euphausiacea					0.1	0.1		
Decapoda			0.2	26.5	T	0.5	0.5	40.3
Decapod megalops	0.1	0.4	T	0.4			0.1	2.9
Carides	0.1	17.8	0.1	54.3			0.2	12.1
Crangonidae			0.1	3.7				
Hippolytidae	0.1	16.6	0.1	35.1			0.2	24.4
Pandalidae			0.1	6.7			0.2	20.9
Anomura			T	0.5				
Callianasidae			T	28.8				
Lithodidae							T	0.1
Paguridae	0.2	37.6	0.3	77.8	T	4.7	0.1	33.7
Brachyura							0.3	7.3
Oxyrhyncha	0.1	0.4	0.5	13.5			0.2	11.2
Majidae			0.1	21.6			0.1	15.9
Brachyrhyncha	T	0.5					0.1	1.5
Atelecyclidae			0.1	62.3			1.4	90.4
Cancridae	0.1	3.6	T	7.2			0.1	12.2
Insecta	T	0.7						
Diptera larvae					2.1	4.3	T	T
Chironomid larvae					0.5	0.3	2.7	1.3
Echinodermata								
Ophiuroidea			T	0.2			T	0.2
Echinoidea			T	0.2				
Chordata								
Vertebrata								
Teleostei	0.2	16.7	0.2	47.5			0.1	19.1
Teleost eggs			1.3	10.2			2.9	13.9

Table 11. The average number and weight (mg) of prey items per masked greenling stomach. (T = trace, J = juvenile, P = pooled. Continued.

	Masked greenling (*Hexagrammos octogrammus*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Teleost larvae			T	3.6				
Cottidae			0.1	14.5			0.1	31.7
Cottid larvae			T	0.7				
Cyclopteridae							T	0.1
Hexagrammidae							T	1.5
Pleuronectidae			T	10.6				
Unidentified	0.2	15.5	1.9	41.6	0.1	T	3.5	48.2
Total number stomachs	36		187		42		207	
Number empty stomachs	P		2		P		6	
Mean fullness	4.5		4.8		5.1		4.6	
Mean length (mm)	140.8		205.4		76.5		204.7	

Table 12. The average number and weight (mg) of prey items per kelp greenling stomach. (T = trace, J = juvenile).

	Kelp greenling (*Hexagrammos decagrammus*)					
	June (J)		June		July	
	Number	Weight	Number	Weight	Number	Weight
Rhodophyta			1.0	53.3		
Mollusca					1.0	232
Gastropoda			0.7	26.0		
Pelecypoda	1.5	22.5	1.0	337		
Pelecypod siphons			1.0	325	1.0	15,038
Annelida						
Polychaeta					1.0	359
Arthropoda						
Crustacea						
Isopoda						
Sphaeromatidae	0.5	11.0				
Gammaridea			159	125		
Decapoda				1,255	5.0	1,050
Carides						
Hippolytidae			0.3	52.3		
Anomura						
Paguridae	0.5	152	1.3	218		
Brachyura						
Oxyrhyncha						
Majidae					1.5	790
Brachyrhncha						
Atelecyclidae			1.0	7,238	0.5	2,250
Cancridae			0.3	871	0.5	1,184
Chordata						
Vertebrata						
Teleostei	0.5	150	2.0	986	1.0	7,111
Unidentified			1.0	421	128.5	3,984
Total number stomachs	2		3		2	
Number empty stomachs	0		0		0	
Mean fullness	6.0		5.3		6.0	
Mean length (mm)	137.0		383.3		391.0	

Table 13. The average number and weight (mg) of prey items per yellow Irish lord stomachs. (T - trace, J = juvenile).

