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OUTER CONTINENTAL SHELF

ENVIRONMENTAL ASSESSMENT PROGRAM

FINAL REPORTS OF PRINCIPAL INVESTIGATORS

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Outer Continental Shelf Environmental Assessment Program

Final Reports of Principal Investigators

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CONTENTS

ECOLOGICAL STUDIES OF INTERTIDAL AND SHALLOW SUBTITAL HABITATS IN LOWER COOK INLET, ALASKA

by

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1.0 SUMMARY

Field studies were conducted from May 1976 to November 1979 in intertidal and shallow subtidal habitats in lower Cook Inlet and the Northeast Gulf of Alaska (NEGOA) to examine species composition, zonation, seasonal patterns, trophic structure, rates of production and energy pathways. Habitats examined included rocky intertidal and subtidal areas, sand beaches and mud flats (Dames & Moore 1976a, 1979b).

1.1 ROCKY HABITATS

Plant and animal assemblages on rocky habitats exhibited strong patterns in zonation and seasonal development in all locations examined. Rocky habitats exhibited high variability in species composition, community structure and productivity.

1.1.1 Kachemak Bay

Algal assemblages were well developed and moderately productive from the mid intertidal zone out to a depth of about 20 m. Fucoid algae and kelps dominated in the intertidal zone and kelps dominated subtidally. Canopy-forming species (*Nereocystis luetkeana* and *Alaria fistulosa*) may have produced from 5 to 18 kg fresh plant matters/m^2/year in well-developed kelp beds. Major understory species (*Laminaria groenlandica* and *Agarum cribrosum*) probably produced less than 3 kg/m^2/year. It appears that sizeable quantities of plant tissue are exported from rock habitats in Kennedy Entrance and Kachemak Bay to the benthos on soft substrates. Macrophytes may contribute 70 g C/m^2/year to the benthos of the whole of outer Kachemak Bay. Combining estimates of phytoplankton production and transfer to the benthos (Larrance and Chester 1979) with patterns of macrophyte production, it appears that the amount of organic carbon reaching the benthos may here be three times higher than elsewhere in lower Cook Inlet.

Invertebrate assemblages were richest in areas of high current flow, e.g. the entrance channel to Jakolof Bay and along the northern shelf of Kachemak Bay. In contrast, invertebrate assemblages were poorly developed

in the kelp beds such as at Seldovia Point. Functionally important animals included herbivores (e.g., sea urchins, chitons and limpets), suspension feeders (e.g., mussels, clams and polychaete worms) and predators/scavengers (e.g., starfish, snails, crabs and fish). Biomass was high in areas with strong tidal currents. The suspension-feeding assemblage at Jakolof Bay was the richest observed in these studies.

1.1.2 West Side of Lower Cook Inlet

Algal assemblages were well developed and moderately productive in the intertidal zone but poorly developed in the subtidal zone. Maximum depth of kelp bed development was about 3 m. Fucoid and ephemeral red algae dominated the mid and low intertidal zones and kelps dominated the lowest intertidal and high subtidal zones. Because the seaweed zone is narrow, the amount of seaweed material exported to other habitats is not large.

Invertebrate assemblages were richest below the seaweed zone. These assemblages were dominated by barnacles, erect and encrusting bryozoans and social ascidians. Species composition strongly resembled those described for the Bering and Beaufort Seas. Functionally important forms included suspension feeders (e.g., barnacles, mussels, polychaetes, bryozoans and ascidians) and predator/scavengers (e.g., starfish and snails). Biomass was low except in locations where the mussel *Modiolus* was common. Invertebrate assemblages were poorly developed in the seaweed zone, probably as a consequence of physical factors such as ice scouring and battering by seaweeds.

1.1.3 NEGOA

Algal assemblages were well developed and highly productive from the mid intertidal zone out to a depth of about 15 m. Fucoid algae and kelps dominated in the intertidal zone and kelps dominated subtidally. Canopy-forming species (mainly *Nereocystis*) may produce up to 70 kg fresh plant material/m^2/yr in the dense kelp beds, but average production probably is less than 10 kg/m^2/yr. It appears that sizeable quantities of plant tissue are exported from rock habitats in NEGOA to the benthos on soft substrates.

Invertebrate assemblages were richest below the seaweed zone. These assemblages were dominated by colonial ascidians and erect bryozoans. Invertebrate assemblages were poorly developed in the seaweed zone, probably as a consequence of battering by kelps and surge activity. Functionally important forms included suspension feeders (e.g., bryozoans and ascidians) and predator/scavengers (e.g., starfish and fish). Biomass was moderate, peaking in summer when the colonial ascidian assemblage was most highly developed.

1.2 SOFT SUBSTRATES

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.

Zonation of the biological assemblages on soft substrates was readily apparent in the distribution of species richness and 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 most abundant in summer, but clams were most abundant in spring. Many species appeared in the samples only as juveniles in the summer, a relatively mild period.

Evaluation of the trophic structures of sand and mud assemblages indicates that all assemblages were based on detritus. The great majority of the organisms were deposit feeders or suspension feeders. Resident predators were uncommon. Feeding observations suggested that a large proportion of the animals living in these habitats were eaten by transient predators from other assemblages and geographic areas. Some of the important groups that foraged 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 suggested that the mud flat assemblage was 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) seemed particularly dependent on mud flat assemblages during spring migration. Greater scaup, oldsquaw, surf scoters and black scoters fed extensively on mud flats in the winter.

1.2.1 Sand Beaches

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 seemed that transient predators, (birds, fish and crabs) were of greater consequence.

1.2.2 Mud Flats

Mud flat faunas were dominated by long-lived clams (e.g., *Mya* spp and *Macoma balthica*) and an echiurid worm. 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 (over 250 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.

Burrow systems constructed by the echiurid worm and *Mya* spp significantly increased the surface area of the mud flats. This additional surface area results in higher microbial standing stocks and oxidation and thus higher productivity.

1.3 POTENTIAL FOR OIL IMPACTS

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) it appears that mud flats are the most sensitive to contamination by crude oil of the substrates examined in this study. Based on the high probability that: (1) much of the seemingly high productivity of mud flats is used by animals from other systems, (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), and (3) that recovery time of an oiled mud flat would be long, the importance of protecting this habitat from pollution is quite obvious. 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 energy budget of Kachemak Bay. Rock habitats and kelp assemblages are probably fairly tolerant to contamination by crude oil.

Except for massive oil spills, impacts from oil development would be generally of a local nature. Onshore facilities would probably be accompanied by chronic contamination. Because of the concentration of relatively unproductive sand beaches in the northern half of lower Cook Inlet, and of highly productive mud flats in Kachemak Bay and on the west side of the inlet, the most acceptable location for development of onshore facilities, in biological terms, is between Anchor Point and Nikiski.

2.0 INTRODUCTION

Counterbalancing the economic and political gain that could be realized from development of potential oil and gas reserves in lower Cook Inlet is the very real prospect that the intertidal and shallow subtidal habitats of that estuary may be exposed to large-scale chronic or acute contamination. The magnitude of this potential problem is dependent primarily on the overall importance of the littoral* zone and its component habitats to the biological systems of the inlet and associated areas and, secondarily, on the actual 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. Since one of the most important human uses of intertidal resources in lower Cook Inlet directly perceived by most individuals is clamming, and since only small segments of the coastline are used, the importance of intertidal habitats is often considered to be low. However, the actual importance and sensitivity of the littoral 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 throughout the world that the greatest observable impacts of oil-related problems occur in the littoral zone (Boesch, Hershner and Milgram 1974; Smith 1968; Nelson-Smith 1972; NAS 1975).

2.1 NATURE AND SCOPE

Littoral 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 1976a). 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 physical, chemical, and biological systems in lower Cook Inlet through its Outer Continental Shelf Environmental Assessment Program (OCSEAP). These studies

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* Littoral in this document is defined as the intertidal and shallow subtidal zone, out to a depth of 25 m.

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 and describe beaches representative of the major littoral habitats in lower Cook Inlet (Dames & Moore 1977a).

This phase of the study was generally qualitative in nature. The intent was to obtain basic descriptions of species composition and community structure of the major littoral habitats in lower Cook Inlet. To accomplish this, data were collected on species composition, density, relative cover of the substrate, zonation, and trophic structure. Based on these observations, generalizations concerning production, trophic dynamics, and relative importance of habitat type were put forth (Dames & Moore 1977a). Field work for this study was carried out in spring and summer of 1976.

These data were used to guide development of a quantitative investigation into the structure of three major littoral habitat types in lower Cook Inlet. The types of data collected include species composition, density, biomass, zonation, seasonal variation, trophic structure, growth rates, and production. Field work for this study was carried out in 1977 and 1978.

The quantitative phase of this project was expanded to include a limited research effort in the northeast Gulf of Alaska (NEGOA), specifically in the ocean entrances to Prince William Sound. Generally the objectives were the same as in lower Cook Inlet, but budgetary constraints limited activities to a much lower level than in Cook Inlet. Field work for this study was carried out in 1978 and 1979.

2.2 OBJECTIVES

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, or areas and relationships with potentially high susceptibility.

3.0 CURRENT STATE OF KNOWLEDGE

Various facets of the major littoral assemblages in lower Cook Inlet have been described in reports since 1975. However, at this time all of the work has been descriptive, based on qualitative and/or quantitative observations. Critical examination of the processes shaping the littoral communities and the potential for impact from OCS oil and gas development awaits experimental studies of the interrelationships and interactions among the various organisms, assemblages and the physical and chemical environment influencing them.

Most of the information describing littoral communities in lower Cook Inlet is included in reports by Dames & Moore (1976a; 1977a; 1979a,b; 1980).

Additional information is included in Lees (MS), Dames & Moore (1976b, 1977b), Blackburn (1977), Erikson (1977), Sundberg and Clausen (1977), Cunning (1977), Driskell and Lees (1977), and Sanger, Jones and Wiswar (1979). These reports provide insights into the composition, structure, function, seasonal variations, and production of the biological assemblages in lagoons, bays, mud flats, kelp beds, sand beaches, rocky intertidal and subtidal habitats, mussel beds and cobble beaches and the distribution, seasonal abundance and diet of many associated birds. These reports indicate that the littoral assemblages in lower Cook Inlet are generally diverse, highly dynamic and highly productive, especially the rocky intertidal habitats, the rocky subtidal areas in Kachemak Bay, and the mud flats.

Dames & Moore (1976a) studied several littoral habitats in Kachemak Bay from 1974 to 1976. The majority of the work was on rocky intertidal and subtidal habitat on both the north and south sides of the bay. The report indicates that vegetative cover and floral composition on rocky habitats varies considerably on a seasonal basis; greatest cover occurs in the summer. A similar pattern was reported for sessile invertebrates such as barnacles and mussels. In addition, it provided a preliminary description of trophic structure on rocky habitats and the seasonal variation in predation rates and predator occurrence. Furthermore, strong differences were reported between the composition and productivity of the assemblages on the north and south borders on Kachemak Bay, and the high standing stocks of the horse mussel Modiolus modiolus on the north shelf were noted.

The intertidal reconnaissance in lower Cook Inlet reported that most of the rocky intertidal habitats are located in Kachemak Bay and Kennedy Entrance on the east, and in Kamishak Bay on the west (Dames & Moore 1977a). 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 intrude deeply 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 mean lower low water -- MLLW) for a large proportion of the shoreline in the lower inlet are characterized by a steeper slope of poorly sorted sand, 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.

Dames & Moore (1977a) also reported important differences in algal distribution and production in lower Cook Inlet. The algal assemblages in the southeastern quadrant of the inlet (including Kachemak Bay) appeared much more productive than in the remaining quadrants, where significant algal production was generally limited to depths of less than 3 m. These patterns were attributed to both turbidity and available substrate. They also suggest that macrophyte production in the SE quadrant of lower Cook Inlet might be of importance in the overall scheme of plant production and trophic dynamics of the inlet.

In addition, the report of Dames & Moore (1976b) that the subtidal epifauna on the west side of the inlet bore a strong resemblance to the assemblages described by MacGinitie (1955) for the Beaufort Sea was corroborated by additional diving studies.

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

Based on the reconnaissance study, intertidal resources were suspected to be important to several non-resident or migratory organisms and other systems. For instance, migratory shorebirds, gulls, and sea ducks feed heavily on soft intertidal substrates. During spring migration, 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 by the reconnaissance studies.

The major objective of the research by Dames & Moore (1979b) and in this report was to more fully describe the systems at specific sites, and to 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.

Dames & Moore (1979b) reported on seasonal, zonal, and geographic variations in abundance, relative cover and biomass of biotic assemblages on rock, sand and mud substrates in lower Cook Inlet. They also discussed variations in growth rates of three major kelp species (Alaria fistulosa, Agarum cribrosum and Laminaria groenlandica) and primary production of Alaria, observing that growth rates of the blades of these three species were highest from March through June and declined to very low rates in late summer through mid-winter. They pointed out that kelps accounted for a major proportion of algal standing stocks on both intertidal and subtidal rocky substrates in Kachemak Bay. They described the infaunal biomass patterns on sand and mud beaches, noting that mud flats support high standing stocks of the clams Mya spp and Macoma balthica, and that the infaunal assemblages on sand beaches is rather impoverished.

Dames & Moore (1979a) investigated composition, abundance, and feeding habits of inshore fish assemblages in lower Cook Inlet, particularly on rocky habitats in Kachemak Bay. Major groups included greenlings, ronquils, sculpins and flatfish. Fish densities and species diversity were highest in summer and lowest in winter. Most species appeared to move to deeper water in the winter. Feeding efforts tended to concentrate on epibenthic forms, especially shrimp and crabs.

Dames & Moore (1980) reported additional information on subtidal habitats, especially rock in Kachemak Bay and northern Kamishak Bay. They compared the biological assemblages in various areas, noting that kelps dominated shallow subtidal areas on the south side of Kachemak Bay, whereas suspension-feeders and kelps dominated similar habitats on the northern shelf of Kachemak Bay. Kelps were generally unimportant below 3 m in Kamishak Bay, and encrusting suspension feeders dominated the fauna. In addition, they examined the Modiolus assemblage in lower Cook Inlet.

The importance of the interactions between birds and the littoral zone has been noted by Erikson (1977), Sanger, Jones and Wiswar (1979), and Dames & Moore (1979b). Erikson (1977) reported on composition, seasonal variations in distribution and abundance of bird assemblages in Kachemak Bay and lower Cook Inlet. The most important year-round groups in littoral habitats included sea ducks, gulls and shorebirds (spring and fall migration). Sanger, Jones and Wiswar (1979) examined food habits of a number of species and found that sea ducks fed heavily on infaunal and sessile epifaunal molluscs whereas gulls had a more catholic diet. Of particular importance to several sea ducks are the clam *Macoma balthica* and the mussel *Mytilus edulis*.

4.0 PHYSICAL SETTING

Cook Inlet is a large tidal estuary located on the northwestern edge of the Gulf of Alaska in southcentral Alaska (Figure 4-1). 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, geographically divided into the upper and lower portions by the East and West Forelands, 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. Most 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 Shelikof 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 western 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 intertidal and shallow water biological communities.

4.1 EAST SIDE OF INLET - ROCK

All of the systematic work on rock habitat on the east side of Cook Inlet was conducted in Kachemak Bay at three key locations, namely, Gull Island, Seldovia Point, and Jakolof Bay. Several other sites have been examined since 1974 (Dames & Moore 1976a; 1979a,b; 1980) including Barabara Point, Cohen Island, Archimandritof Shoals, and the north shelf of Kachemak Bay west to Anchor Point. These areas comprise a broad variety of habitat types and biotic assemblages.

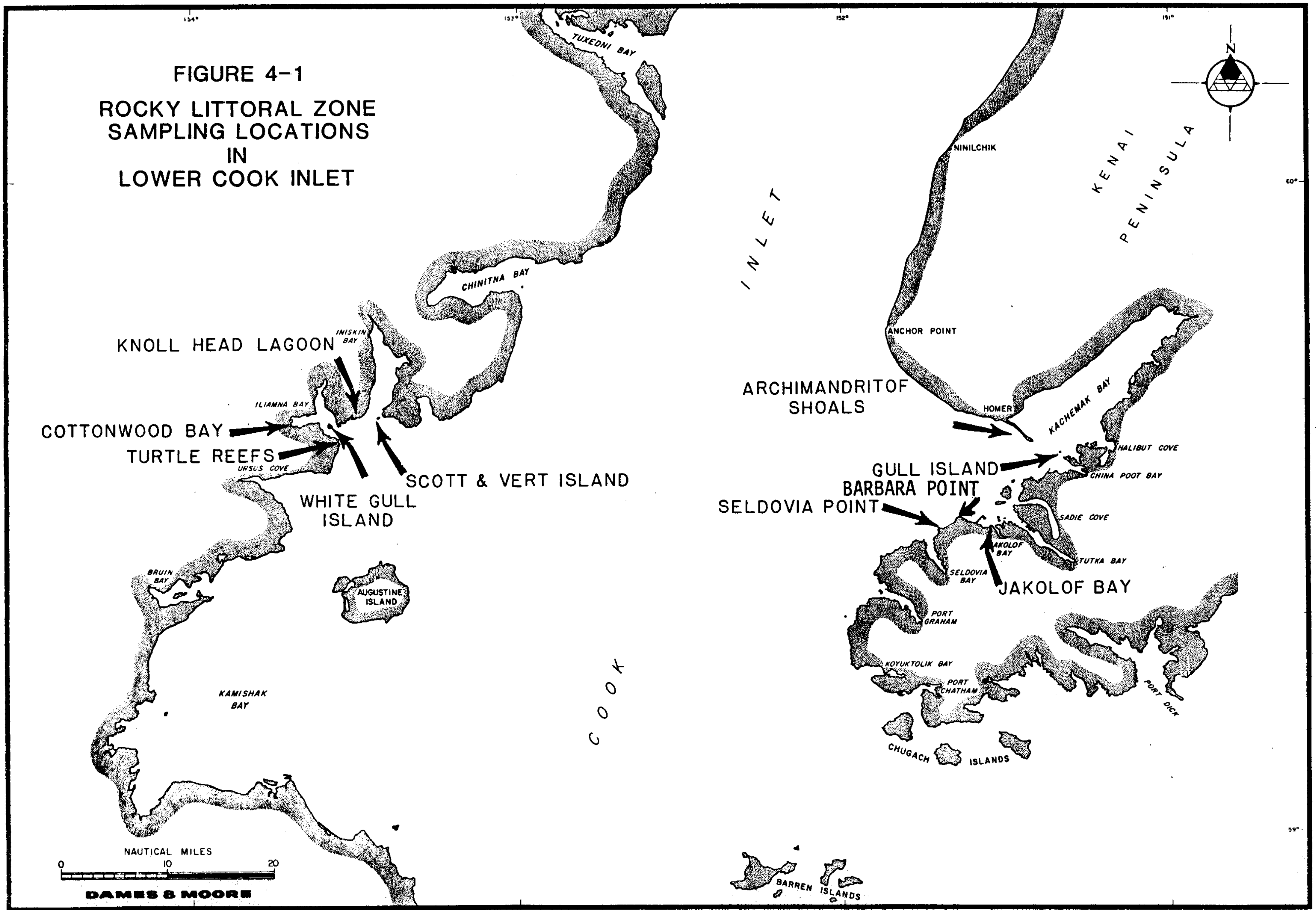


FIGURE 4-1

ROCKY LITTORAL ZONE SAMPLING LOCATIONS IN LOWER COOK INLET

4.1.1 Gull Island

Gull Island is a series of rocky islets located less than 4.8 km southeast of Homer Spit (Figure 4-1). The highest recorded land elevation on the island is 26 m above sea level.

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 bird population 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 tip of the island. This rock, named "Gorilla Rock" because of its silhouette when viewed from the west (Dames & Moore 1976a), rises approximately 14 m MLLW. At extreme low tides, a band of the macrophyte zone, approximately 4.85 m (16.0 ft) high, is exposed to the atmosphere. Below the intertidal zone, the sea floor is exposed bedrock that abuts the vertical rock face; farther offshore are found outcroppings and channels. At depths of 12-50 m below MLLW is an expanse of silty clay.

Sampling at Gull Island was conducted on a transect established in 1974 (Dames & Moore 1976a) 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 macrophyte zone. The upper portion of the transect (0 to about 8 m) sloped steeply to a relatively low elevation. A narrow, flat bench extended from about the 10-m pin to the 20-m pin (Figure 4-2). Beyond this pin the bench dropped sharply about 1 m to a second algal-covered 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; 15 m: +0.2 m MLLW; 20 m: +0.0 m MLLW (Dames & Moore 1976a).

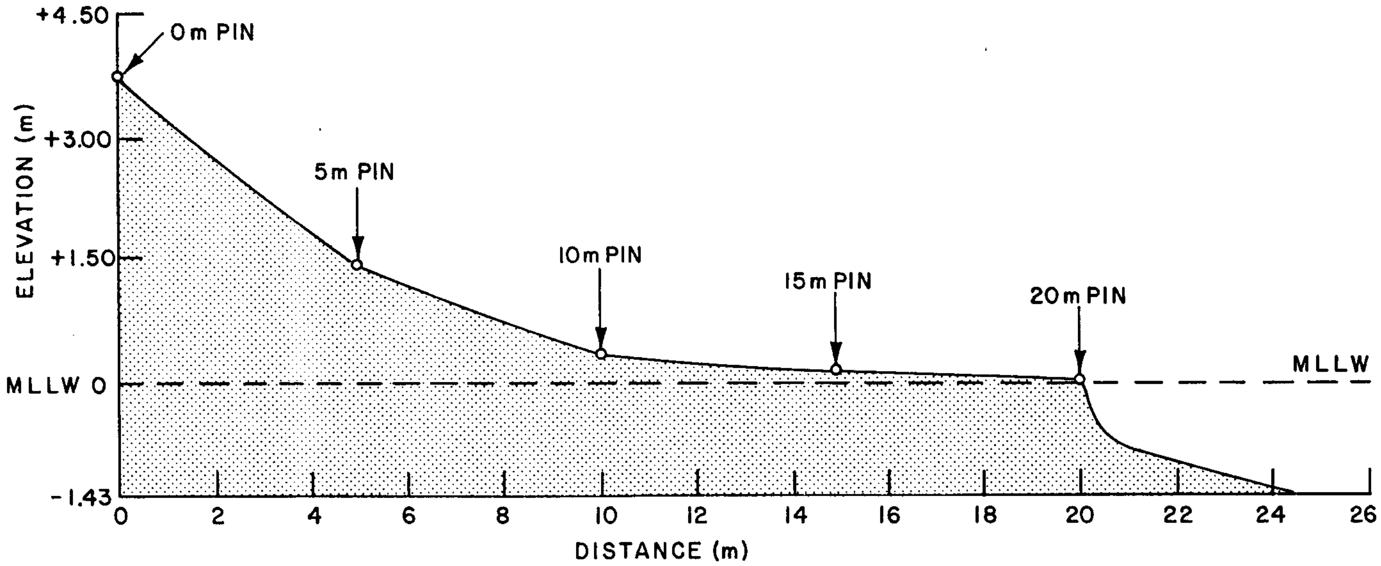


FIGURE 4-2

PROFILE OF PERMANENT TRANSECT ON GORILLA ROCK, GULL ISLAND

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, owing to several nearby glacial streams.

4.1.2 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 4-1). The bay is generally shallow and has a narrow entrance less than 12 m 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 1976a). 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 1976a). Between this terrace and the floor of the channel is a moderate talus or bedrock slope. Fine sands and calcareous shell debris are conspicuous features at certain locations on the reef. Strong tidal currents are typical of this location, especially the entrance channel. 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. The currents encourage the proliferation of suspension feeding forms (i.e., sea anemones, barnacles, sabellid polychaetes, and nestling clams), which are visual dominants at this location and depth (Dames & Moore 1976a). In the shallow areas, the kelp *Alaria fistulosa* forms a heavy growth with a thick floating canopy in the summer. The algal understory beneath the *Alaria* bed is also thick, comprising numerous species of brown, red, and green algae.

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 1976a).

4.1.3 Seldovia Point

Seldovia Point is a prominent land projection on the south side of Kachemak Bay northeast of the entrance to Seldovia Bay (Figure 4-1). 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 m in elevation rises sharply from the rocky shoreline (Dames & Moore 1976a). 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 intertidal zone. The rock bench and boulder field continues into the subtidal zone adjacent to Seldovia Point. Exposed bedrock, cobbles, and expanses of sand are characteristic features of the sea floor. Moderate amounts of shell debris are present in the sand. The substrate is frequently coal pavement and outcrops.

The largest and most conspicuous kelp bed in Kachemak Bay is found between Seldovia Point and Barabara Point. From 1974 through 1978 a major part of the kelp bed was located off the northeast side of the point (Dames & Moore 1976a) 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 1976a) extending north-northwest 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 4-3). The nearshore subtidal zone was sampled from the intertidal-subtidal fringe out to the 18-m contour, approximately 2.7 km offshore. The increase in depth is uniform and gradual; reef structures are generally small.

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 refracted swells 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 1976a). However, conditions in fall and winter are somewhat more rigorous. Inshore currents are typically strong, especially during periods of spring tides. Nevertheless, silt is commonly observed on most of the solid substrate and associated vegetation in the sublittoral zone.

4.1.4 Barabara Point

The kelp bed at Barabara Point is continuous with that at Seldovia Point but is strongly dominated by bull kelp. The depth of the area surveyed was about 10 m. The boulder-bedrock substrate, with numerous crevices and ledges, offers considerable bottom relief. Many of the outcrops appear to be low-grade coal well overgrown with encrusting coralline algae and epifaunal invertebrates. Tidal currents are considerably dampened by the effects of the large kelp bed, and thus the substrate and understory algae are rather more silty than at Seldovia Point.

4.2 WEST SIDE OF INLET - ROCK

All of the systematic work on rock habitat on the west side of lower Cook Inlet was conducted in Kamishak Bay at three locations, namely, Scott

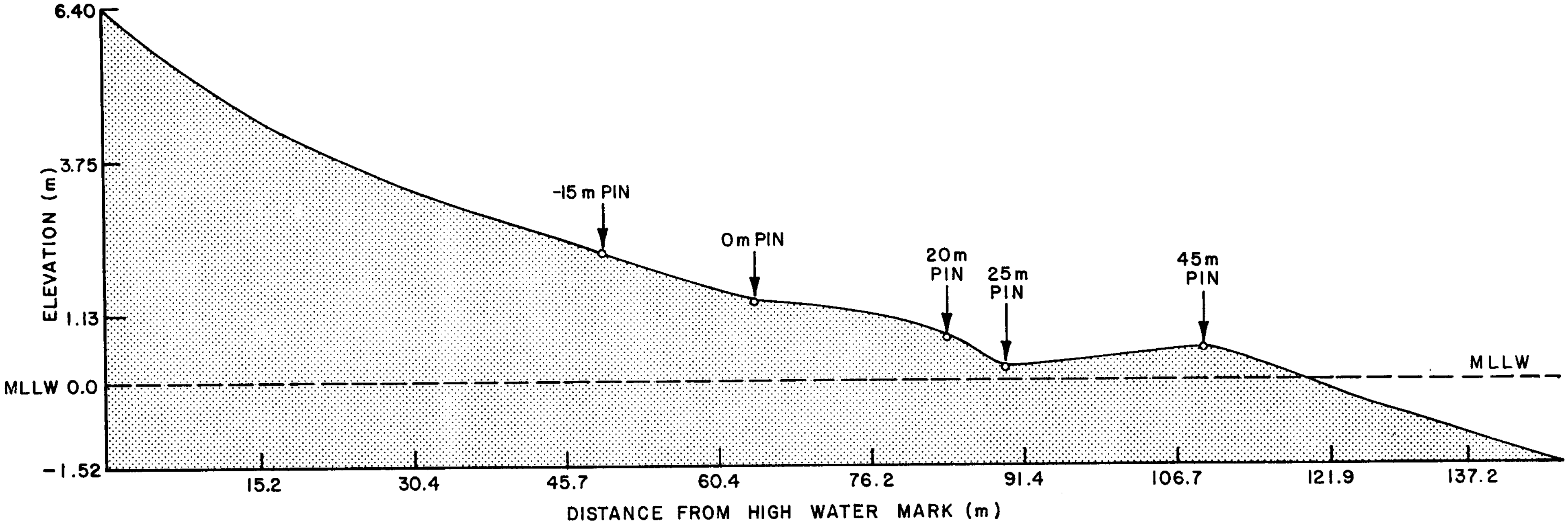


FIGURE 4-3

PROFILE OF PERMANENT TRANSECT AT SELDOVIA POINT

Island, Knoll Head Lagoon, and White Gull Island. A number of other sites have been examined on the west side of Cook Inlet since 1975 (Dames & Moore 1977a), including several sites each at Chinitna, Iniskin and Bruin Bays and near the mouth of the Douglas River. These areas comprise a broad variety of habitat types and biotic assemblages.

4.2.1 Scott Island

Scott Island is a low, relatively flat island of moderate size (30 ha) on the east side of the entrance to Iniskin Bay (Figure 4-1). Large reefs marked by a number of small islets and emergent rocks provide the shorelines of the island considerable protection, especially during low tides, from the oceanic swells crossing lower Cook Inlet from the ocean entrances. The island is heavily wooded and is protected around much of its perimeter by steep cliffs, some 30 m in height, that extend well down into the intertidal zone. Small gravelly beaches on the landward sides (NE, N, and W) 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 crossed a rock bench sloping generally seaward. The transect was cut by several shallow surge channels and two major lateral ridges. The upper level sampled was 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 are scattered about this bench. Below this level, scattered channels of shelly gravel and sand interspersed with bedrock extend subtidally. Bedrock of Scott Island consists of a conglomerate of cobbles, fist-sized or larger, 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 predominates, and rock is limited to scattered medium to large boulders extending up to 2 m above the sand.

4.2.2 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 Bay 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 4-1).

Offshore, a series of low reefs oriented nearly parallel to shore protects these beaches from most of the southerly swells originating at the ocean entrances, except when the tide is fairly high. Tidal currents are fairly weak because of the protection of these reefs and the remoteness of the site from the entrances of nearby bays.

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, on a lower, more gently rounded ridge, 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 boulder-filled tide pools break up the beach pattern.

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.

4.2.3 White Gull Island

White Gull Island is a small, low-lying island situated in the mid-channel entrance to the Iliamna-Cottonwood Bay complex (Figure 4-1). The protected west and north sides of the island have moderately sloped beaches of cobble, gravel and coarse sand interspersed with bedrock ribs and outcrops. The east shore, facing lower Cook Inlet with little protection from swells coming through the ocean entrances, 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. Because of its mid-channel location in the mouth of a bay, tidal currents are strong and turbulence is high. Even in protected locations around the islet, concentrations of suspended particles should be high.

The study transect was on the exposed side of the island. It ran due east across the bench between two elevated rock outcrops that extend to 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 marked by 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, near or slightly above MLLW, contains 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 slopes 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.

4.3 NORTHEASTERN GULF OF ALASKA (NEGOA)

4.3.1 Zaikof Point, Montague Island

Zaikof Point is located on the southeast corner of Zaikof Bay, just west of Schooner Rock (Figure 4-4). The elevation of the drift log pile in the intertidal zone indicates that the area is exposed to heavy surf from the north or the southeast. Our experience working at the site indicates also that it is routinely exposed to strong tidal currents flowing into and out of Prince William Sound through Hinchinbrook Entrance.

Water clarity in the study area is quite variable because it is exposed alternately to water masses of at least two radically different origins. The most usual condition seems to be exposure to clear oceanic water from the Gulf of Alaska. Occasionally, turbid water originating from the Copper River intrudes across Hinchinbrook Entrance to bathe Zaikof Point. During these periods, the silt-laden water seems restricted mainly to the top several meters of the water column.

The substrate in the study area is mainly rock. Although the slope is generally fairly gentle, surface relief is moderate. The substrate is mainly a combination of bedrock, reefs and boulders of variable size. However, with increasing depth, pockets of sand and shell debris occur with increasing frequency, until, between depths of 16 and 18 m, this substrate type supplants rock as the dominant substrate. Outside this depth range, tidal currents throw the unconsolidated sediment into sand waves up to 45 cm high. As a consequence of the depth and substrate gradients and high surface relief, habitat diversity is high at Zaikof Point.

The study area for these surveys was the same as that used by Rosenthal (1980). Consequently, after the May 1978 survey, we were able to work around a series of "permanent" transect lines that Rosenthal installed to facilitate his fish censuses. Therefore, horizontal control of the levels sampled was good.

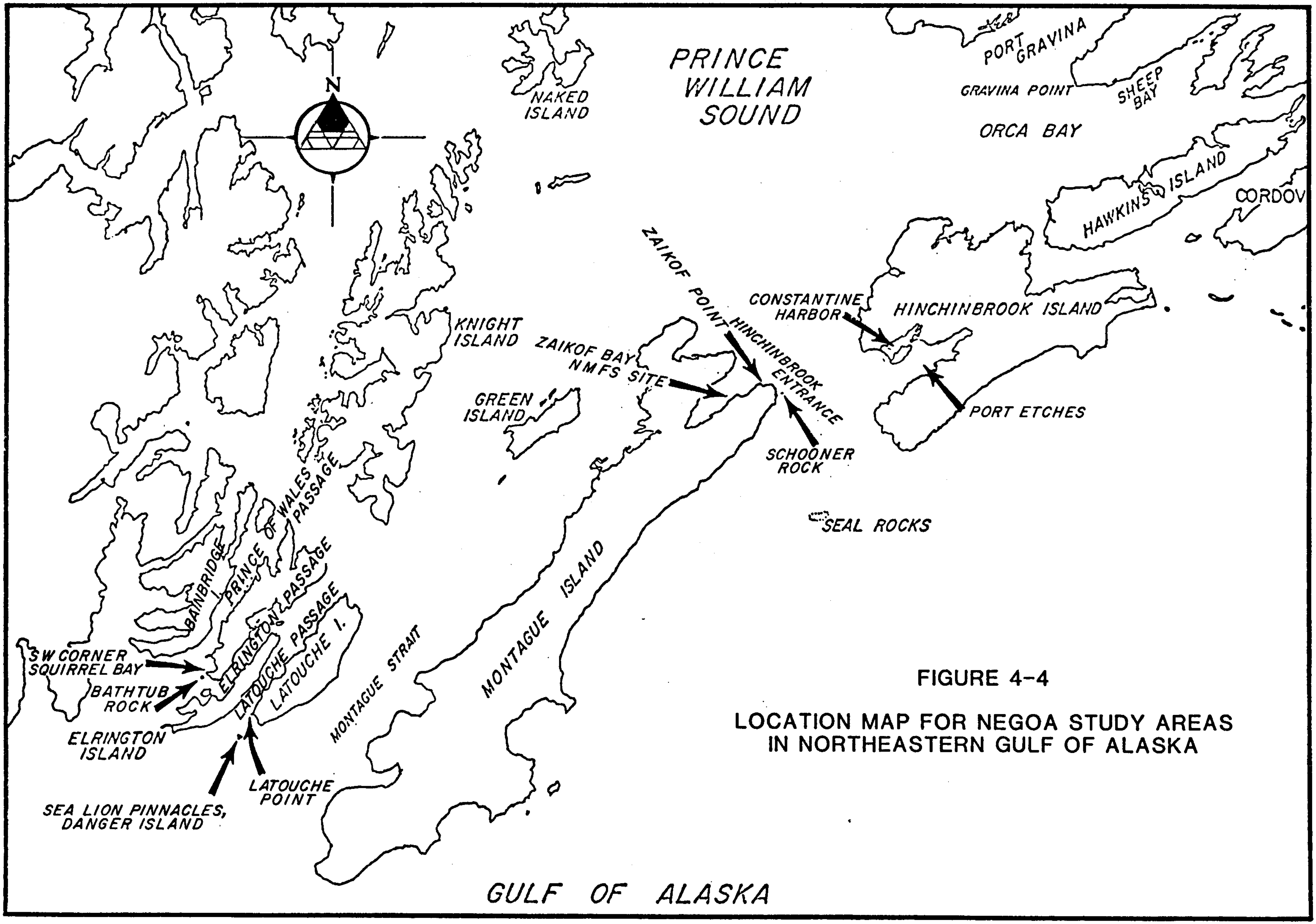


FIGURE 4-4

LOCATION MAP FOR NEGOA STUDY AREAS IN NORTHEASTERN GULF OF ALASKA

4.3.2 Zaikof Bay - the NMFS Study Site

Zaikof Bay, located on the northeast corner of Montague Island, is situated on the west side of Hinchinbrook Island (Figure 4-4). The beach and associated rocky subtidal slope is generally narrow and composed of boulders. The inner bay is moderately well protected from swells out of the Gulf of Alaska or Prince William Sound. Generally, water clarity was lower than at Zaikof Point or Schooner Rock.

The NMFS study site, located on a rocky promontory on the south side of the bay, is marked by an ADF&G stream marker. The shallow subtidal area is a moderate slope of talus. Patches of sand and shell debris are frequently interspersed in the boulders. A layer of fine silt forms a thin veneer over the rock and epibiota during most of the year. At a depth of 12 to 15 m, the boulder field gives way to a sand/shell debris substrate with gentle to moderate slope.

4.3.3 Schooner Rock, Montague Island

Schooner Rock, located just southeast of Zaikof Point (Figure 4-4), is generally exposed to the same oceanographic and hydrographic conditions as Zaikof Point, except currents and surge activity are more extreme. The area is characterized by considerable turbulence during periods of tidal flow.

Generally, the subtidal substrates examined around Schooner Rock were medium to large-sized boulders or rock slabs, up to 6 m high, sloping fairly steeply into deeper waters. Surface relief was especially notable at the southeast end of the rock where room-sized boulders and tall pinnacles were observed. Pockets and channels between boulders were filled with sand/shell debris below about 20 m, but rock surfaces were swept clean above that depth.

4.3.4 Port Etches - Constantine Harbor, Hinchinbrook Island

This enclosed bay complex is located on the west end of Hinchinbrook Island, across Hinchinbrook Entrance from Zaikof Bay and Schooner Rock (Figure 4-4). Generally, the areas examined are fairly well protected from heavy storm surge or strong tidal currents. This area is apparently strongly affected by outflow from the Copper River; the water is characteristically more turbid than at Zaikof Point or Schooner Rock. In addition, salinity is probably lower in these areas, especially inside Constantine Harbor, than at Zaikof Point or Schooner Rock.

The substrate is basically unconsolidated. At the Port Etches site, the substrate was silty, fine sand with scattered cobbles and small boulders covering about 3 percent of the bottom. At the Constantine Harbor site, the substrate was a sandy silt.

4.3.5 Sea Lion Pinnacles, Danger Island

The Sea Lion Pinnacles site is situated strategically at the extreme southern end of Danger Island between Montague Strait and Latouche Passage (Figure 4-4). Although basically directly exposed to storm surge from the Gulf of Alaska, it is slightly protected by the offshore pinnacles located about 100 m farther south and an associated reef that extends about a mile in a southwesterly direction. Tidal currents range from moderate to weak, but the hydrodynamic regime is considered rigorous. Water quality is quite high. Water clarity is usually good, and salinity is only slightly affected by freshwater run off.

Bottom relief is high and similar to that described for Schooner Rock. Near shore, bedrock predominates, but it is highly fractured and large pinnacles, channels, ledges and slabs are common; slope is moderate to steep. At a depth of about 15 m, boulder fields with boulders ranging from 1 to 3 m in diameter predominate. The slope of these fields ranges from slight to moderate.