	Yellow Irish lord (*Hemilepidotus jordani*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta							T	59.2
Phaeophyta			T	39.1	T	0.1	T	1.7
Rhodophyta							T	2.5
Angiosperma								
Potamogetonaceae			T	1.8				
Cnidarea								
Scyphozoa							T	17.7
Ectoprocta	0.2	0.9	T	T				
Mollusca								
Gastropoda							0.1	10.4
Prosobranchia								
Acmaeidae							T	2.2
Fisurellidae							0.1	16.8
Lacunidae	T	0.1			T	0.7	0.3	8.8
Opisthobranchia								
Nudibranchia								
Doridae							T	0.9
Pelecypoda			0.1	28.5	0.2	0.5	0.2	16.7
Pelecypod siphons	T	1.0					0.1	5.3
Cardiidae					T	2.1		
Nuculandae	T	11.0						
Nuculidae					T	1.6		
Veneridae			T	1.6				
Cephalopoda			T	1.7				
Annelida								
Polychaeta	T	4.3	T	36.3			T	50.5
Eunicidae			T	3.1				
Glyceridae					T	6.8		
Goniadidae			T	11.1				
Onuphidae							T	31.5
Arthropoda								
Crustacea	0.2	71.3	0.4	114	T	0.4	T	89.8
Copepoda								
Calanoida	T	T						
Harpacticoida	0.1	T						
Cirripedia			T	1.1			T	1.7
Mysidacea	T	0.1					T	3.4
Isopoda								
Munnidae	T	T						
Sphaeromatidae	0.1	5.7					0.1	5.1
Amphipoda								
Caprellidea					0.5	3.1	T	0.2
Gammaridea	0.1	2.9	T	0.1	1.1	23.3	0.3	6.9
Euphausiacea					T	0.6	0.1	3.2
Decapoda	0.1	10.7	T	69.1	0.2	5.5	0.1	113
Decapod megalops	0.2	13.4			0.7	28.1	T	0.5
Carides	0.1	168	0.3	753	0.7	240	0.3	822
Crangonidae					T	8.2		
Hippolytidae							T	1.3
Pandalidae	0.1	277	0.6	2,795	0.1	212	0.1	439
Anomura								
Lithodidae					T	0.5		

Table 13. The average number and weight (mg) of prey items per yellow Irish lord stomachs. (T = trace, J = juvenile). - Cont.

	Yellow Irish lord (*Hemilepidotus jordani*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Paguridae	0.1	46.2	0.1	263	0.1	10.7	0.1	127
Brachyura	T	0.9	T	109	0.9	31.7		
Oxyrhyncha	T	9.4			0.2	7.6	0.2	10.0
Majidae	0.4	103	0.3	968	0.8	111	0.9	960
Brachyrhyncha					T	6.6		
Atelecyclidae							0.1	73.4
Cancridae					T	4.2		
Pinnotheridae			T	1.1			0.1	50.3
Echinodermata								
Ophiuroidea	T	3.8	0.1	11.7	0.1	4.5	T	14.7
Chordata								
Vertebrata								
Teleostei	0.1	181	0.1	212	0.1	89.8	0.2	328
Teleost larva			T	0.8				
Anoplopomatidae			T	531				
Clupeiformes							T	76.2
Cottidae							0.1	3,694
Stichaeidae			T	45.1	T	16.9	T	210
Unidentified	T	3.1			0.3	3.4	0.3	56.2
Total number stomachs	73		80		42		65	
Number empty stomachs	27		13		3		12	
Mean fullness	3.3		4.0		4.4		3.8	
Mean length	171.3		293.4		150.6		281.4	

Table 14. The average number and weight (mg) of prey items per red Irish lord stomach.

	Red Irish lord (*Hemilepidotus hemilepidotus*)			
	June		July	
	Number	Weight	Number	Weight
Chlorophyta				
Ulotrichales			0.2	65.8
Phaeophyta			0.2	48.7
Mollusca				
Gastropoda			0.2	115
Prosobranchia				
Trochidae			0.2	2.5
Amphineura				
Polyplacophora	0.5	6.6	0.2	275
Pelecypoda				
Mytilidae			0.2	30.8
Cephalopoda			0.2	8.8
Arthropoda				
Crustacea				
Cirripedia			0.3	786
Decapoda			0.2	182
Brachyura				
Oxyrhyncha				
Majidae			0.7	410
Brachyrhyncha				
Atelecyclidae			0.3	8,761
Cancridae			3.2	2,775
Chordata				
Vertebrata				
Teleostei	2.5	3,140		
Unidentified			1.3	1,217
Total number stomachs	2		6	
Number empty stomachs	0		1	
Mean fullness	4.0		4.0	
Mean length (mm)	279.0		252.0	

Table 15. The average number and weight (mg) of prey items per *Myoxocephalus* spp. stomach. (T = trace, J = juvenile, P = pooled).

	Myoxocephalus spp.							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Phaeophyta			T	249				
Desmarestiaceae			T	139				
Rhodophyta							T	95.9
Angiosperma								
Potamogetonaceae	T	15.4					0.2	83.8
Cnidarea								
Anthozoa							0.1	21.5
Mollusca								
Pelecypoda	0.1	15.2						
Pelecypod siphons			T	5.7				
Annelida								
Polychaeta			0.1	13.2	T	0.1	T	91.4
Arthropoda								
Crustacea	0.1	10.6			0.2	3.2		
Copepoda								
Calanoida					1.5	11.1		
Harpacticoida					1.5	6.0		
Cirripedia							T	26.7
Mysidacea					T	1.1		
Isopoda					T	0.1		
Idoteidae	0.1	2.1						
Sphaeromatidae	0.2	13.1			T	1.0		
Amphipoda								
Caprellidea	T	0.5						
Gammaridea	6.2	182			4.3	51.3		
Decapoda	T	28.0	0.2	47.7				
Carides	0.1	85.8	0.1	239	T	0.1		
Crangonidae	T	109	0.1	162				
Pandalidae	0.1	353	0.4	1,524			0.1	944
Anomura								
Paguridae					0.1	11.6		
Brachyura							T	2.1
Oxyrhyncha	0.1	12.8	T	130			T	118
Majidae	0.4	1,660	0.2	1,233	T	55.9	0.4	2,981
Brachyrhyncha								
Atelecyclidae			T	1,029	0.2	11.7	0.1	368
Cancridae	0.1	51.4	T	798			0.1	1,330
Insecta								
Tricoptera							T	7.0
Teleostei	0.1	72.2	0.3	6,365	0.2	129	0.2	2,170
Ammodytidae	0.1	99.4			T	16.4		
Anoplopomatidae			0.1	18,471				
Clupeidae	T	21.6						
Cottidae			0.1	28,543	0.1	30.6	T	5,603
Gadidae			T	1,680			T	2,595
Osmeridae			0.1	836				
Perciformes			T	346				
Pleuronectidae	T	69.2	T	3,088			0.1	1,798
Salmonidae							T	37.4
Unidentified	0.2	3.3	T	T	0.1	18.6	0.1	219
Total number stomachs	39		33		58		36	
Number empty stomachs	4		8		P		14	
Mean fullness	4.7		3.5		3.9		2.9	
Mean length (mm)	138.7		403.8		103.6		401.4	

Table 16. The average number and weight (mg) of prey items per sandfish stomach. (J = juvenile).

	Sandfish (*Trichodon trichodon*)			
	June		July	
	Number	Weight	Number	Weight
Arthropoda				
Crustacea	20.0	793		
Euphausiacea			0.5	125
Amphipoda				
Gammaridea			0.1	3.5
Decapoda				
Carides			0.2	11.9
Anomura				
Paguridae			0.1	0.7
Brachyura megalops	33.0	383	0.2	0.7
Chordata				
Vertebrata				
Teleostei			0.9	2,809
Ammodytidae			1.5	834
Clupeiformes			0.1	366
Total number stomachs	1		26	
Number empty stomachs	0		0	
Mean fullness	6.0		5.4	
Mean length (mm)	121.0		168.8	

Table 17. The average number and weight (mg) of prey items per snake prickleback stomach. (T = trace, J = juvenile, P = pooled).