4.3.6 Latouche Point, Latouche Island

At Latouche Point, the sites occupied were located toward the middle and west side of the point on a broad shelf approximately 10 to 12 m deep (Figure 4-4). One of the sites was located on a portion of this shelf bordering Latouche Passage. The areas examined are generally protected from direct exposure to storm surge and from free-flowing tidal currents, but the hydrodynamic regime is by no means calm or protected. Circulation driven by surge and tidal currents assure that water exchange is continuous and water quality is good. Furthermore, surge activity, although dampened by terrain features or kelp beds between the area and the open Gulf of Alaska, is a force that must be considered during or after a small storm and must be impressive during large storms.

The substrate ranges from bedrock to boulder fields with varying coverage by sand and shell debris between the boulders. Boulder size generally does not exceed a diameter of 1 m. In the boulder fields, bottom relief is relatively low, but on bedrock, fractures have created large channels and ledges, and relief is high.

4.3.7 The Southeastern Corner of Evans Island

Two general areas were examined at the southeastern corner of Evans Island, between Elrington and Bainbridge Passages (Figure 4-4). We surveyed the macrophyte assemblage in a bull kelp bed at the southern corner of Squirrel Bay. Moreover, we examined species composition and depth zonation of the macrophyte and invertebrate assemblages at "Bathtub Rock", a large sea stack lying about 300 m off the southeast end of Evans Island. Both areas are somewhat protected from storm surge directly off the Gulf of Alaska but, undoubtedly, are subject to heavy turbulence and tidal currents during storms and spring tides. Bathtub Rock is the more exposed of the two areas to both surge and tidal currents; currents are particularly strong along its southern face and the ridge extending southwest from the rock. Water quality should be good at both sites, but water clarity was always better around Bathtub Rock than in the bull kelp bed.

The substrate at Bathtub Rock was largely bedrock except on the west and northwest facings where the bottom was a boulder slope with sand channels at about 13 m. The face of the pinnacle was virtually vertical from the northern side south to the southern face and west to the southwestern ridge. The vertical face ended in a sand flat along the north and east faces of the rock at a depth of about 23 m, but on the southern side facing Elrington Passage, it continued on to greater depths.

In the bull kelp bed near Squirrel Bay, the bottom was a gently sloping boulder field with channels and pockets of sand and shell debris. Boulders ranged up to 1.5 m in diameter.

4.4 SOFT SUBSTRATES IN LOWER COOK INLET

The report by Hayes et al. (1977) provides useful characterizations of numerous beaches of all types 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 from about +0.7 m to MLLW and a broad, flat, more consolidated fine sand low-tide terrace extending out into the subtidal zone (Figure 4-5). 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 4-5).

The beaches selected for study in lower Cook Inlet and discussed herein include three of sand and two of mud. Two sandy beach sites were located on the east side of lower Cook Inlet (Figure 4-6). 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 Iniskin Beach site was chosen because of its convenience to the

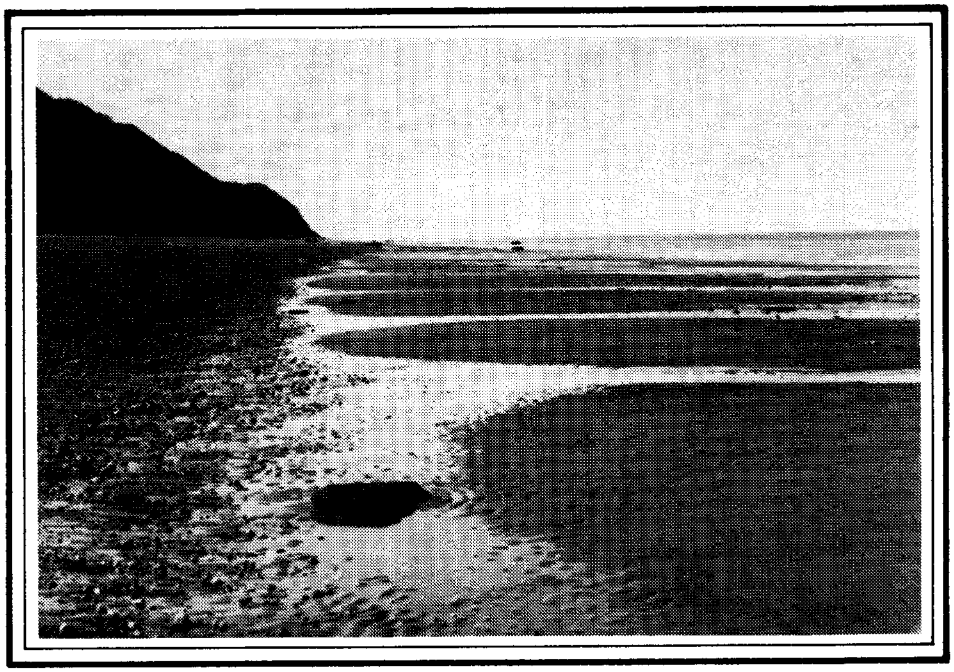


FIGURE 4-5

VIEW OF BEACH AT DEEP CREEK,
SHOWING STRUCTURE OF THE FORESHORE IN 1977

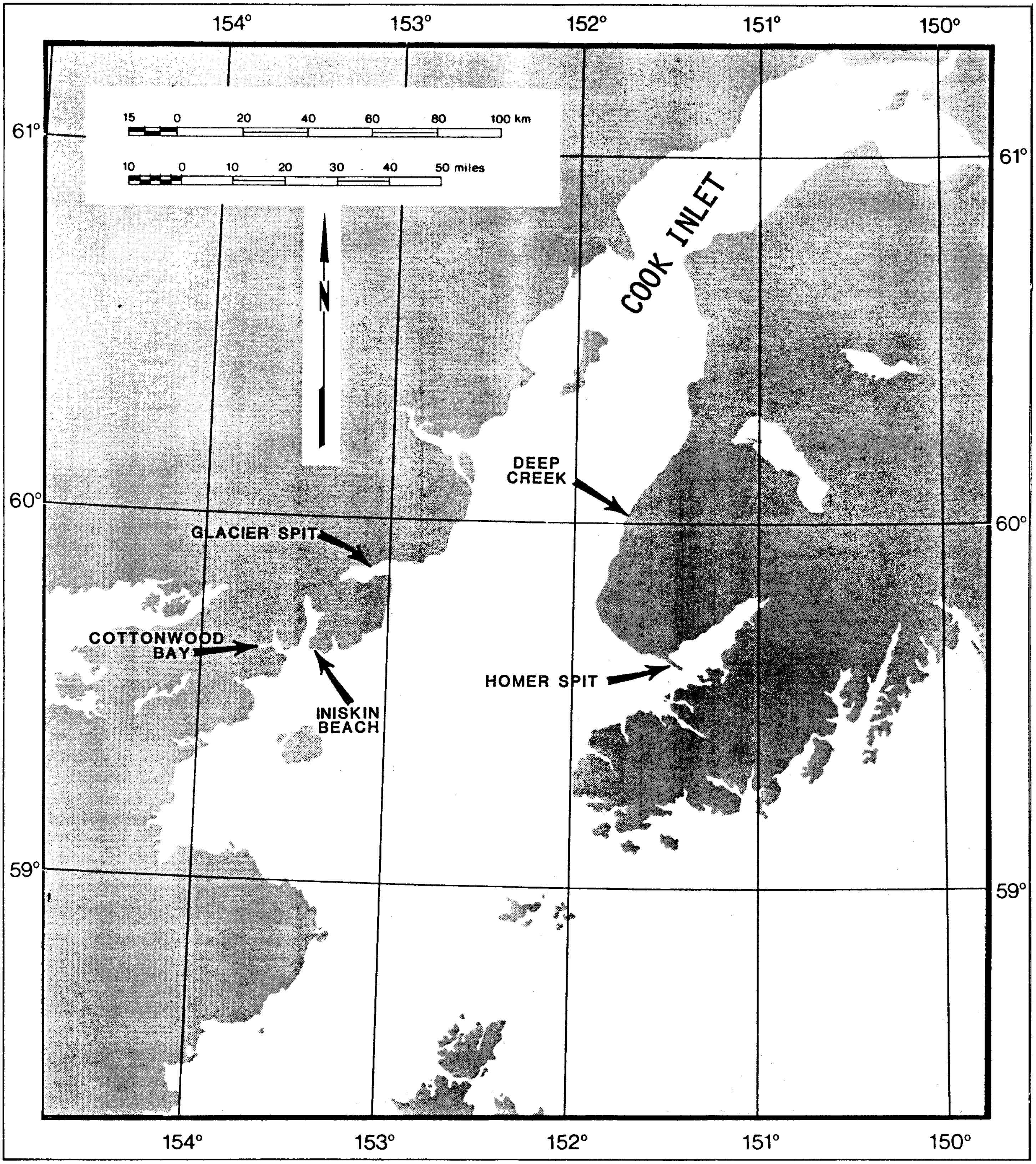


FIGURE 4-6

LOCATION MAP SHOWING SAMPLING AREAS FOR SAND AND MUD BEACHES IN LOWER COOK INLET

OCSEAP Cottonwood base camp. Both mud flat sites are located on the west side of the Inlet (Figure 4-6). The Glacier Spit site in Chinitna Bay was chosen because its fauna is typical of mud flats on the west side and has year-round residents and shelter (Dames & Moore 1977a). Logistics and protection during storms were important criteria in selection of sites on the west side of the inlet. Because of the large volume of samples collected at each site, access was an important criterion at all sites.

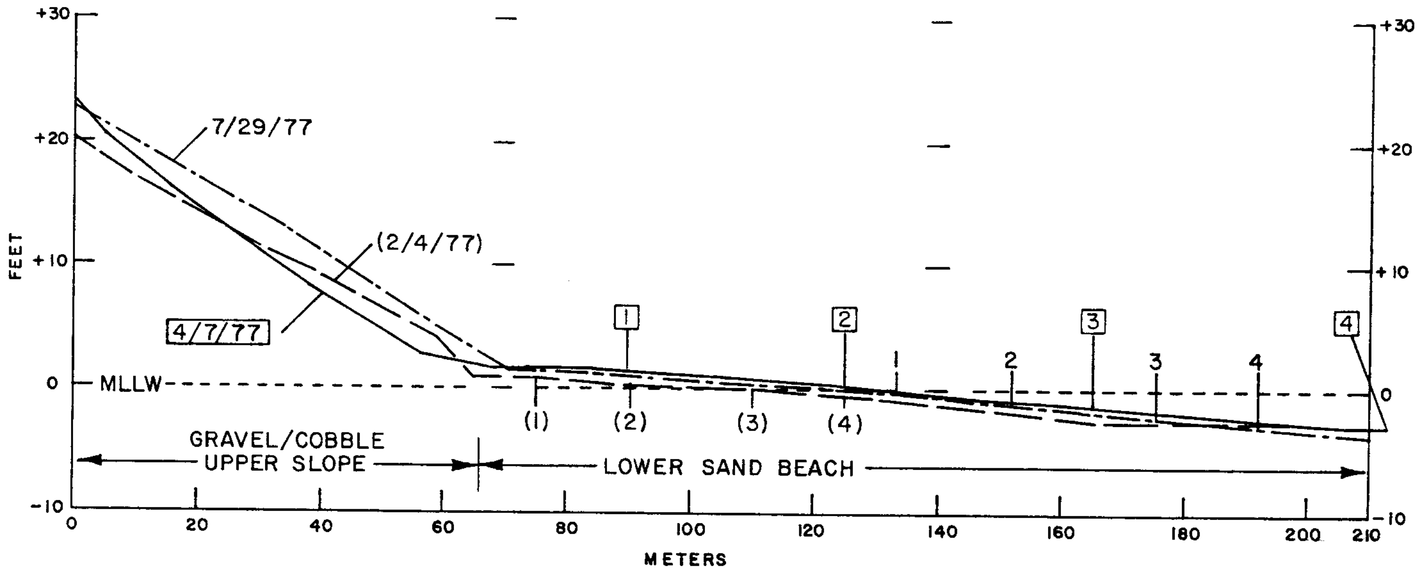
4.4.1 Sand Beaches - Homer Spit, Deep Creek and Iniskin Beach

The sandy beaches located on the east side of lower Cook Inlet (Figure 4-6) were both selected for accessibility by four-wheel drive vehicle. Based on his razor clam surveys, Mr. David Nelson, ADF&G (personal communication), indicated that the Deep Creek site, 2.4 km 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, 4 km south of the Kachemak Drive, because it appeared to support a richer fauna and higher standing stock than the Deep Creek site.

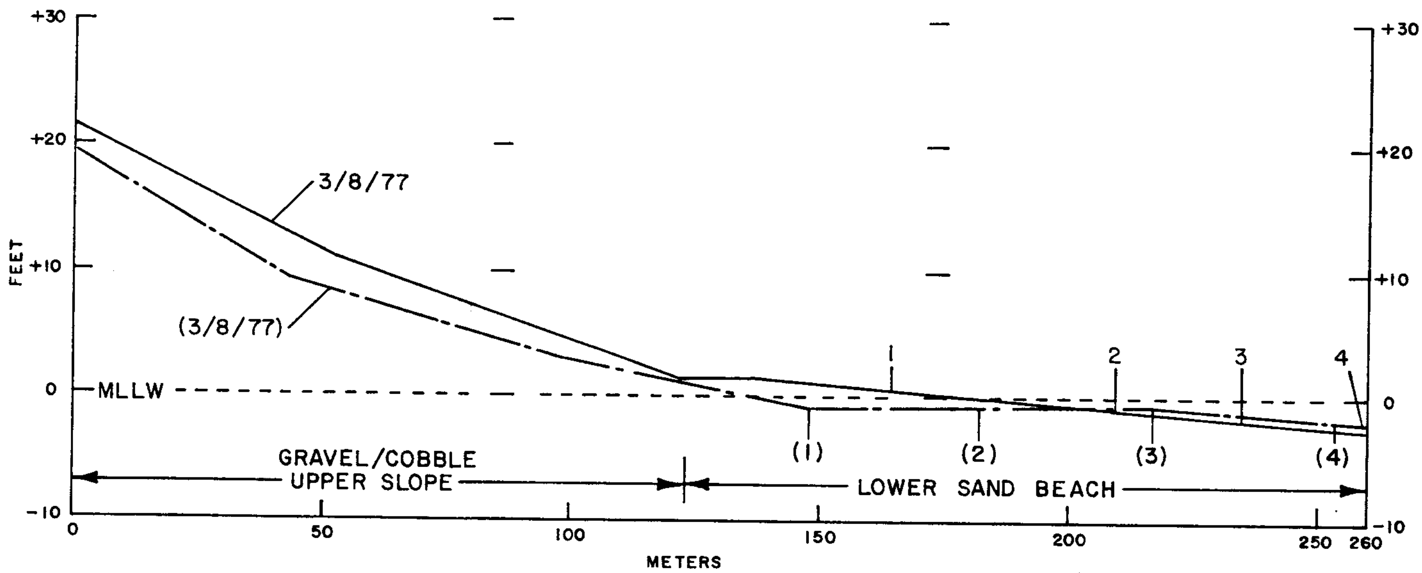
Corrected beach profiles for the Deep Creek and Homer Spit sites (Figure 4-7) provide two important pieces of information. First, it appears that the shape of the beaches change very little seasonally compared to beaches exposed to the open ocean (Bascom 1964).

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. Based on Shepard (1963), the beach at Homer also should be coarser and more porous.



DEEP CREEK



HOMER SPIT

FIGURE 4-7

BEACH PROFILES FOR DEEP CREEK AND HOMER SPIT

Based on sediment samples collected at two levels from both lower beaches, sediment conditions are quite similar (Table 4-1). 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.

The beach at Iniskin Beach was somewhat wider than at Homer Spit or Deep Creek (Figure 4-7 and Table 4-1). Furthermore, the median grain size of the sediment was somewhat finer. Both of these factors indicate that Iniskin Beach is more protected than Homer Spit or Deep Creek. In fact, it is protected by offshore rock reefs that, during low spring tides, give the area a lagoonal quality.

4.4.2 Mud Flat - Glacier Spit, Chinitna Bay and Cottoonwood Bay

The Glacier Spit mud beach study site is adjacent to the Byer homestead in Chinitna Bay, on the west side of the inlet. It was chosen because it was a typical mud flat, and had 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 4-8). 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 indicate that the sediment is basically a silty sand with appreciable clay (Table 4-1). 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.

TABLE 4-1 MEDIAN GRAIN SIZE (mm) AND SEDIMENT TYPE FOR INTERTIDAL SOFT SUBSTRATE SAMPLING SITES IN LOWER COOK INLET, SUMMER 1978

Location/Level	Replicate 1	2	3	$\bar{x} \pm s$	Sediment Type
<u>Sand Beaches</u>					
Homer Spit					
30 m	0.24	0.28	0.35	0.29 ± 0.06	Fine Sand
135 m	0.21	0.25	0.22	0.23 ± 0.02	Fine Sand
Deep Creek					
90 m	0.26	0.28	0.24	0.26 ± 0.02	Fine Sand
165 m	0.22	0.21	0.21	0.21 ± 0.01	Fine Sand
Iniskin Beach					
130 m	0.17	--	--	--	Fine Sand
260 m	0.13	--	--	--	Fine Sand
386 m	0.105	--	--	--	Fine Sand
<u>Mud Flats</u>					
Chinitna Bay					
50 m	0.0805	0.0805	0.043	0.068 ± 0.022	Sandy Silt
350 m	0.105	0.105	0.108	0.106 ± 0.002	Sandy Silt
500 m	0.11	0.11	0.108	0.109 ± 0.001	Sandy Silt
Cottonwood Bay					
150 m	0.018	0.0205	0.03	0.023 ± 0.006	Sandy Silt
200 m	0.0205	0.02	0.0205	0.020 ± 0.000	Sandy Silt
300 m	0.0305	0.02	0.017	0.023 ± 0.007	Sandy Silt

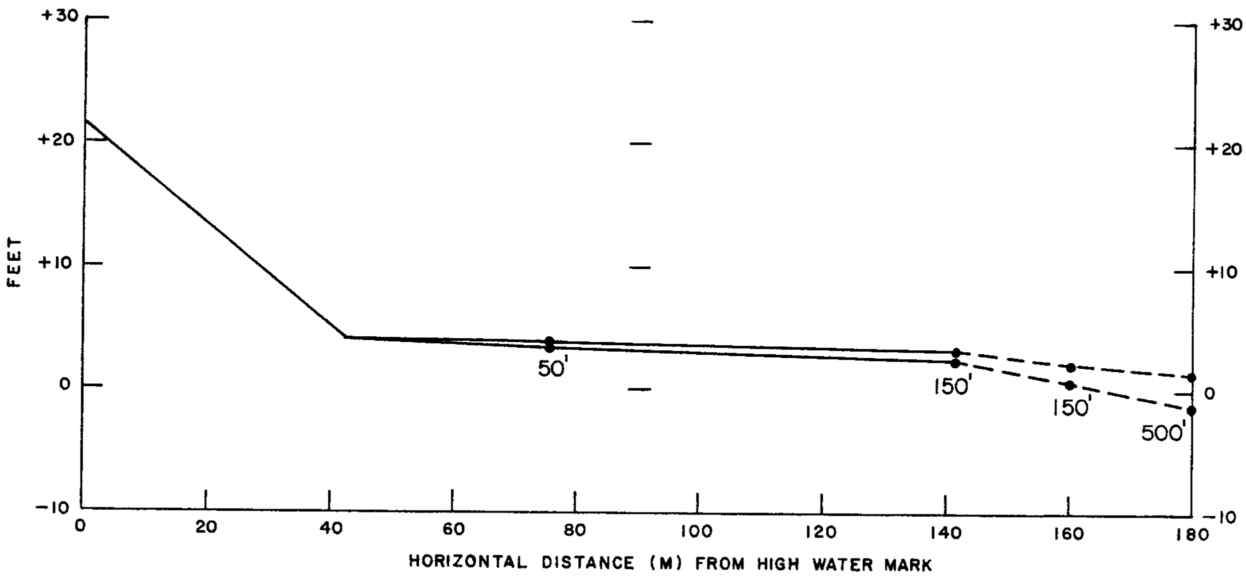


FIGURE 4-8

ESTIMATED BEACH PROFILE FOR GLACIER SPIT, CHINITNA BAY

The Cottonwood Bay mud beach site is located in a small bight on the southern shoreline of Cottonwood Bay, on the west side of Cook Inlet. This site was chosen largely because of its proximity to the NOAA/OCSEAP base camp 402 m to the east of the sampling site. The base point of the transect is a rock face at the head of the bight with the transect extending perpendicular to the upper beach.

The basic structure of the beach at the Cottonwood site is very similar to that at Glacier Spit both in regard to the slope of the upper gravel beach and the slope of the mud flat. In addition, sediment samples from the Cottonwood site indicate that the sediment is basically an unconsolidated sandy silt with some clay. Median grain size was finer at Cottonwood than at Chinitna (Table 4-1), and the sediment surface was quite sloppy. At the lowest sampling station, a stratum of gravel was encountered about 15 to 20 cm below the surface.

4.4.3 Sampling Levels

At the sites at Homer Spit, Chinitna Bay, Iniskin Beach, and Cottonwood Bay, sampling levels were established at predetermined distances from the gravel-sand interface or some notable landmark. The location of these levels and their approximate elevations are indicated in Table 4-2.

At the Deep Creek site, we attempted to locate the levels according to predetermined elevations, specifically, MLLW, -0.3, -0.6, and -0.9 m. 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 4-3.

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

TABLE 4-2 LOCATION AND APROXIMATE ELEVATION OF SAMPLING LEVELS AT HOMER SPIT AND GLACIER SPIT, CHINITNA BAY, 1977

Sampling Level	Homer Spit: Distance from Interface (meters)	Homer Spit: Approximate Elevation (meters) 3/8/77	Homer Spit: Approximate Elevation (meters) 7/28/77	Glacier Spit, Chinitna Bay: Distance from Interface (meters)	Glacier Spit, Chinitna Bay: Approximate Elevation (meters)
1 (Upper)	30	+0.23	-0.3	50	1.16 to 1.10
2	75	-0.23	-0.23	150	0.99 to 0.76
3	100	-0.53	-0.15	350	0.64 to 0.27
4 (Lower)	135	-0.76	-0.46	500	0.40 to -0.36

	Iniskin Beach 4/26/78 and 8/18/78		Cottonwood Bay 5/6/78 and 8/19/78	
1 (Upper)	130	0.0	50	-0.27
2	260	-0.36	150	-0.46
3 (Lower)	386	-0.76	300	-1.04

TABLE 4-3 VARIATION IN APPROXIMATE ELEVATION (METERS) OF SAMPLING LEVELS AT DEEP CREEK IN 1977

Sampling Level	4 February 1977	7 April 1977	19 July 1977
1 (Upper)	+0.30	+0.46	0.0
2	+0.15	+0.15	-0.30
3	0.0	-0.38	-0.61
4 (Lower)	-0.15	-0.84	-0.84

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 predetermined 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.

4.4.4 General Environmental Conditions

A comparison of environmental conditions at the five sites reveals some distinct differences. The factors considered are sediment temperature, 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 probably somewhat lower at Chinitna Bay, Cottonwood Bay, Iniskin Beach, 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 sites. Chinitna and Cottonwood Bays may also experience stronger winds than the other sites, causing greater wind chill effects. The surface layer of sediment freezes at all sites during low tides in late fall and winter, but our impression is that it freezes deeper at Chinitna and Cottonwood.

The scouring effects of sea ice range from substantial at Chinitna and Cottonwood Bays 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 eastern sand beaches, but can occur during harsh winters. Floe ice at Glacier Spit and Cottonwood Bay 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 and Cottonwood Bay, which are essentially estuarine and situated in bays near a number of streams. This inference is supported by the salinity patterns described for Cook Inlet 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 and Cottonwood Bay. 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, and probably at Iniskin Beach. Homer Spit has a maximum fetch for direct wind waves of 161 km and is only slightly protected from waves generated in Shelikof 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 the south, west and north, and so is probably disturbed by wave action more regularly, the maximum fetch for direct waves is only about 48 km. Because the stronger north and south waves will approach at an oblique angle, their force will be greatly reduced. Iniskin Beach is exposed to storm surge from the southeast off the Gulf of Alaska, but offshore reef systems should provide it substantial protection, especially during low tides. Furthermore, it is well protected to the south and southeast and is probably the most protected of the sand beaches. Glacier Spit and Cottonwood Bay are generally protected from all but small wind waves from the east, and surf over 1 m high is probably rare.

The influence of tidal currents varies greatly among the five sites. Exposure is greatest at Deep Creek as it is located directly on the shoreline of the inlet. The Homer Spit and Iniskin Bay sites are only slightly affected by tidal currents because of the protection provided by the Spit, particularly during outgoing tides or reefs. Glacier Spit, located near the head of Chinitna Bay and the Cottonwood Bay site, are 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, the 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.

5.0 METHODS AND MATERIALS

Methods used to sample both rocky and soft littoral substrates in lower Cook Inlet during 1977 and 1978 largely evolved from techniques used by Dames & Moore (1976a, 1977a) 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.

5.1 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 Chapter 4.0, sampling was focused on permanently marked transects at discrete intertidal levels or subtidal depths.

5.1.1 Quadrat Count and Removals

A stratified random sampling design was used to gather most of the data on distribution, abundance, and standing stocks obtained in this study. At each sampling level a 30- or 50-m long surveying tape was laid out along the beach or depth contour perpendicular to the transect. Intertidally and subtidally, 0.25-m^2 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 non-encrusting 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) while stringing 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 statistical 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 due to 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 to more than $1500/m^2$ for mussels, etc. Biomass of functionally important species may range from 20 g/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 often so dramatic that identification of seasonal and bathymetric patterns for dominant species was possible.

5.1.2 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.

5.1.3 Laboratory Techniques

Algal samples were removed from the quadrats and returned to the laboratory where they were sorted to the lowest practical taxon. In 1977, 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 kelps, stipe and total lengths and whole wet weight were measured for individual plants to provide data on age-structure and length-weight relationships. In 1977 aggregate weights were obtained for *Fucus*, but in 1978 we obtained some individual plant weights as well.

5.2 GROWTH

Information on growth and growth rates of major laminarian algae was obtained by direct tagging experiments, and by analysis of length-frequency and biomass data (Dames & Moore 1979b). Limited growth data for certain key animals were also obtained using the latter method.

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).

5.3 NUMERICAL ANALYSIS

As indicated above (Section 5.1.1), 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:

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

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

where:

$\bar{x}$ = the arithmetic mean of a sample set

n = the number of observations

t = 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 normal 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 (ANOVA) (Siegel 1956). The most frequently used test was the Kruskal-Wallis ANOVA. In places where it is used, only the significance level will be noted. All other tests will be noted by name.

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. Raw data have been submitted to NOAA in the NODC digital data format.

Estimates of primary production have been calculated for three kelps (Agarum cribrosum, Alaria fistulosa, and Laminaria groenlandica) Two basic models have been used. In Alaska, Alaria is effectively an annual species, facilitating construction of a horizontal life table. As a consequence, estimation of its primary production, based on best estimates of its horizontal life tables, is a reflection of the growth and survivorship performance of a cohort through the year (see Dames & Moore 1979b, for details and computations).

In contrast, both Agarum and Laminaria are perennials, and efforts to define age structure were ineffective. As a consequence, estimates of primary production were based on the average ratio of productivity to biomass (P:B ratios). Details are presented in Section 6.2.4, where the presence of data makes the explanation simpler and more appropriate.

5.4 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:

SPECIALIST	TAXON
Dr. Thomas Widdowson Calif. State Univ., Long Beach	- Algae- Phaeophyta
Dr. Robert Scagel University of British Columbia	- all major algal taxa
Dr. Isabel Abbott Stanford University	- Rhodophyta
Dr. Joan Stewart Scripps Institute of Oceanography	- Rhodophyta - Delesseriaceae
Dr. Rita O'Clair University of Alaska - Juneau	- Polychaeta
Mr. Rick Rowe University of Southern California	- Polychaeta
Ms. Janet Haig University of Southern California	- Paguridae
Mr. Rae Baxter Alaska Department of Fish and Game	- Mollusca
Mr. James Vallee Pacific Bio-Marine	- Tunicata
Dr. Robert Lavenberg Los Angeles County Museum of Natural History	- Fish

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

5.5 DISTRIBUTION AND ABUNDANCE - SOFT SUBSTRATES

5.5.1 Field Procedures

A stratified random sampling design was employed to examine the infauna of sand beaches at Homer Spit, Deep Creek, and Iniskin Beach, and the mud flats at Glacier Spit, Chinitna Bay, and Cottonwood Bay. A transect extending across the beach from a specified point was established on each beach. Samples were collected at three or four specified levels or distances from the base of each transect (Figure 4-7; Table 4-2). At each level, a measured line was laid out parallel to the shoreline and a set of vertical core samples was collected at pre-determined 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. Core samples were 10 cm in diameter (78.5 cm^2) by about 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 mm screen to reduce the amount of inorganic material, then rebagged and preserved with a 10 percent formaldehyde-sea water solution.

Approximate beach profiles were determined using a calibrated 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. These 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 and oceanographic phenomena and correction factors are important sources of error. For instance, heavy wind or wave action or deviations in barometric pressure from average can significantly alter the observed tidal elevations for a day.

5.5.2 Laboratory Analysis

In the laboratory the portion of each core sample remaining on the sieve after screening 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, the rough sorted samples 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 noted in Section 5.4.

Following identification, the samples were re-examined to obtain length and weight data. Lengths of gammarid amphipods and small clams were measured on a dissecting microscope equipped with an ocular micrometer. Length of gammarids was measured from the tip of the rostrum to the posterior end of the pleon. 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 $\pm$5 mg.

5.5.3 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 ($\pm$ 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 ($\pm$ s) number of species per core, and 3) the Brillouin diversity index ($H=1/N\ (\log_2 \frac{N!}{n_1, n_2, \ldots n_j}$), where n_1, n_2, $\ldots n_j$ are the number of individuals in species 1 through j. The equability 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, 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 surveys and had a density exceeding $100/m^2$ in a majority of surveys were categorized as "Dominants". "Subdominants" also occurred in each survey, but their density did not exceed $100/m^2$ more than twice. Species that occurred in a majority of surveys were categorized as "Frequent", regardless of density, and those that showed a definite seasonal abundance were considered "Seasonal". Species that occurred in four of the five surveys at Chinitna Bay and species that occurred on one of the surveys at Cottonwood Bay were categorized as "Frequent".

Estimates of secondary production were calculated for two clams (Macoma balthica and Mya spp). Estimation of production for Macoma balthica was based on a best estimate of its horizontal life table. This was facilitated by the appearance of a strong year-class in 1976 and the subsequent opportunity to follow that year-class until 1978, thereby obtaining real information on growth and mortality rates. For details, see Section 6.3.2.1.

For Mya, the presence of three species confounded such attempts. We were unable to segregate the 0-year class to species and therefore, were unable to establish growth and mortality curves for the early portion of any of these species. An additional problem was that the density of each of these species was too low to permit collecting suitable numbers of adult specimens for population analysis within the framework of a general sampling program designed for description of a mud flat assemblage. As a consequence, the alternative selected was to use a P:B ratio determined by Burke and Mann (1974) for *M. arenaria* in Nova Scotia as a factor by which to multiply average biomass for *Mya* spp to estimate its annual tissue production. Such an estimate obviously has several limitations.

6.0 RESULTS

6.1 INTERTIDAL ROCKY HABITATS

6.1.1 East Side of Lower Cook Inlet

6.1.1.1 Gull Island

The general characteristics of rocky intertidal communities on the Gull Island ("Gorilla Rock") transect have been described by Dames & Moore (1976a) 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 mean sea level--MSL) to near MLLW with an understory of several reds

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

(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 rock surface. The Alaria plants in this zone were largely attached to the shells of B. cariosus (Figure 6-1) 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 Sections 5.1.1 and 5.1.2. These data constitute a continuation of some types of data that were reported by Dames & Moore (1976a) in 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 6-1 and 6-2.

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* Includes forms called Callophyllis in Dames & Moore (1976a).
** Includes forms called Iridaea in Dames & Moore (1976a).

FIGURE 6-1

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

TABLE 6-1 GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS, 1977

Level/Species	Date/Average Percent Cover or No./m^2 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
Mytilus edulis	21.7	27.1	19.7	24.0	24.0[(a)]
(#/m^2)					
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
(#/m^2)					
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
(#/m^2)					
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

(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 6-1 GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS, 1977 Sheet 2 of 2

Level/Species	Date/Average Percent Cover or No./m^2				
	2/16/77	5/23/77	6/27-30/77	8/27-30/77	10/13/77
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 6-2 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 6-2 GULL ISLAND INTERTIDAL INVERTEBRATE DOMINANTS, 1978 Sheet 2 of 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 6-2 and 6-3**). 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 6-1). Lowest coverage (0.3 percent) in May 1978 (Table 6-2) 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 6-1) 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

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

** See Table 6-3 for key to abbreviations in Figures 6-2 and 6-3.

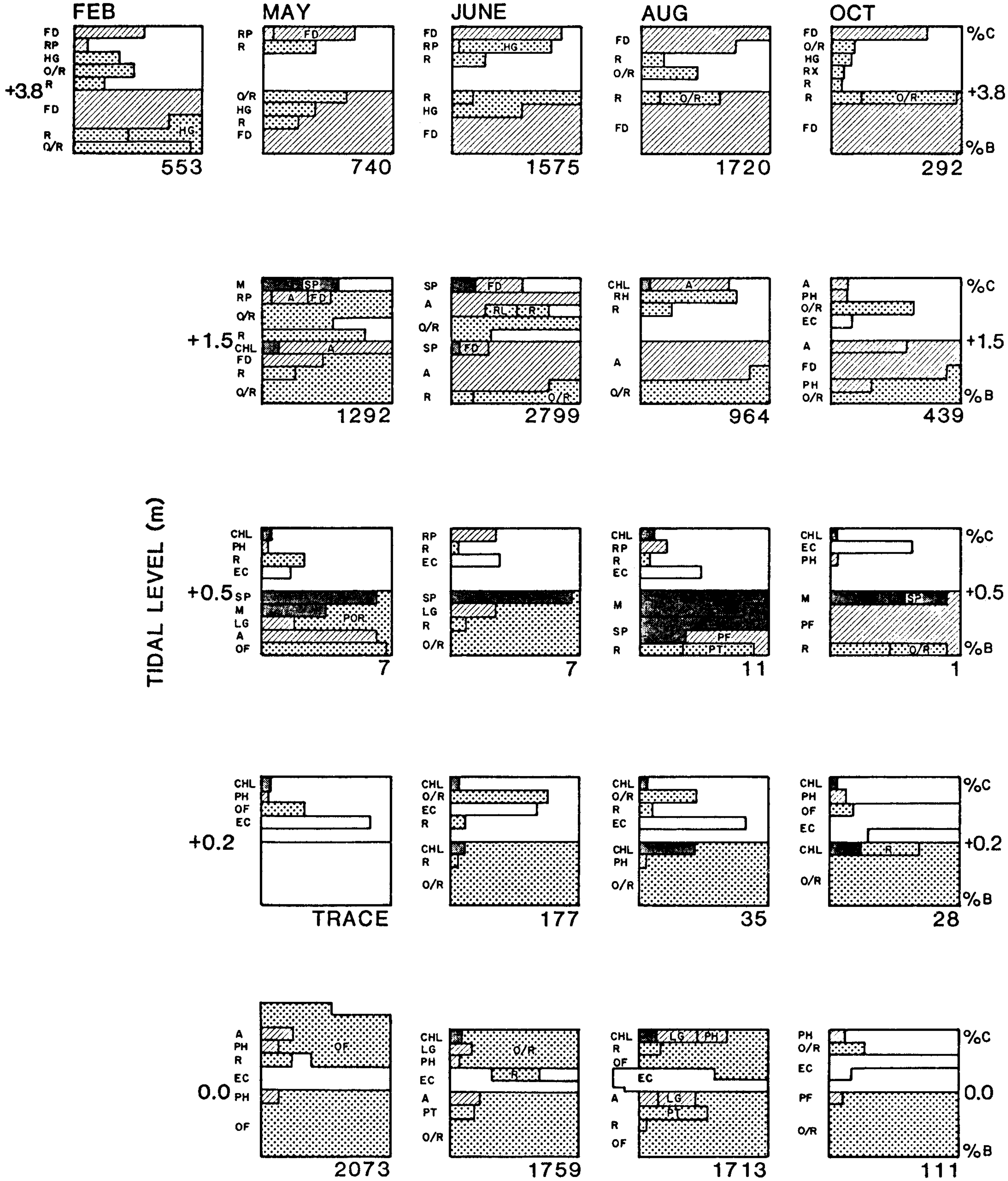


FIGURE 6-2

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

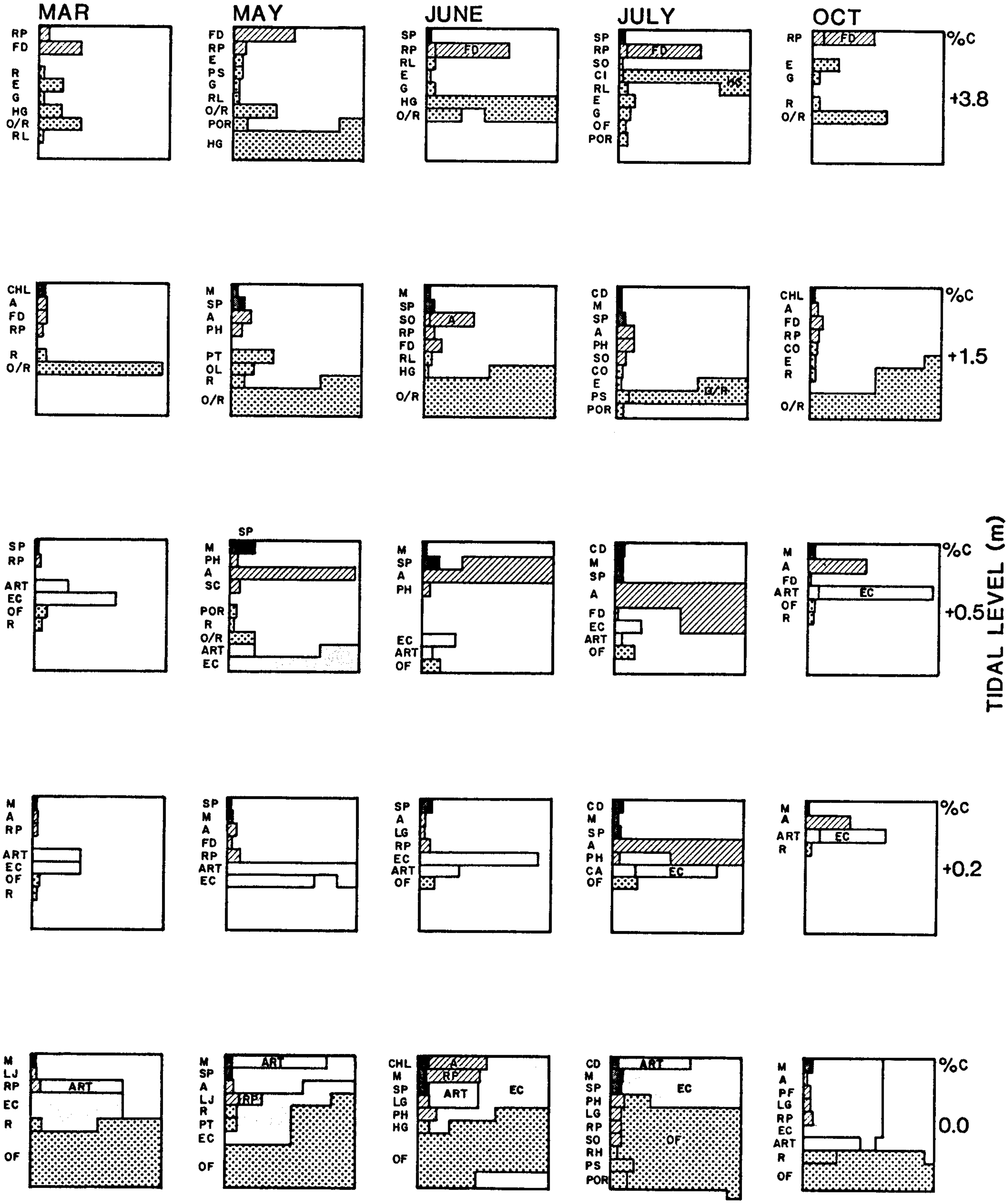


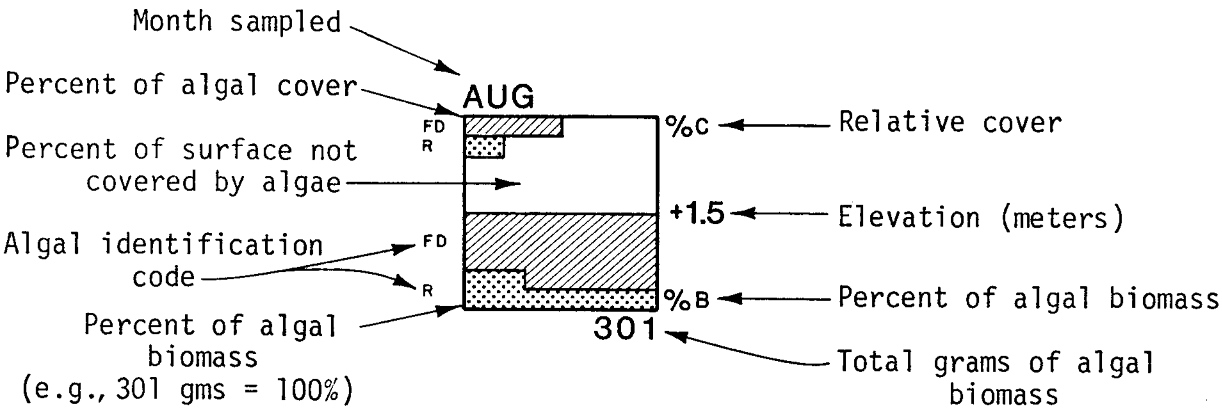
FIGURE 6-3

ZONATION AND COVER OF ALGAE AT GULL ISLAND IN 1978

TABLE 6-3 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*
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*
SO	*Soranthera ulvoidea*
SP	*Spongomorpha* spp
TM	*Turnerella mertensiana*

KEY TO FIGURES 6-2, 6-3, 6-4, and 6-5



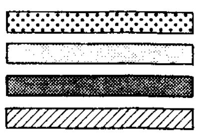
Each □ = 2 percent; each full column = 20 percent

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 6-3 each □ = 1 percent cover and each full column = 10 percent; biomass was not measured.

limpets apparently occurs in early summer (e.g., Table 6-2) with a gradual 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/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 1976a). 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 6-2, 6-3). In previous years, midsummer coverage of Alaria had ranged from 30 to 90 percent in this area (Dames & Moore 1976a).

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 6-4, 6-5). 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 6-1, 6-2). During the winter months (e.g., February

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

TABLE 6-4 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/m²	%	gm/m²	%	gm/m²	%	gm/m²	%	gm/m²
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 6-5 GULL ISLAND ALGAL COVER (PERCENT) BY MAJOR TAXON, 1978

	Tide Level				
Month/Taxon	+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 $429.3/m^2$) 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 $66.4/m^2$ 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 $240.7/m^2$ in June 1978.

Several sea anemone species were also abundant at the +1.5-m level. Metridium senile reached a density of $108.3/m^2$ 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 $21.6/m^2$) 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 1976a). 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 6-1, Figures

6-2 and 6-3). New sets 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 6-2) 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 6-2). 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 6-4). 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* that, 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 accounted 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 4-2) 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 6-2 and 6-3), 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 targide 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 6-1 and 6-2). 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 $8.0/m^2$).

6.1.1.2 Seldovia Point

General ecological features of Seldovia Point intertidal and subtidal communities have been described by Dames & Moore (1976a) 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 their major predator, 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 +2.0 m the reds were clearly dominant to about the +1.5-m level. 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 assemblages included large numbers of a small sea cucumber, Cucumaria vegae, the isopods Gnorimosphaeroma oregonensis and Pentidothea wosnesenskii, gammarid amphipods, urchins, a predatory snail Volutharpa ampullacea, 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 vicinity of MLLW

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

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.

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. Sampling was in accordance with procedures described in Sections 5.1.1 and 5.1.2.

+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 cobbles and gravel. This variability in substrate was reflected in patchy 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 6-4 and 6-5). 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.

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

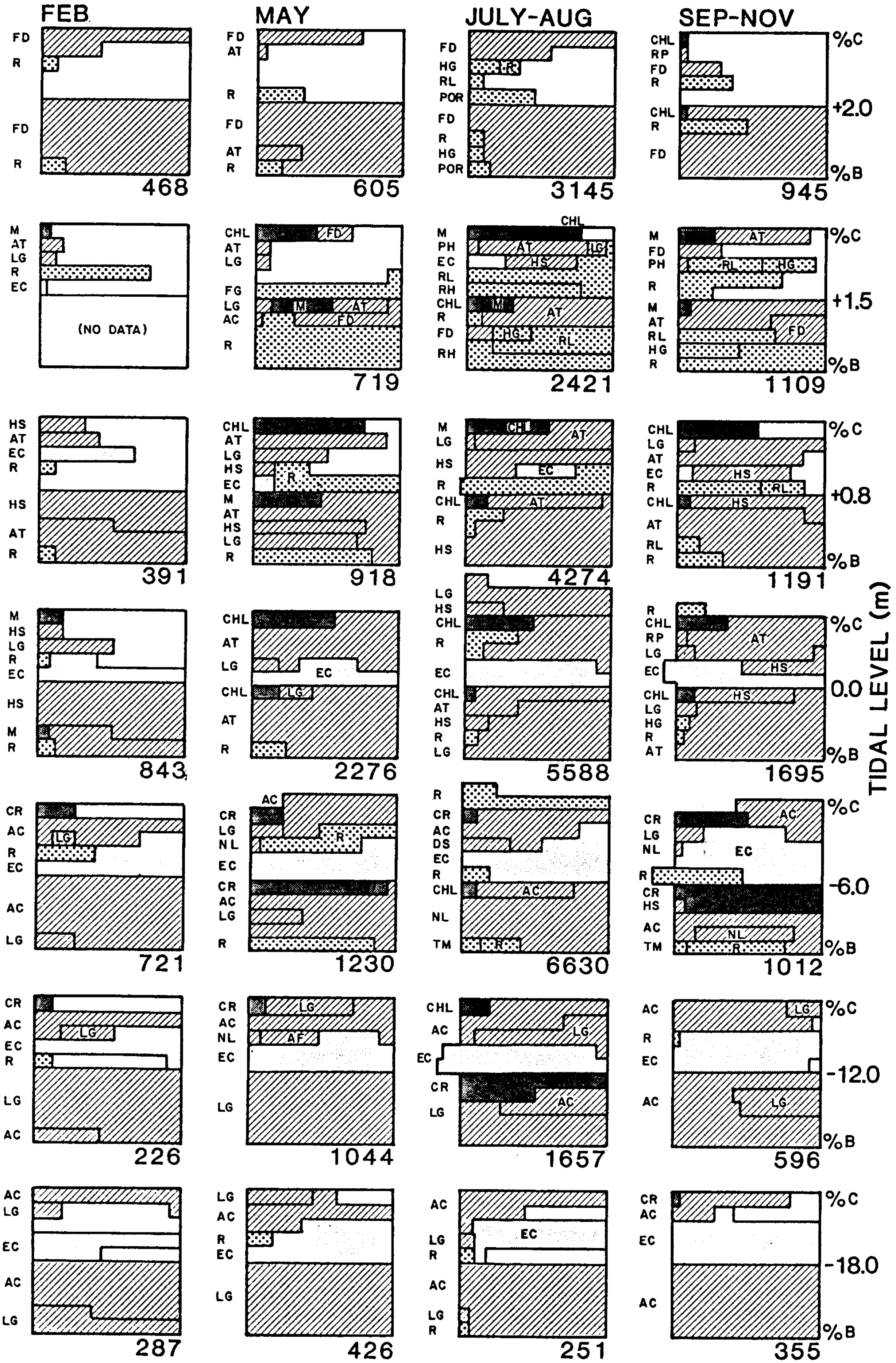
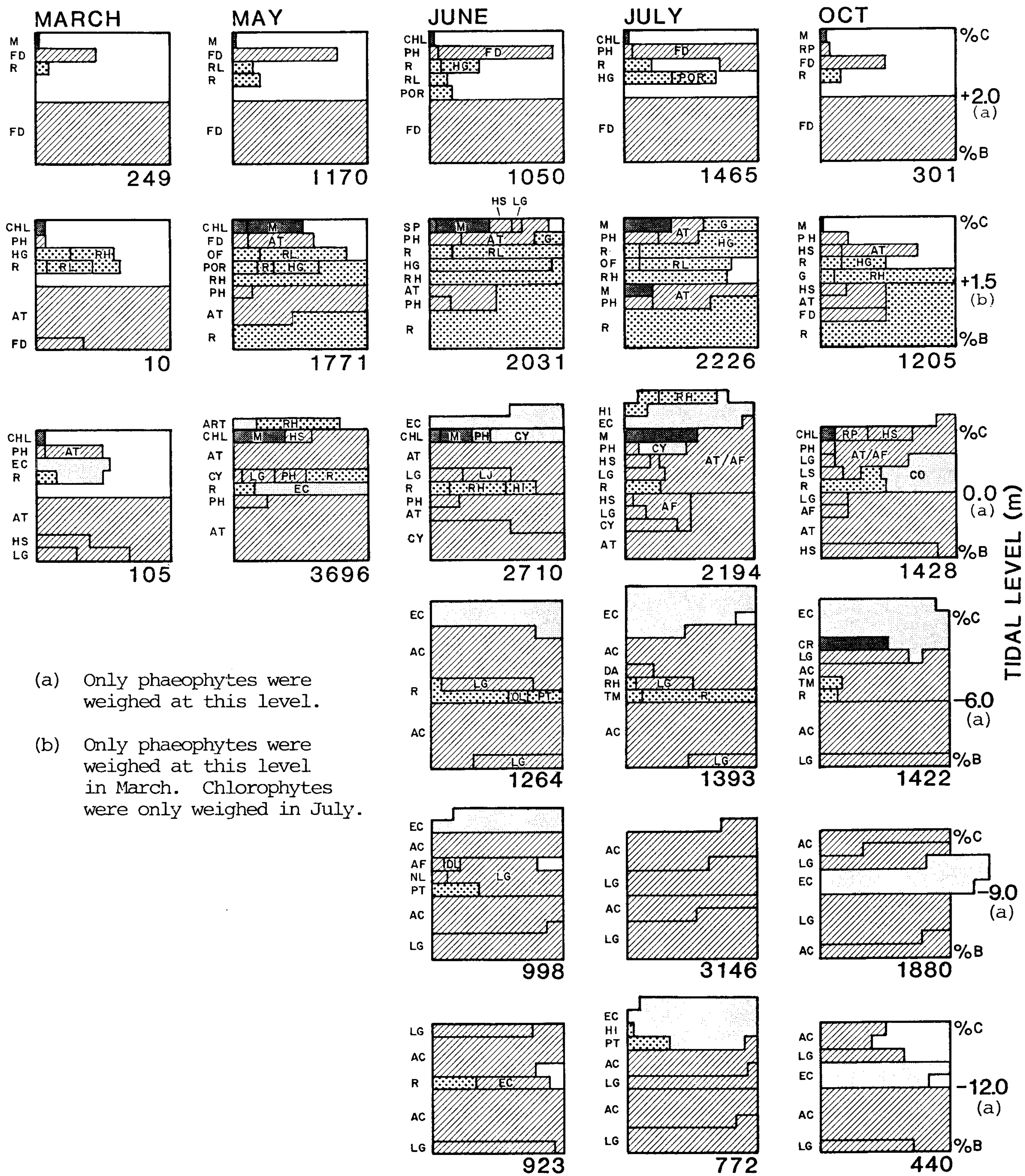


FIGURE 6-4

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 6-5

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

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 6-6 and 6-7). 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 6-6), 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 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 6-6 and 6-7).

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 6-6 and 6-7).

+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 6-8 and 6-9, Figures

TABLE 6-6 SELDOVIA POINT INTERTIDAL INVERTEBRATE DOMINANTS, 1977

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
+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 6-6 SELDOVIA POINT INTERTIDAL INVERTEBRATE DOMINANTS, 1977

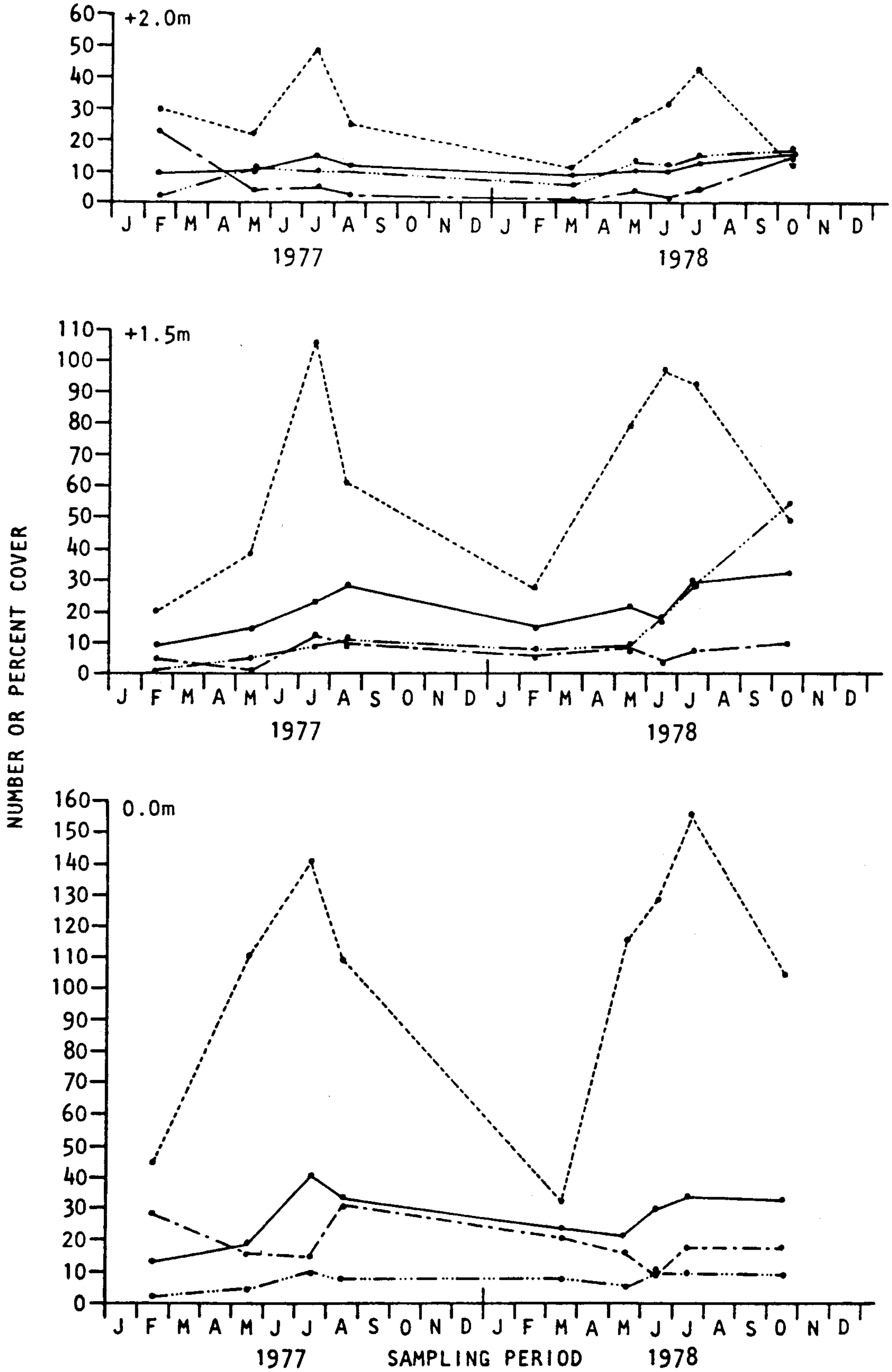
Sheet 2 of 2

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

TABLE 6-7 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	44.4	100.8	66.8	108.8	99.6
Anthozoa[a]	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	37.6	44.8	52.8	65.2	91.6
Anthozoa[b]	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	14.8	13.2	14	36.0	7.0
Anthozoa[b]	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.



KEY:
TOTAL PERCENT ALGAL COVER ....
TOTAL ANIMAL SPECIES ————
AVERAGE PERCENT ANIMAL COVER —·—·—
ANIMAL DENSITY NO./m^2 x 10 —···—···—

FIGURE 6-6

TRENDS IN COMMUNITY PARAMETERS AT SELDOVIA POINT IN 1977-1978

TABLE 6-8 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^2	%	gm/m^2
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 6-9 SELDOVIA POINT ALGAL COVER AND BIOMASS BY CLASS, 1978

	Tide Level					
	+2 m		+1.5 m		+0.0 m	
Month/Taxon	%	gm/m^{2}(a)	%	gm/m^{2}	%	gm/m^{2}(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

6-4 and 6-5). Reduction in standing crop began by August; 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.

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 crossed laterally 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 6-8 and 6-9).

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 6-6), 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 6-8, 6-9). 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 6-6). Laminarians accounted for greater than 90 percent of algal biomass at this level with the remaining portion about equally split between reds and greens. Average algal biomass peaked at 5,588 g/m^2 in July 1977 and 3,696 g/m^2 (phaeophytes only) in May 1978 (Tables 6-8 and 6-9).

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 6-5, 6-6) 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

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* The fixed pin at this level was actually at about +0.3 m 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.

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 6-6). Moreover, no one or two animals were vastly more abundant than all others as occurred with limpets and Siphonaria at higher levels.

6.1.2 West Side of Lower Cook Inlet

6.1.2.1. Scott Island

No previous detailed ecological surveys of Scott Island have been conducted. Based on aerial surveys, Dames & Moore (1977a) 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 (2292 g/m^2) was recorded in July (Table 6-10). 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 transect at this level included a fairly broad (2 - 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 contribute a total coverage of about 55 percent when averaged over the entire sampling period. These included Rhodomela larix and Odonthalia floccosa (to 18.2 percent), and encrusting corallines (to 4.9 percent); 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 6-11). 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 Nucella 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.

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

TABLE 6-10

SCOTT ISLAND ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

Month Taxon	"Fucus" %	"Fucus" gm/m^{2} (b)	"Rhodymenia" %	"Rhodymenia" gm/m^2	"Laminarian" %	"Laminarian" 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.

TABLE 6-11 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
	"Rhodymeria" 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
	"Laminarian" 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 "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. palmata (up to 64.3 percent) and R. liniformis (up to 74.2 perent). Maximum biomass for red algae was 4.6 kg/m^2 in June (Table 6-10). Other plants that contributed significantly to the vegetative assemblage at this level included Fucus (up to 1019 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 6-11); neither appeared to contribute appreciably. Motile forms were likewise sparse. Only limpets (Acmaridae) were consistently present throughout the sampling period with greatest numbers (4.7/m^2) in September. Hermit crabs were not present in spring and early summer but increased to 10.6/m^2 (2 spp) by September.

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 supported 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, occurring mainly in the pools, was a dominant plant (up to 43.3 percent cover and 1873.4 g/m^2) but the red algae Rhodymenia palmata (38 percent cover) and R. liniformis (up to 20 percent cover), occurring mainly on emergent rocks, 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 1.0 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 Pagarus beringanus, and the helmet crab Telmessus cheiragonus (Table 6-11). As in the Rhodymenia zone, few species were present throughout the study period and there was a general increase in density of most animals through the summer.

6.1.2.2 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 hogback in an area of maximum development of the "Fucus" zone. Fucus maintained 45 percent coverage 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 6-12). Other important algae at this level included an unidentified encrusting green alga (to 4.7 percent), the red alga Rhodomela larix (to 25.7 percent), and an unidentified red algal film (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.

TABLE 6-12 KNOLL HEAD ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

	Zone					
	"Fucus"		"Transition"		"Rhodymenia"	
Month Taxon	%	gm/m^{2} (b)	%	gm/m^2	%	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.

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 (to 15.8 percent) and C. dalli (to 8.4 percent). Motile organisms included the grazing snail L. sitkana, which was abundant (although not enumerated) and was observed laying eggs in June. Other grazers included a few limpets (Acmaeidae to 46.7/m^2) and very few chitons. The predaceous gastropod Nucella emarginata was very common (to 28.8/m^2), 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 6-12). Fucus also contributed appreciably to cover and biomass (up to 31.8 percent and 992.2 g/m^2) occurring primarily on dryer upper surfaces. 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 primarily in moist crevices. The red Gigartina papillata was fairly common in all surveys (up to 18.1 percent).

Very few animals were found at this level (Table 6-13). The only taxa consistently observed were the sponge Halichondria (up to 4.3 percent cover), amphipods, the hermit crabs Pagarus 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 Rhynochozoon bispinosum (up to 7.6 percent cover). Many of these species were most common in September, but densities were quite low for all invertebrates.

The "Rhodymenia" Zone

The substrate at a lower level was 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

TABLE 6-13 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
P. beringanus	0.7	0.7	3.2
	"Rhodymenia" zone		
(% Cover)			
Rhynchozoon bispinosum	0.5	1.0	4.8
(#/m^2)			
Acmaeidae	2.0	0	3.2
?Dendrodoa pulchella	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

the highest prominences. This level supported the lushest development of algae biomass (up to 4.01 kg/m^2 by June; Table 6-12) at this site, mainly from the contribution of R. palmata.

The fauna was sparsely developed (Table 6-13). 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 Dendroboa pulchella (up to $3.3/m^2$). Many 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. However, large areas were devoid of macroalgae despite the scarcity of herbivores. The horse mussel Modiolus modiolus was present in the lowest channels although beds were not dense; shell debris indicated recent mortality. Large anemones (Tealia and Cribrinopsis) were common in protected areas under boulders. Several starfish (Henricia leviusculus, Solaster stimpsoni, and Leptasterias ?hylodes) were observed. Other species seen included the thatched barnacle B. cariosus, the lined chiton Tonicella lineata, and a greenling Hexagrammos sp.

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 increasingy less important at lower levels (Table 6-12).

6.1.2.3 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 4.2.4). Coverage by the rockweed *Fucus distichus* increased from 18 to 28 percent from June to September 1978 with maximum biomass (993.8 g/m^2) in July. Several red algae including *Rhodomela larix* (to 4.6 percent), unidentified polysiphonous forms (Rhodomelacea; to 1.4 percent) and encrusting corallines (to 1.8 percent) were also common, primarily in small tide pools and moist crevices (Table 6-14).

The fauna at this level, as was typical of the "*Fucus*" zone elsewhere on the west side, was somewhat sparse. *Balanus glandula* (to 36 percent cover in July; Table 6-15) and *Chthamalus dalli* (to 3.9 percent cover in July) were the only significant sessile forms. *Nucella emarginata* were numerous (to 63.6/m^2 in August, mostly juveniles) 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.

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.

TABLE 6-14 WHITE GULL ISLAND ALGAL COVER AND BIOMASS BY MAJOR TAXON, 1978

Month Taxon	"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	1527.1
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	2682.7
Rhodophyta				
encrusting corallines	1.0	--	10.3	--
other	7.0	--	44.4	784.2
Total	46.8	993.8	144.1	3495.5
September				
Chlorophyta				
encrusting	0.2	--	0.9	--
other	--	--	0.4	--
Encrusting reds & browns	6.7	--	3.2	--
Phaeophyta	28.2	869.0	41.5	1104.8
Rhodophyta				
encrusting corallines	1.8	--	4.5	--
other	4.8	--	19.4	293.1
Total	41.7	869.0	69.9	1379.9

(a) Includes *Ralfsia pacifica* and other unidentified Rhodophyta and Phaeophyta.

(b) Only Phaeophyta weighed at this level.

TABLE 6-15 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 transect 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 19.3 percent in July), 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 $39.6/m^3$) 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; and Constantinia simplex) 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, $27.6/m^2$) and starfish (Leptasterias ?hexactis, to $12.4/m^2$) ranged throughout this sampling level, probably in response to barnacle density, but generally seeking 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.

6.1.3 Comparisons of Intertidal Study Sites by Numerical Parameters

The intertidal sampling program produced a substantial quantity of numerical data in several categories, namely, number of algal species per quadrat, algal cover, algal biomass, number of animal species per quadrat, animal cover, and animal density. Sampling was stratified by elevation at each study site, thus permitting evaluation of the data by analysis of variance (ANOVA) techniques. These data, summarized in Tables 6-16 through 6-21, were evaluated with a factorial ANOVA (Steel and Torrie 1960) and the Student's t-test. The significance levels of the comparisons are summarized in Table 6-22.

Examination of Tables 6-16 to 6-21 reveals inconsistencies in available data for the study sites and these, in turn, highlight some of the differences in the structure, species composition and appearance of the biological assemblages at the various sites. For example, algal species characterizing the various zones examined were substantially different at Knoll Head Lagoon and White Gull Island from the other sites. At Gull Island, Seldovia Point and Scott Island the three major algal assemblages discerned were strongly and recognizably dominated by Fucus, Rhodymenia and laminarian kelps, respectively. In contrast, at Knoll Head Lagoon, a transition assemblage including both Rhodymenia spp and kelps was found at the intermediate level sampled. At the lowest level sampled, Rhodymenia supplanted the usual kelps which were found only in surge channels at very low elevations. At White Gull Island, a similar transition assemblage was found at the intermediate level, and the lower level was absent because a sheer rock face extended from the intermediate level to a depth of about 10 m.

All potential comparisons were not made. For instance, parameters were not compared between Gull Island and Seldovia Point. Furthermore, lack of

TABLE 6-16 AVERAGE NUMBER OF ALGAL SPECIES (NUMBER/0.25 m^2) IN INTERTIDAL SURVEYS IN 1978

Site	Zone			
	Fucus	Transition	Rhodymenia	Laminarian
East Side	4.8 ± 2.1	--	7.3 ± 2.7	8.4 ± 2.8
Gull Island	5.6 ± 1.5	--	6.0 ± 2.6	8.6 ± 3.3
Seldovia Point	4.1 ± 2.3	--	8.1 ± 2.4	8.2 ± 2.6
West Side	6.4 ± 2.9	11.3 ± 3.4	9.3 ± 2.6	10.1 ± 2.9
Scott Island	6.9 ± 3.1	--	8.8 ± 2.4	10.1 ± 2.9
Knoll Head	7.5 ± 2.2	12.5 ± 3.1	10.1 ± 2.7	--
White Gull Island	4.9 ± 2.4	10.5 ± 3.4	--	--
Overall - 7.6 ± 3.4	5.6 ± 2.6	11.3 ± 3.4	8.1 ± 2.8	8.9 ± 2.9

TABLE 6-17 AVERAGE RELATIVE COVER (%) BY ALGAE IN INTERTIDAL SURVEYS IN 1978

Site	Zone			
	Fucus	Transition	Rhodymenia	Laminarian
East Side	25.6 ± 25.7	--	54.1 ± 37.3	99.4 ± 55.7
Gull Island	26.9 ± 28.3	--	29.7 ± 20.7	85.2 ± 35.0
Seldovia Point	24.5 ± 23.4	--	68.5 ± 37.5	107.7 ± 63.8
West Side	82.2 ± 44.0	145.6 ± 58.5	141.9 ± 47.2	108.9 ± 56.1
Scott Island	106.8 ± 34.1	--	127.3 ± 48.3	108.9 ± 56.1
Knoll Head	91.8 ± 44.2	175.0 ± 47.8	165.4 ± 35.0	--
White Gull Island	44.1 ± 26.1	127.7 ± 57.9	--	--
Overall - 82.9 ± 60.4	53.0 ± 45.6	145.6 ± 58.5	87.1 ± 59.3	102.5 ± 55.8

TABLE 6-18 AVERAGE BIOMASS OF ALGAE (g/0.25 m^2) IN INTERTIDAL SURVEYS IN 1978

Site	Zone: Fucus	Transition	Rhodymenia	Laminarian*
East Side	211.8 ± 307.4	--	401.0 ± 360.5	512.3 ± 615.7
Gull Island**	--	--	--	--
Seldovia Point	211.8 ± 307.4	--	401.0 ± 360.5	512.3 ± 615.7
West Side	349.7 ± 268.2	637.5 ± 327.5	844.3 ± 393.5	625.7 ± 510.1
Scott Island	462.5 ± 300.4	--	849.3 ± 444.1	625.7 ± 510.1
Knoll Head	357.8 ± 245.2	834.0 ± 201.2	836.7 ± 314.9	--
White Gull Island	200.8 ± 149.9	518.3 ± 334.3	--	--
Overall - 482.1 ± 435.7	300.4 ± 289.4	637.5 ± 327.5	611.0 ± 435.6	558.5 ± 574.4

* Only kelps collected at this level; biomass of other algae at this level was insignificant

** Algae not collected for biomass in 1978

TABLE 6-19 AVERAGE NUMBER OF ANIMAL SPECIES (NUMBER/0.25 m^2) IN INTERTIDAL SURVEYS IN 1978

Site	Zone			
	Fucus	Transition	Rhodymenia	Laminarian
East Side	5.2 ± 2.2	--	9.5 ± 3.7	11.6 ± 4.6
Gull Island	6.3 ± 1.5	--	10.7 ± 2.6	15.7 ± 3.6
Seldovia Point	4.5 ± 2.4	--	8.7 ± 4.1	9.1 ± 3.3
West Side	7.0 ± 2.2	9.5 ± 4.9	3.9 ± 3.3	5.2 ± 3.4
Scott Island	6.8 ± 2.5	--	3.1 ± 2.7	5.2 ± 3.4
Knoll Head	7.5 ± 2.1	5.1 ± 3.3	5.2 ± 3.8	--
White Gull Island	6.9 ± 1.9	12.2 ± 3.7	--	--
Overall - 7.6 ± 4.3	6.1 ± 2.4	9.5 ± 4.9	7.4 ± 4.4	9.5 ± 5.2

TABLE 6-20 AVERAGE RELATIVE COVER (%) BY ENCRUSTING ANIMALS IN INTERTIDAL SURVEYS IN 1978

Site	Zone			
	Fucus	Transition	Rhodymenia	Laminarian
East Side	36.1 ± 40.8	--	29.7 ± 32.7	24.8 ± 21.1
Gull Island	77.2 ± 23.6	--	65.3 ± 24.0	40.5 ± 20.8
Seldovia Point	2.4 ± 6.0	--	9.1 ± 13.8	16.3 ± 15.9
West Side	20.3 ± 15.5	24.7 ± 23.0	3.8 ± 6.1	3.3 ± 5.7
Scott Island	12.7 ± 11.2	--	4.0 ± 7.0	3.3 ± 5.7
Knoll Head	17.3 ± 8.7	5.9 ± 7.4	3.5 ± 4.2	--
White Gull Island	32.0 ± 17.4	36.1 ± 21.8	--	--
Overall - 23.2 ± 28.1	28.2 ± 31.9	24.7 ± 23.0	20.0 ± 29.0	17.7 ± 20.3

TABLE 6-21 AVERAGE DENSITY OF MOTILE EPIFAUNAL ANIMALS (NUMBER/0.25 m^2) IN INTERTIDAL SURVEYS IN 1978

Site	Zone			
	Fucus	Transition	Rhodymenia	Laminarian
East Side	42.9 ± 32.7	--	103.1 ± 174.8	69.6 ± 92.2
Gull Island	60.6 ± 29.0	--	172.8 ± 257.1	156.8 ± 103.1
Seldovia Point	32.0 ± 30.3	--	61.6 ± 75.1	17.7 ± 7.9
West Side	18.1 ± 11.9	13.5 ± 14.8	2.1 ± 2.6	3.3 ± 3.6
Scott Island	19.7 ± 12.9	--	1.8 ± 2.1	3.3 ± 3.6
Knoll Head	17.7 ± 9.3	2.3 ± 2.1	2.5 ± 3.1	--
White Gull Island	16.3 ± 12.4	20.4 ± 15.0	--	--
Overall - 42.0 ± 89.2	29.7 ± 27.0	13.5 ± 14.8	64.2 ± 145.4	48.1 ± 81.8

TABLE 6-22 SUMMARY OF LEVELS OF SIGNIFICANCE INDICATED BY ANALYSIS OF VARIANCE (ANOVA) AND STUDENT'S T-TEST EVALUATING THE DISTRIBUTION PATTERNS OF SELECTED NUMERICAL PARAMETERS FOR INTERTIDAL STUDY SITES IN LOWER COOK INLET, 1978. VALUES IN TABLE REPRESENT THE PROBABILITY OF THE NULL HYPOTHESIS, I.E., THAT THE DIFFERENCES OBSERVED ARE DUE TO RANDOM VARIATION

	ANOVA							Student's t-Test	
		Both Sides			West Side				
	Among all Sites	Overall	By Site	By Zone	Overall	By Site	By Zone	Between East and West Side	Between Scott Is. and Knoll Head Lagoon
Number of Algal Species	<0.0001	--	--	--	0.001	0.001	0.001	<0.0001	0.018
Algal Cover	<0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001	0.002
Algal Biomass	<0.0001	--	--	--	0.001	0.001	0.001	<0.0001	0.693
Number of Animal Species	<0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.123
Cover by Encrusting Animals	0.0085	0.001	0.001	0.001	0.001	0.001	0.001	<0.0001	0.102
Density of Motile Epifaunal Animals	0.0011	0.001	0.001	0.023	0.001	0.007	0.001	0.0001	0.727

completeness in data precluded comparisons among the three sites on the west side. Finally, data were not compared among zones for all study sites.

All comparisons between the east and west sides must be tempered by an important consideration; namely, that sampling sites on the east side were examined in four seasons whereas those on the west side were only examined in spring and summer. Consequently, east side values are relatively lower than those for the west side because winter and fall values are generally lower. This is particularly true of algal parameters such as relative cover and biomass.

6.1.3.1 Number of Algal Species

The overall average number of algal species (species richness) observed in 0.25 m^2 quadrats at intertidal sites in 1978 was 7.6 (Table 6-16). Species richness varied significantly overall (ANOVA; $P<0.0001$). Species richness also varied significantly between the east and west sides (Student's t-test; $P<0.0001$); it was higher at sites on the west side (Table 6-16). Plant species richness varied significantly at the west side study sites over all observations, by site and by zone (ANOVA; $P=0.001$ in all cases). The differences among sites on the west side are not clear because of data gaps, but analysis with a Student's t-test indicates that species richness was significantly higher at Scott Island than at Knoll Head Lagoon ($P=0.018$). Species richness consistently increased from the *Fucus* zone to the laminarian zone on both sides of the inlet (Table 6-16), except in the transition zone, noted above to include species from both the *Rhodymenia* and laminarian zone.

6.1.3.2 Algal Cover

The overall average for relative cover by algae at intertidal sites in 1978 was 82.9 percent (Table 6-17). Algal cover varied significantly overall (ANOVA; $P<0.0001$). Algal covers also varied significantly between the east and west sides (Student's t-test; $P<0.0001$); it was higher at sites on the west side (Table 6-17). Algal cover varied significantly over all observations, by site and by zone for all data combined and at the west side study sites (ANOVA; P=0.001 in all cases). The differences among sites on the west side are not clear because of data gaps, but analysis with a Student's t-test indicates that algal cover was significantly higher at Knoll Head Lagoon than at Scott Island (P=0.002). Plant cover generally was higher at Seldovia Point than at Gull Island in 1978. Algal cover generally increased from the *Fucus* zone to the laminarian zone on both sides of the inlet (Table 6-17), but again, the transition zone was an exception.

6.1.3.3 Algal Biomass

The overall average for algal biomass at intertidal sites in 1978 was 482.1 g/0.25 m^2, or 1928.4 g/m^2 (Table 6-18). Algal biomass varied significantly overall (ANOVA: P<0.0001). Algal biomass also varied significantly between the east and west sides (Student's t-test; P<0.0001); it was higher at sites on the west side (Table 6-18). Algal biomass varied significantly at the west side study sites over all observations, by site and by zone (ANOVA; P=0.001 in all cases). The differences among sites are not clear because of data gaps, but analysis with a Student's t-test indicates no significant differences between algal biomass at Scott Island and Knoll Head Lagoon (P=0.693). Algal biomass generally was lowest in the *Fucus* zone but data gaps cloud the patterns at lower levels (Table 6-18).

6.1.3.4 Number of Animal Species

The overall average number of animal species (species richness) observed on 0.25 m^2 quadrats at intertidal sites in 1978 was 7.6 (Table 6-19). Species richness varied significantly overall (ANOVA; P<0.0001). Species richness also varied significantly between the east and west sides (Student's t-test; P<0.0001); it generally was higher at sites on the east side (Table 6-19). Species richness varied significantly over all observations by site and by zone for all data combined and at the west side study sites (ANOVA; P=0.001 in all cases). Animal species richness was consistently higher at Gull Island than at Seldovia Point, but the differences among sites on the west side are not clear because of data gaps; analysis with Student's t-test suggests that species richness did not vary significantly between Scott Island and Knoll Head Lagoon (P=0.123). Species richness increased consistently from the *Fucus* zone to the laminarian zone at both study sites on the east side of the inlet, but no clear pattern was apparent at the west side sites (Table 6-19).

6.1.3.5 Cover by Encrusting Animals

The overall average for relative cover by encrusting animals (mainly barnacles, mussels and sponges) at intertidal sites in 1978 was 23.2 percent (Table 6-20). Epifaunal cover varied significantly overall (ANOVA; P=0.0085). Cover also varied significantly between the east and west sides (Student's t-test, P<0.0001); it was higher at sites on the east side (Table 6-20). Epifaunal cover varied significantly over all observations, by site and by zone for all data combined and on the west side of the inlet (ANOVA: P=0.001 for overall and by site, P=0.006 by zone). Cover by encrusting animals was substantially higher at Gull Island than at Seldovia Point and all other sites. It also was higher at White Gull Island than at the other west side sites (Table 6-20). Cover by encrusting epifaunal animals was highest in the *Fucus* zone on both sides of the inlet and generally decreased evenly toward the laminarian zone (Table 6-20). A notable exception occurred at Seldovia Point, where cover by *Balanus glandula* was low in the *Fucus* zone and *B. cariosus* was abundant in the laminarian zone.