	Snake prickleback (*Lumpenus sagitta*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Protozoa								
Foraminifera							T	T
Ectoprocta			0.1	0.1			T	T
Mollusca								
Gastropoda					0.2	0.4	T	0.2
Opisthobranchia								
Tectibranchia	4.0	12.0	0.1	T	0.1	T		
Pelecypoda	3.0	17.0	2.2	7.5			0.1	T
Pelecypod siphons	2.0	2.0	0.2	3.4			T	0.1
Cardiidae			0.1	0.3				
Nuculanidae			0.1	T				
Annelida								
Polychaeta	20.0	189	5.9	102	0.6	9.4	2.4	39.9
Lumbrineridae			0.4	1.9				
Nereidae			0.1	T				
Oweniidae	2.0	56.0						
Polynoidae			0.1	0.2				
Phyllodocidae			0.1	0.1			T	0.2
Spionidae							T	T
Arthropoda								
Crustacea								
Ostracoda	6.0	8.0						
Copepoda								
Calanoida			0.4	0.3	0.3	T		
Harpacticoida			0.1	0.1	15.1	2.6	0.9	0.2
Cirripede larvae					0.3	0.1		
Cumacea			2.2	3.9	0.2	0.1		
Amphipoda								
Gammaridea	10.0	10.0	4.5	34.0	101	91.7	392	255
Euphausiacea			0.1	0.2				
Decapoda								
Caridea							6.8	51.0
Brachyura megalops			0.6	6.2				
Echinodermata								
Echinoida			0.1	0.1				
Ophiuroida			0.1	0.2			T	0.3
Chordata								
Vertebrata								
Teleostei			0.1	T				
Teleost egg			242	84.8	23.3	26.7	0.7	0.8
Unidentified			7.7	8.2	0.9	0.3	2.2	1.4
Total number stomachs	1		17		10		27	
Number empty stomachs	0		1		P		4	
Mean fullness	6.0		4.2		4.2		4.5	
Mean length (mm)	229.0		344.9		196.6		286.8	

Table 18. The average number and weight (mg) of prey items per crescent gunnel stomach. (T = trace, J = juvenile, P = pooled).

	Crescent gunnel (*Pholis laeta*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Rhodophyta	0.3	T					0.1	T
Mollusca								
Gastropod veliger					0.5	0.1		
Pelecypoda							0.1	T
Pelecypod siphons							1.3	7.8
Annelida								
Polychaeta							0.1	5.2
Arthropoda								
Crustacea								
Copepoda								
Calanoida					4.0	0.1	3.7	0.1
Harpacticoida	5.0	1.2	2.3	1.0	35.0	1.6	5.3	0.4
Ostracoda					3.5	0.1	37.8	17.7
Cirripedia							2.6	4.9
Cirripede larvae	0.5	T						
Cumacea	0.8	0.5					0.3	0.3
Isopoda								
Idoteidae	0.5	1.0	0.2	7.8				
Limnoridae	0.8	2.8	1.4	3.7	0.5	0.5	1.1	2.8
Munnidae					0.5	0.1		
Sphaeromatidae	0.5	1.8	0.9	7.8			0.1	0.3
Amphipod								
Gammaridea	9.5	57.5	16.6	117			7.0	37.6
Decapod								
Decapod megalops	0.3	0.8						
Carides							0.2	1.3
Anomura								
Paguridae			0.1	0.6				
Unidentified			2.8	1.3			0.7	3.2
Total number stomachs	4		12		2		12	
Number empty stomachs	0		P		0		1	
Mean fullness	4.8		3.1		3.0		3.6	
Mean length (mm)	99.7		167.0		101.5		158.3	

Table 19. The average number and weight (mg) of prey items per flathead sole stomach. (T = trace, J = juvenile, P = pooled).