6.1.3.6 Density of Motile Epifaunal Animals

The overall average density of motile epifaunal animals (mainly chitons, limpets and periwinkles) was 42.0/0.25 m^2, or 168/m^2 (Table 6-21). Animal density varied significantly overall (ANOVA; P=0.001) and between east and west sides of the inlet (Student's t-test; P<0.0001); it was considerably higher on the east side (Table 6-21). Animal density varied significantly over all observations, by site and by zone, for all data combined, and on the west side of the inlet (ANOVA; P=0.001 for all cases except P=0.023 for both sides, by zone). Animal density at Gull Island was substantially higher than at Seldovia Point and all other sites. It also was higher at White Gull Island than at the other west side sites (Table 6-21). Motile epifaunal animals were generally more abundant at the lower levels than at the upper levels.

6.1.3.7 Summary of Tests of Significance

Data indicating the levels of significance of variations observed in the numerical parameters for these study sites are summarized in Table 6-22. Basically, these data indicate several strong patterns. The data for all parameters exhibit broad overall variability, but are sufficiently consistent within each study site to create statistically significant differences. The only comparisons tested, that did not exhibit significant differences were comparisons of algal biomass, species richness of animals, cover by encrusting animals and density of motile animals between Scott Island and Knoll Head Lagoon (Table 6-22).

6.2 ROCKY SUBTIDAL HABITATS

6.2.1 East Side of Cook Inlet

6.2.1.1 Seldovia Point

The study sites were generally located along the southwestern edge of the large kelp bed extending between Seldovia Point and Barabara Point (Figure 4-1) in the approximate area studied by Dames & Moore (1976a). Although the main canopy of this kelp bed is formed by *Nereocystis* (personal observation), in areas exposed to strong tidal currents the borders are dominated by *Alaria fistulosa* out to a depth of about 11 m. Neither of these species was sufficiently dense in this kelp bed to form a canopy in water much deeper than 12 m or shallower than about 5 m.

Subtidal biological assemblages between depths of 6 and 18 m at Seldovia Point were examined during eight survey periods in 1977 and 1978. During 1977, stations were located by triangulation on prominent terrain features. However, the inaccuracy of this navigation technique, together with the naturally high variability of the subtidal assemblages, combined to produce a higher degree of variation in the data than was desired. Consequently, in 1978 we established permanent stations by installing sonar beacons and transect lines to facilitate relocation of the sites and monitoring of various animal and plant populations. However, this effort was only marginally successful because of poor weather and equipment failure.

Initially, a principal consideration used in determining station locations was to obtain data on the kelp assemblage across a broad depth gradient. Depths selected were 6 m, 12 m, and 18 m, and we assumed that at least one of the shallower stations would be located within the area circumscribed by the surface canopy. We had sampled in two periods in 1977 (February and May) before the surface canopy developed to the extent that it became apparent it was located between the inner stations. We continued sampling at the original sites through 1977 to obtain data on a full algal cycle, but in 1978 we discontinued the 18-m station and added a 9-m station in the area of the surface canopy. However, the edge of the kelp bed is patchy and unpredictable from year to year, and unfortunately, the permanent station markers were not under the canopy during 1978.

As a consequence of these problems, the data contain gaps and variability is higher than is desirable. However, several patterns are fairly clear and the data permit useful descriptions and predictions concerning the flora and fauna associated with kelp beds in Kachemak Bay.

Flora

As in the intertidal zone, kelps dominate the subtidal algal asemblages visually, in biomass, and probably in terms of function. The magnitude of this dominance is apparent in Figures 6-4 and 6-5 and Table 6-23. Two

TABLE 6-23 RELATIVE COVER, DENSITY AND BIOMASS OF MAJOR ALGAL TAXA AT OUR DEPTH LEVELS DURING 1977 AND 1978 AT SELDOVIA POINT

Survey Dates	Agarum % Cover	Agarum Density (No./m^2)	Agarum Biomass (g/m^2)	Laminaria % Cover	Laminaria Density (No./m^2)	Laminaria Biomass (g/m^2)	fleshy red algae	encrusting red algae
6-m Depth Level								
February 1977	31.0	13.5	681.2	3.9	5.7	38.3	1.3	37.4
May 1977	38.3	5.7	729.1	5.0	16.2	89.4	35.3	44.7
August 1977	43.0	3.1	897.2	-	1.2	18.7	21.5	50.2
September 1977	29.2	11.3	647.0	3.5	3.3	29.0	14.0	62.1
June 1978	80.7	43.4	1088.0	13.9	21.4	176.1	21.1	45.3
June-July 1978	62.3	26.9	1246.8	8.8	6.9	146.6	21.6	66.0
October 1978	57.8	25.4	1131.3	13.9	13.5	291.1	6.1	70.6
$\bar{x}$	48.9	18.5	917.2	8.2	9.7	112.7	17.3	53.8
s	18.8	14.2	240.9	4.8	7.4	99.1	11.3	12.5
9-m Depth Level								
November 1977*	1.9	0.7	24.9*	5.1	1.0	10.9*	3.1*	55.6*
June 1978	40.3	13.4	573.6	42.5	20.1	424.5	6.9	37.4
June-July 1978	58.3	13.4	969.6	47.5	17.4	2176.6	-	-
October 1978	26.2	17.5	454.6	30.6	39.8	1425.4	-	59.2
$\bar{x}$	41.6	14.8	665.9	40.2	25.8	1342.2	-	48.3
s	16.1	2.4	269.6	8.7	12.2	879.0	-	15.4
12-m Depth Level								
February 1977	43.6	7.8	36.5	7.3	7.5	171.8	1.7	32.3
May 1977	28.6	13.7	705.7	12.0	18.7	289.8	15.4	72.2
August 1977	25.3	6.3	412.6	30.2	8.6	749.5	-	40.0
November 1977	35.5	13.4	458.5	4.7	6.8	137.7	0.1	60.7
June 1978	60.9	10.7	747.9	15.8	4.0	175.5	7.2	49.4
June-July 1978	37.0	5.6	440.1	21.3	18.7	331.2	6.9	68.0
October 1978	18.0	10.5	376.9	7.6	13.0	63.0	0.4	37.0
$\bar{x}$	35.6	9.7	466.9	14.1	11.0	74.1	5.3	53.8
s	14.0	3.2	253.0	9.1	5.9	228.4	5.9	13.6
18-m Depth Level								
February 1977	20.0	9.3	207.4	3.6	2.7	80.0	0.1	28.9
May 1977	30.4	18.6	312.0	8.5	3.1	113.8	1.8	45.5
August 1977	23.4	7.2	245.4	2.4	0.9	3.3	2.2	58.3
November 1977	21.8	9.5	355.2	0.3	0.3	-	0.05	64.0
$\bar{x}$	23.9	11.2	280.0	3.7	1.8	49.3	1.0	49.2
s	4.6	5.1	66.2	3.5	1.4	56.7	1.1	15.6

* The nature of the biological assemblage at this study site differed considerably from that examined in subsequent surveys at this depth or elsewhere; these data were not to calculate any statistics.

very important species, Alaria fistulosa and Nereocystis luetkeana, were noted above, but useful data on relative cover, density or biomass at Seldovia Point were not collected.* However, data collected for Nereocystis at other sites (discussed in later sections on Barabara Point and NEGOA) indicate that standing stocks (and probably primary production) of bull kelp in an established canopy may be at least five times that of the understory species.

Among the understory kelps, Agarum cribrosum consistently appeared more abundant than Laminaria groenlandica in terms of relative cover and biomass (Table 6-23). These patterns held seasonally and across the depth gradient. Biomass and relative cover of Agarum decreased evenly from the 6-m level to the 18-m level (Table 6-23). The pattern was highly significant for biomass and marginally so for relative cover ($P<0.01$ and $P<0.1$, respectively; Kruskal-Wallis one-way analysis of variance). Biomass and relative cover of Laminaria were less evenly distributed; both parameters were highest at the 9-m level and lowest at the 18-m level. Both patterns were highly significant ($P<0.01$; Kruskal-Wallis ANOVA). The reason that the biomass of Laminaria was lowest at 6 m may be that the sampling sites, although not directly under the canopy, were often heavily shaded by the canopy. Foliose and filamentous red algae (e.g., Constantinea simplex, Turnerella mertensiana and Odonthalia kamtschatica) also decreased significantly in abundance from the 6-m level to the 18-m level ($P<0.05$; Kruskal-Wallis ANOVA). In contrast, the relative cover of encrusting red algae (e.g., encrusting coralline algae and Hildenbrandia) changed little across the depth gradient, and variability in cover was low; at all levels, approximately 50 percent of the rock substrate was covered by encrusting algae.

Total recorded biomass of the understory algae (i.e. species other than A. fistulosa and N. luetkeana) was highest at the 9-m level, where understory kelps averaged nearly 2 kg/m^2. These kelps averaged nearly 1 kg/m^2 at the 6-m level and declined to about 0.3 kg/m^2 at the 18-m level. If the canopy-forming species were included, biomass would be considerably higher at both the 6- and 9-m levels, probably averaging closer to 20 kg/m^2.

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* It should be noted that collection of suitable data of populations on these very large algae is a very time consuming activity requiring considerable logistical support.

Seasonal patterns are not clearly exhibited in the data, even though they were obvious to observers and were clear in the data for intertidal habitats (see Sections 6.1.1.1 - Gull Island and 6.1.1.2 - Seldovia Point). Two important reasons for the lack of clarity are inconsistency in sampling locations and the high degree of heterogeneity in the algal assemblage with the resultant variability of the data. As was the case in the intertidal zone, maximum cover and biomass was observed during mid to late summer. These parameters began to decrease from blade erosion and plant mortality during fall storms and declined until about March, when increased growth rates and recruiting sporophytes caused these parameters to increase.

Fauna

The faunal assemblage in the kelp bed off Seldovia Point is poorly developed in comparison with assemblages observed in the kelp beds at Jakolof Bay, along the northern side of Kachemak Bay (Archimandritof Shoals to Anchor Point; Dames & Moore 1976a; 1980), below the kelp beds on the west side of lower Cook Inlet, or in kelp beds along the shore of the Gulf of Alaska. Generally, species richness, density and biomass of motile and sessile epifaunal invertebrates were relatively low.

About 30 taxa were considered important at Seldovia Point based on frequency of occurrence, density or relative cover (Table 6-24). Molluscs and echinoderms appeared to be the dominant major taxa. Qualitatively, the invertebrate assemblage varied little across the depth gradient sampled; only a small number of species were not observed at all levels. Some of the more common and widely distributed species included the gastropods *Acmaea mitra*, *Fusitriton oregonensis*, the chitons *Tonicella insignis* and *T. lineata*, the arborescent bryozoans *Flustrella gigantea* and *Microporina borealis*, the sea stars *Crossaster papposus*, *Henricia leviuscula* and *H. sanguinolenta*, the sea urchin *Strongylocentrotus droebachiensis* and the colonial ascidian *Ritterella pulchra*. The butter clam *Saxidomus giganteus* was also an important infaunal form in unconsolidated substrate but was not consistently censused.

TABLE 6-24 DENSITY (NO./m^2) AND DEPTH DISTRIBUTION OF IMPORTANT SPECIES AT SELDOVIA POINT

	Depth (m)			
TAXA	6	9	12	18
PORIFERA - combined % cover*		1.2	2.5	2.3
CNIDARIA				
Abietinaria spp - % cover		1.0		1.2
MOLLUSCA				
Acmaea mitra	2.7	1.6	2.8	0.8
Acmaeidae, unid.	0.7			
Boreotrophon clathrus			0.9	
Calliostoma ligata				1.5
Cryptochiton stelleri			0.5	
Fusitriton oregonensis	0.5	0.4	1.4	0.7
Margarites pupillus			1.9	1.5
Saxidomus giganteus	58.8		12.0	19.2
Tonicella insignis	0.4	2.5	2.4	4.1
T. lineata	11.9	5.2	4.6	1.4
Trichotropis cancellata	1.1		1.3	
ARTHROPODA - Crustacea				
Elassochirus gilli	0.5			
Pagurus spp	2.0		0.8	
BRYOZOA				
Flustrella gigantea - % cover	1.5	6.2	15.5	18.8
Heteropora sp - % cover	0.5			0.4
Microporina borealis - % cover	0.2	3.6	2.4	2.6
ECHINODERMATA				
Crossaster papposus	0.2	0.1	0.4	0.09
Cucumaria miniata				0.08
Henricia leviuscula	0.1		0.1	0.02
H. sanguinolenta	0.3		0.4	0.02
Henricia spp			0.6	
Orthasterias koehleri				0.4
Pteraster tesselatus				0.01
Pycnopodia helianthoides				0.01
Solaster stimpsoni				0.01
Strongylocentrotus drobachiensis	6.5	3.3	1.5	1.3
S. franciscanus	0.5	0.01		0.01
UROCHORDATA - Ascidiacea				
Ritterella pulchra - % cover	1.5		0.5	0.3

* Unless indicated beside species name, numbers represent number per m^2.

Seasonal patterns in abundance of the invertebrates were not clearly demonstrated (Tables 6-25, 6-26, 6-27 and 6-28). This does not indicate the absence of such patterns but, rather, reflects deficiencies in the data from sampling problems (discussed above) and the difficulty of adequately sampling populations with low densities. Generally, our impression was that the invertebrates exhibited only small fluctuations in density or relative cover in contrast to seasonal changes in the algae and fishes (Dames & Moore 1979a). With the exception of the hydroids, bryozoans and colonial ascidians, most of the important invertebrates live at least several years.

Generally, herbivores were more common at the shallower levels and suspension feeders were more common at the deeper levels (Table 6-29). These abundance patterns seemed well correlated with depth, and it seems probable that they are influenced strongly by the development of the algal assemblage. Herbivores were more abundant in areas with higher biomass and density of algae. This relationship was particularly noticeable in the sea urchin S. droebachiensis, generally a macroherbivore (Table 6-29). The relationship was also clear for the microherbivorous chitons Tonicella insignis and T. lineata when combined, but these species have contrasting abundance patterns (Table 6-24). T. lineata is relatively more successful at the shallower levels; whereas T. insignis is more successful at the deeper stations. The main distinctions between micro and macroherbivores are the size of the algae consumed and the method of feeding. Microherbivores generally graze on filamentous forms such as juvenile sporophytes or gametophytes, and on algal films or encrustations, feeding by "licking" the rock surface with a rasp-like tongue. In contrast, macroherbivores generally feed on large pieces of drifting or attached kelp and do not routinely rasp the surface of the rock.

The suspension-feeding assemblage generally was poorly developed. Suspension feeders became more abundant as the kelp bed became thinner (in deeper waters), probably because of an inverse relationship between the development of a kelp bed and current velocity near the substrate. This relationship was particularly noticeable in the arborescent, fleshy bryozoan Flustrella gigantea (Table 6-24). The most important epifaunal suspension

TABLE 6-25 DENSITY (NO./m^2) OR RELATIVE COVER (%) OF IMPORTANT INVERTEBRATES DURING SURVEYS AT THE 6-m LEVEL OFF SELDOVIA POINT

TAXA	1977 2/10-12	1977 5/10-13	1977 8/4-5	1977 9/13	1978 6/1-2	1978 7/11-12	1978 10/30-11/8	Average Density or Cover
MOLLUSCA								
Acmaea mitra*	0	0.8	3.0	2.4	7.2	-	-	2.7
Acmaeidae, unid.	1.1	0	0	-	1.6	-	-	0.7
Fusitriton oregonensis	0.7	0.2	1.3	0.5	0	0.8	0	0.5
Saxidomus giganteus	-	58.8	-	-	-	-	-	-
Tonicella insignis	1.0	P	0	0	2.0	P	0	0.4
T. lineata	1.3	31.2	15.0	14.1	15.6	P	5.8	11.9
Tonicella spp	-	10.0	-	-	-	-	-	-
ARTHROPODA - Crustacea								
Elassochirus gilli	1.0	0.8	0.3	0	-	-	-	0.5
Pagurus spp	3.0	4.0	P	P	-	-	-	2.0
BRYOZOA								
Flustrella gigantea (% cover)	5.5	0.4	0.4	0.6	1.7	P	1.9	1.5%
Heteropora sp (% cover)	0.5	0.9	0.3	1.1	0.2	-	0	0.5%
Microporina borealis (% cover)	1.0	0	0	0	0.2	P	0	0.2%
ECHINODERMATA								
Crossaster papposus	0	0.04	0.2	0	0.4	-	0.4	0.2
Henricia leviuscula	0	0.02	0	0	0.4	-	-	0.1
H. sanguinolenta	1.0	0	0.2	0.2	0	-	-	0.3
Strongylocentrotus drobachiensis	2.2	5.3	12.5	6.4	4.8	8.0	-	6.5
S. franciscanus	0	0.03	P	0	0.4	2.4	-	0.5
UROCHORDATA - Ascidiacea								
Ritterella pulchra (% cover)	0.3	3.8	1.0	2.1	0.3	-	-	1.5%

* Unless indicated beside species name, numbers represent number per m^2.

TABLE 6-26 DENSITY (NO./m^2) OR RELATIVE COVER (%) OF IMPORTANT INVERTEBRATES DURING SURVEYS AT THE 9-m LEVEL OFF SELDOVIA POINT

TAXA	SURVEY PERIODS 1977 11/2-5	SURVEY PERIODS 1978 6/1	SURVEY PERIODS 1978 10/30-11/8	Average Density or Cover
PORIFERA				
Mycale lingua (% cover)	0	0.7	2.8	1.2%
CNIDARIA				
Abietinaria spp (% cover)	2.9	P	0	1.0%
MOLLUSCA				
*Acmaea mitra**	P	3.4	1.3	1.6
Fusitriton oregonensis	0.5	P	0.7	0.4
Tonicella insignis	0	7.4	0	2.5
T. lineata	3.0	12.0	0.7	5.2
BRYOZOA				
Flustrella gigantea (% cover)	3.1	5.6	10.0	6.2
Microporina borealis (% cover)	8.1	1.6	1.0	3.6
ECHINODERMATA				
Crossaster papposus	0.2	0	0	0.1
Strongylocentrotus drobachiensis	1.2	8.6	0	3.3
S. franciscanus	0.03	0	0	0.01

* Unless indicated beside species name, numbers represent number per m^2.

TABLE 6-27 DENSITY (NO./m^2) OR RELATIVE COVER (%) OF IMPORTANT INVERTEBRATES DURING SURVEYS AT THE 12-m LEVEL OFF SELDOVIA POINT

	SURVEY PERIODS							
	1977				1978			Average Density or Cover
TAXA	2/10-12	5/10-13	8/4-5	11/2-5	6/1-2	7/11-12	10/30-11/8	
PORIFERA								
Porifera, unid. (% cover)	4.2	0	2.5	2.7	3.3	5.0	0	2.5%
MOLLUSCA								
Acmaea mitra*	0	10.0	3.0	1.6	2.7	2.4	0	2.8
Boreotrophon clathrus	0	2.4	0	0	2.7	0	1.4	0.9
Cryptochiton stelleri	0.3	2.8	0.3	0	P	0	P	0.5
Fusitriton oregonensis	6.6	0.6	1.0	P	0	0.8	0.7	1.4
Margarites pupillus	0.4	4.0	P	P	P	-	5.3	1.9
Saxidomus giganteus	-	12.0	-	P	P	-	A	-
Tonicella insignis	1.3	4.0	0	1.6	6.7	2.4	0.7	2.4
T. lineata	1.6	16.0	4.0	2.0	4.0	1.6	2.7	4.6
Tonicella spp	-	8.0	-	3.6	-	-	-	5.8
Trichotropis cancellata	2.7	4.0	P	1.6	0	0.8	0	1.3
ARTHROPODA - Crustacea								
Pagurus spp	2.7	1.2	0	P	0	-	0.8	0.8
BRYOZOA								
Flustrella gigantea (% cover)	13.2	5.6	12.3	18.4	32	18	8.8	15.5%
Microporina borealis (% cover)	3.6	0.6	7.5	2.3	P	1.4	1.4	2.4%
ECHINODERMATA								
Crossaster papposus	P	0.07	1.0	0.4	0	P	P	0.4
Henricia leviuscula	P	0.03	0	P	0	0	0	0.1
H. sanguinolenta	P	0.04	P	P	1.3	P	P	0.4
Henricia spp	0.3	-	-	-	-	0.8	-	0.6
Strongylocentrotus drobachiensis	0.3	3.1	2.6	0.6	1.3	2.4	0	1.5
UROCHORDATA - Ascidiacea								
Ritterella pulchra (% cover)	0.3	3.3	0	0	P	0	0	0.5%

* Unless indicated beside species name, numbers indicate number per m^2.

TABLE 6-28 DENSITY (NO./m^2) OR RELATIVE COVER (%) OF IMPORTANT INVERTEBRATES DURING SURVEYS AT THE 18-m LEVEL OFF SELDOVIA POINT

TAXA	SURVEY PERIODS 1977 2/10-12	5/10-13	8/4-5	11/2-5	Average Density or Cover
PORIFERA					
Porifera, unid. (% cover)	P	5.3	1.7	2.1	2.3%
CNIDARIA					
Abietinaria sp (% cover)	0	0.8	3.3	0.5	1.2%
MOLLUSCA					
Acmaea mitra*	0	0.5	1.3	1.3	0.8
Calliostoma ligata	0	0.5	5.3	0	1.5
Fusitriton oregonensis	1.1	0.06	0	1.5	0.7
Margarites pupillus	P	2.4	3.3	P	1.5
Saxidomus giganteus	-	19.2	-	-	-
Tonicella insignis	0	10.4	0	6.0	4.1
T. lineata	0.6	1.6	0	3.5	1.4
Tonicella spp	0	2.5	6.0	5.8	3.6
BRYOZOA					
Flustrella gigantea (% cover)	18.0	21.7	12.8	22.8	18.8%
Heteropora sp (% cover)	0	0.9	0.2	0.6	0.4
Microporina borealis (% cover)	1.8	1.7	3.2	3.6	2.6
ECHINODERMATA					
Crossaster papposus	0	0.04	P	0.3	0.09
Cucumaria miniata	0	0.3	0	0	0.08
Henricia leviuscula	0	0.07	0	0	0.02
H. sanguinolenta	0	0.07	P	0	0.02
Henricia spp					
Orthasterias koehleri	0.6	0.2	0.7	0	0.4
Pteraster tesselatus	0	0.04	0	0	0.01
Pycnopodia helianthoides	0	0.02	P	0	0.01
Solaster stimpsoni	0	0.02	0	0	0.01
Strongylocentrotus drobachiensis	0.3	0.4	4.0	0.3	1.3
S. franciscanus	0	0.04	0	0	0.01
UROCHORDATA - Ascidiacea					
Ritterella pulchra (% cover)	0	0	1.2	0	0.3%

* Unless indicated beside species name, numbers indicate number per m^2.

TABLE 6-29 RELATIONSHIPS IN DENSITY (NO./m^2) OR RELATIVE COVER (%) AMONG THE MAJOR INVERTEBRATE CONSUMER CATEGORIES AT VARIOUS DEPTH LEVELS AT SELDOVIA POINT

CONSUMER GROUP	Depth (m) 6	9	12	18
Herbivores - total	22.7*	12.6	17.6	11.2
Microherbivore	15.7	9.3	15.6	12.9
Macroherbivore	7.0	3.3	2.0	1.3
Suspension feeder**	3.7%	12.0%	20.9%	26.6%
Predator/scavenger	3.6	0.5	4.6	1.3

* Numbers represent No./m^2 unless indicated otherwise.
** Excludes clams such as Saxidomus, which were not routinely censused.

feeders, in terms of biomass, were probably the bryozoans Flustrella and Microporina and the brittle star Ophiopholis.

The predator/scavenger assemblage generally was not well developed; densities were low, and the average animal size was small. Distribution patterns were unclear for the predator/scavengers. The major species included the snails Boreotrophon clathrus and Fusitriton oregonensis, hermit crabs, and the sea stars Crossaster papposus and Henricia sanguinolenta (Table 6-24). Except for Henricia, which apparently feeds on sponges, most of these species are generalists (i.e. non-specific feeders).

6.2.1.2. Barabara Bluff

The site surveyed at Barabara Bluff was a well-developed kelp bed located at the 10-m depth. The study site was high relief bedrock and boulders. As is typical of the kelp beds along the southern shore of Kachemak Bay, the site had a multilayered macrophyte assemblage. The floating canopy was formed solely by the bull kelp Nereocystis luetkeana. The species exhibited patchy distributions; average density ranged from 0.6 - 3.6/m^2. Standing crop averaged 5438.4 g/m^2 and ranged from 0 to 20 kg/m^2 (Table 6-30).

The algal understory was dominated by the kelps Agarum and Desmarestia, but their distribution was also quite patchy. Agarum, the major species, averaged 22.6 percent relative cover with 8/m^2; its standing crop averaged 312.8 g/m^2. Desmarestia aculeata, with 5.6 percent relative cover, averaged only 28 g/m^2. Laminaria groenlandica was sparse. Beneath the phaeophytes, the filamentous rhodophyte ?Pterosiphonia provided 37.2 percent relative cover.

Abundance was not recorded for the epifauna; however, a partial species list was obtained. Suspension feeders included the polychaete Thelepus cincinnatus, the bivalves Protothaca staminea and Saxidomus giganteus, the bryozoans Flustrella, Heteropora and Terminoflustra, the echiurid worm

TABLE 6-30 RELATIVE COVER, DENSITY AND BIOMASS OF MAJOR ORGANISMS IN BULL KELP BED NEAR BARABARA POINT ON 13 JULY 1978

ALGAE - Phaeophyta	
Agarum cribrosum - % cover	22.6 ± 27.7
no./m^2	8.0
g/m^2	312.8
Desmarestia aculeata - % cover	5.6 ± 5.7
g/m^2	28.0
Laminaria groenlandica - % cover	0.2 ± 0.6
no./m^2	0.2
g/m^2	1.2
Nereocystis luetkeana	
Adults - no./m^2	1.0
Juveniles - no./m^2	0.2
g/m^2	5438.4
ALGAE - Rhodophyta	
?*Pterosiphonia* sp - % cover	37.2 ± 25.4
MOLLUSKA - Polyplacophora	
Cryptochiton stelleri - no./m^2	0.2
ECHINODERMATA - Asterozoa	
Pycnopodia helianthoides - no./m^2	0.01
Strongylocentrotus drobachiensis - no./m^2	14.2

Bonelliopsis alaskana, the tunicates Distaplia occidentalis and Halocynthia aurantium, and the brittle star Ophiopholis aculeata.

The dominant grazer was the urchin Strongylocentrotus drobachiensis; average density was $14.2/m^2$. Other grazers included the molluscs Acmaea mitra, Tonicella lineata and T. insignis, and the red urchin S. franciscanus.

Predator/scavengers were plentiful; they included the hermit crab Elassochirus gilli, the shrimp Lebbeus grandimanus (in association with the anemone Cribrinopsis similis), the nudibranch Hermissenda crassicornis, the asteroids Crossaster papposus, Henricia sanguinolenta, Orthasterias koehleri and Pycnopodia helianthoides. Also observed were kelp and rock greenlings, the searcher Bathymaster caeruleofasciatus, a wolf-eel Anarrhichthys ocellatus, and several small rockfish of the genus Sebastes.

6.2.2 West Side of Lower Cook Inlet - Kamishak Bay

Studies on rocky sublittoral habitats in Kamishak Bay were conducted during summer 1978 and have been reported in detail by Dames & Moore (1980). Appropriate sections have been summarized and are presented herein for completeness. Six areas in the vicinity of Cottonwood Bay and Scott Island, including Scott Island, Knoll Head Lagoon, Black Reef, White Gull Island, and Turtle Reef, were surveyed at least once (Figure 4-1). Because of high turbidity, conditions generally were poor for conducting quantitative studies; thus, most of the data are of a qualitative nature.

6.2.2.1 Scott Island

In June 1978, we sampled the laminarian zone off the intertidal transect at Scott Island (Figure 4-1). At a depth of 2 m, Laminaria plants were of moderate size and appeared healthy. Plant density (including juveniles) ranged from $1.6 - 4/m^2$. Estimates of relative cover and biomass averaged 54 percent and $1040.6\ g/m^2$, respectively. Other algae present included Agarum, Desmarestia and four species of rhodophytes (Dames & Moore 1980).

The substrate out to a depth of 6 m in the channel offshore of the intertidal transect was a flat, current-swept sandy gravel with scattered cobble and boulders up to 2 m in diameter. Laminaria and Agarum, attached to small rocks or shell, were being swept along the bottom by tidal currents. Densities averaged 0.6 and $0.3/m^2$, respectively. Epifaunal animals, mostly clustered around large cobble, were sparse. Important suspension feeders included several species of bryozoans, the hydroid Abietinaria, two sabellid polychaetes and an unidentified ascidian. Important predators included the snails Neptunea lyrata and Fusitriton, and the asteroids Leptasterias spp and Henricia sanguinolenta.

On an isolated boulder about 2 m high in mid-channel, adult plants of Agarum and Laminaria and several rhodophytes were present. Important epifaunal forms included the sponge Mycale lingua, the hydroid Abietinaria gigantea, Balanus rostratus, spawning Fusitriton and large Strongylocentrotus drobachiensis. Also recorded were the greenlings Hexagrammos stelleri and H. octogrammus, the latter guarding an egg clutch in a colony of Abietinaria.

6.2.2.2 Knoll Head Lagoon

The study site at Knoll Head Lagoon was a narrow, rocky beach extending into the subtidal zone (Figure 4-1). Boulders were common on the bedrock at a 3-m depth, and the rock beach was replaced by a fine gravel/shell debris substrate with ripple marks at 7 m. During the reconnaissance dive on 11 June, it was noted that the assemblage varied from 100 percent cover by various algal species at 1-m depths to no algae and heavy cover by suspension feeders and grazers at 3.3-m depths.

In the shallow macrophyte zone, species of algae were common. The kelps Laminaria and Alaria praelonga were dominant forms. In August, these two species averaged 31.7 and 62.5 percent relative cover and 13.6 and 17.2 $/m^2$, respectively, at +0.3- to -0.6-m depths. Biomass estimates exceeded 1.5 kg/m^2 for each of these species. At -1.8 m, average densities decreased to a range of 0.8 to $1/m^2$ for Alaria and 4.6 to $8/m^2$ for Laminaria. Agarum became more common with greater depth but was relatively insignificant below the 3-m depth.

Directly below the algal belt large species of the anemones *Tealia crassicornis* and *Cribrinopsis similis* were abundant. With increasing depth below the algal belt, hard substrate supported a rich diversity of suspension feeders. *Modiolus* was patchy, but extremely dense patches were observed. Estimated average density in an aggregation at -1.8 m was $261/m^2$. An additional 22 species of suspension feeders were recorded. Some of the major species were *Balanus rostratus alaskensis*, hydroids (*Abietinaria* spp), the sponges *Halichondria panicea* and ?*Mycale lingua*, and in deeper areas the bryozoan *Costazia* ?*surcularis*.

Thirty-one species of predators and grazers were observed. At -1.8 m, grazers, including the chitons *Tonicella lineata* ($23/m^2$) and *Mopalia* sp ($4/m^2$), and the gastropod *Trichotropis insignis* ($8/m^2$) were most abundant. Also abundant at this depth was the hermit crab *Pagurus hirsutiusculus* ($5/m^2$) and the small anemone *Anthopleura artemisia* ($8/m^2$).

At 3.6- to 4.8-m depths, areas of the cobble/gravel substrate were impoverished while bedrock and boulders had moderate epibiotic cover. Common species on the boulders included small *Agarum* and *Laminaria*, *Fusitriton oregonensis*, the bivalve *Pododesmus macroschisma*, the small asteroid *Leptasterias* ?*hylodes* and an occasional large *Strongylocentrotus drobachiensis*. Cobble/gravel substrate replaced rock below a depth of 5 m.

Fish were uncommon throughout the area. Density of the whitespotted greenling *Hexagrammos stelleri*, the most abundant fish, averaged $0.1/m^2$.

6.2.2.3 White Gull Island

Reconnaissance dives were made off the west or the lee side of White Gull Island in June, and along the exposed, east side of the island in August (Figure 4-1). Intertidally, the lee side of the island comprised two substrates, i.e., a coarse gravel beach and sheer rock faces. These substrates extended subtidally and then graded through an area of low-relief cobble and small boulders to small gravel and shell debris, finally turning into silt and gravel flats in the southern entrance channel.

The only organism observed on the intertidal gravel beach was Littorina. Macrophytes were first encountered in a gravel/shell debris flat with cobble and boulders at a depth of 1.1 m but only extended to a depth of 3.6 m. Important macrophyte species included Monostroma, Alaria taeniata, Desmarestia aculeata, and at a deeper depth, Agarum cribrosum, Laminaria groenlandica and saccharina. Numerous hydroid and bryozoan species, an orange, encrusting sponge and the bivalves Astarte sp and Macoma sp formed the suspension-feeding component of the assemblage. Predator/scavenger species included the gastropods Boreotrophon sp, Buccinum glacialis, Natica clausa and Neptunea ?lyrata, three species of Leptasterias and whitespotted greenlings.

The deeper portions of the entrance channel were mainly a small gravel/ shell debris flat. Near slack tide, a fine, flocculent layer of silt covered the bottom. Below -2.8 m, the flat was completely devoid of macroalgae. One of the more important epifaunal species was the sabellid polychaete Schizobranchia ?insignis. This tubicolous suspension feeder was observed in dense clusters up to 1.3 m in diameter and extending 0.3 m above the bottom. In addition, the macrofauna comprised numerous other deposit and suspension feeders, including the anemone Tealia ?lophotensis, a terebellid polychaete, the hydroids Abietinaria spp and ?Obelia sp, the bryozoans Dendrobeania murrayana and Eucratea loricata, and the bivalve Clinocardium sp. Predators included the hermit crabs Elassochirus tenuimanus and Pagurus ochotensis, the gastropods Neptunea lyrata and Oenopota spp, the large asteroid Leptasterias polaris acervata, whitespotted greenlings and rock soles. Hermit crabs and Neptunea were occasionally observed in the midst of the sabelled clumps; both groups are reported to feed on Schizobranchia in this manner (Dames & Moore 1980; Shimek, personal communication).

The exposed, east side of White Gull Island comprises a broad intertidal bedrock shelf which abruptly breaks into a vertical face at approximately 1.6 m below MLLW. A steep talus slope commences at 4.4 to 5.4 m below MLLW and continues down to about 11.1 m below MLLW, where a gravel/shell debris flat was encountered.

Although Alaria and Laminaria were abundant atop the bench, macrophytes were generally absent below its edge. On the vertical rock face, suspension feeders dominated. Young specimens of the anemone Metridium senile (<10 cm high) were the most abundant forms. Also common were the small sea cucumber Eupentacta quinquesemita, the anemones Tealia crassicornis and Cribrinopsis sp, several species of sponge, hydroids, bryozoans and tunicates and the predatory gastropods Neptunea and Fusitriton. Grazer species were uncommon.

The talus slope and boulder field were dominated by various suspension feeders. Important species included the orange, social tunicate, Dendrodoa pulchella, the bryozoan Costazia ?surcularis, the sponge Mycale and the barnacle Balanus rostratus. Coverage by these species was considerable; the epifaunal mat was complex.

6.2.2.4 Black Reef

Black Reef is a bedrock pinnacle surrounded by a talus slope (Figure 4-1). Subtidally, the reef has a vertical face with slight undercutting. The talus slope commences at a depth of about 4 to 6 m. With boulders up to 2 m in diameter and many crevices and small caves, surface relief is high. At about 9.3 m, rock gives way to a flat bottom of silty sand, gravel, and shell debris with small ripple marks. The reef is openly exposed to any wave action generated across lower Cook Inlet or from the intense "williwaw" winds jetting through the surrounding mountain passes.

The only significant macrophyte cover at the site occurred above a depth of 1.8 to 3.0 m. Dominant algae were Laminaria groenlandica, Alaria taeniata, Rhodymenia palmata, and encrusting coralline algae. Macrophytes were totally lacking below a depth of 4.7 m. Below the laminarian zone were the anemones Tealia crassicornis and Cribrinopsis, and below that, a band of the small, social tunicate Dendrodoa pulchella. The remainder of the rock face was dominated by various species of bryozoans, sponges and Balanus rostratus. Beneath the shallow overhangs, the sea cucumbers Psolus sp and Eupentacta, and the gastropods Calliostoma ligata and Margarites pupillus were reported. The grazers Tonicella spp, Mopalia spp and Ischnochiton trifidus were present but sparse. Finally, at the base of the face, many specimens of Boreotrophon clathrus were feeding on small patches of barnacles.

On the boulders at 4.7 m, a few Agarum and Rhodymenia plants were the only macrophytes present. The rock was covered mostly by Balanus rostratus, the digitate bryozoan Costazia ?surcularis, the sponges Mycale ?lingua and Halichondria panicea, the tunicate Dendrodoa pulchella, and encrusting coralline algae. Commonly observed under and around the boulders were the clam Mya truncata, the small decorator crab Oregonia gracilis, and the brittle star Ophiopholis aculeata. The latter was very abundant in crevices, among barnacles, in bryozoan colonies and crawling over rocks.

6.2.3 Northeastern Gulf of Alaska (NEGOA)

Subtidal rock habitats in several locations in or near the ocean entrances between NEGOA and Prince William Sound were examined on several occasions during 1978 and 1979 (Figure 4-4). Two surveys were conducted each year. However, weather conditions did not permit examination of each station during each survey. As a consequence, the data for most locations are somewhat spotty and seasonal variations are not well represented.

Nevertheless, these data provide some useful insights into seasonal patterns, zonation in shallow subtidal habitats, and species composition of the assemblages. Furthermore, integration of these data with descriptions from earlier work (Dames & Moore 1977c) provides some insight into long-term stability.

6.2.3.1 Zaikof Point, Montague Island

The biota at Zaikof Point (Figure 4-4) was among the richest observed during the NEGOA surveys. Approximately 180 species were identified, and numerous additional species were collected for lab identification. Some of the richer taxa included Mollusca, Echinodermata, Tunicata, Cnidaria and Bryozoa. The biota had a distinctly exposed-coast flavor, especially between depths of 1 and 7 m, where the flora was dominated by the kelps *Nereocystis*, *Laminaria dentigera*, *L. yezoensis*, and *Pleurophycus gardneri*, and the red algae *Ptilota* spp, and the epifauna was dominated by encrusting colonial tunicates. This impression was heightened by the frequent occurrence of the hydrocoral *Allopora californica*, the sea strawberry *Gersemia rubiformis* and the richness of the ascidian fauna.

Flora

Kelps dominated the flora out to a depth of about 12 m (Table 6-31). Plant biomass and relative cover were quite high out to about 7 m; dominant species were *Nereocystis*, *L. dentigera*, *L. groenlandica*, and *P. gardneri* (Table 6-31). *Laminaria dentigera* declined in importance below about 3 m, whereas *L. groenlandica* became more important. Between 7 and 12 m, kelps still were a dominant form, but biomass and cover were much lower; dominant species included *L. groenlandica* and *Agarum cribrosum*. Below 12 m, seaweeds generally were uncommon (Table 6-31). The brown alga *Desmarestia ligulata* was periodically common, but biomass was never high. The reasons for this rapid decline are probably related to the disappearance of proper substrate, the turbidity and scouring induced by the interaction of the swift tidal currents and the increasing amounts of sand and shell debris at the lower depths.

Seasonal patterns in biomass and relative cover were not sharply defined but are apparent. Summer values were generally higher than those observed in spring. Standing stocks of algae appear to have been greater in 1978 than in 1979, but the data are not conclusive.

Fauna

The fauna, characterized by a well-developed epifaunal mat, was strongly dominated by bryozoans and colonial tunicates (Table 6-32). The most important bryozoan was the erect, articulated *Microporina borealis*, generally common at all levels except the lower level. Seasonal patterns in abundance of Bryozoa, in general, and *Microporina* specifically, were not clearly defined.

TABLE 6-31 COMPARISON OF RELATIVE COVER AND BIOMASS OF DOMINANT PLANTS AT EACH LEVEL AT ZAIKOF POINT

	May 1978			August 1978			April 1979			July 1979			Average	
Depth (m)/Taxa	Cover (%)	Biomass (g/m^2)	Density (no./m^2)	Cover (%)	Biomass (g/m^2)	Density (no./m^2)	Cover (%)	Biomass (g/m^2)	Density (no./m^2)	Cover (%)	Biomass (g/m^2)	Density (no./m^2)	(%)	(g/m^2)
0 - 3														
Laminaria spp[1]	85	--	--											
L. dentigera	--	6629	--											
L. yezoensis	--	1706	--											
Pleurophycus gardneri	31	2047	--											
Ptilota spp	23	--	--											
Nereocystis luetkeana		910	0.07											
		11,292												
3-7 (upper)														
Agarum cribrosum				19	332		12	268		25	531		19	377
Laminaria spp				59			41	60		83	--		61	--
L. dentigera					557			1350			0			636
L. groenlandica					3443			556			3864			2621
L. yezoensis					651			5			318			325
Nereocystis luetkeana						0.115		74	1.9		780	0.6		
Pleurophycus gardneri				17	2020		15	269		16	429			906
enc. coralline algae				42			58			37	--			
					7003			2582			5922			5169
7-12 (middle)														
Agarum cribrosum	31	682		28	476		3.3	18		25	122		21	325
Laminaria spp	49	--		34	--		11	--		21	--		29	
L. dentigera	--	--		--	0		--	125		--	134			86
L. groenlandica	--	758		--	781		--	164		--	207			478
L. yezoensis	--	231		--	116		--	0		--	90			109
enc. coralline algae	22	--		14	--		9			12	--			
Nereocystis luetkeana						0.05		2						
Pleurophycus gardneri	5	25		3	--		9	245		14	264			134
		1696			1373			554			817			1110
12-15														
Agarum cribrosum							0	0		2	35			
Laminaria spp							0	0		0	0			
L. groenlandica							0	0		2	45			
L. yezoensis							2	42		0	0			
Desmarestia ligulata							<0.8	--		24	--			
Nereocystis luetkeana						0.005	0	0		--	6	4.6		
								42			86			64

[1] Includes L. dentigera.

TABLE 6-32 COMPARISON OF RELATIVE COVER (PERCENT) BY DOMINANT ENCRUSTING INVERTEBRATES AT ZAIKOF POINT

Depth (m)/Taxa	May 1978	August 1978	April 1979	July 1979
3-7 (6.8)				
Bryozoa - Total		35.7	23.9	35.9
Dendrobeania murrayana		2.9	0.3	6.1
Microporina borealis		20	21.4	25.0
Tricellaria		11.6	--	4.0
Tunicata - total		12.4	9.8	22.2
Didemnum spp		8.8	2.5	13.7
Ritterella pulchra		0	7.1	0
Sand/shell colonial		1.8		
Yellow spatter tunicate		1.2		
7-12 (10.1)				
Tunicata - total	33.3	3.4	13.3	15.2
Didemnum spp		0	1.4	2.0
Ritterella pulchra	33.3	--	11.2	--
Mushroom tunicate	--	0.8	0	10.3
Shell/sand tunicate	--	1.7	0	2.5
Bryozoa, total	--	28.8	33.9	41.7
Microporina borealis	--	20.2	27.0	36.8
Hippodiplosia murrayona	--	0	3.4	0.5
Dendrobeania ?albidum	--	0	2.0	2.8
12-15 (14.0)				
Bryozoa - Total			8.8	20.4
Microporina borealis			3.2	9.0
Dendrobeania murrayana			2.2	7.0
Hippodiplosia insculpta				2.2
Abietinaria spp			1.2	3.0
Total tunicata			30.3	5.7
Ritterella pulchra			29.0	0
Mushroom tunicate			0	4.0

Distribution and abundance patterns for tunicates were unclear and complicated by the bewildering variety of species and their growth forms. This situation was further exacerbated by taxonomic problems. The family Synoicidae, in which specialists were able to identify eight species and distinguish eleven others, appeared to be quite rich.

Colonial tunicates were an important component of the epifaunal mat, contributing substantially to epifaunal standing stocks. However, the development of the colonies varied considerably seasonally. Greatest development appeared to be linked to peaks in phytoplankton standing stocks as colonies collected after mid-summer could not be identified because the zooids had regressed or degenerated. Some of the species commonly encountered were Aplidium arenatum, Ritterella pulchra, Didemnum albidum, Synoicun jordani, and Distaplia occidentalis. However, annual variation in species dominance appeared considerable.

The development of colonies of the bryozoan Membranipora membranacea on the laminarian kelps was remarkable in August 1978. Encrustation of up to 90 percent of the blade surface was noted for Pleurophycus. Fouling to such a degree was not noted in other surveys.

Sea stars, snails and hermit crabs were the major motile epifaunal invertebrates. The principal sea stars included Dermasterias imbricata, Pycnopodia helianthoides, Henricia leviuscula, and Crossaster papposus. Ten other species were observed. Combined densities of sea stars were always less than $0.5/m^2$. The major snail observed was Margarites pupillus which occurred at densities of less than $2/m^2$ until July 1979, when it attained densities ranging from 8.8 to $42/m^2$. Other commonly observed species included Calliostoma ligata, Trichotropis cancellata, and Trophonopsis lasius. Large snails such as Fusitriton oregonensis were uncommon.

The main hermit crab observed was Pagurus beringanus, represented mostly by juvenile specimens. Although juvenile P. beringanus were commonly observed climbing on the blades of the large kelps and crawling on the epifaunal mat at the upper and middle levels, they appeared to be uncommon at the lower levels, Apparently, few hermit crabs attained adulthood. Other species observed included P. kennerlyi, Elassochirus gilli, E. tenuimanus, and Discorsopagurus schmitti.

Zonation

Data on relative cover by kelps, red algae and epifaunal invertebrates have been integrated in Table 6-33 to provide a better indication of the patterns in zonation and species dominance at Zaikof Point. Out to a depth of 7 m, kelps formed a moderate surface canopy and an understory that almost completely covered the bottom. The main species were Nereocystis, Laminaria dentigeria, L. yezoensis, Pleurophycus, and Agarum. Ptilota contributed a substantial amount of cover out to about 3 m (Table 6-31), but other foliose red algae were rather inconspicuous. Encrusting coralline algae consistently covered an appreciable proportion of the hard substrate in this depth range. Encrusting epifaunal organisms formed a loose mat over a considerable proportion of the bottom. The dominant forms were erect, branching bryozoans and colonial encrusting tunicates.

Between 7 and 12 m, kelps again formed an important understory, but their importance was reduced. The main species were L. groenlandica, L. yezoensis, and Agarum. Bull kelp formed a substantial surface canopy out to about 10 m. Encrusting coralline algae were less important than at the upper level. Bryozoans and tunicates were both as important as at the upper level, but Microporina and Ritterella were the only remaining important species.

Between 12 and 15 m, all algae were sparse and generally unimportant. Although they covered about a third of the substrate, most species were small and filmy and probably contributed relatively little to overall biomass at this level. In addition, bryozoans covered considerably less surface area than in shallower areas; Microporina and Dendrobeania were the most important species. Tunicates, covering an area approximately the same as bryozoans at this level, were approximately as abundant as at the upper two levels; no species was conspicuously more common than the others.

TABLE 6-33 COMPARISON OF RELATIVE COVER (%) OF IMPORTANT SPECIES AT DIFFERENT DEPTHS AT ZAIKOF POINT, MONTAGUE ISLAND

Depth/Taxon	May 1978	August 1978	April 1979	July 1979
1-7 m				
ALGAE				
Phaeophyta (Brown Algae)		94	68	124
Laminaria spp (*L. dentigera*, *yezoensis*)	--	59	41	83
Pleurophycus gardneri	--	17	15	16
Agarum cribrosum	--	19	12	25
Rhodophyta (Red Algae)	--	45	66	43
Encrusting red algae	--	42	58	37
Foliose red algae	--	4	9	6
INVERTEBRATA				
Bryozoa	--	36	24	36
Microporina borealis	--	20	21	25
Tricellaria sp	--	12	--	4
Dendrobeania murrayana	--	3	0.3	6
Tunicata	--	12	10	22
Didemnum albidum	--	9	3	14
Ritterella pulchra	--	0	7	0
Primary space not accounted for		10	8	5
7-12 m				
ALGAE				
Phaeophyta (Brown Algae)	85	65	23	75
Laminaria spp (*L. groenlandica*, *yezoensis*)	49	34	11	21
Pleurophycus gardneri	5	3	9	14
Agarum cribrosum	31	28	3	25
Rhodophyta (Red Algae)	27	18	23	18
encrusting red algae	22	17	10	12
foliose red algae	4	0.4	13	6
INVERTEBRATA				
Bryozoa	--	29	34	42
Microporina borealis	--	20	27	37
Tunicata	33	3	13	15
Ritterella pulchra	33	--	11	--
Sand/shell	20	20	20	20
Primary space not accounted for	--	31	23	11
12-15 m				
ALGAE				
Phaeophyta	--	--	4	28
Laminaria spp	--	--	2	2
Agarum cribrosum	--	--	0	2
Desmarestia ligulata	--	--	2	24
Rhodophyta	--	--	16	14
Encrusting algae	--	--	10	8
Foliose red algae	--	--	6	6
INVERTEBRATA				
Bryozoa	--	--	9	20
Microporina borealis	--	--	3	9
Dendrobeania murrayana	--	--	2	7
Tunicata	--	--	30	6
Sand/shell debris	24	24	24	24
Primary space available (%)			27	42

Dominant encrusting species occupied a greater proportion of the available space at the upper levels than at the lower level. An average of only 7 percent of the surface remained unaccounted for after summing the area covered by encrusting algae, bryozoans and tunicates. When the amount of sand and shell debris was accounted for at the middle and lower levels, the rock surface not covered by dominant encrusting organisms was 22 and 34 percent, respectively. However, bare rock was observed very infrequently, and the difference appears to be a consequence of increasing diversity at the deeper levels and problems associated with visually sampling a complex fauna. Sand and shell material were dusted over much of the hard substrate at the lower levels and some of the epifaunal organisms incorporate this material into their body wall, making accurate cover estimates quite difficult.

6.2.3.2 Zaikof Bay, the NMFS Site, Montague Island

The biota at the NMFS site (Figure 4-4) was among the least diverse of the rock habitats observed during the NEGOA surveys. Approximately 120 species have been identified at this site since it was first occupied in 1975; numerous additional species were collected for lab identification. Some of the richer taxa were Mollusca, Bryozoa, Rhodophyta and Crustacea. The biota lacked the appearance of an open coast assemblage, a characteristic reinforced by the thin veneer of silt dusting most surfaces. The epifaunal mat was not robust or heavily encrusting.

Flora

Understory kelps dominated the flora at all depths surveyed where rock was the major substrate (Table 6-34). Plant cover and densities were moderate. In the single instance where plant biomass data were collected, it, too, was moderate. Cover, density and biomass generally appeared greater at the shallower levels for all species. Dominant species were *Agarum cribrosum*

TABLE 6-34 COMPARISON OF DENSITY, RELATIVE COVER (%) AND BIOMASS (g/m^2) FOR DOMINANT PLANTS AT TWO LEVELS AT THE NMFS SITE IN ZAIKOF BAY

	November 1975*		March 1976*		June 1976*		August 1978			April 1979	
Depth (m)/Taxa	No./m^2	% cover	No./m^2	% cover	No./m^2	% cover	No./m^2	% cover	g/m	No./m^2	% cover
3-7 m - Upper											
Agarum cribrosum	7.0	26	10.6	44	2.6	--	12.3	50	1430	--	--
Laminaria groenlandica	--	--	1.9	--	2.3	--	3.4	--	5	--	--
L. saccharina	0	0	0	0	0	0	8.3	--	136	--	--
L. yezoensis	--	--	1.6	--	0.1	--	1.7	--	258	--	--
Laminaria spp	12.0	25	0.8	18	--	--	1.8	23	0.5	--	--
encrusting red algae	--	38	--	29	--	--	--	6	--	--	--
									1829		
7-15 m - Lower											
Agarum cribrosum	3.0	17	5.2	39	4.4	25	7.3	33	901	3.9	33
L. groenlandica	--	--	2.9	--	2.3	--	0.3	--	24	3.9	35
L. yezoensis	--	--	0.2	--	0.2	--	0.3	--	0	0	--
Laminaria spp	1.1	13	0.2	18	16.3	13	10.7	4	13	6.0	--
encrusting red algae	--	78	--	34	--	21	--	6	--	--	22
Ralfsia pacifica	--	16	--	9	--	--	--	12	--	--	0
									938		

* Based on Rosenthal and Lees (1977)

and *Laminaria groenlandica* (Table 6-34). The predominance of *Agarum* and the moderate biomass level are probably related to the turbidity level at this site.

Encrusting red algae (*Hildenbrandia* and corallines) generally appeared more abundant at the lower level (Table 6-34). Again, seasonal patterns were not clear.

Development of the flora apparently can vary tremendously between years. From June 1975 to August 1978, biomass and relative cover were never notably high. However, the development of *L. groenlandica* at the lower level was remarkable in April 1979. Although not particularly noticeable in the plant cover data (Table 6-34), the development of *L. groenlandica* was such that the visual appearance of the site was quite different from previous survey periods. In fact, the plants were so large they hindered survey work. We noted a similar condition in Constantine Harbor, in Port Etches, and R.J. Rosenthal observed similar conditions in the kelping grounds on the northeastern shore of the Sound (personal communication). Such conditions were not apparent at the more exposed sites (e.g., Zaikof Point, Schooner Rock, Danger Island or the southwestern corner of Evans Island) where kelp bed development still resembled early spring conditions.

Fauna

The fauna, characterized by a moderately developed epifaunal mat, was dominated by bryozoans and barnacles. Generally the epifaunal mat was better developed at the lower level (Table 6-35). However, seasonal patterns were unclear. Several erect bryozoans were important during the study; the most reliable and common species were *Microporina borealis* and *Flustrella gigantea*. A heavy set of barnacles was first noted in March 1976; the population peaked in August 1978 and declined drastically by the following April (Table 6-35). This cycle was closely approximated by the density of potential barnacle predators, especially the snails *Onchidoris borealis* and *Nucella lamellosa*, and the sunstar *Pycnopodia helianthoides*. By August 1978, when barnacle cover peaked at 28.3 percent at the upper level and 20.0

TABLE 6-35 RELATIVE COVER (%) BY INVERTEBRATES AT THE NMFS SITE IN ZAIKOF BAY

	SURVEY				
Depth (m)/taxa	November 1975	March 1976	June 1976	August 1978	April 1979
3-7					
Microporina borealis	4.8	14.6	--	4.7	--
Flustrella gigantea	3.8	3.2	--	1.2	--
Distaplia occidentalis	1.3	1.7	--	0	--
Didemnum albidum	0.3	0.3	--	0.1	--
Balanus rostratus alaskensis	0	10.6	--	20.0	--
Dendrobeania murrayana	0.3	0	--	3.8	--
Heteropora sp	0.5	0.2	--	0.3	--
	11.0	20.0		10.1	
7-15					
Microporina borealis	30.0	3.6	16.7	14.7	2.4
Balanus rostratus alaskensis	0	8.8	7.5	28.3	1.8
Flustrella gigantea	7.4	4.8	0.8	0.1	2.5
Didemnum albidum	1.8	0	3.3	0	0.1
Heteropora sp	2.6	0.2	0.2	0.2	0
Phidolopora pacifica	1.8	0	0.2	0.2	0
Distaplia occidentalis	0	0.6	0.2	0.1	0
Dendrobeania murrayana	0.2	0	3.9	11.7	0.9
Alcyonidium pedunculatum	0	0	1.6	0.7	0
	43.8	9.2	26.9	27.7	5.9

*Based on Dames & Moore (1977c)

percent at the lower level, barnacle predator density had attained $60.3/m^2$ at the lower level and $11.1/m^2$ at the upper level (Table 6-36). The *Pycnopodia* population was dominated by juveniles approximately 3 to 4 cm in diameter. Only *Pycnopodia*, a very opportunistic predator, was still common after the ensuing crash in the barnacle population.

Sea stars, snails and hermit crabs were the major motile epifaunal invertebrates. *Pycnopodia* and *Evasterias* were the major starfish. The main snails included *Acmaea mitra*, *Nucella lamellosa*, *Onchidoris bilamellata* and *Trichotropis cancellata*. The main hermit crab, *Pagurus beringanus*, was represented mainly by juveniles. Although species diversity of hermit crabs was high (9 species), the only other common species was the tube-dwelling *Discorsopagurus schmitti*.

Zonation

Data on relative cover by kelps, red algae and epifaunal invertebrates from Dames & Moore (1977c) have been integrated into Table 6-37 to provide a better indication of patterns in zonation and species dominance at the NMFS site. Understory kelps formed a canopy over the bottom out to a depth of about 12 m, the lower limit of the talus slope. Foliose red algae were of little significance, but encrusting coralline algae covered a substantial portion of the rock. The epifaunal organisms formed an incomplete mat over the available rock surface, leaving a fair amount of bare rock exposed. All of these taxa occurred in greater abundance at the lower level (Table 6-37). However, differences in species composition between the two levels were not important, i.e., zonation patterns were poorly developed.

6.2.3.3 Schooner Rock, Montague Island

Reconaissance surveys were made at the northern end of Schooner Rock (Figure 4-4) on 19 May 1978 and on the southeastern side on 11 April 1979 to provide descriptions of the flora and fauna. A total of over 150 algal and invertebrate taxa was recorded, comprising 18 algae, 33 cnidarians, 26 molluscs, 20 bryozoans, and 22 ascidians (Appendix B). In addition, Rosenthal

TABLE 6-36 DENSITY (No./m^2) OF COMMON EPIFAUNAL INVERTEBRATES AT THE NMFS SITE, ZAIKOF BAY

	SURVEY				
Level/Taxa	November* 1975	March* 1976	June* 1976	August 1978	April 1979
Upper					
Paguridae, unid.	10.0	10.2	--	31.2	--
Tonicella spp	7.0	1.3	--	1.6	--
Crucigera zygophora	--	20.9	--	1.6	--
Amphissa columbiana	0	0.9	--	0.7	--
Pycnopodia helianthoides	0	0.3	--	3.5	--
Nucella lamellosa	0	0	--	1.2	--
Onchidoris bilamellata	0	0	--	6.4	--
Evasterias troschelii	0	0	--	0.4	
Lower					
Paguridae, unid	8.8	8.8	3.7	50.7	3.0
Crossaster papposus	0.8	--	--	0	0.2
Acmaea mitra	0.8	--	0.3	2.7	--
Pycnopodia helianthoides	0.8	0.5	0.3	1.7	1.5
Nucella lamellosa	1.6	--	--	21.3	0
Crucigera zygophora	6.4	8.8	--	--	28.0
Tonicella spp	--	6.4	1.7	0.4	3.0
Orthasterias koehleri	--	0.2	0.7	--	--
Evasterias troschelii	0	0.5	0	0.2	1.0
Onchidoris bilamellata				37.3	0

*Based on Dames & Moore (1977c)

TABLE 6-37 COMPARISON OF RELATIVE COVER (%) BY IMPORTANT TAXA AT DIFFERENT DEPTHS AT THE NMFS SITE, ZAIKOF BAY

	SURVEY				
Depth/Taxon	November* 1975	March* 1976	June* 1976	August* 1978	April* 1979
3-7 m					
ALGAE					
Phaeophyta (Brown Algae)	56	79	--	73	--
Agarum cribrosum	26	44	--	50	--
Laminaria spp	25	18	--	23	--
Rhodophyta (Red Algae)	40	49	--	6	--
encrusting red algae	38	29	--	6	--
foliose red algae	2	20	--	0.4	--
INVERTEBRATA					
Bryozoa	9	19	--	10	--
Microporina borealis	5	15	--	5	--
Dendrobeania murrayana	0.3	0	--	4	--
Tunicata	3	6	--	0.1	--
Balanus rostratus alaskensis	0	11	--	20	--
7-15 m					
ALGAE					
Phaeophyta	46	66	53	49	68
Agarum cribrosum	17	39	25	33	33
Laminaria spp	13	18	13	4	35
Rhodophyta	79	37	28	9	25
encrusting red algae	78	34	21	6	22
foliose red algae	0.4	3	7	3	3
INVERTEBRATA					
Bryozoa	42	9	25	29	6
Microporina borealis	30	4	17	15	2
Dendrobeania murrayana	0.2	0	4	12	1
Tunicata	2	4	4	0	1
Balanus rostratus alaskensis	0	11	8	28	2

*Based on Dames & Moore (1977c)

(1980) reported nearly 30 species of fishes from Schooner Rock. These inventories are far from complete, especially for groups such as the red algae, sponges, hydroids, crustaceans, and tunicates due to complexity of the groups and the difficulty in field identification. Apparently differences in species richness between the northern and southeastern end of the rock are probably due mainly to disparities in collection efforts.

The biota was quite rich and was characteristic of an exposed coastal habitat. The algal component was dominated by kelps which extended to a depth of about 17 m. Some of the red algae extended to at least 23 m, but algal biomass beyond 12 m was low. The epifauna was strongly dominated by suspension feeders, particularly ephemeral forms such as hydroids, bryozoans, and colonial ascidians (Appendix B).

The only clam observed, Musculus vernicosus, is basically an annual. Large, long-lived suspension feeders such as the sea cucumber Cucumaria miniata and the sea anemone Metridium senile were only observed below 15 m.

Domination by ephemeral forms implies that seasonal fluctuations in the biomass of suspension feeders is dramatic in contrast to areas dominated by long-lived suspension feeders such as clams or sea cucumbers. This may be a response to the intense disturbances caused by storm surge and logs, wide seasonal variation in the availability of suspended food, predation by sea otters, or a combination of these factors. Although the hydrocoral Allopora is an important encruster in shallow water, the simple habitus of the colonies suggests that this depth range is subjected to severe poundings. This impression is supported by the deformed condition of individuals of the sea star Pisaster ochraceas in this area; nearly all specimens exhibit evidence of considerable damage (e.g., arms missing or very stubby and foreshortened).

The predator/scavenger component was moderately diverse (12 snails, 8 crustaceans and 9 sea stars, as well as at least 30 fish species), but the density of invertebrate predators was generally low. Furthermore, the invertebrate predator populations were characterized by fairly small individuals, suggesting high mortality, slow growth or both.

The fish component is apparently dense, diverse and robust mainly in the summer within the depth range considered (Rosenthal 1980). Most species probably move into deeper water during the winter. This adaptation probably serves as much to escape the effects of winter storm surge as it is to take advantage of the larger food resources available in the shallow subtidal regions during the milder summer months.

6.2.3.4 Port Etches and Constantine Harbor, Hinchinbrook Island

Reconnaissance surveys were made on 11 and 12 April 1979, in the northeastern corner of Port Etches, about 500 m south of the entrance channel into Constantine Harbor, and in Constantine Harbor about 100 m north of its entrance channel (Figure 4-4). Marine plants visually dominated both areas (Tables 6-38 and 6-39). Epifaunal organisms were uncommon at both sites, and although shell debris from Mya truncata and Saxidomus giganteus was commonly observed, large clams were not observed despite a concerted search. Evidence of foraging by sea otters (e.g., broken shells and excavations) was common.

Plant cover was moderate in both sites (Tables 6-38 and 6-39). Laminaria saccharina and Desmarestia aculeata were the dominant species; the most important subdominant at the Port Etches site was Agarum (Table 6-38), whereas at the Constantine Harbor site, it was the sea grass Zostera (Table 6-39). The plant assemblages, although generally equally rich, were qualitatively rather different (Appendices C and D), exhibiting only about 25 percent overlap.

Density of epifaunal animals seemed higher in Constantine Harbor than in Port Etches despite the indications of Tables 6-38 and 6-39; sampling effort for epifaunal forms was lower in Port Etches and the density estimates are probably unrealistically high. However, the epifaunal assemblage was clearly substantially richer in Port Etches than in Constantine Harbor, and a considerable qualitative difference existed (Appendices C and D). Overlap

TABLE 6-38 ALGAL DENSITY AND RELATIVE COVER IN THE NW CORNER OF PORT ETCHES, NEAR ENTRANCE TO CONSTANTINE HARBOR ON 11 APRIL 1979; DEPTH 5.5 - 7.6 m

TAXA	DENSITY (No./m^2)	COVER (%)
PLANTS		
Agarum cribrosum	1.1	11.7 + 18.9
encrusting coralline algae	-	0.2 ± 0.4
foliose red algae	-	1.3 ± 2.6
Laminaria spp*	8.4	50.3 + 30.0
L. groenlandica	1.6	4.0 + 12.6
L. saccharina	9.2	43.0 + 38.0
L. yezoensis	1.2	3.0 + 9.5
Rhodymenia pertusa	-	1.8 + 3.2
ANIMALS		
Evasterias troschelii	0.22	-
Henricia leviuscula	0.22	-
Melibe leonina	0.22	-
TOTAL		65.6
Sand/Shell substrate		97.0

* Pooled for combined observations of two divers; specific data were provided by only one observer.

TABLE 6-39 DENSITY AND/OR RELATIVE COVER OF DOMINANT ORGANISMS 100m N OF THE ENTRANCE IN CONSTANTINE HARBOR, PORT ETCHES ON 12 APRIL 1979; DEPTH 4.6 - 6.1 m

TAXA	DENSITY (no./m^2)	COVER (%)
PLANTS		
Desmarestia aculeata	-	33.2 + 17.1
Laminaria saccharina	2.2	25.5 + 32.4
Monostroma fuscum	-	0.2 + 0.6
Palmaria palmata	-	1.4 + 2.9
Pylaiella littoralis	-	0.6 + 1.5
Spongomorpha saxatilis	-	1.0 + 3.0
Zostera marina	-	13.6 + 8.6
ANIMALS		
Dermasterias imbricata	0.03	-
Melibe leonina	0.37	-
Pholis laeta	0.07	-
Pycnopodia helianthoides	0.18	-
TOTAL		75.5

of faunal species was only 23 percent. Generally, the biota in Port Etches included a larger proportion of marine taxa whereas the biota in Constantine Harbor was characterized by estuarine species.

6.2.3.5 Sea Lion Pinnacles, South End of Danger Island

The biota at Sea Lion Pinnacles, at the south end of Danger Island (Figure 4-4) was quite rich, colorful and attractive. Approximately 150 species were identified in the course of field work here, and numerous additional species were collected for lab identification. Some of the richer taxa were Tunicata, Cnidaria, Bryozoa, and Mollusca. The biota was typical of exposed coasts. The flora was dominated by the kelps. The epifauna was strongly dominated by encrusting colonial tanicates.

Flora

Kelps dominated the flora out past a depth of about 15 m and then declined rapidly in importance between 15 m and 20 m (Table 6-40). Plant biomass and relative cover were moderate out to about 15 m. The dominant species included Nereocystis to a depth of 15 m, Laminaria dentigera to a depth of about 5 m, Pleurophycus out to about 10 m, and L. groenlandica and L. yezoensis between about 5 m and 15 m. Coverage by encrusting coralline algae was moderate to a depth of about 15 m and declined sharply below that (Table 6-40), probably as a consequence of competition with encrusting epifaunal forms. Although not satisfactorily reflected in the data, Nereocystis formed a substantial bed along the southwestern side of the island, adjacent to the study site. Species composition of the laminarian understory was patchy, depending largely on exposure to surge activity. Laminaria dentigera and Pleurophycus, living in the most exposed areas, are most tolerant. Laminaria yezoensis is somewhat more tolerant than L. groenlandica, which generally extends deeper than the two former species. Agarum is least tolerant of surge and its paucity at the lower levels in this area may have been a consequence of competition with encrusting epifaunal forms. The only algae observed at a depth of 30 m were Callophyllis and encrusting corallines; both were uncommon.

TABLE 6-40 COMPARISON OF RELATIVE COVER AND BIOMASS OF DOMINANT PLANTS AT EACH LEVEL AT SEA LION PINNACLES, DANGER ISLAND

Depth (m)/Taxa	May 1978 Cover (%)	May 1978 Biomass (g/m^2)	May 1978 Density ($no./m^2$)	August 1978 Cover (%)	August 1978 Biomass (g/m^2)	August 1978 Density ($no./m^2$)	July 1979 Cover (%)	July 1979 Biomass (g/m^2)	July 1979 Density ($no./m^2$)
<u>7-12</u>									
L. groenlandica	--	--	--	18	1152	24.8	--	--	--
L. yezoensis	--	--	--	21	638	12.0	--	--	--
Nereocystis luetkeana	--	--	--	--	--	0.9	--	--	--
Pleurophycus gardneri	--	--	--	28	2441	8.8	38	--	18.0
encrusting coralline alga	--	--	--	38	--	--	24	--	--
<u>12-17</u>									
Agarum cribrosum	--	--	--	18	--	5.3	1	25	0.3
Laminaria groenlandica	--	--	--	--	--	32.0	--	2614	9.7
L. yezoensis	--	--	--	--	--	9.3	--	1049	5.0
Laminaria spp.	--	--	--	43	--	--	80	58	--
Nereocystis luetkeana	--	--	--	--	--	0.08	--	--	--
Pleurophycus gardneri	--	--	--	43	--	5.3	8	930	0.6
encrusting coralline alga	--	--	--	32	--	--	34	--	--
sand/shell	--	--	--	--	--	--	36	--	--
								3676	
<u>17-22</u>									
Agarum cribrosum	13	65	4.0	0	0	1.6	--	--	--
Laminaria groenlandica	6	19	23.4	9	--	2.0	--	--	--
encrusting coralline alga	2	--	--	2	--	--	--	--	--
<u>20-30</u>									
encrusting coralline alga	--	--	--	--	--	--	1	--	--

Fauna

The fauna was dominated by an epifaunal mat with motile epifaunal forms other than sea stars uncommon and well concealed, probably reflecting both the influence of winter storms and sea otters in the area. Encrusting colonial tunicates strongly dominated the epifauna out to about 25 m, below which bryozoans, sponges and cnidarians became important (Table 6-41). Tunicates routinely covered 30 percent of the rock surface but in spring tunicate colonies covered up to 85 percent of the bottom. The major tunicate species observed during this survey were Aplidium arenatum, Didenmum ?albidum, and Distaplia smithi. In 1975-76, Dames & Moore (1977c) reported Distaplia occidentalis the dominant tunicate, again covering up to 30 percent of the rock substrate. It is our impression that dominance in the epifaunal mat changes frequently among a suite of encrusting colonial tunicates; causative factors are unknown. Furthermore, the development of the tunicate colonies changes dramatically seasonally. As noted above, best development is in spring, and by late summer colonies have regressed to a point where identification is not possible due to morphological deterioration of the zooid. Colonies appear to be prolific, fast-growing annuals, all features of colonizing, pioneer species. The pattern of dominance by colonial tunicates above 20 m may be a consequence of the exposure of the area to heavy wave action during winter storms. Furthermore, brittle, erect animals such as the coral Allopora or the bryozoans Heteropora and Hippodiplosi would have lower survivorship rates than soft, encrusting tunicates.

The influence of winter storms is also suggested by the paucity of motile invertebrates, including large sea stars. Among the more common motile invertebrates were the sea stars Pycnopodia helianthoides, Henricia leviuscula and H. sanguinolenta, and below 20 m, Ceramaster articus. Above 20 m, the small "arboreal" mussel Musculus vernicosus was periodically common to abundant. The main grazing species were the chiton Tonicella lineata and the limpet Acmaea mitra, both with fairly low densities; sea urchins were not observed.

TABLE 6-41 COMPARISON OF RELATIVE COVER (%) BY DOMINANT ENCRUSTING INVERTEBRATES AT SEA LION PINNACLES, DANGER ISLAND

Sheet 1 of 2

Depth (m)/Taxa	May 1978	August 1978	July 1979
7-12			
TUNICATA			
Didemnum ?albidum	--	--	20
green colonial tunicate	--	--	5
yellow spatter encrusting tunicate	--	--	2
Synoicum jordani	--	--	2
BRYOZOA			
Microporina borealis	--	--	5
12-17			
TUNICATA			
Didemnum ?albidum	--	11	8
Distaplia occidentalis	--	1	0.2
Metandrocarpa taylori	--	6	0.3
Synoicum jordani	--	2	1
Aplidium arenatum	--	5	0
yellow spatter encrusting tunicata	--	10	6
Bryozoa			
Tricellaria sp	--	1	--
17-22			
TUNICATA			
?Aplidium arenatum	65	17	--
Metandrocarpa taylori	--	2	--
Didemnum ?albidum	1	11	--
Distaplia occidentalis	2	--	--
D. smithi	17	T	--
BRYOZOA			
Microporina borealis	1	4	--
CNIDARIA			
Abietinaria spp	2	1	--
Aglaophenia sp	--	1	--
Clavularia sp	2	T	--

TABLE 6-41 COMPARISON OF RELATIVE COVER (%) BY DOMINANT ENCRUSTING INVERTEBRATES AT SEA LION PINNACLES, DANGER ISLAND

Sheet 2 of 2

Depth (m)/Taxa	May 1978	August 1978	July 1979
22-30			
BRYOZOA			
Heteropora sp	--	--	Dominant
Microporina borealis	--	--	Abundant
Hippodiplosia insculpta	--	--	Common
CNIDARIA			
Sertulariidae, unid. spp	--	--	Common
Allopora californica	--	--	Common
TUNICATA			
Distaplia occidentalis	--	--	Common

Zonation

Data on relative cover by kelps, red algae and encrusting epifaunal invertebrates have been integrated into Table 6-42 to provide a better indication of the pattern of zonation and species dominance at Sea Lion Pinnacles. Understory kelps nearly covered the bottom out to a depth of 12 m. Between 7 and 12 m, the main species were Laminaria groenlandica, L. yezoensis, and Pleurophycus gardneri. In addition, bull kelp formed a substantial surface canopy. Foliose red algae were patchy and sparse under the kelp canopy. The main species were Ptilota filicina, Delesseria decipiens and Rhodymenia pertusa. Encrusting red algae, mainly corallines, covered between a quarter and a third of the available rock surface. Encrusting epifaunal species also covered about a third of the bottom, but the mat was not well developed. The main encrusters were thin colonial tunicates such as Dideminum ?albidum or a species resembling bright yellow paint dribbled and spattered over the bottom. Bryozoans were sparse.

From 12 to 17 m, the algal assemblage was quite similar (Table 6-42). Bull kelp formed a thin surface canopy. The main laminarians in the understory were the same. Foliose red algae were again sparse. Encrusting red algae covered over a third of the bottom. The epifaunal mat was again dominated by thin colonial forms of tunicates, but some of the fleshier forms such as ?Aplidium arenatum were present.

Below 17 m, the appearance of the benthos was dramatically different. Bull kelp plants were small and scattered. The kelp understory, dominated by sieve kelp (Agarum), became sparse. Both encrusting and foliose red algae became sparse. The appearance of the biota, strongly dominated by encrusting invertebrates, especially tunicates, became more complex. Fleshy colonial forms such as ?Aplidium arenatum formed thick carpets over more than half of the surface of the boulders, especially in spring and early summer. Seasonal and long-term changes in relative cover, composition, and appearance of this carpet were quite remarkable. Also, the motile epifaunal assemblages became more complex.

TABLE 6-42 COMPARISON OF RELATIVE COVER (%) OF IMPORTANT TAXA AT DIFFERENT LEVELS AT SEA LION PINNACLES, DANGER ISLAND

Sheet 1 of 2

Depth (m)/Taxa	May 1978	August 1978	July 1979
7-12			
ALGAE			
Phaeophyta (Brown Algae)	--	70	92
Laminaria spp	--	39	49
Agarum cribrosum	--	2	5
Pleurophycus gardneri	--	28	38
Rhodophyta (Red Algae)	--	44	48
Encrusting red algae	--	39	26
Foliose red algae	--	5	19
INVERTEBRATA			
Bryozoa	--	--	6
Microporina borealis	--	--	5
Tunicata			31
Didemnum ?albidum	--	--	20
yellow spatter encrusting tunicate	--	--	2
green colonial encrusting tunicata	--	--	5
Synoicum jordani	--	--	2
12-17			
ALGAE			
Phaeophyta (Brown Algae)	--	105	89
Laminaria spp	--	43	80
Agarum cribrosum	--	18	1
Pleurophycus gardneri	--	43	8
Rhodophyta (Red Algae)		42	48
Encrusting red algae	--	35	40
Foliose red algae	--	6	8
INVERTEBRATA			
Bryozoa	--	1	0.1
Tunicata	--	35	20
Didemnum ?albidum	--	11	8
Synoicum jordani	--	2	1
?*Aplidium arenatum*	--	5	0
yellow spatter encrusting tunicate	--	10	6
Metandrocarpa taylori	--	6	0.3

TABLE 6-42 COMPARISON OF RELATIVE COVER OF IMPORTANT TAXA AT DIFFERENT LEVELS AT SEA LION PINNACLES, DANGER ISLAND

Sheet 2 of 2

Depth (m)/Taxa	May 1978	August 1978	July 1979
17-22			
ALGAE			
Phaeophyta (Brown Algae)	23	9	--
Agarum cribrosum	13	T	--
Laminaria spp	6	9	--
Rhodophyta (Red Algae)	4.4	12	--
Encrusting red algae	4	8	--
Foliose red algae	0.4	4	--
INVERTEBRATA			
Bryozoa (moss animals)	1	5	--
Tunicata (sea squirts)	86	52	--
?*Aplidium arenatum*	65	17	--
Distaplia smithi	17	P	--
D. occidentalis	2	0	--
Didemnum ?albidum	1	11	--
can-o-corn tunicate	0	20	--
Metandrocarpa taylori	0	2	--
22-30			
ALGAE			
Rhodophyta (Red Algae)	--	--	Sparse
INVERTEBRATA			
Bryozoa (moss animals)			
Heteropora sp	--	--	Dominant
Microporina borealis	--	--	Abundant
?*Rhamphostomella* sp	--	--	Common
Hippodiplosia insculpta	--	--	Common
Tunicata (sea squirts)			
Distaplia occidentalis	--	--	Common
Porifera (sponges)	--	--	Common
Cnidaria (corals and hydroids)			
Allopora californica	--	--	Common
Sertulariidae, unid.	--	--	Common

Below 22 m, seaweeds were insignificant. The biota was almost totally dominated by a confusing array of encrusting or sessile epifaunal invertebrates. Although tunicates remained important, bryozoans, sponges, hydroids and the hydrocoral Allopora (=Stylantheca) californica became important. Erect or massive species such as Allopora and the bryozoans Heteropora and ?Rhamphostomella and the sponges Tetilla arb and ?Stylissa stipitata were common. The epifauna contributed more to surface relief and substrate complexity. In addition, the ichthyofauna was much richer at this level. Common fishes included black, dusky, copper, china, tiger and Puget Sound rockfish, ling cod and Pacific halibut. Many large adult fishes were observed.