	Flathead sole (*Hippoglossoides elassodon*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Cnidarea								
Hydrozoa	T	0.3						
Ectoprocta					T	1.7	T	0.3
Brachiopoda			T	0.9				
Mollusca								
Pelecypoda	T	0.2			0.1	0.1		
Pelecypod siphons	0.9	2.0	T	T	1.7	5.8		
Cardiidae			T	8.9				
Nuculidae	T	0.1						
Nuculanidae	0.1	3.9						
Annelida								
Polychaeta	0.1	0.6	T	0.1	0.2	2.0	T	1.5
Capitellidae	T	0.1						
Glyceridae					T	T		
Maldanidae	T	0.4			T	1.3		
Opheliidae	T	T			T	0.7		
Pectinariidae	T	0.1						
Arthropoda								
Crustacea	0.1	2.4			T	0.3		
Copepoda								
Calanoida	1.1	0.4			0.1	0.6		
Harpacticoida	T	T						
Mysidacea	0.4	19.7	0.1	8.9	0.8	6.5		
Cumacea	T	T			T	1.4		
Isopoda								
Munnidae	T	T						
Amphipoda								
Gammaridea	0.2	0.6			0.1	0.8		
Euphausiacea	0.9	32.5	0.8	59.4	1.6	15.2	0.7	6.2
Decapod megalops	0.1	0.7						
Decapod zoea								
Caridea	T	26.5	0.1	48.7	4.1	23.6	0.2	120
Crangonidae	T	11.2			T	16.1		
Hippolytidae	T	0.1						
Pandalidae	T	22.8	1.0	3,049	0.1	223	0.9	2,012
Anomura								
Paguridae							T	18.2
Brachyura megalops	0.1	2.2						
Majidae	T	0.8			T	4.5		
Echinodermata								
Ophiuroidea	T	0.7	T	0.6				
Chordata								
Teleostei	0.1	11.0	T	76.6	0.2	48.2	T	85.0
Teleost larva	T	2.2	T	2.0				
Ammodytidae					T	5.4		
Cottidae					T	2.4		
Cottid larva	0.1	4.1			T	0.6		
Hexagrammidae					T	3.5		
Osmeridae					0.1	18.4		
Perciformes	T	0.5						
Perciform larva	T	0.5						
Pholidae			T	13.3	T	7.4		
Pleuronectidae	T	0.2			T	3.0		
Stichaeidae			T	91.5	T	20.1	T	295
Unidentified	T	T			T	0.1		
Total number stomachs	305		89		134		42	
Number empty stomachs	P		29		P		15	
Mean fullness	3.2		3.6		3.4		3.0	
Mean length (mm)	147.7		307.3		149.5		338.4	

Table 20. The average number and weight (mg) of prey items per rock sole stomach. (T = trace, J = juvenile, P = pooled).

	Rock sole (*Lepidopsetta bilineata*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta	T	0.9	T	12.3				
Ulotrichales			T	T			T	14.7
Rhodophyta	T	0.9	T	12.1	T	4.5	T	15.2
Phaeophyta	T	0.3			T	0.3	T	0.8
Angiosperma								
Potamogetonaceae			T	2.7			T	T
Protozoa								
Foraminifera					T	T	T	T
Cnidarea								
Hydrozoa					T	0.1	T	T
Nemertinea			T	0.1			T	13.0
Priapulida			T	17.8	T	0.2	T	12.2
Ectoprocta					T	0.2	T	T
Mollusca								
Amphineura								
Polyplacophora					T	T		
Gastropoda								
Prosobranchia								
Acmaeidae	T	0.1	T	T	T	T	T	2.1
Fissurellidae			T	1.4	T	2.7	T	1.2
Lacunidae			T	T				
Lepetidae	T	21.9	0.1	17.9	0.1	16.3	0.3	83.3
Opisthobranchia								
Tectibranchia								
Aglajidae							0.4	19.1
Bullidae			T	T			T	T
Nudibranchia								
Dorididae					T	0.1	T	0.1
Pelecypoda	0.1	3.8	0.5	31.3	0.9	3.9	0.6	60.7
Pelecypod siphons	5.7	14.6	0.8	23.9	3.0	11.9	2.0	376
Cardiidae			T	0.5				
Nuculanidae			T	1.8	T	0.8	T	10.4
Myidae			T	2.6			T	0.1
Tellinidae			0.7	37.8			T	3.1
Veneridae	T	T	0.3	8.3	T	T		
Cephalopoda			T	0.1				
Annelida								
Polychaeta	1.9	52.4	7.6	244	1.7	34.9	6.2	217
Ampharetidae	T	1.8	0.1	1.4	T	0.1	T	1.8
Cirratulidae			T	0.1				
Flabelligeridae							T	1.0
Glyceridae	0.1	18.2	0.2	25.3	0.1	1.0	0.1	27.4
Goniadidae			T	T	0.1	1.5	0.2	3.6
Lumbrineridae	0.2	1.9	0.9	3.4	0.4	2.2	0.3	6.9
Maldanidae			T	23.7	T	10.8	0.1	6.8
Nephtyidae					T	10.9	T	17.2
Nereidae	T	2.2	T	55.0			0.1	136
Onuphidae			T	0.9	T	T	T	53.2
Opheliidae	0.2	3.9	0.2	3.7	T	0.2	0.1	6.4
Orbiniidae			T	0.3	T	0.1	T	25.6
Oweniidae	0.2	3.7	0.5	13.5	T	0.6	1.7	22.5
Pectinariidae	T	0.9	T	3.2	T	1.1	T	3.6
Phyllodocidae	T	0.2	0.1	5.5	0.3	4.6	0.2	3.4

Table 20. The average number and weight (mg) of prey items per rock sole stomach. (T = trace, J = juvenile, P = pooled). - Continued.

	Rock sole (*Lepidopsetta bilineata*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Pilargidae			T	1.2				
Polynoidae			T	0.3	T	0.6	0.1	5.6
Sabellaridae	T	T			T	0.4		
Serpulidae	T	0.2	0.1	2.1	0.1	0.5	T	0.1
Sabellidae					T	0.2		
Spionidae	0.3	5.0	2.3	49.8	1.6	12.8	T	1.3
Syllidae			T	T	T	T		
Terebellidae	T	0.1	0.1	0.4			T	17.0
Arthropoda								
Crustacea			T	T				
Ostracoda	T	T						
Copepoda								
Calanoida					T	0.1		
Harpacticoida	T	0.1						
Cirripedia			T	0.6	0.1	0.2	T	0.2
Mysidacea					T	0.2	T	0.1
Cumacea	0.2	0.6	0.2	1.1	0.2	0.9	0.8	2.1
Isopoda							T	0.3
Sphaeromatidae	T	0.1	0.5	12.8				
Amphipoda								
Caprellidea	T	T	T	T	0.1	0.3	T	T
Gammaridea	2.5	14.1	3.9	51.8	6.7	25.2	5.8	58.5
Amphithoidae			T	2.7				
Corophiidae					T	0.1		
Gammaridae			0.4	9.6				
Euphausiacea			T	0.1	T	T		
Decapoda			T	28.8	T	0.1	T	0.4
Decapod megalops	0.3	3.3	0.1	0.6				
Carides	0.3	32.1	T	6.3	0.2	1.1	0.4	6.9
Crangonidae			T	0.4				
Anomura								
Lithodidae megalops	T	T						
Paguridae	T	1.4	T	4.4	T	T	T	18.4
Brachyura			T	23.3				
Oxyrhyncha	0.1	1.0	0.1	3.2	T	0.1		
Majidae	T	0.1	T	0.2	0.1	2.3	0.1	8.9
Brachyrhyncha								
Atelecyclidae			T	12.2			T	0.2
Insecta								
Diptera larva					T	T		
Chironomid pupa					T	T		
Echinodermata								
Holothuroidea			T	1.3			T	6.4
Echinoidea			T	T				
Dendrasteridae								
Strongylocentrotidae	T	0.5						
Ophiuroidea	T	0.1	0.1	1.9	T	0.1	0.1	0.6
Chordata								
Vertebrata								
Teleostei	T	0.3	0.1	174	T	40.7	0.3	1,501
Teleost larva	0.1	4.0	T	33.4				
Teleost egg	T	T	63.4	26.3	0.2	0.2	2.3	2.6
Agonidae	T	0.2						

Table 20. The average number and weight (mg) of prey items per rock sole stomach. (T = trace, J = juvenile, P = pooled). - Continued.