6.2.3.6 Latouche Point, Latouche Island - The Macrophyte Assemblage

Data collected at Latouche Point (Figure 4-4) clearly indicate the variability in development of the macrophyte assemblage in time and space. Data were collected in May and August 1978 at three locations between 9 and 14 m deep. Kelps dominated the biota in terms of biomass and appearance in all surveys (Table 6-43), but the dominant species and degree of development varied considerably.

Greatest development of the kelp assemblage, based on relative cover, plant density and biomass, was observed in August (Table 6-43). On the shelf, relative cover and density increased by a factor of three from May to August, but biomass increased by two orders of magnitude. The dramatic increase in biomass was largely due to the development of the Nereocystis (bull kelp) population, but a ten-fold increase in biomass was also apparent in the laminarian kelps.

The differences between the shelf and the Latouche Passage site probably are related to differences in exposure. Substrate at both sites was a mixture of boulders, bedrock and sand-shell channels. However, the shelf site is moderately exposed to storm surge off the Gulf of Alaska whereas the passage site is somewhat protected from storm surge from most directions. However, the passage site is routinely exposed to tidal currents between the

TABLE 6-43 COMPARISON OF RELATIVE COVER AND BIOMASS OF DOMINANT PLANTS AT EACH LEVEL AT LATOUCHE POINT

TAXA	15 May 1978 The Shelf - 10 m			15 May 1978 Latouche Passage - 10 m			11 August 1978 The Shelf - 9-11 m			12 August 1978 The Bull Kelp Bed 11-14 m		
	Cover (%)	Biomass (g/m²)	Density (no./m²)	Cover (%)	Biomass (g/m²)	Density (no./m²)	Cover (%)	Biomass (g/m²)	Density (no./m²)	Cover (%)	Biomass (g/m²)	Density (no./m²)
Agarum cribrosum	4.0	--	--	13.3	535.4	2.1	6.4	--	0.6	--	155.3	0.8
Cymathere triplicata	0.8	0.4	--	--	2.9	0.1	17.9	--	1.6	0	0	0
Desmarestia sp	0.5	9.4	--	0.3	--	--	--	--	--	0	0	0
Laminaria spp	25.4	--	--	51.7	--	--	65.0	--	--	66.0	--	--
L. dentigera	--	--	--	--	--	--	--	--	4.5	--	260.0	1.7
L. groenlandica	--	110.8	2.8	--	892.8	14.1	--	1513.0	2.8	--	2631.7	12.1
L. yezoensis	--	144.8	2.8	--	69.1	3.6	--	1736.0	5.7	--	--	0.6
Nereocystis luetkeana	0	0	0	--	--	0.05	--	15119.2	0.4	--	27000*	2.3
Pleurophycus gardneri	1.0	52.4	0.4	0	0		20.7	1234.2	0.8	40.8	1703.8	3.8
Foliose red algae	11.6	--	--	16.5	--	--	9.5	--	--	--	--	--
articulated coralline algae	4.5	--	--	0	--	--	12.1	--	--	--	--	--
encrusting coralline algae	3.0	--	--	19.2	--	--	27.9	--	--	--	--	--
TOTAL	50.8	317.8	6.0	101.0	1500.2	19.95	159.5	19602.4	16.4	106.8*	31750.8	21.3

*Estimate based on product of average density and average size of Nereocystis plants collected
**Kelp only; no data for red algae

Gulf of Alaska and Prince William Sound through Latouche Passage, and thus circulation, water quality and exposure to inorganic nutrients are probably better than on the shelf.

In August, we examined a dense bull kelp bed at Latouche Point to obtain information on well developed algal stands. This was contrasted with the bed that developed on the shelf. In both instances, standing stocks of bull kelp were very high. In the dense bull kelp bed, the standing crop was estimated to be nearly twice that at the shelf site, and the high estimate is probably moderately conservative. Actual removals, such as were used to estimate standing stocks of laminarians, were not feasible because the stipes and blades were badly tangled in the dense bull kelp bed.

A comparison of species composition and patterns in relative cover between 1978 (Table 6-43) and 1975-76 (Table 6-44, based on Dames & Moore 1977c) indicates that the macrophyte assemblage on the shelf may be moderately stable. Throughout that period, Laminaria spp have remained a strong dominant in the understory (range of relative cover from 25 to 65 percent, and averaging about 40 percent). Agarum, Pleurophycus, and Cymathere have remained important subdominants (range of relative cover from about 1 to 20 percent, and averaging 10, 6 and 4 percent, respectively). However, it appears that laminarians covered more area and red algae less in 1978 than during 1975-76.

6.2.3.7 The Southwest Corner of Evans Island

A total of 125 taxa was recorded in field observations at Bathtub Rock and on the southwestern corner of Evans Island (Appendix E). This included 24 algal taxa, 19 species of molluscs and over 10 species each of Cnidaria, Bryozoa, Crustacea, Echinodermata, Ascidiacea, and fishes. Kelps visually dominated the macrophyte assemblage to a depth of 13 m; plants extended to a depth of at least 17 m. The flora and fauna were characteristic of exposed or well-circulated habitats.

TABLE 6-44 SUMMARY OF RELATIVE COVER (%) DATA FOR MACROPHYTES ON THE SHELF AT LATOUCHE POINT IN 1975-76, BASED ON ROSENTHAL AND LEES (1977)

Taxa	September 1975	Survey November 1975	March 1976	June 1976
Agarum cribrosum	21	17	7	5
Cymathere triplicata	0	0	0	0
Laminaria spp	35	35	44	38
Pleurophycus gardneri	4	Trace	8	4
Foliose red algae	18	7.5	24.5	17
Articulated coralline algae	15	9	15	5
Encrusting red algae	58	54	58	26
TOTAL COVER (%)	151	121	156.5	101

Basically, the epifaunal assemblage was dominated by suspension feeders. The herbivore component was not well developed. Bryozoans and colonial ascidians dominated except in areas of extreme exposure to currents where the large sea anemone Metridium senile dominated. Bryozoans and colonial ascidians are generally short-lived whereas Metridium is long-lived. The dense population of Metridium on the sharp rock ridge extending from the southwest corner of Bathtub Rock included sizeable proportions of both large adults and juveniles but was dominated by adults to 1.5 m tall.

The predator/scavenger component was fairly well developed. Major groups included sea stars, fishes, snails and crustaceans. Nearly half of the prey items noted in feeding observations were bryozoans (especially Microporina) and 25 percent were tunicates. In the area dominated by Metridium, Dermasterias was commonly observed feeding on juvenile sea anemones.

Data collected in a Nereocystis bed at the southwest end of Evans Island (Figure 4-4) provide an indication of the structure of the macrophyte assemblage at this location. The relationships of the understory kelps are similar to that described for Sea Lion Pinnacles and Latouche Point. L. dentigera dominated out to at least 6 m, but was virtually absent at 11 m. In contrast, A. cribrosum and L. groenlandica were sparse at 6 m but dominant at 11 m (Table 6-45). Time constraints did not allow adequate sampling of Nereocystis; all estimates are considered low based on recollection of the area.

6.2.4 Productivity: Biomass Ratios and Primary Production

6.2.4.1 Population Parameters for Agarum cribrosum

Several population parameters for Agarum cribrosum were routinely measured at the subtidal sites at Seldovia Point. The most important of these parameters include density, biomass and size structure. Growth rates were measured at Jakolof Bay (Dames & Moore 1979b). Size measurements included stipe length, total length, and total weight, permitting assessment of several morphometric relationships and a condition factor.

TABLE 6-45 COMPARISION OF RELATIVE COVER, DENSITY AND BIOMASS OF DOMINANT PLANTS AT TWO DEPTHS ON THE SW CORNER OF EVANS ISLAND

	4/6/79 Depth: 5.5-6 m		7/18/79 Depth: 11-12.8 m		
TAXA	Cover (%)	Density (No/m^2)	Cover (%)	Density (No/m^2)	Biomass (g/m^2)
Agarum cribrosum	16.7	2.1	58.0	10.6	1056.8
Laminaria spp	--	18.8**	--	16.9**	--
L. dentigera	61.7	31.3*	0	0	0
L. groenlandica	--	0.7*	62.0	24.8*	1484.2
L. yezoensis	0.9	4.0*	6.0	2.4*	281.6
Nereocystis luetkeana	--	0.06	--	0.3	3480.4
Pleurophycus gardneri	2.5	1.0	2.0	0.1	0
Foliose red algae	11.9	--	--	--	--
Articulated coralline algae	0.7	--	--	--	--
Encrusting red algae	28.9	--	--	--	--
TOTALS	123.3	58.0	128.0	55.1	6303.0

*Based on 1/4m^2 quadrat estimates
**Based on generic data from 1/2 m x 5 m quadrat estimates

Density

Density data summarized in Table 6-23 do not indicate clear defined temporal patterns or depth relationships. Densities were generally somewhat lower in 1977 than in 1978, and lower densities were observed in mid-summer (late June through August). The relationship between density and depth was unclear in 1977, but clearly reduced densities were observed at greater depths in 1978. Density was more stable for larger plants (stipe length > 5 cm), ranging between 2.3 and 6.8/m^2 and averaging about 4.9/m^2 across the subtidal sampling area (Table 6-46).

The density of small *Agarum* increased dramatically in the study area between November 1977 and June 1978, especially at the 6-m level (Tables 6-23 and 6-46). Furthermore, the elevated densities persisted for the duration of the study. This suggests that recruitment was better during that period than during the previous year.

Biomass

Biomass also exhibited moderate variability among sampling levels and surveys (Table 6-23). The high variability observed at the 12-m level was probably due to problems in satisfactory station relocation in conjunction with substrate heterogeneity. As in the case of density, biomass appeared to be generally higher in 1978 than in 1977, and tended to be higher in spring and summer and at the shallower stations. Wet whole weight *Agarum* averaged about 0.54 kg/m^2 in the subtidal area over the study period.

Size Structure

Size frequency histograms were constructed using plants collected to estimate density and biomass. As a consequence, the number of plants measured during each period varied directly with density. Thus, in periods of low density, definition of the histograms was somewhat reduced. Because of the opposing processes of growth and blade erosion, blade length and total length are not suitable measurements for comparing size structure from different

TABLE 6-46 AVERAGE DENSITY AND VARIATION IN AVERAGE STIPE LENGTH FOR TWO SIZE CATEGORIES IN THE SUBTIDAL POPULATION OF *AGARUM CRIBROSUM* AT SELDOVIA POINT

Survey	Overall	Small Plants Stipe (<5 cm)	Large Plants Stipe (≥5 cm)	Overall	Small Plants (<5 cm)	Large Plants (≥5 cm)
2/77	9.7	--	--	--	--	--
5/77	9.0	3.6	5.4	6.2 ± 4.1	2.9 ± 1.5	8.8 ± 3.2
8/77	4.4	2.1	2.3	5.0 ± 3.5	2.8 ± 1.4	7.7 ± 2.8
9/77	11.3	6.9	4.4	4.4 + 2.9	3.2 + 0.2	7.2 ± 2.4
11/77	11.7	5.2	6.5	6.1 + 3.5	3.3 + 1.1	7.9 ± 2.9
6/78	25.0	18.2	6.8	3.4 + 3.6	2.1 + 1.2	8.2 ± 3.4
6-7/78	15.6	12.2	3.5	3.4 + 2.7	2.2 + 1.3	7.3 ± 1.6
10-11/78	17.7	14.5	3.2	2.7 + 2.7	1.7 + 1.3	7.1 ± 2.2

locations or times in populations of laminarian kelps. Instead, stipe length has been used frequently to examine size and age structure (e.g., Mann 1972) and was measured for that purpose during this study. However, we simultaneously conducted a growth study at Jakolof Bay which indicated that stipes of a large proportion of adult plants at that location shrank or did not grow, and those that grew did so slowly and irregularly (Dames & Moore 1979b). This casts doubts on the efficacy of examining age structure through stipe length or using size structure to measure growth rates and follow year-classes at this location.

Further evidence of this difficulty is provided by examination of temporal changes in size structure (based on stipe length) in subtidal populations of Agarum at Seldovia Point (Figure 6-7). Modes representing year-classes are not clearly defined nor do they appear to show growth with passing seasons. This was particularly noticeable for smaller plants between June and October-November 1978. Although a large proportion of the total population had stipe lengths less than 5 cm in June, modal (Figure 6-7) and average size (Table 6-46) had not increased by October-November. Furthermore, density reductions clearly interpretable as mortality were not apparent in these modes between June and October-November.

Primary Production of Agarum

Estimates of primary production for subtidal populations of Agarum were calculated using plant size data, a length-weight regression, estimates of standing stocks for Agarum from 1977 and 1978, and two assumptions. These assumptions, based on studies at Jakolof Bay (Dames & Moore 1979b), are that 1) the average rate of blade elongation was 57.7 cm/year and 2) this rate is size-independent. The five steps involved are:

1) Calculate plant blade production for individual plants by multiplying a ratio of blade weight to blade length by the average annual growth (AGI) increment. (Appendix E).

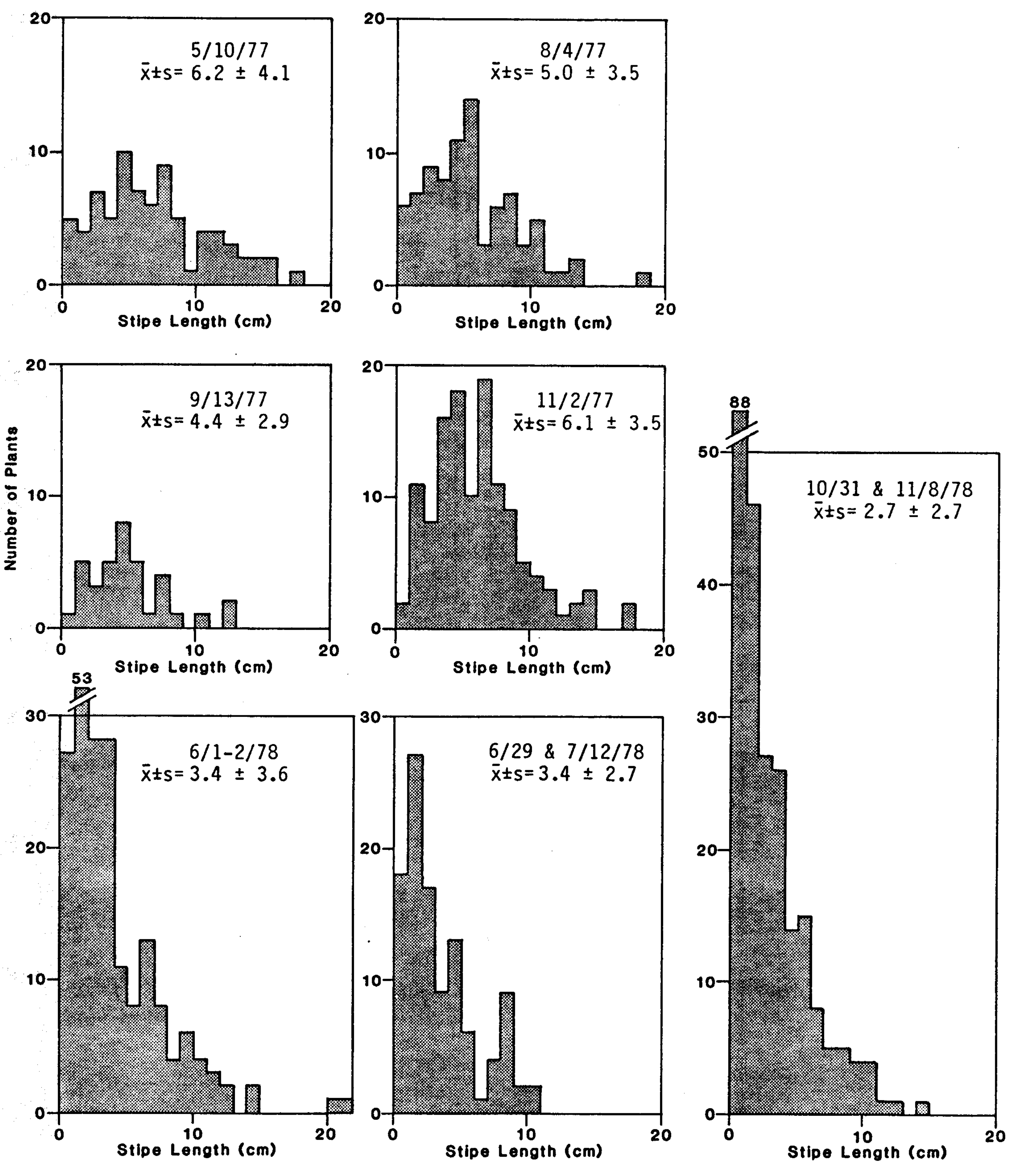

FIGURE 6-7

SIZE FREQUENCY HISTOGRAMS COMPARING SIZE STRUCTURE OF SUBTIDAL POPULATIONS OF THE KELP, *Agarum cribrosum* AT SELDOVIA POINT IN 1977 & 1978

Method A:

$$P_A = B_o/BL \times AGI$$

B_{oi} B_o = the actual blade weights for individual plants are collected at Jakolof Bay on 29 March, 1979.

BL_i BL = the individual blade lengths

AGI = 57.7 cm/yr for Agarum

Method B:

$$P_B = BW/BL \times AGI$$

To reduce variability in B_o/BL, a regression was calculated using B_o/BL vs. stipe length (SL) for each plant. As expected, the correlation was highly significant (Figure 6-8). Standardized estimates of blade weight per blade length (BW/BL) were then obtained from the regression equation using stipe lengths for individual plants.

The estimates of BW/BL calculated by Method B are, on the average, higher for smaller plants and lower for larger plants than appears to be the case in the sample (compare regression line with data points in Figure 6-8). As a consequence of the preponderance of smaller plants, the mean value of P/B estimated by Method B was higher than by Method A.

2) Estimate individual P/B_o ratios using both methods A & B.

3) Calculate regressions for the relationships between both estimates of P/B vs. SL. Since the estimates from Method A produced the best fit, that regression formula was used for subsequent calculations. The relationship between P/B estimates determined by Method A and stipe length are shown in Figure 6-9. Also the regression equation is indicated and a regression line plotted.

4) Calculate P/B. An estimate of P/B was calculated for the Seldovia Point population of Agarum in May 1977 and June 1978 based on size

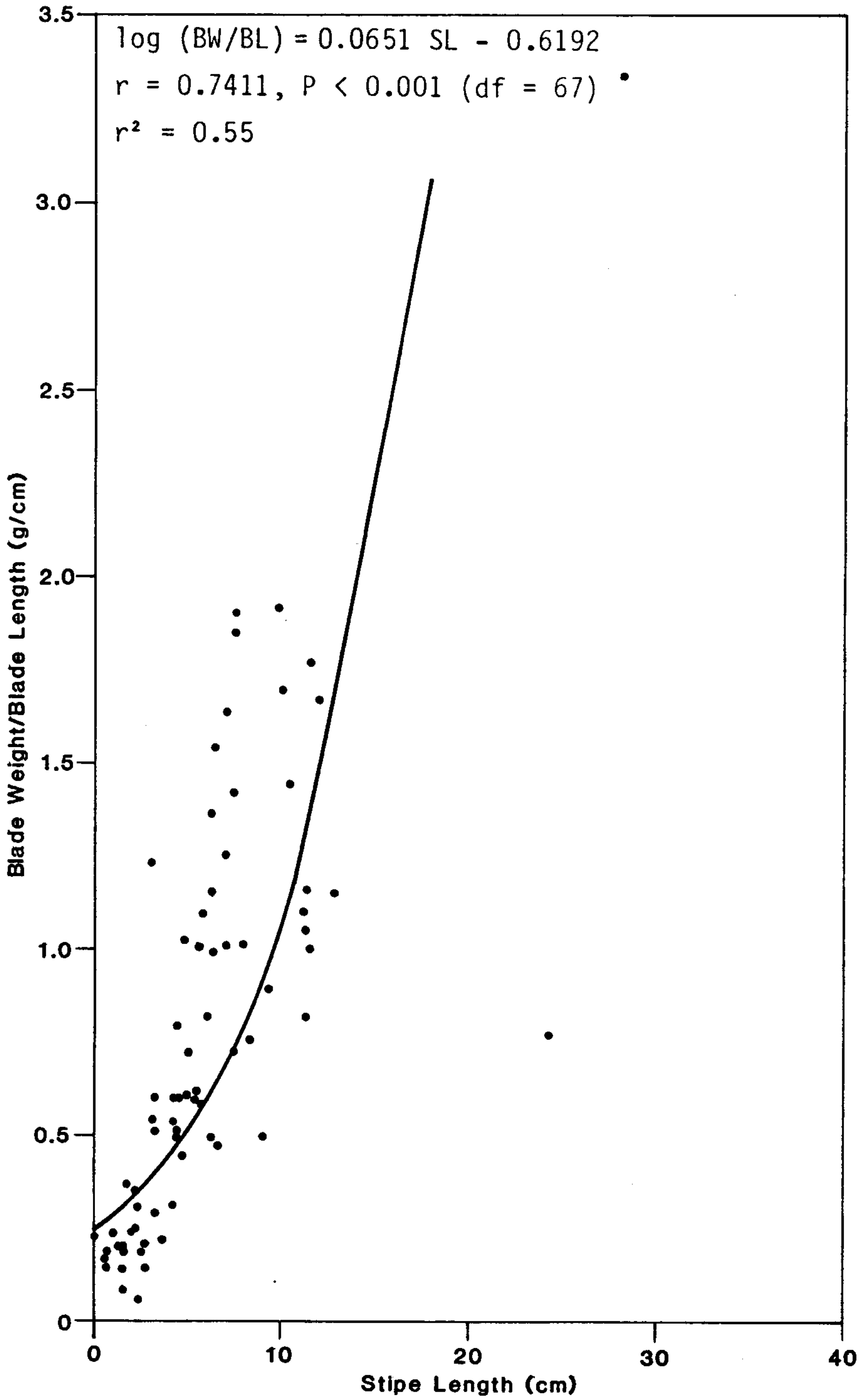

FIGURE 6-8

RELATIONSHIP BETWEEN STIPE LENGTH (SL) & THE RATIO OF BLADE WEIGHT (g) TO BLADE LENGTH (cm) FOR Agarum cribrosum AT JAKOLOF BAY, 29 MARCH 1979

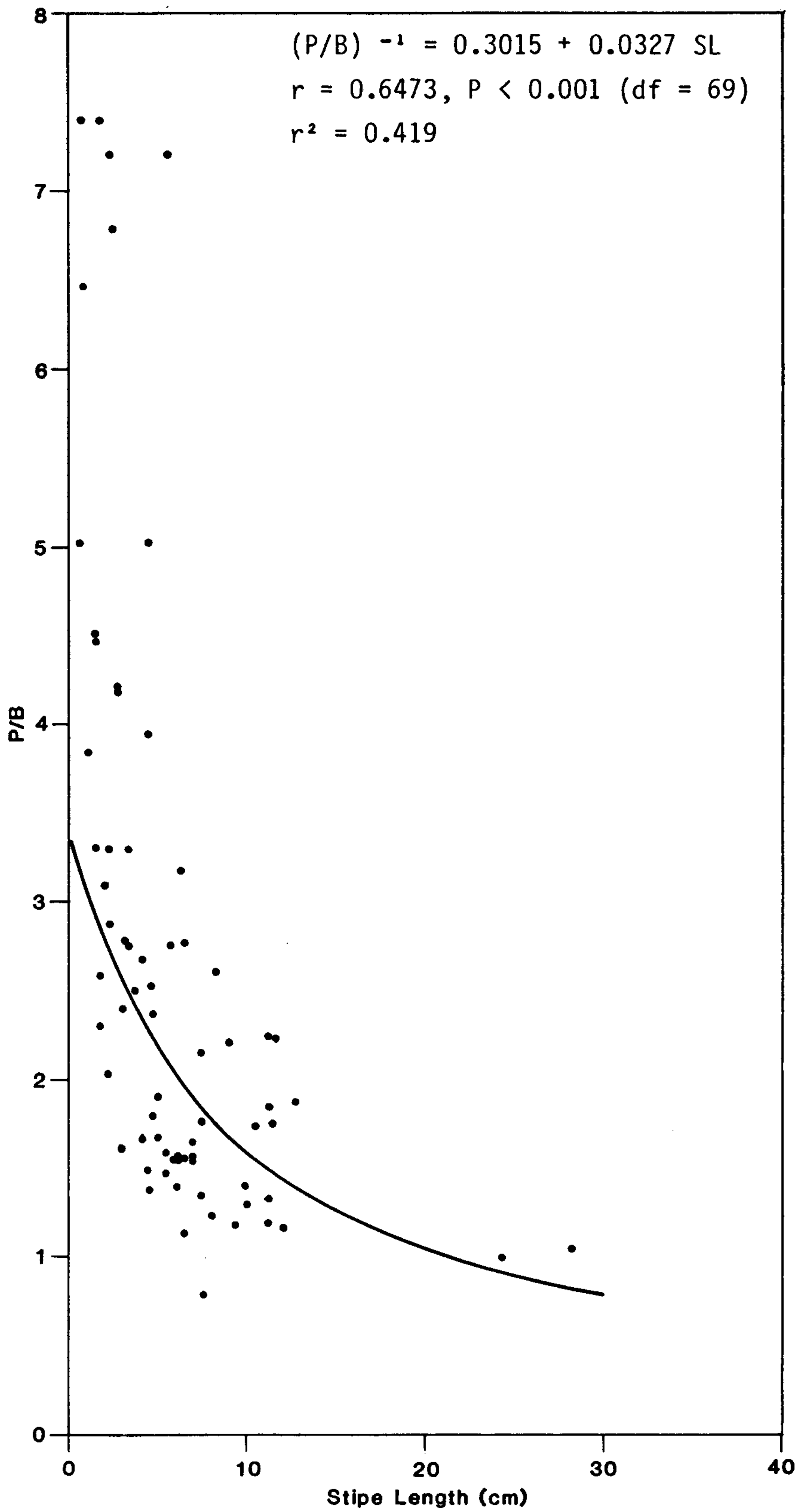

FIGURE 6-9

RELATIONSHIP BETWEEN STIPE LENGTH (SL) & RATIO OF PRODUCTIVITY (P) TO BIOMASS (B) FOR *Agarum cribrosum* AT JAKOLOF BAY structures represented in Figure 6-7. An estimate of $(P/B)_i$ was computed for each size class, weighted according to class frequency, and then used to calculated $P/\bar{B}$.

Based on this procedure, P/B was 2.05 and 2.48, respectively, for May 1977 and June 1978. P/B was higher in 1978 because of the larger proportion of smaller plants, which have higher P/B ratios.

5) **Estimate blade tissue production.** Using these ratios and the average biomass estimates for those years (Table 6-23), the tissue production by Agarum in the Seldovia Point study area is estimated to have ranged from 915 g/m^2 in 1977 to 2427 g/m^2 in 1978, and to have averaged 1223 g/m^2 over the survey period. Generally, these estimates are probably rather conservative. Overall density and biomass estimates for 1978 do not include data for the 18 m level and are thus somewhat more generous than the 1977 estimates. It is clear, however, based on data from the 6 and 12 m levels, that density was, in fact, higher in 1978. On the other hand, average values for P/B are somewhat conservative because the regression equation used (see Figure 6-9) appeared to underestimate P/B considerably for smaller plants, which dominated the population in 1978.

6.2.4.2 Population Parameters for Laminaria groenlandica

Several population parameters for Laminaria groenlandica were routinely measured at both intertidal and subtidal sampling levels at Seldovia Point. The most important of these parameters include density, biomass and size structure. Size measurements included stipe length, total length, and total weight, permitting assessment of several morphometric relationships, growth rate and a condition factor.

Density

Density data summarized in Tables 6-23 and 6-47 suggest that density is highest in spring and summer and lowest in fall and winter. Furthermore,

TABLE 6-47 AVERAGE DENSITY (No. OF PLANTS/m^2) AND BIOMASS (g/m^2) OF LAMINARIA GROENLANDICA IN INTERTIDAL AREAS AT SELDOVIA POINT IN 1977 AND 1978

	Density				Biomass			
Elevation (m)	1.5	0.8	0.0	Overall	1.5	0.8	0.0	Overall
2/77	0.8	0	0	0.2	0	0	0	0
5/77	0	23	4.4	13.2	17.5	121.1	111.6	84.5
7/77	3.6	15.2	182.0	66.9	35.0	23.1	3714.3	1257.5
8/77	0.4	1.2	42.4	15.2	9.1	0.4	240.3	85.8
3/78	0	--	6.4	3.2	0	--	6.0	3.0
5/78	0	--	80.0	40.0	0	--	66.5	33.3
6/78	0.4	--	101.6	51.0	0.6	--	31.0	15.8
6-7/78	5.6	--	66.4	36.0	10.4	--	63.9	37.2
10/78	0.4	--	25.5	11.6	0	--	11.1	4.9
					8.1	48.2	530.6	202.8
					11.9	64.2	1288.6	786.4

densities were probably somewhat higher in 1978 than in 1977. Within these temporal patterns, densities in the intertidal zone were generally somewhat higher than at the subtidal sites. Densities in the intertidal zone were generally considerably higher at the lowest level surveyed and were dramatically lower in winter. In the subtidal zone, densities were usually higher at the 9- and 12-m levels than elsewhere, and seasonal variation was less dramatic than intertidally. In both intertidal and subtidal habitats, populations were spatially quite patchy.

Comparisons between density of adult and juvenile plants do not provide clear insight into temporal recruitment patterns (Table 6-48). However, juvenile plants were generally more dense than adult plants in summer.

Biomass

Biomass exhibited considerable variability among sampling levels and surveys (Table 6-23 and 6-47), and few strong patterns were apparent. Highest biomass values were observed during summer months in both the intertidal and subtidal areas. In the intertidal zone, biomass was greatest in 1977, but subtidally, it was greatest in 1978. Overall, biomass was higher and less variable in the subtidal zone where it averaged about 0.33 kg/m^2 than in the intertidal zone. In the intertidal zone, biomass averaged 0.2 kg/m^2 between the 0.0- and 1.0-m levels. Although not measured, biomass increased at lower levels in the intertidal zone (personal observation).

Size Structure

The size structure of Laminaria populations changed considerably during the study, both seasonally and between years (Figures 6-10 and 6-11). The populations included a larger proportion of mature plants in 1977 than in 1978 intertidally and subtidally, and by 1978, the intertidal population comprised mainly juvenile plants (Figure 6-11). The subtidal population appeared to comprise a sizeable proportion of adults throughout the study, but the proportion was greatest in 1977.

TABLE 6-48 AVERAGE DENSITY FOR ADULT AND JUVENILE *LAMINARIA GROENLANDICA* AT SUBTIDAL LEVELS AT SELDOVIA POINT

Survey	Juveniles	Adults	Overall
2/77	2.0	3.9	5.9
5/77	3.2	1.1	4.3
7/77			--
8/77	1.3	0.7	2.0
9/77			--
11/77	--	--	1.3
3/78			--
5/78			--
6/78	2.1	17.6	19.7
6-7/78	9.9	3.8	13.7
10-11/78	9.4	5.4	14.8

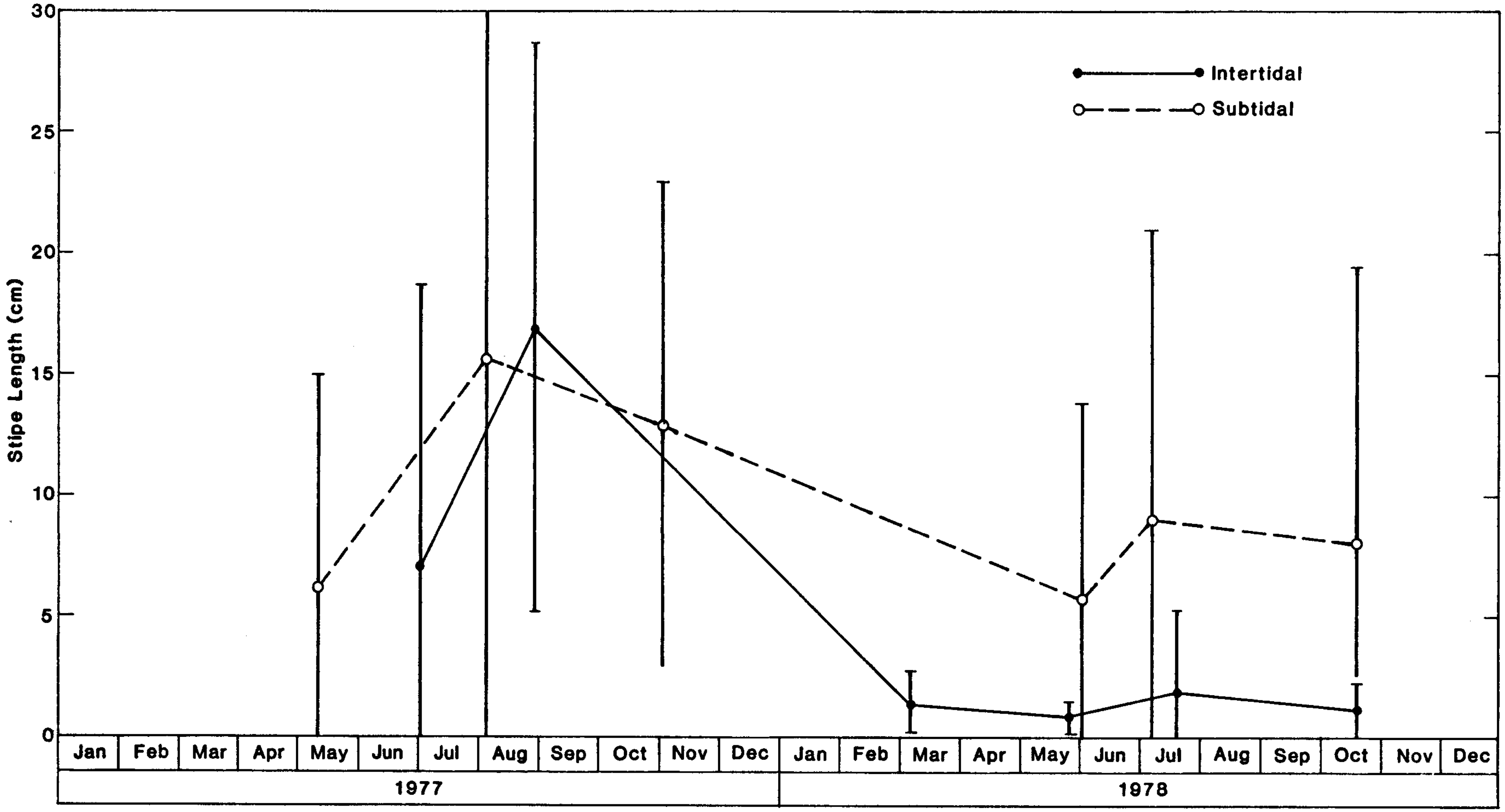

FIGURE 6-10

VARIATION IN MEAN STIPE LENGTH (±s) OF <u>Laminaria groenlandica</u>
IN INTERTIDAL & SUBTIDAL POPULATIONS AT SELDOVIA POINT IN 1977 - 1978

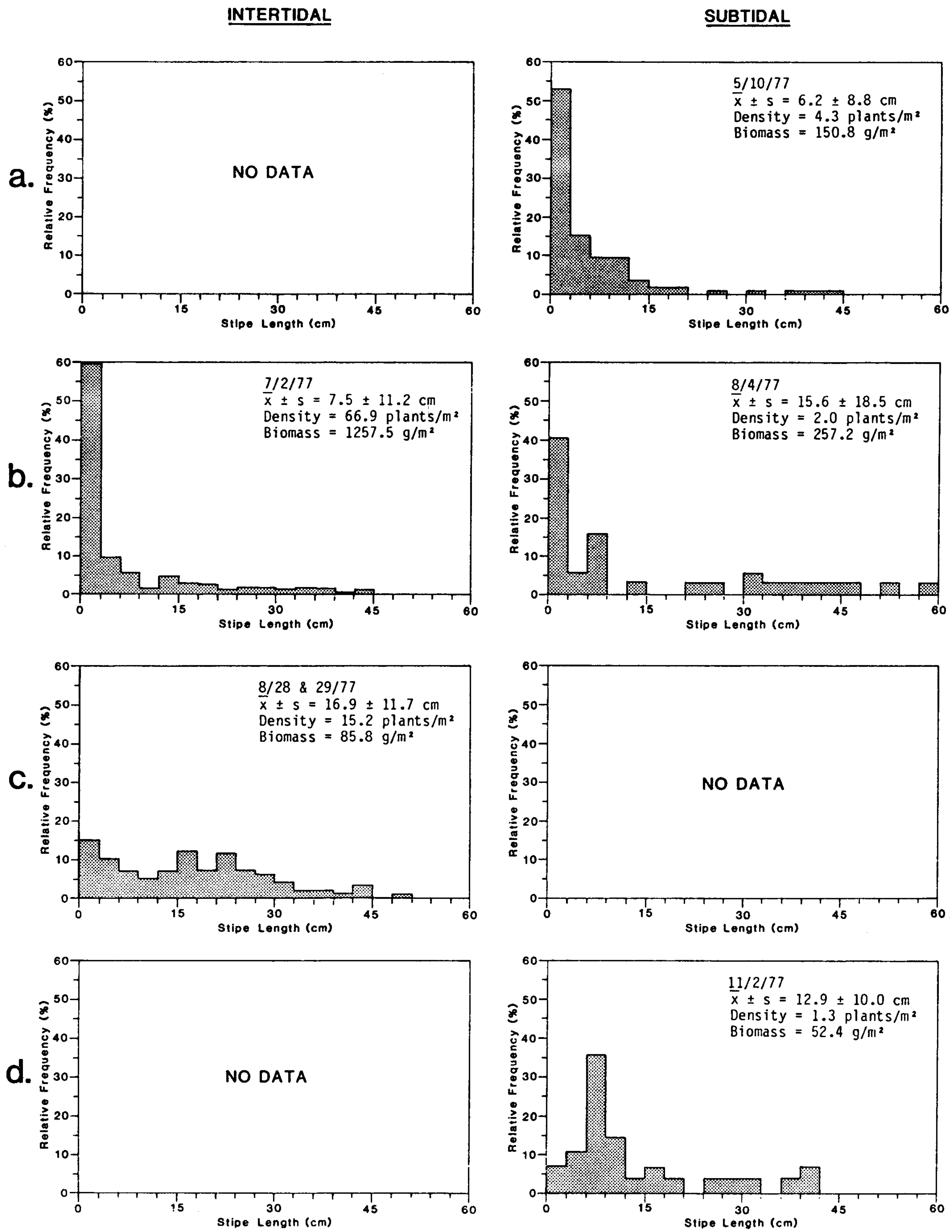

FIGURE 6-11 (1 of 2)

SIZE FREQUENCY HISTOGRAMS COMPARING RELATIVE SIZE STRUCTURE OF INTERTIDAL & SUBTIDAL POPULATIONS OF THE KELP *Laminaria groenlandica* AT SELDOVIA POINT IN 1977 & 1978

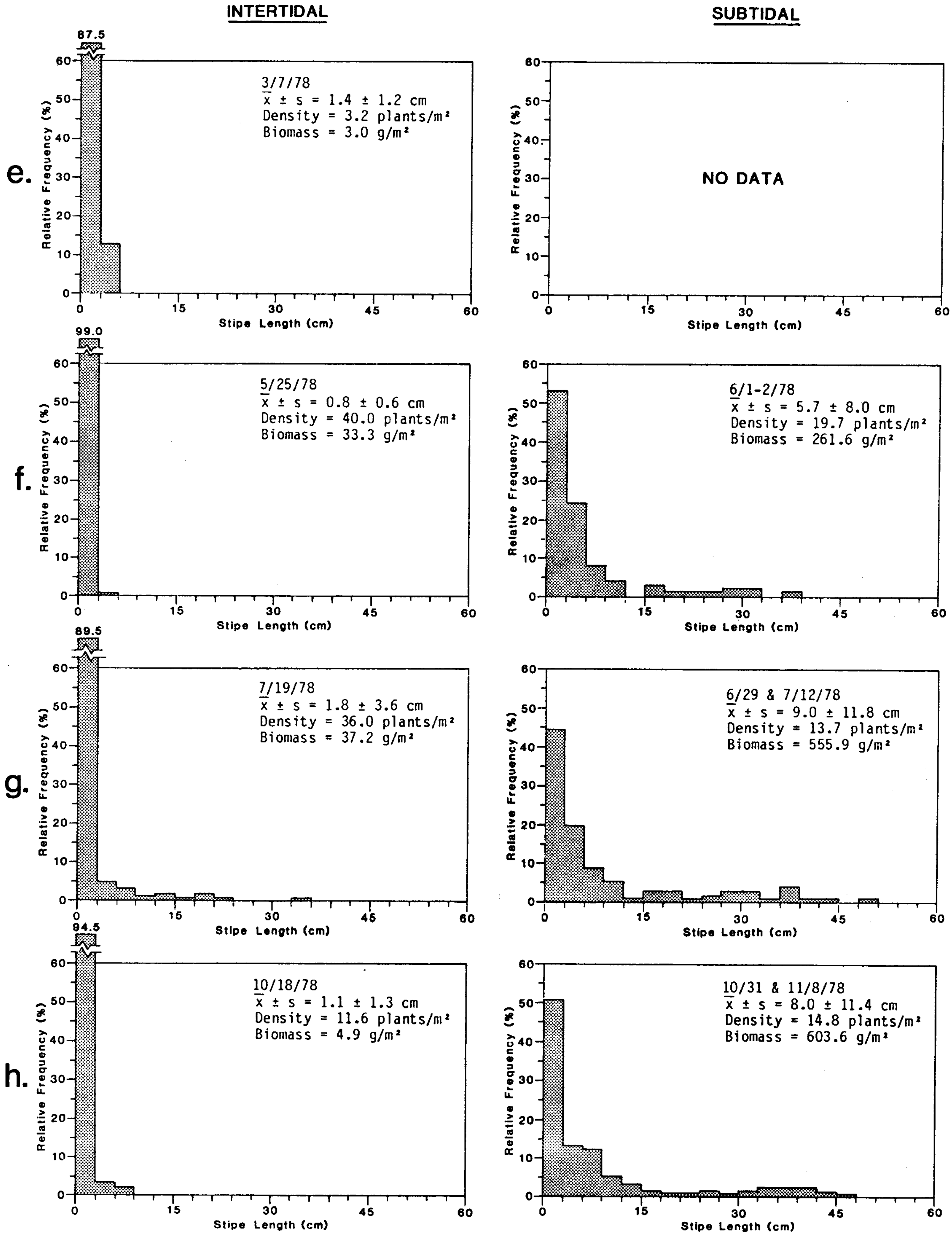

FIGURE 6-11 (2 of 2)

SIZE FREQUENCY HISTOGRAMS COMPARING RELATIVE SIZE STRUCTURE OF INTERTIDAL & SUBTIDAL POPULATIONS OF THE KELP *Laminaria groenlandica* AT SELDOVIA POINT IN 1977 & 1978

Although Dames & Moore (1979b) observed stipe growth in tagged plants, little evidence of an appreciable change in average stipe length of small plants was apparent in the size data (Figure 6-11). A partial explanation of this might be that, although most stipe growth was observed during the winter and early spring in the growth experiments (Dames & Moore 1979b), no stipe length data are available from Seldovia Point during that period. However, since appreciable stipe growth was observed for Laminaria in the Jakolof study, size structure may be a useful indicator of age structure. On this assumption, it appears that the age structure of the intertidal population was highly variable whereas the subtidal population is substantially more stable. Furthermore, the intertidal population appears to be nearly annual, whereas the subtidal population appears perennial.