	Rock sole (*Lepidopsetta bilineata*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Ammodytidae			0.1	176			T	101
Clupeidae			T	27.7			T	58.0
Cottidae	T	0.5			T	3.8		
Cottid larva			T	1.1				
Hexagrammid larva			T	0.1				
Osmeridae			T	30.0			T	140
Perciform larva								
Pholidae							T	18.5
Stichaeidae							T	4.9
Pleuronectidae	T	1.8	T	0.2			T	17.5
Unidentified	1.9	8.1	0.2	125	0.3	6.8	6.5	33.0
Total number stomachs	382		311		206		182	
Number empty stomachs	P		P		P		40	
Mean fullness	3.8		3.3		3.8		3.7	
Mean length (mm)	142.5		283.2		135.1		296.6	

Table 21. The average number and weight (mg) of prey items per yellowfin sole stomach. (T = trace, J = juvenile, P = pooled).

	Yellowfin sole (*Limanda aspera*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Chlorophyta			T	8.7				
Ulotrichales			T	0.2			T	0.2
Rhodophyta	T	4.3	T	4.5			T	22.5
Phaeophyta			T	0.1	T	T		
Angiosperma								
Potamogetonaceae	T	T	T	T			T	T
Protozoa								
Foraminifera	T	T			0.1	T		
Cnidarea			T	10.8			T	6.8
Hydrozoa			T	T	T	T	T	0.7
Scyphozoa							T	31.9
Ctenophora							T	1.8
Nemertinea					T	2.3	T	0.5
Priapulida							T	T
Ectoprocta							T	T
Brachiopoda			T	0.1				
Sipunculida							T	11.1
Mollusca							T	42.1
Gastropoda							T	13.3
Prosobranchia								
Acmaeidae							T	1.2
Fissurellidae			T	0.3				
Lepetidae			0.3	75.3	T	0.6	0.1	29.8
Opisthobranchia								
Tectibranchia								
Retusidae							T	T
Scaphandridae								
Pelecypoda	1.8	10.0	0.8	47.4	0.4	1.8	2.2	81.2
Pelecypod siphons	7.3	15.6	1.4	26.3	8.2	18.2	4.6	42.7
Cardiidae	T	3.7	T	2.1	T	0.1	T	23.7
Hiatellidae					T	T		
Mactridae			T	1.0	T	1.2		
Myidae			T	1.6			T	0.1
Nuculanidae			T	0.2				
Pectiniidae			T	0.1	T	0.3	T	13.7
Tellinidae			0.1	9.9			T	9.0
Veneridae	T	T						
Echiuroidea			T	40.2			T	100
Annelida								
Polychaeta	1.2	28.0	1.3	10	1.1	16.1	1.5	62.1
Ampharetidae					T	0.2	T	2.5
Eunicidae			T	101				
Glyceridae	T	T	T	0.2	T	0.7	0.5	10.2
Goniadidae					T	T	T	0.2
Lumbrineridae	T	0.2	0.1	0.2	0.2	0.4	0.2	0.4
Maldanidae	T	0.1	T	11.7	T	1.0	T	1.4
Nephtydae			T	10.9			T	2.8
Nereidae			T	2.1			T	T
Opheliidae	0.1	1.5	0.1	7.2			0.6	20.7
Orbiniidae					T	2.9	T	0.1
Oweniidae	0.1	0.3	T	0.4	0.2	3.0	T	0.1
Pectinariidae	T	0.1	T	0.1			T	0.1
Phyllodocidae	T	T	T	1.5	0.2	0.1	T	7.8

Table 21. The average number and weight (mg) of prey items per yellowfin sole stomach. (T = trace, J = juvenile, P = pooled). - Cont.

	Yellowfin sole (*Limanda aspera*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Polynoidae	T	1.2					T	T
Sabellaridae	T	T			T	T		
Sabellidae					T	T		
Scalibregmidae							0.5	6.2
Spionidae	T	0.1						
Syllidae							T	0.1
Terebellidae	T	0.1					T	7.1
Arthropoda								
Crustacea	T	0.1	T	3.4	T	0.1	T	0.1
Copepoda								
Calanoida	T	T					T	T
Harpacticoida					0.2	T		
Cirripedia					0.1	0.8	0.2	16.4
Cirripede larvae	T	T			0.1	T		
Mysidacea	T	2.3	T	0.2	0.1	2.5	T	0.1
Cumacea	0.2	1.7	T	0.3	T	0.1	1.0	1.7
Isopoda					T	T		
Sphaeromatidae			T	T				
Amphipoda								
Caprellidea	T	0.1			T	0.2	0.1	0.5
Gammaridea	0.6	1.9	0.3	2.4	0.6	8.1	2.4	6.9
Hyperiidea							T	T
Euphausiacea	T	T	0.3	8.8	T	0.1	0.1	0.7
Decapoda					T	0.9	T	0.9
Carides	T	T	0.1	85.3	0.2	1.5	1.0	33.4
Crangonidae	T	0.3	T	3.4	T	1.4	T	3.2
Hippolytidae	T	0.1					T	0.1
Pandalidae			0.1	184			0.1	211
Anomura			T	15.8				
Lithodidae	T	0.1						
Paguridae			T	3.7	T	0.1	T	6.2
Brachyura			T	1.1			0.1	14.6
Brachyura megalops	0.6	2.7	0.2	0.3				
Brachyura zoea					T	T		
Oxyrhyncha	0.4	8.3	0.3	7.0	T	1.0	T	0.1
Majidae	0.7	18.8	0.1	28.2	0.4	11.2	T	50.2
Insecta							T	T
Diptera							T	T
Echinodermata								
Echinoidea			T	T	T	T	T	0.3
Holothuroidea					T	0.1		
Ophiuroidea	T	0.3	0.1	1.8	0.1	0.8	0.4	12.1
Chordata								
Vertebrata								
Teleostei	T	24.7	0.1	193	T	51.4	0.1	149
Teleost egg	T	0.1			3.1	2.7		
Teleost larva	T	1.6	T	0.7			T	1.1
Ammodytidae							T	3.4
Cottid larva			T	0.2				
Osmeridae			T	126				
Pleuronectidae					T	0.9		
Stichaeidae			T	4.7				
Unidentified	T	1.5	12.1	47.9	0.4	1.8	0.3	165
Total number stomachs	337		317		133		168	
Number empty stomachs	P		116		P		39	
Mean fullness	3.2		2.7		3.2		3.2	
Mean length (mm)	149.5		257.0		139.9		259.8	

Table 22. The average number and weight (mg) of prey items per Pacific halibut stomach. (T = trace, J = juvenile).

	Pacific halibut (*Hippoglossus stenolepis*)							
	June (J)		June		July (J)		July	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Mollusca								
Gastropoda	T	3.2						
Prosobranchia								
Pelecypoda					0.1	15.5		
Arthropoda								
Crustacea	0.2	61.0						
Mysidacea	0.3	18.6						
Decapoda								
Carides					0.1	5.1		
Crangonidae	0.2	38.3						
Pandalidae	2.1	8,508	4.0	2,304				
Anomura								
Paguridae	T	34.2			0.2	495		
Brachyura								
Oxyrhyncha								
Majidae	0.1	37.0			0.1	4.4	0.1	121
Chordata								
Vertebrata								
Teleostei	0.7	1,976	0.5	176	0.4	2,002	0.4	4,773
Ammodytidae					1.5	1,565		
Anoplopomatidae			1.0	27,446				
Clupeidae	0.1	1,069						
Total number stomachs	23		2		13		7	
Number empty stomachs	1		0		3		3	
Mean fullness	4.6		5.5		2.9		2.0	
Mean length (mm)	387.9		896.0		390.8		504.1	

Table 23. The average number and weight (mg) of prey items per sablefish stomach. (J = juvenile).

	Sablefish (*Anoplopoma fimbria*) June (J)	
	Number	Weight
Arthropoda		
Crustacea		
Mysidacea	0.1	0.2
Euphausiacea	4.7	420
Decapoda		
Carides	0.1	97.2
Brachyura megalops	1.7	16.9
Chordata		
Vertebrata		
Teleostei	0.5	1,465
Clupeidae	0.1	233
Osmeridae	0.7	8,317
Total number stomachs	25	
Number empty stomachs	3	
Mean fullness	5.4	
Mean length (mm)	300.8	

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