Primary Production

Primary production was calculated separately for intertidal and subtidal habitats using the same rationale and procedures as were described for Agarum in the previous section. Generally, the same assumptions are involved except that the average rate of blade elongation for Laminaria was 90 cm/year. As in the case of Agarum, the growth rate was assumed independent of size (Dames & Moore 1979b).

Most of the estimates are summarized in Appendix G. The relationships of individual values for B_o/BL to stipe length are shown in Figure 6-12. Moreover, the relationships between the individual values of P/B, as calculated by Method A, and stipe length are shown in Figure 6-13. Using the regression equation given in Figure 6-13, and size structures represented in Figure 6-11, the estimates of P/B calculated for the subtidal population of Laminaria at Seldovia Point were 3.21 and 3.27 for May 1977 and June 1978, respectively. Estimates of P/B ratios for intertidal populations at Seldovia Point in July 1977 and July 1978 were 3.20 and 3.82. The increase in P/B in July 1978 is a result of a shift in the size structure to small plants.

Using these average ratios and the average biomass estimates for these years (Table 6-23 and 6-47), estimated tissue production by Laminaria ranged

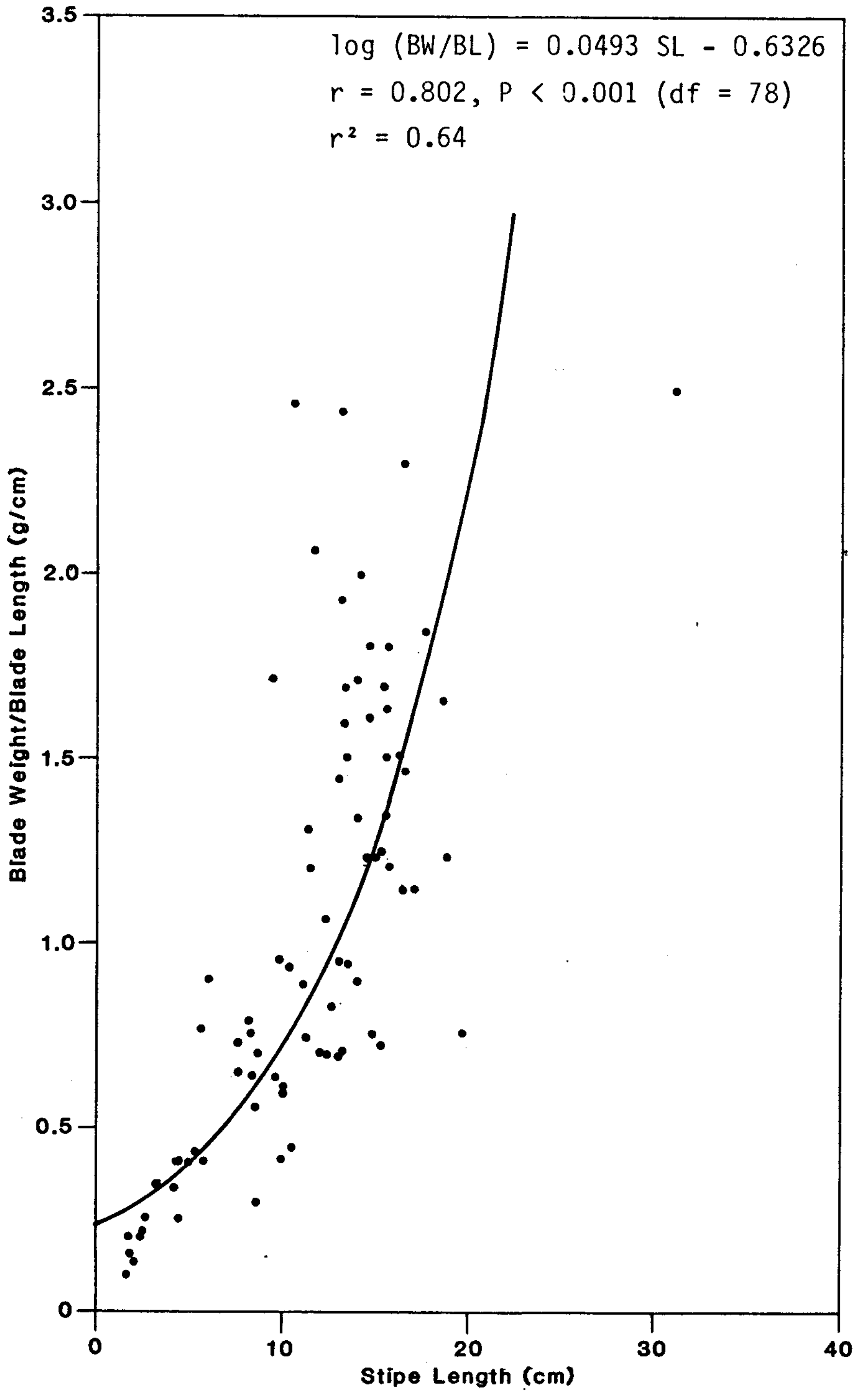

FIGURE 6-12

RELATIONSHIP BETWEEN STIPE LENGTH (SL) & THE RATIO OF BLADE WEIGHT (g) TO BLADE LENGTH (cm) FOR *Laminaria groenlandica* AT JAKOLOF BAY, 29 MARCH 1979

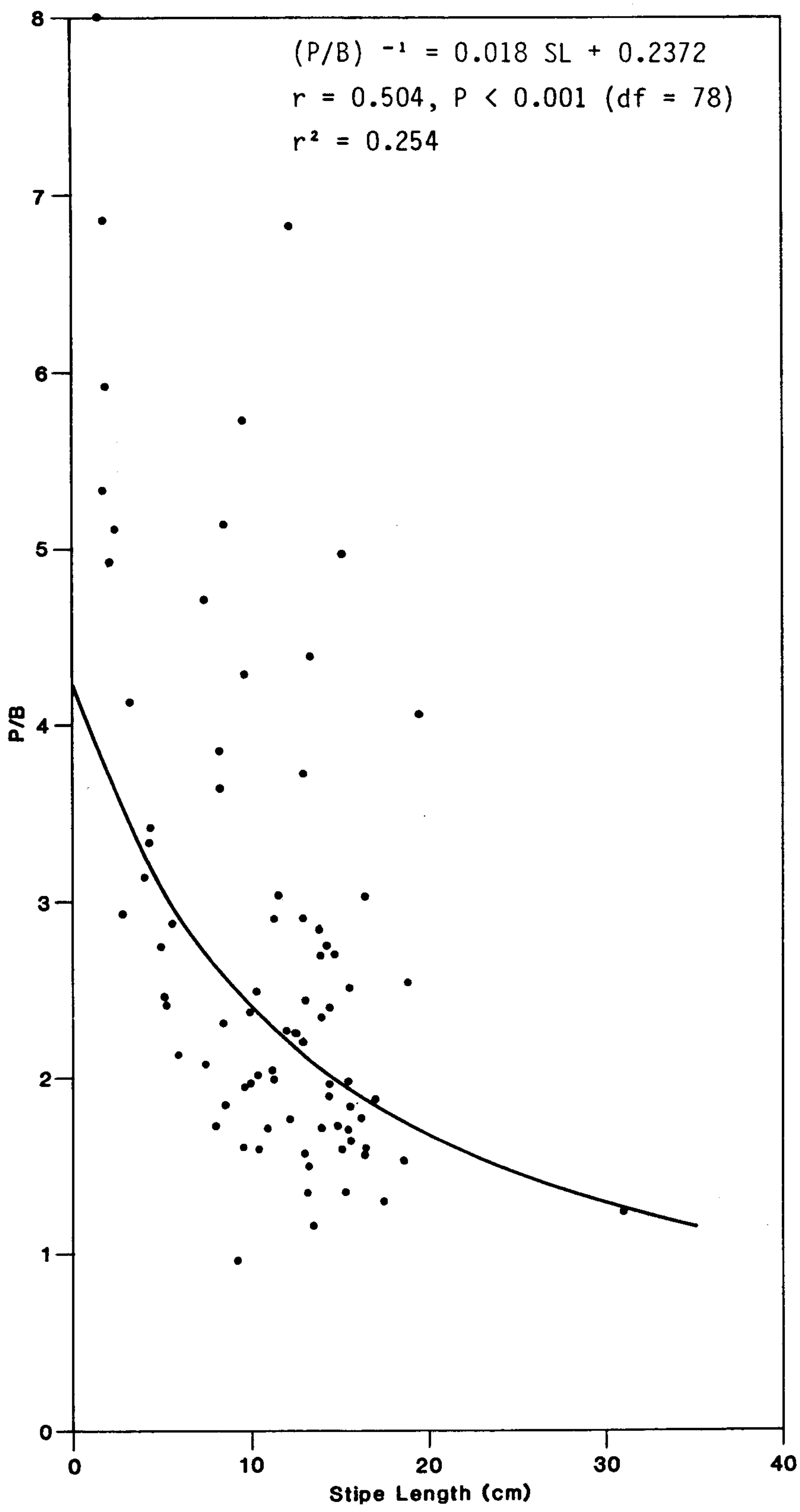

FIGURE 6-13

RELATIONSHIP BETWEEN STIPE LENGTH (SL) & RATIO OF PRODUCTIVITY (P) TO BIOMASS (B) FOR <u>Laminaria groenlandica</u> AT JAKOLOF BAY between 649 g/m^2 and 755 g/m^2 in the intertidal Laminaria zone, and between 1013 g/m^2 and 1032 g/m^2 in the subtidal zone.

Generally, these estimates are probably rather conservative. The reasons for this are described in the section discussing primary production of Agarum.

6.2.4.3 Site-Specific Primary Production

Site-specific estimates of primary production have been computed for several sites in lower Cook Inlet and NEGOA using the P/B ratios estimated for Agarum and L. groenlandica above. The method, described by Mann (1972), involves multiplying an appropriate estimate of P/B by an estimate of average annual biomass. The P/B ratios used are as follows:

Kelp	P/B Ratio
Agarum cribrosum	2.25
Laminaria spp	3.25
Nereocystis luetkeana	3.00
Pleurophycus gardneri	3.00

The P/B ratios for Nereocystis and Pleurophycus are rough estimates. Both are probably conservative, especially the estimate for Nereocystis, a rapidly growing annual plant (Scagel 1947). In addition, it is probable that the ratio for L. dentigera is higher than that determined for L. groenlandica.

In some instances, it seemed feasible to estimate a range of average annual biomass from single collections of data, based on two assumptions: 1) that average annual biomass ranges from 50 to 75 percent of the maximum standing crop, and 2) that the maximum standing crop generally occurs during July and August.

Seldovia Point

The estimates of average biomass for Agarum and Laminaria are based on data in Table 6-23. For Nereocystis, the estimate of biomass is based on a single survey in an open bull kelp bed near Barabara Point (Table 6-30). The standing stock determined for that site was considerably less than that observed at Latouche Point (Table 6-37) and probably is a reasonably conservative estimate of average biomass for the Seldovia Point bull kelp bed.

Nereocystis appears to be the dominant producer in areas where it forms a bed (Table 6-49), generally from about 3- to 12-m depths in much of the Seldovia Point bed. Agarum was the most important understory kelp at the 6-m and 18-m levels, where light levels were at the bottom may be more suitable for it than for Laminaria. The latter was more important in areas inshore and outside the kelp bed, as was usually the case at the 9-m level, but the species was supplanted in importance below 12-m and under the surface canopy by Agarum.

The estimated total production of about 20 kg/m^2 out to the 9-m level is probably reasonable for areas where the kelp canopy is at least fairly well developed.

Zaikof Point

Estimates of average biomass for Laminaria spp, Pleurophycus and Agarum are based on data in Table 6-31. Insufficient data are available for the 0- to 3-m level, but data obtained (Table 6-31) indicate that understory production by Laminaria spp and Pleurophycus may exceed that for understory species at the 3- to 7-m level (Table 6-50).

Although Nereocystis forms a loose bed between 3 and 7 m (Table 6-31), the biomass data available are unsatisfactory and so it is not feasible to estimate average animal standing stocks or production. Despite this omission, production by understory kelps at the 3- to 7- m level was quite high (Table 6-50). Laminaria spp were the understory dominants; bull kelp

TABLE 6-49 COMPARISON OF ESTIMATED PRIMARY PRODUCTION OF MAJOR KELPS AT VARIOUS DEPTHS AT SELDOVIA POINT

KELP TAXON	Depth (m) 6	9	12	18
Agarum cribrosum - Ave. biomass (g/m^2)	872	650	371	280
Estimated Annual Production ($g/m^2/yr$), estimated P/B ratio of 2.25	1,962	1,463	835	630
Laminaria groenlandica - Ave. biomass (g/m^2)	113	1,342	274	49
Estimated Annual Production ($g/m^2/yr$), estimated P/B ratio of 3.25	367	4,362	891	159
Total Understory Kelp Production ($g/m^2/yr$)	2,329	5,825	1,726	789
Nereocystis luetkeana - Ave. biomass (g/m^2)**	5,400	5,400	1,800	0
Estimated Annual Production ($g/m^2/yr$), estimated P/B ration of 3.0	16,200	16,200	5,400	0
Total Annual Production ($g/m^2/yr$)	18,529	22,025	7,126	789

* Insufficient data to permit inclusion of Alaria fistulosa.

** Average biomass based on data collected at 10 m near Barabara Point, at the east end of the Seldovia Point kelp bed.

TABLE 6-50 ESTIMATES OF PRIMARY PRODUCTION FOR LAMINARIAN KELPS AT ZAIKOF POINT, BASED ON ESTIMATED P/B RATIOS FROM KACHEMAK BAY

	0 to 3 m Level		3 to 7 m Level		7 to 12 m Level	
Kelp Taxon	Average Biomass (g/m^2)	Primary Production ($g/m^2/yr$)	Average Biomass (g/m^2)	Primary Production ($g/m^2/yr$)	Average Biomass (g/m^2)	Primary Production ($g/m^2/yr$)
Laminaria spp	4170 - 6250	12,510 - 18,750	3602	11,707	587	1,908
Pleurophycus gardneri	1025 - 1535	3075 - 4605	906	2,945	134	436
Agarum cribrosum	0	0	377	848	325	731
Total Estimated Plant production (g tissue/m^2/yr)		15,585 - 23,355		15,500		3,075

production figures would add considerably to the total. Production at the 7- to 12- m level was again dominated by Laminaria spp; although markedly lower than at the upper levels, it was still high. Low average biomass at the 12- to 15-m level (Table 6-31) suggests that production at that level is low.

Zaikof Bay, NMFS Site

Although little plant biomass data were collected at the Zaikof Bay NMFS site (Table 6-34), we have used them to estimate ranges of average plant biomass and annual production. These estimates, based on the assumptions stated above, are quite preliminary.

The estimates of plant production are generally considerably lower than those reported for the upper levels at Zaikof Point but are higher at the lower level here than at the lowest level at the point (Table 6-51). The kelp assemblage extends deeper at the NMFS site than at Zaikof Point, probably as a consequence of the abrasive action induced by the combination of tidal currents and suspended sand and shell debris toward the lower edge of the boulder field at Zaikof Point. Agarum is more important at all levels at the NMFS site (Table 6-51), suggesting that light levels are generally lower there; in fact, water clarity generally was only moderately good at this site during diving surveys.

Sea Lion Pinnacles

Collection of plant biomass data at Sea Lion Pinnacles was spotty (Table 6-40). However, enough data are available to suggest that plant production was substantial down to a depth of at least 17 m (Table 6-52). Although no data are available from MLLW to 7 m, it is probable that plant production was quite high, based on qualitative examination of the development of the kelp assemblage in that level. Between 7 and 17 m, standing stocks and plant production of laminarians were similar. Although not quantified, bull kelp production was probably lower from 12 to 17 m.

TABLE 6-51 ESTIMATES OF PRIMARY PRODUCTION FOR LAMINARIAN KELPS AT THE ZAIKOF BAY NMFS SITE

	Level (m)			
	3 to 7		7 to 12	
Kelp Taxon	Average Biomass (g/m^2)*	Primary Production ($g/m^2/yr$)	Average Biomass (g/m^2)*	Primary Production ($g/m^2/yr$)
Agarum cribrosum	715-1,000	1600-2,250	450-675	1000-1,520
Laminaria spp.	130-200	420-650	20-25	65-80
Total estimated plant production (g tissue/m^2/yr)		2020-2900		1065-1600

*Based on assumptions stated at the beginning of Section 6.2.4.3, and thus a range of values is presented.

TABLE 6-52 ESTIMATES OF PRIMARY PRODUCTION FOR LAMINARIAN KELPS AT SEA LION PINNACLES, DANGER ISLAND

	Level (m)					
	7 to 12		12 to 17		17 to 22	
Kelp Taxon	Average Biomass (g/m^2)*	Primary Production ($g/m^2/yr$)	Average Biomass (g/m^2)*	Primary Production ($g/m^2/yr$)	Average Biomass (g/m^2)*	Primary Production ($g/m^2/yr$)
Laminaria spp	950-1425	3100-4600	1860-2800	6050-9100	10-15	30-50
Pleurophycus gardneri	1220-1830	4000-5950	450-700	1500-2275	--	
Agarum cribrosum	20-25	45-55	10-15	20-35	30-45	65-100
Total estimated plant production (g tissue/m2/yr)		7145-10,605		7570-11,410		95-150

* Based on assumptions stated at the beginning of Section 6.2.4.3, and thus a range of values is presented.

Production estimates in the 7- to 12-m level were notably higher than the estimate for the same depth range at Zaikof Point, where production may have been adversely effected by abrasion from suspended sediments. Significant plant production obviously extended quite a bit deeper at Sea Lion Pinnacles than at Zaikof Point. Agarum cribrosum never attained importance.

Latouche Point

Estimates of average biomass for Laminaria spp, Pleurophycus, Agarum and Nereocystis are based on data in Table 6-43. Data were only collected at the 9-m level. Two estimates of production were computed (Table 6-53). The lower estimate is based on all biomass data collected at Latouche Point. The higher estimate, based on data collected from a dense, robust bull kelp bed located centrally south of Latouche Point, was an attempt to evaluate maximal production in dense kelp beds. Generally, algal production is quite high at Latouche Point. This is largely because of the extent of the Nereocystis bed; bull kelp appears to dominate plant production which may, in the dense kelp beds, exceed 70 kg/m^2 annually.

6.3 SOFT SUBSTRATES

At the three sand beaches and the two mud flats studied, the representative faunas were distinctly different. In all, over 85 taxa were identified in the core samples. Twenty-nine species were identified from seven surveys on the sand beach at Deep Creek (Table 6-54; the fauna was dominated by the gammarid amphipod Eohaustorius eous. Thirty-seven species were identified from seven surveys on the sand beach at Homer Spit (Table 6-54); the fauna was dominated by the polychaete Scolelepis sp. Twenty-one species were identified from two surveys on the sand beach at Iniskin Beach (Table 6-54); the fauna was dominated by the Eohaustorius eous. Fifty-two species were identified from five surveys on the mud flat at Chinitna Bay (Table 6-54); the fauna was dominated by the clams Macoma balthica, Mya arenaria, and M. priapus. Forty-four species were identified from two suveys on the mud

TABLE 6-53 ESTIMATES OF PRIMARY PRODUCTION FOR UNDERSTORY AND CANOPY-FORMING KELPS AT 9-m DEPTH AT LATOUCHE POINT

TAXA	Average Biomass (g/m^2)	Average Primary Production ($g/m^2/yr$)	Dense Bull Kelp Bed - Primary Production ($g/m^2/yr$)*
Agarum cribrosum	173	390	175 - 260
Laminaria spp	920	2990	4700 - 7050
Pleurophycus gardneri	750	2438	2560 - 3835
Nereocystis luetkeana	10,530	31,590	40,500 - 60,750
TOTAL	12,373	37,408	47,935 - 71,895

* Biomass values based on Table 6-43, 12 August 1978; production estimates based on assumptions stated at the beginning of Section 6.2.4.3, and thus a range of values is presented.

TABLE 6-54 FREQUENCY OF OCCURRENCE OF SPECIES FROM SANDY AND MUDDY INTERTIDAL SITES IN LOWER COOK INLET; 1977-1978 Sheet 1 of 5

TAXA	Location/No. of surveys Deep Creek (7)	Homer Spit (7)	Iniskin Beach (2)	Chinitna Bay (5)	Cottonwood Bay (2)
PLATYHELMINTHES					
Turbellaria, unid.	0	1	0	0	0
NEMERTEA					
Nemertea, unid.	1	2	0	1	0
ANNELIDA - Oligochaeta					
Oligochaeta, unid.	0	1	0	1	0
ANNELIDA - Hirudinea					
Hirudinea, unid.	0	0	0	1	0
ANNELIDA - Polychaeta					
Abarenicola pacifica	1	1	0	1	0
Ampharete acutifrons	0	0	0	2	0
Aphroditoidae, unid.	0	0	0	1	0
Aricidea neosuecica	0	0	0	0	1
Axiothella rubrocincta	0	0	0	1	0
Capitella capitata	5	1	0	0	2
Capitella sp	1	0	0	4	0
Chaetozone setosa	0	0	0	1	1
Cirratulidae, unid.	1	0	0	0	0
Eteone nr *longa*	6	5	1	5	1
Eteone sp	0	0	0	2	1
Gattyana treadwelli	0	0	0	5	2
Glycinde picta	0	0	0	3	2
Glycinde polygnatha	0	0	0	1	0
Glycinde sp	0	0	1	0	0
Harmothoe imbricata	0	0	0	0	1
Laonome kroyeri	0	0	0	5	1
Lumbrineris sp	1	0	0	0	0

TABLE 6-54 FREQUENCY OF OCCURRENCE OF SPECIES FROM SANDY AND MUDDY INTERTIDAL SITES IN LOWER COOK INLET; 1977-1978 Sheet 2 of 5

TAXA	Location/No. of surveys Deep Creek (7)	Homer Spit (7)	Iniskin Beach (2)	Chinitna Bay (5)	Cottonwood Bay (2)
Magelona pitelkai/ *Magelona* sp	0	4	2	0	0
Maldanidae, unid.	0	0	1	1	0
Nephtys sp	6	7	2	4	2
?*Nephtys* sp	0	0	0	1	0
Paraonella platybranchia	7	7	2	1	0
Paraonidae, unid.	0	0	0	2	0
Pholoe minuta	1	0	0	3	1
Phyllodoce groenlandica	0	0	0	5	1
Polychaeta, unid.	0	0	0	1	1
Polydora caulleryi	0	0	0	2	0
P. polybranchia	0	0	0	2	0
Polydora sp	0	0	0	0	2
Polygordius sp	0	0	0	1	0
Potamilla sp	1	0	0	1	0
Prionospio steenstrupi	0	0	0	3	1
Sabellidae, unid.	0	1	0	0	1
Scolelepis sp	7	7	2	0	0
Scoloplos armiger	7	3	2	3	1
Spio filicornis	0	0	0	2	1
Spionidae sp 1	0	0	0	0	1
Spionidae sp 2	0	0	0	0	1
Spionidae, unid.	0	1	0	2	0
Spiophanes ?*bombyx*	0	1	0	0	0
Typosyllis sp	0	1	0	0	0
ECHIURA					
Echiurus echiurus	0	0	0	5	2

TABLE 6-54 FREQUENCY OF OCCURRENCE OF SPECIES FROM SANDY AND MUDDY INTERTIDAL SITES IN LOWER COOK INLET; 1977-1978 Sheet 3 of 5

TAXA	Location/No. of surveys Deep Creek (7)	Homer Spit (7)	Iniskin Beach (2)	Chinitna Bay (5)	Cottonwood Bay (2)
ARTHROPODA - Crustacea					
Acarina, unid.	0	0	0	1	0
Acanthomysis sp	0	0	1	0	0
Anisogammarus pugettensis	4	1	1	3	1
Anonyx sp	0	1	0	0	0
Archaeomysis grebnitzkii	3	2	0	0	0
Atylus sp	2	1	1	0	0
Calliopius sp	0	0	0	0	1
Copepoda, unid.	0	1	0	0	0
Crangon alaskensis elongata	0	1	0	0	0
Crangon sp	1	1	2	2	0
Cyclopodia, unid.	0	0	0	1	0
Diastylis sp	0	0	0	1	1
Decapoda, unid.	0	0	0	0	1
Eohaustorius eous	7	7	2	2	0
Eusiridae, unid.	0	0	0	0	1
Gammaridae, unid. (red eye)	0	0	0	1	0
Gammaridae, unid.	0	1	0	0	0
Gammaridae sp A	1	0	0	0	0
Gnorimosphaeroma oregonensis	1	0	0	0	0
Harpacticoida, unid.	0	0	0	2	1
Hippomedon sp	0	0	1	0	0
Ischyroceridae, unid.	0	0	0	1	0
Isopoda, unid.	1	0	0	0	0
Lamprops carinata	0	1	0	0	0
L. quadriplicata	0	1	0	0	0
Lamprops sp	2	2	1	2	1

TABLE 6-54 FREQUENCY OF OCCURRENCE OF SPECIES FROM SANDY AND MUDDY INTERTIDAL SITES IN LOWER COOK INLET; 1977-1978 Sheet 4 of 5

TAXA	Location/No. of surveys Deep Creek (7)	Homer Spit (7)	Iniskin Beach (2)	Chinitna Bay (5)	Cottonwood Bay (2)
Monoculodes sp	1	0	0	0	0
Orchestia sp	0	0	0	0	1
Paraphoxus milleri	7	7	2	0	0
Paroediceros sp	2	1	0	0	0
Pontogenia sp	0	0	0	0	1
Pontoporia femorata	0	0	0	1	0
Saduria entomon	0	0	0	1	0
Synchelidium sp	0	1	0	0	0
Synopiidae, unid.	0	0	0	1	0
Talitroidae, unid.	0	1	0	0	2
Talitrus sp	0	0	0	1	0
Tritella pilimana	0	0	0	5	1
ARTHROPODA - Insecta					
Insecta, unid.	0	0	1	2	1
Staphylinidae, unid.	0	1	0	0	0
MOLLUSCA - Gastropoda					
Aglaja sp	0	0	0	3	1
Cylichna ?alba	0	0	0	0	1
Cylichna sp	0	0	0	3	0
Gastropoda, unid.	0	0	1	1	1
Lacuna sp	0	0	0	0	1
Littorina sitkana	0	1	0	0	0
Littorina sp	0	0	0	0	1
Nucella lima	1	0	0	0	0
Nucella sp eggs	0	0	0	0	1
MOLLUSCA - Pelecypoda					
Clinocardium sp	0	2	0	5	1

TABLE 6-54 FREQUENCY OF OCCURRENCE OF SPECIES FROM SANDY AND MUDDY INTERTIDAL SITES IN LOWER COOK INLET; 1977-1978 Sheet 5 of 5

TAXA	Location/No. of surveys Deep Creek (7)	Homer Spit (7)	Iniskin Beach (2)	Chinitna Bay (5)	Cottonwood Bay (2)
Macoma balthica	2	1	0	5	2
Macoma sp	0	0	0	1	0
Mytilus edulis	1	2	0	0	0
Mya arenaria	0	0	0	5	0
M. priapus	0	0	0	5	0
M. truncata	0	0	0	4	0
Mya spp	0	0	0	5	1
Orobitella sp	0	0	0	0	1
Protothaca staminea	0	2	0	0	0
Pseudopythina sp	0	0	0	5	2
Siliqua patula	0	0	1	0	0
Spisula polynyma	0	5	0	0	0
Tellina lutea	0	2	1	0	0
PHORONIDA					
Phoronida, unid.	0	0	1	0	0
ECTOPROCTA					
Buskia sp	0	0	0	0	1
CHORDATA - Pisces					
Ammodytes hexapterus	1	3	0	0	0
Fish larvae, unid.	0	0	0	1	0
Liparis sp	0	0	0	0	1

flat at Cottonwood Bay (Table 6-54); the fauna was dominated by the spoonworm Echiurus echiurus and the small commensal clam Pseudopythina sp. Although unmeasured, the mud flats also supported appreciable standing crops of benthic diatoms and filamentous brown and green algae in the summer.

6.3.1 Sand Beaches

6.3.1.1 Biological Assemblage of the Sand Beach at Deep Creek

The infaunal assemblage at the Deep Creek site was sampled seven times during the two-year period covered by this report, namely on 4 February, 7 April, 29 July, and 10 November 1977, and 8 April, 16 August, and 1 November 1978. Twenty-eight taxa, including eleven polychaetes, twelve crustaceans, two pelecypods, one gastropod, one nemertean, and one fish were identified during the sampling period.

Quantitatively, the infauna was dominated strongly by gammarid amphipods, especially the haustoriid Eohaustorius eous (Table 6-55). Paraphoxus milleri was also found on all surveys but was of lesser numerical importance.

An unidentified member of the amphipod family Gammaridae (Gammaridae sp A*) was quite abundant in July 1977. The remaining species were of only marginal numerical importance. Dominant polychaetes, in order of importance, included Scolelepis sp, Paraonella, Scoloplos, and Eteone.

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 Chapter 5.0). Species composition was then compared among the sampling levels. According to these criteria Eohaustorius was the most important species at the upper level, followed by Eteone (Table 6-56). The

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* The gammarid was suspected of being immature Anisogammarus, but positive identification was not feasible.

TABLE 6-55 AVERAGE DENSITY (no/m^2) OF COMMON SPECIES AT DEEP CREEK

	4 February 1977		7 April 1977		19 July 1977		10 November 1977		8 April 1978		16 August 1978		1 November 1978	
TAXA	(no./m^2)	%	(no./m^2)	%	(no./m^2)	%	(no./m^2)	%	(no./m^2)	%	(no./m^2)	%	(no./m^2)	%
NEMERTEA										(1.2)				
Nemertea, unid														
ANNELIDA - Polychaeta		(18.5)*		(12.9)		(13.4)		(36.8)		(21.2)		(22.5)		(17.1)
Capitella capitata	9.6	1.8			9.6	0.8	6.4	1.6	3.2	0.6			9.2	0.3
Capitella sp											25.5	1.4		
Eteone nr longa	44.6	8.6	9.6	1.6	9.6	0.8			12.8	2.9	8.5	0.5	12.8	1.0
Nephtys sp			9.6	1.6	9.6	0.8	3.2	0.8	6.4	1.2	4.2	0.2	P	--
Paraonella platybranchia	15.9	3.0	9.6	1.6	12.7	1.0	47.7	12.3	28.7	5.4	80.7	4.4	47.5	3.2
Scolelepes sp	15.9	3.0	35.0	5.4	92.3	7.4	73.2	18.8	35.0	6.7	275.8	15.3	161.3	12.1
Scoloplos armiger (adult)	6.9	2.1	15.9	2.7	31.8	2.6	9.6	2.5	19.1	3.6	25.5	1.4	4.2	0.3
Scoloplos armiger (juvenile)											47.2	0.2		
ARTHROPODA - Crustacea		(81.9)		(84.7)		(84.8)		(63.1)		(74.5)		(77.3)		(82.8)
Anisogammarus pugettensis	6.4	1.2	6.4	1.0	0	0	3.2	0.8			8.5	0.5		
Archaeomysis grebnitzkii	3.2	0.6			3.2	0.2							4.2	0.3
Atylus sp											12.7	0.7	4.2	0.3
Eohaustorius eous	404.2	78.3	461.5	78.8	648.4	51.9	222.8	57.4	372.4	70.9	1196.6	66.2	1031.1	77.2
Gammaridae sp A					388.3	31.2								
Lamprops sp											42.5	2.4	4.2	0.3
Paraphoxus milleri	9.6	1.8	28.6	4.9	19.1	1.5	19.1	4.9	12.7	2.4	131.6	7.3	55.2	4.1
MOLLUSCA - Gastropoda										(0.6)				
Nucella lima									3.2	0.6				
MOLLUSCA - Pelecypoda														
Macoma balthica									6.4	1.2	4.2	0.2		

TABLE 6-56 IMPORTANT SPECIES AT EACH LEVEL AT DEEP CREEK FOR 1977-1978

	Sampling Level (M)			
TAXA	+0.3	0.0	-0.3	-0.9
POLYCHAETES				
Capitella capitata		Frequent		
Eteone nr *longa*	Frequent	Frequent		
Nephtys sp				Frequent
Paraonella platybranchia		Frequent	Sub-Dominant	Frequent
Scolelepis sp		Sub-Dominant	Dominant	Dominant
Scoloplos armiger			Frequent	Frequent
CRUSTACEANS				
Eohaustorius eous	Sub-Dominant	Dominant	Dominant	Dominant
Gammaridae sp A		Seasonal	Seasonal	Seasonal
Paraphoxus milleri		Frequent	Sub-Dominant	Sub-Dominant

0.0-m level also was dominated by Eohaustorius, whereas the lower two levels were dominated by Eohaustorius and Scolelepis. The former was the only species important at all levels.

The relationship between elevation and density was examined, and only the increase of Eohaustorius at lower elevations departed significantly from random ($P<0.005$). Densities of Scolelepis were generally larger at the lower levels but, when tested on unpooled data, the increase was significant only in November 1978 ($P<0.005$). Densities of Paraphoxus also increased with depth, but this was not significant largely due to the low densities at each level. In addition, densities during the summer months appeared to be quite variable for several species. It appears that the -0.3-m level is near the upper limit for Scolelepis and Paraphoxus at this beach. The paucity of statistically significant elevation-related density patterns among species observed is probably a consequence of limited sampling or a high degree of patchiness, as well as changes in the beach shape and corresponding movement of animal populations in relation to sampling levels.

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 tide.

Seasonal Patterns

Seasonal patterns were apparent for several common species, namely Scolelepis, Scoloplos, Eohaustorius and Paraphoxus. In all cases, these species were more abundant in the summer than in fall or winter (Table 6-55).

In addition, strong differences in abundance seemed to exist between 1977 and 1978. This was clearly apparent by comparing summer survey densities for the dominant species. Summer and fall densities averaged over 30 percent higher for Paraonella, Scolelepis, Eohaustorius, and Paraphoxus in 1978 (Table 6-55).

Biomass

The fauna was dominated by polychaetes in all surveys except in July 1977 when gammarids were very abundant (Table 6-57). In order of importance, the dominant polychaetes were Scoloplos, Scolelepis, Nephtys, Abarenicola, Eteone, Paraonella and Capitella. The dominant gammarid was Eohaustorius in all surveys except in July 1977, when Gammaridae sp surpassed Eohaustorius.

Biomass levels were relatively low and consistent throughout the years (Table 6-57). This low level was affected strongly by large, uncommon species such as Abarenicola, Nephtys or Ammodytes, or spatially and temporally patchy species such as Gammaridae sp A (Figure 6-14). In all surveys, two general trends became apparent. Biomass increased from the upper to the lower level following the spatial distribution of dominant species. However, this pattern was not statistically significant ($P>0.1$). In addition, biomass increased consistently during the spring and summer months and decreased in the fall reflecting the increase in dominant species as well as the appearance of several seasonal species during this period. This pattern was significant for 1977 ($P<0.01$), but not in 1978 ($P>0.75$).

Size Structure

Observations on size structure were attempted for the gammarid Eohaustorius eous and the polychaete Scolelepis to provide insight into growth rates and life cycle.

The length-frequency histograms for Eohaustorius were constructed for each level and pooled samples for each survey. Based on these data, it appears that at least two age classes were present in the population throughout the year (Figure 6-15). The younger age-class appeared less abundant during 1977 and spring 1978. In August 1978, the density of the younger age-class increased considerably and remained large in November 1978. Generally, the relative size of the two age classes tends to indicate low recruitment. The reproductive potential of other haustoriids is reported to be fairly low (Sameoto 1969a, b).

TABLE 6-57 AVERAGE BIOMASS (g/m^2) OF COMMON TAXA AT DEEP CREEK

TAXA	April 77 (g/m^2)	%	July 77 (g/m^2)	%	November 77 (g/m^2)	%	April 78 (g/m^2)	%	August 78 (g/m^2)	%	November 78 (g/m^2)	%
NEMERTEA								(4.5)				
Nemertea, unid												
ANNELIDA - Polychaeta	(2.16)*	(50.9)		(22.5)	(1.30)	(50.8)		(62.6)	(5.42)	(55.7)	(3.70)	(46.4)
Abarenicola pacifica			0.40	2.0			1.10	17.1				
Capitella capitata			0.10	0.5	0.04	1.5	0.02	0.3			0.02	0.2
Eteone nr *longa*	0.08	1.9	0.09	0.4			0.51	7.9	0.08	0.8	0.03	3.8
Nephtys sp	0.58	13.7	0.47	2.4	0.04	1.5	0.09	1.4	0.09	0.9	0.76	9.5
Paraonella platybranchia	T	T	0.01	T	0.04	1.5	0.06	0.9	0.30	3.0	0.07	0.9
Scolelepis sp	0.52	12.2	0.71	3.6	0.76	29.3	1.03	16.0	0.72	7.2	1.67	21.0
Scoloplos armiger (adult)	0.98	23.1	2.69	13.5	0.42	16.2	1.22	19.0	4.22	42.4	0.87	10.9
Scoloplos armiger (juvenile)									0.01	0.1		
ARTHROPODA - Crustacea	(2.05)	(48.2)	(15.3)	(75.8)	(1.28)	(49.0)	(1.97)	(30.6)	(4.23	(44.2)	(3.57)	(46.0)
Anisogammarus pugettensis	0.19	4.5	0	0	0.27	10.4	0	0	0.02	0.2		
Eohaustorius eous	1.71	40.3	2.91	14.7	0.78	29.7	1.58	24.3	3.72	37.4	3.32	41.8
Gammaridae sp A			11.93	60.1								
Paraphoxus milleri	0.15	3.4	0.19	1.0	0.23	8.9	0.39	6.1	0.49	4.9	0.25	3.1
MOLLUSCA - Gastropoda								(2.3)				
MOLLUSCA - Pelecypoda								(0.7)				
CHORDATA - Pisces												(7.3)
Ammodytes hexapterus											0.58	7.3

*Numbers in parentheses are totals for the indicated major taxa.

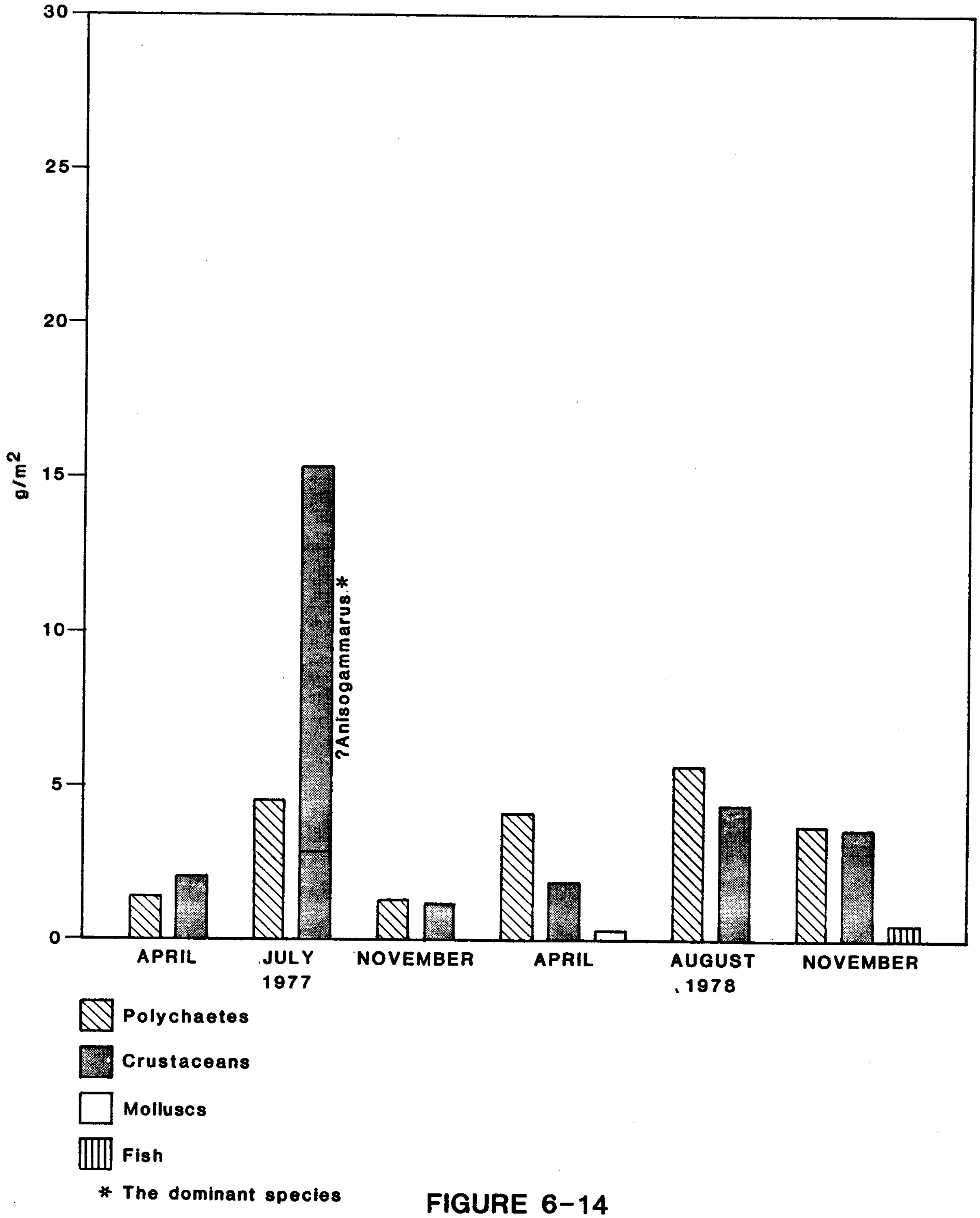


FIGURE 6-14

BIOMASS OF MAJOR TAXA AT DEEP CREEK, 1977-1978

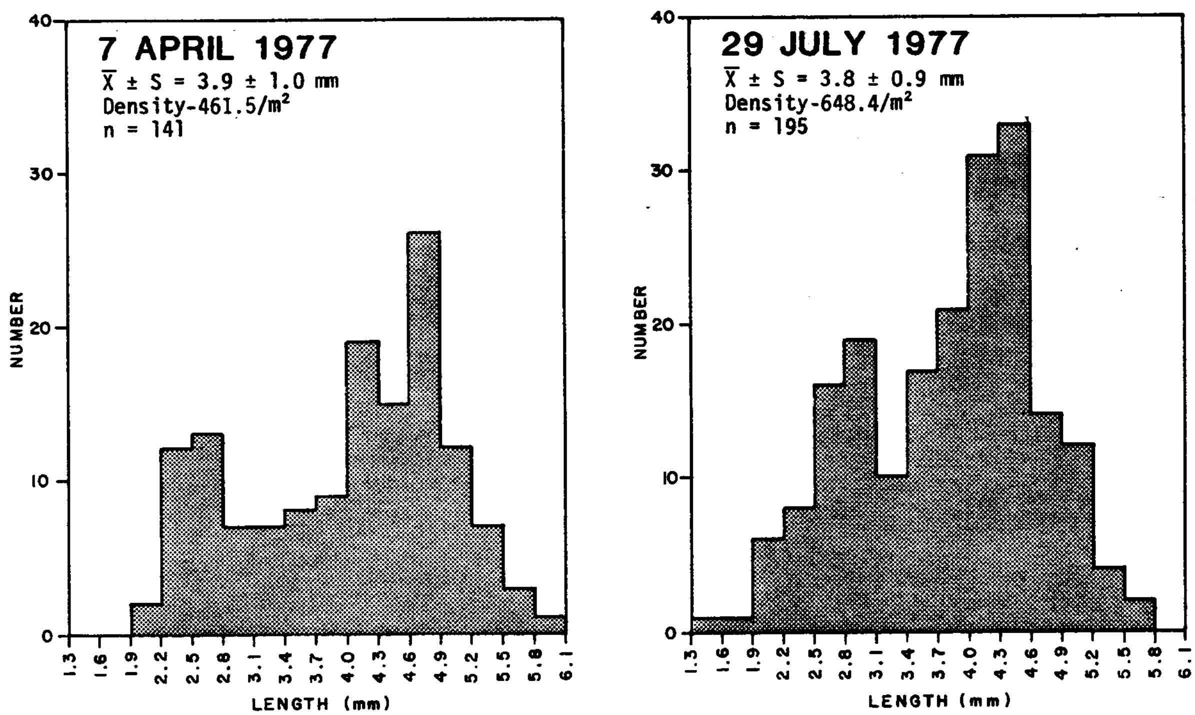
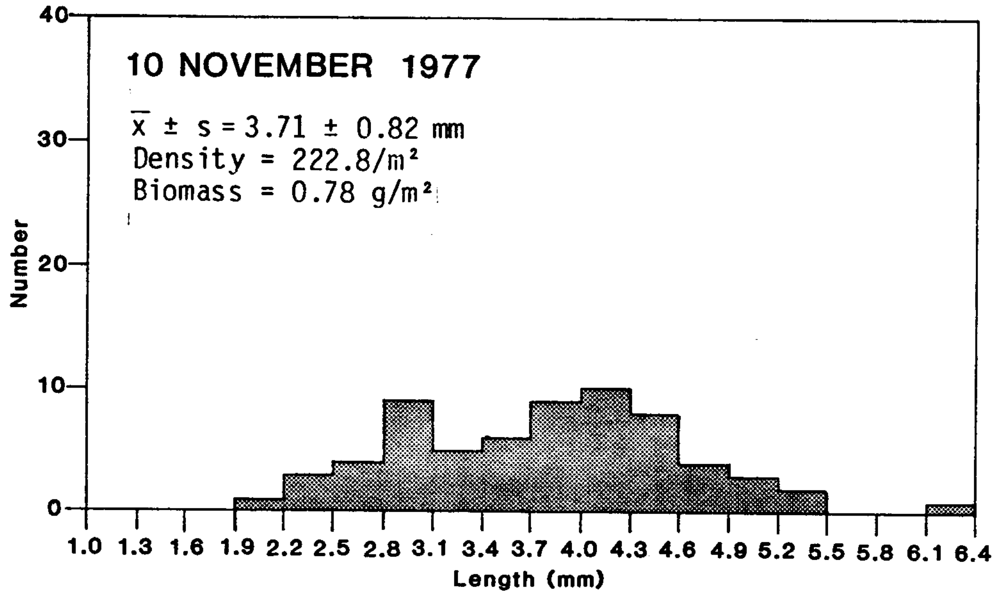


FIGURE 6-15 (1 of 3)

LENGTH-FREQUENCY HISTOGRAMS
FOR Eohaustorius eous FROM DEEP CREEK



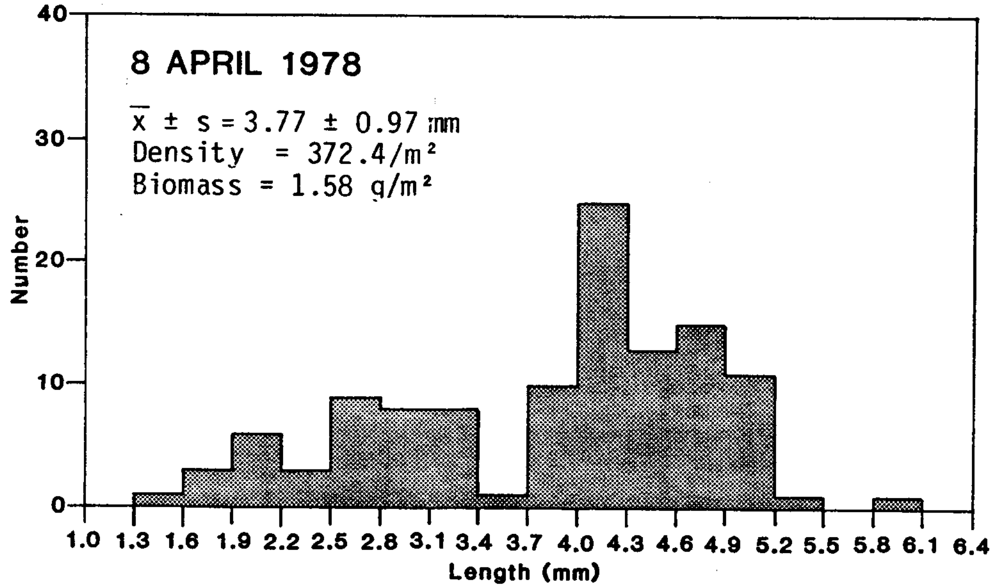
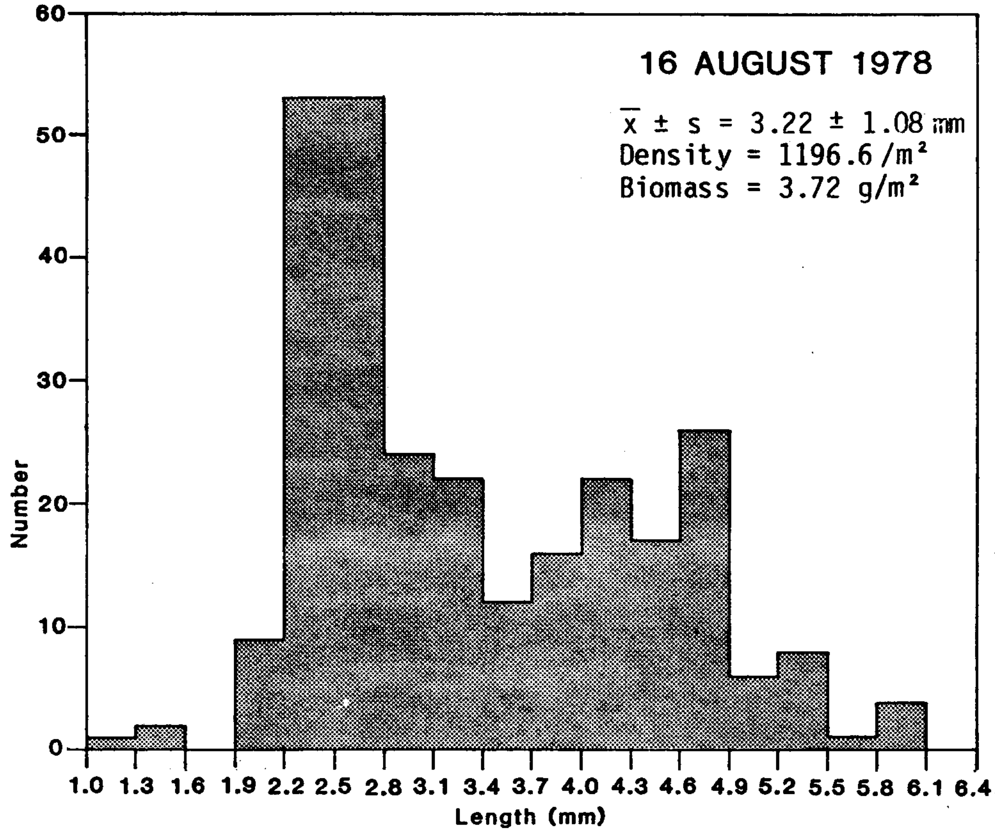


FIGURE 6-15 (2 of 3)

LENGTH-FREQUENCY HISTOGRAMS

FOR Eohaustorius eous

AT DEEP CREEK



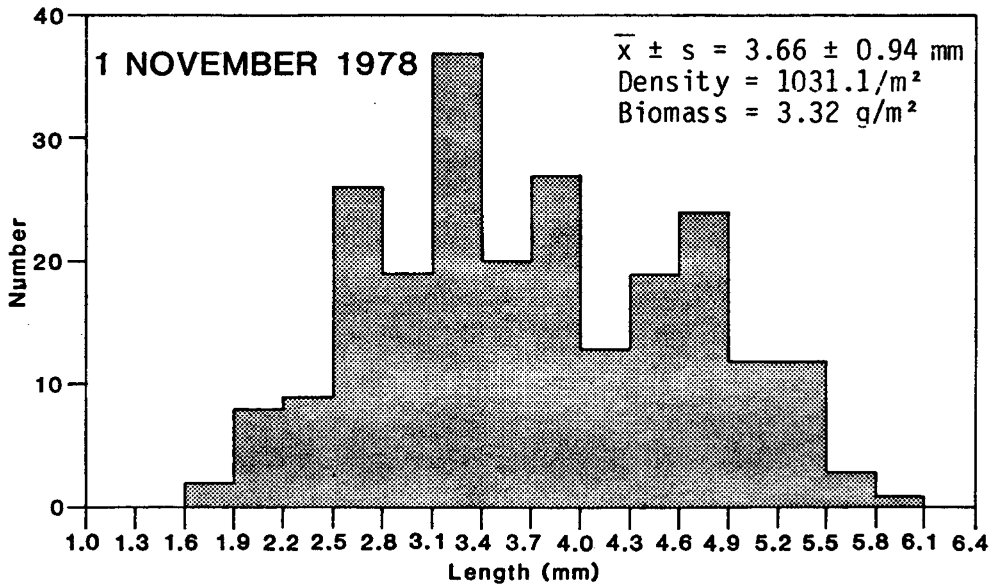


FIGURE 6–15 (3 of 3)

LENGTH-FREQUENCY HISTOGRAMS

FOR <u>Eohaustorius</u> <u>eous</u>

AT DEEP CREEK

The growth rate for the age-classes was examined by comparing modes for each survey. Patterns were not clearly defined. Growth of the younger year class appeared to be rather slow in 1977, while the growth rate for 1978 appeared to be slightly faster. Modal size for the older size class decreased in 1977, but increased in 1978. The reasons for the differences between size structure in 1977 and 1978 are unclear. Data for *Paraphoxus milleri* (Figure 6-16) and Gammaridae sp A (thought to be juvenile *Anisogammarus*) are inadequate.

Also, useful measurements were not obtained for Scolelepis because of its fragility and the 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 smaller in winter or spring and larger in summer.

Numerical Parameters

Patterns in numerical parameters were rather straightforward and somewhat consistent throughout the two-year study. Abundance, species richness, species diversity, and evenness followed the same pattern during the period of the study, increasing from spring to summer and decreasing during the fall and winter months (Figure 6-17). These parameters also tended to increase from higher to lower elevations (Table 6-58).

The significance of the observed seasonal changes in abundance was tested by level using Kruskal-Wallis analysis of variance on unpooled data. Seasonal fluctuations between the February and March samples in 1977 were not significant, but the increases from March to July and the subsequent decreases from July to November were significant for the upper three levels (all $P<0.005$). No significant change in abundance was found at the lowest level throughout the 1977 sample period. In 1978, the increases from April to August were significant at all levels ($P<0.005$ to $P<0.025$), but the decrease in November was only significant at the upper levels ($P<0.05$ and $P<0.005$). The lowest level exhibited a considerable amount of stability throughout the two-year study period. Densities were generally somewhat higher in 1978 than in 1977.

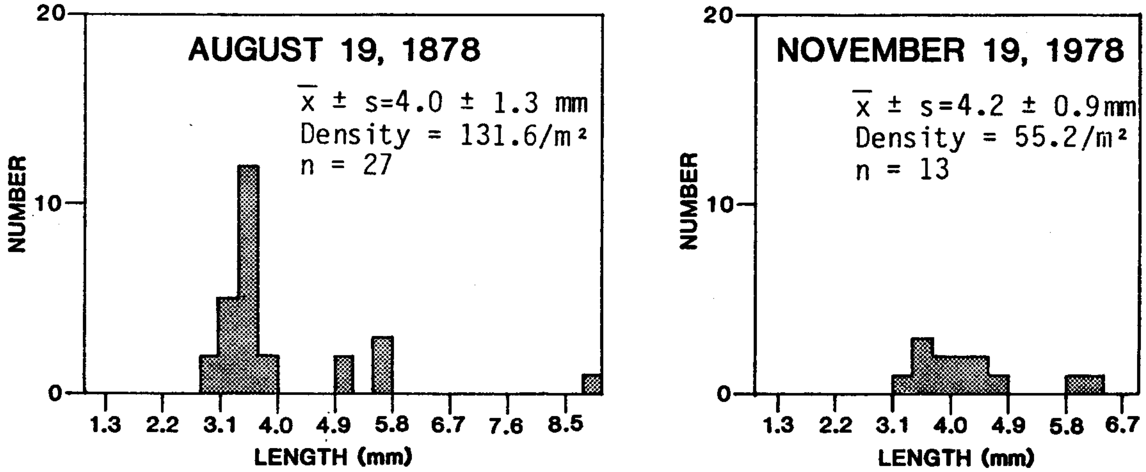


FIGURE 6-16

LENGTH-FREQUENCY HISTOGRAMS
FOR *Paraphoxus milleri* FROM DEEP CREEK, 1978

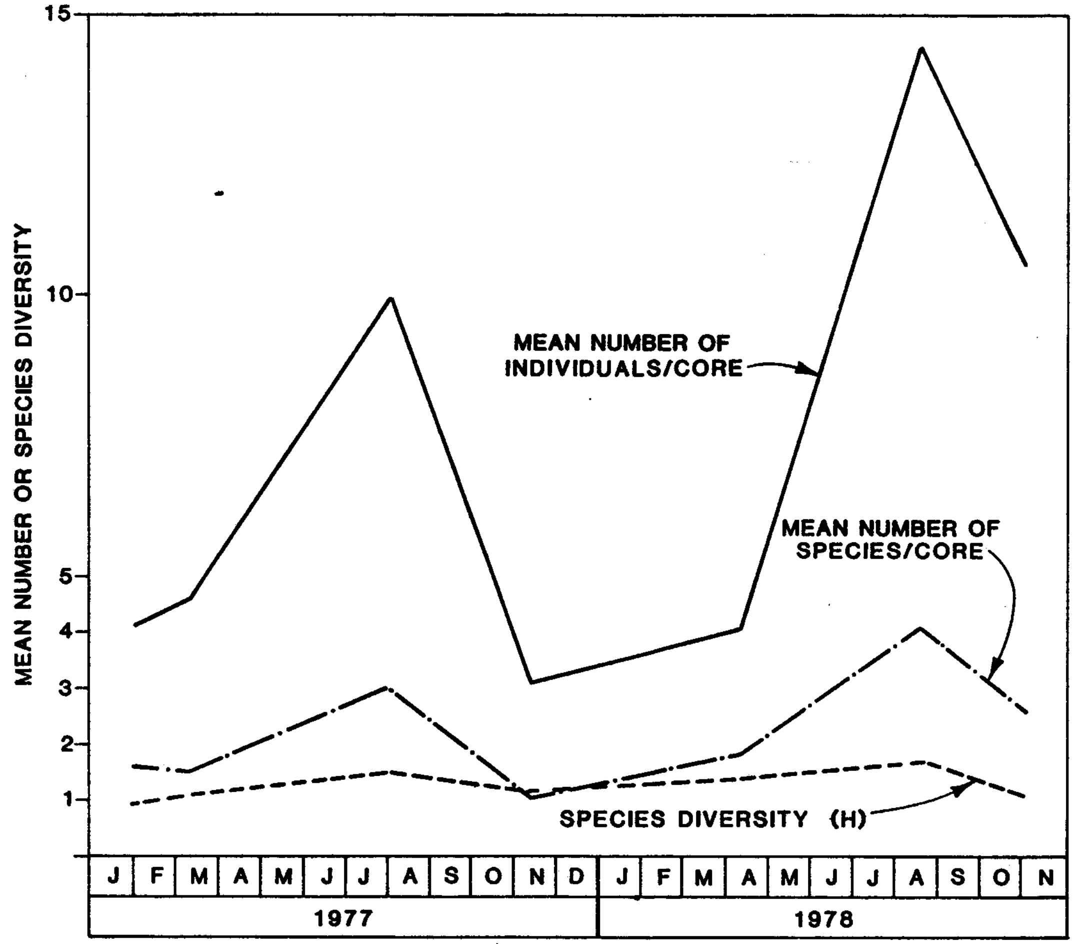


FIGURE 6-17

TEMPORAL PATTERNS IN NUMERICAL PARAMETERS FOR DEEP CREEK, 1977-1978

TABLE 6-58 SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT DEEP CREEK

Sampling Level (m)	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	Biomass Grams wet weight per m^2
4 February 1977									
+0.3	18	1.8 ± 1.9	229.2	4	1.3 ± 0.7	1.32	4.5	0.62	--
0.0	21	2.1 ± 1.6	267.4	3	1.2 ± 0.4	0.70	7.0	0.54	--
-0.3	39	3.9 ± 1.7	496.6	6	1.7 ± 0.8	1.05	6.5	0.35	--
-0.9	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									
+0.3	10	1.0 ± 0.9	1127.3	5	0.8 ± 0.6	1.50	2.0	0.57	2.87
0.0	31	3.1 ± 3.2	3394.7	5	1.2 ± 0.8	0.64	6.2	0.31	1.34
-0.3	35	3.5 ± 2.8	6445.6	6	1.3 ± 0.9	0.96	5.8	0.32	3.12
-0.9	108	10.8 ± 4.8	1375.1	7	2.6 ± 1.3	0.95	15.4	0.28	9.65
Overall	184			10			18.4		
$\bar{x} \pm s$		4.6	585.7		1.5	1.01 ± 0.36		0.37 ± 0.13	4.25 + 3.69
29 July 1977									
+0.3	39	3.9 ± 2.3	496.6	5	2.0 ± 0.9	1.15	7.8	0.44	3.95*
0.0	173	17.3 ± 16.3	2202.7	12	3.9 ± 1.4	1.72	14.4	0.27	48.70
-0.3	101	10.1 ± 4.9	1286.0	11	3.4 ± 1.3	1.56	9.2	0.27	13.36
-0.9	84	8.4 ± 6.2	1069.5	9	2.7 ± 1.3	1.51	9.3	0.34	13.33
Overall	391			16			24.4		
$\bar{x} \pm s$		9.9	1263.7		3.0	1.51 ± 0.25		0.33 ± 0.08	19.84 ± 19.75
10 November 1977									
+0.3	4	0.4 ± 1.0	50.9	4	0.4 ± 1.0	1.26	1.00	0.60	1.22
0.0	2	0.2 ± 0.6	25.5	2	0.2 ± 0.6	0.59	1.00	0.75	0.10
-0.3	44	4.4 ± 7.8	560.1	5	1.2 ± 2.0	1.30	8.80	0.49	2.65
-0.9	72	17.2 ± 7.0	916.6	7	2.4 ± 2.3	1.75	10.29	0.48	6.38
Overall	122			9			13.56		10.35
$\bar{x} \pm s$		3.1	388.3		1.05 ± 0.99	1.23 ± 0.48		0.58 ± 0.13	2.59 ± 1.74

TABLE 6-58 SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT DEEP CREEK

Sampling Level (m)	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	Biomass Grams wet weight per m^2
				4 April 1978					
+0.3	6	0.6 ± 0.8	76.4	5	0.6 ± 0.8	1.50	1.20	0.57	1.46
0.0	24	12.4 ± 2.83	305.5	7	1.3 ± 1.2	1.09	13.42	0.35	2.63
-0.3	66	6.6 ± 4.7	840.2	13	3.1 ± 1.5	1.66	5.08	0.24	12.73
-0.9	69	6.9 ± 3.7	878.4	7	2.4 ± 1.2	1.29	9.86	0.35	8.90
Overall	165			15			11.00		25.72
$\bar{x} \pm s$		4.1	525.1		1.85 ± 1.12	1.39 ± 0.25		0.38 ± 0.14	6.43 ± 5.32
				16 August 1978					
0.0	81	8.1 ± 4.0	1031.1	10	4.0 ± 2.2	2.10	8.1	0.48	6.71
-0.3	240	24.0 ± 8.2	3055.2	11	4.4 ± 1.3	1.32	21.8	0.23	11.43
-0.9	108	11.0 ± 4.0	1400.3	10	3.9 ± 1.3	1.65	10.8	0.31	11.72
Overall	429			15			28.6		29.86
$\bar{x} \pm s$		14.4	1828.9		4.10 ± 0.26	1.69 ± 0.39		0.34 ± 0.13	9.95 ± 2.81
				1 November 1978					
0.0	43	4.3 ± 2.7	547.3	8	2.1 ± 0.7	1.17	5.38	0.28	2.84
-0.3	105	10.5 ± 4.7	1336.7	6	2.4 ± 0.8	1.11	17.50	0.36	4.44
-0.9	167	16.7 ± 7.3	2156.9	10	3.4 ± 1.2	1.07	16.70	0.26	16.58
Overall	315			15			21.00		23.86
$\bar{x} \pm s$		10.5	1336.6		2.63 ± 0.68	1.12 ± 0.05		0.30 ± 0.05	7.95 ± 7.51

Spatially, there was a general increase in abundance with decreasing depth. These differences among levels were significant for spring and summer surveys ($P<0.005$ to $P<0.025$), but did not depart from random in the fall surveys in November 1977, 1978 and the winter survey in February 1978.

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.

Species richness (number of species) was similarly tested on unpooled data for number of species per core. Increases from April to July 1977, were significant at all levels as were the decreases from July to November. In 1978, species richness increased significantly from April to August ($P<0.05$) at all except the -0.3-m level. Decreases in the fall on the November survey at the 0.0-m and -0.3-m levels were significant ($P<0.025$ and $P<0.005$ respectively). Species richness was slightly higher in 1978 than in 1977.

Spatially, species richness generally increased with depth except during the summer month where the higher values occurred at the middle levels. This overall pattern was significant when tested on pooled data using Friedman X^2 analysis of variance ($P<.0.01$).

Species diversity was generally higher during the summer months and lower during the fall and winter (Figure 6-17). However, this pattern was not significant ($P>0.5$). Differences between the lower three levels throughout the study were not significant ($P>0.75$).

Evenness parameters closely follow other numerical parameters and show a definite seasonal pattern. Species appeared to be less equitably distributed at the lower elevations and during the summer months. This is mainly a reflection of the large increase in density of the few dominant organisms at lower elevations and during warmer seasons.

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 show signs of becoming asymptotic (Figure 6-18). However, at several locations it appeared that increased sampling would have yielded more species (i.e., July 1977, 0.0, -0.3, and -0.9-m, November 1977, 0.0-m, April 1978, -0.3 and 0.0-m, and November 1978, -0.9-m). The species area curves by level for both 1977 and 1978 showed a similar pattern by season. The rate of accrual was rather rapid during the summer and much slower during the fall, winter, and spring. The pattern accentuates the lower species diversity during the colder months.

The composite species area curves showed a consistent pattern of species acquistion. During the mild summer months, the rate of accrual was more rapid (the steepest slope) in comparison to the slow rate of accrual for the winter month (the flatter slope). This is probably a reflection of the intensity of physical parameters in the winter. With improving conditions throughout spring and summer, species are able to expand their distribution to the shallower levels.

6.3.1.2 Biological Assemblage of the Sand Beach at Homer Spit

The infaunal assemblage of the Homer Spit station was sampled seven times during the course of the study. Sampling dates were 17 February, 7 March, 28 July, and 11 November, 1977 and 10 February, 17 August, and 16 October, 1978. Thirty-seven taxa, including one flatworm, two nemerteans, ten polychaetes, sixteen crustaceans, one insect, six molluscs, and one fish, were identified from the core samples (Table 6-59).

Quantitatively, the infauna was strongly dominated by polychaetes, especially *Scolelepis* sp and *Paraonella platybranchia*. Gammarid amphipods were substantially less important, with *Eohaustorius eous* and *Paraphoxus milleri* the predominant species. The pink-necked clam *Spisula polynyma* was the major mollusc and the Pacific sand lance *Ammodytes hexapterus* was the only fish in the samples.

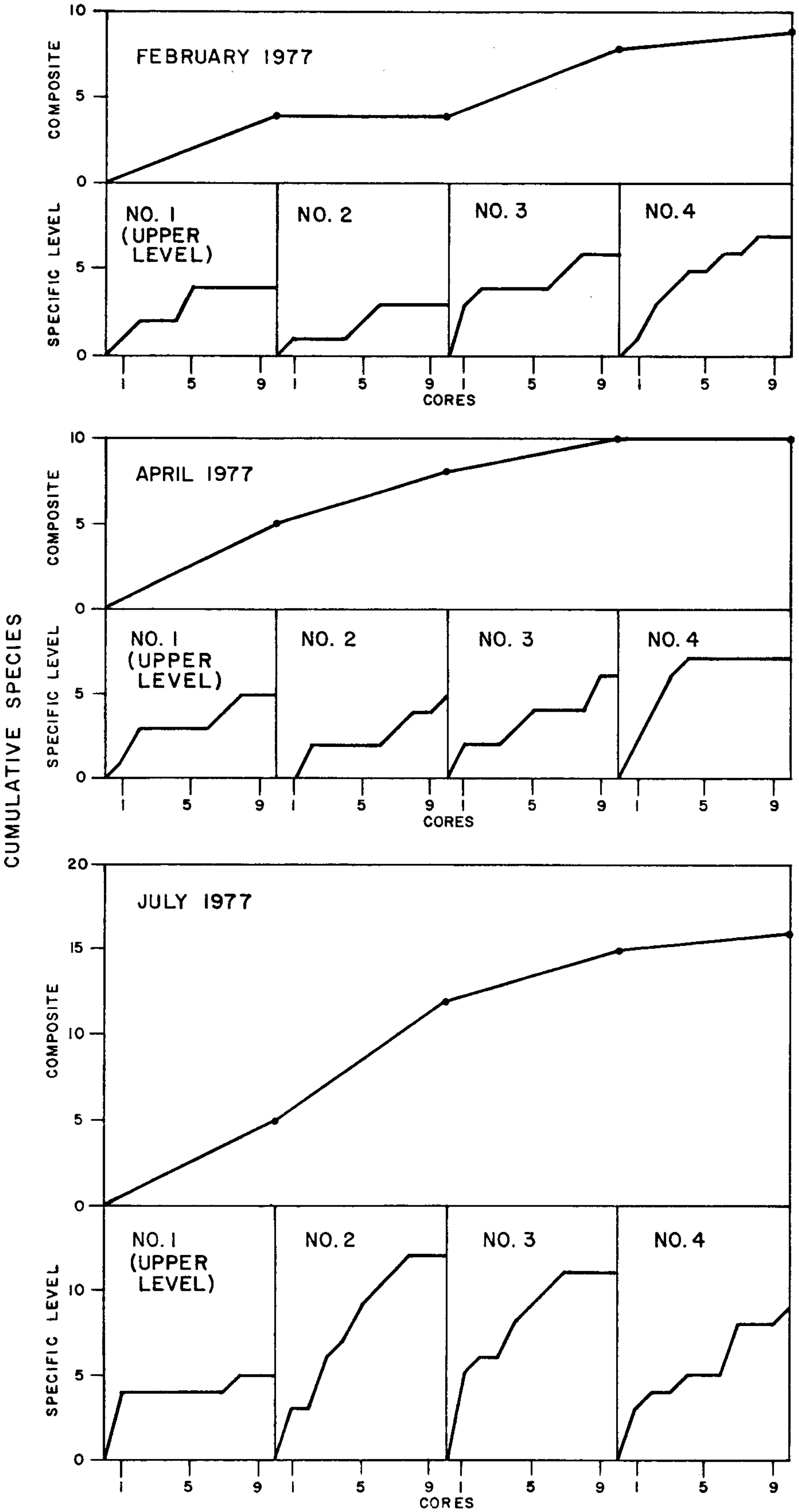


FIGURE 6-18 (1 of 3)

SPECIES/AREA CURVES FOR DEEP CREEK

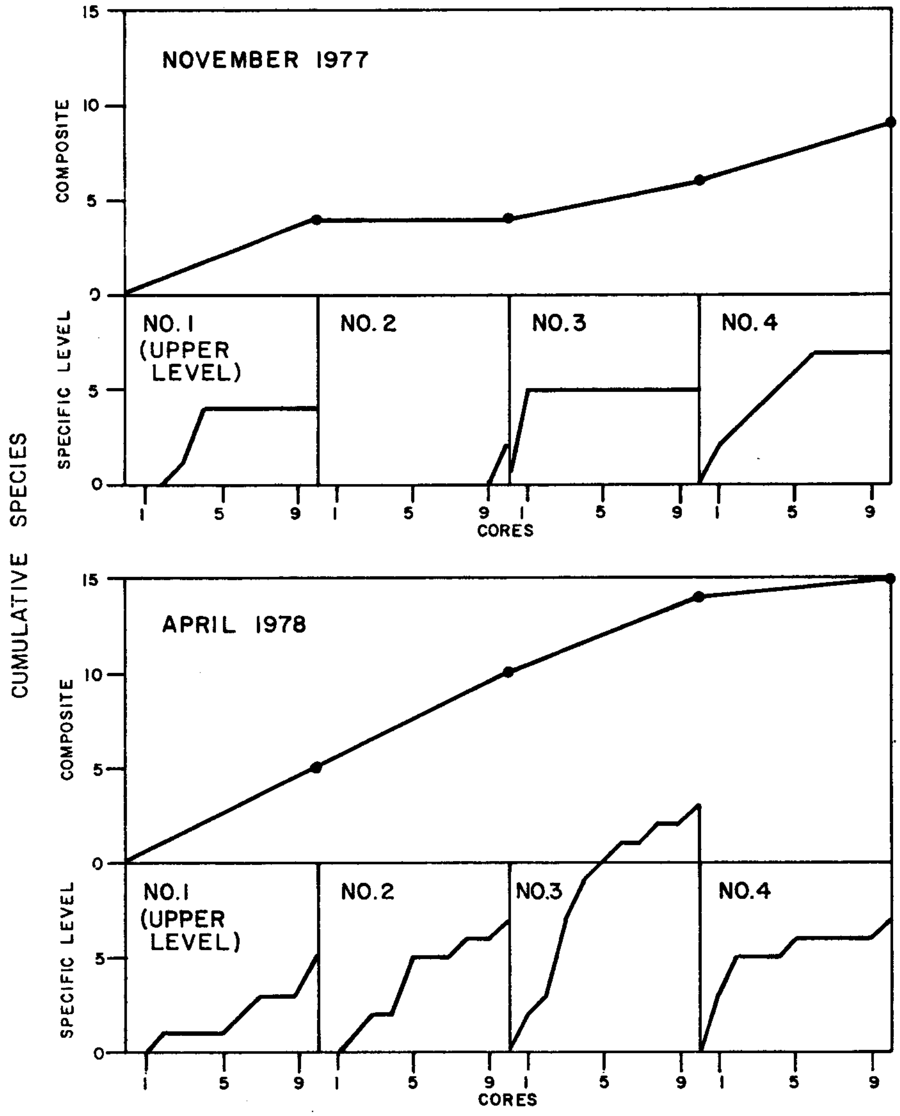


FIGURE 6-18 (2 of 3)

SPECIES/AREA CURVES FOR DEEP CREEK

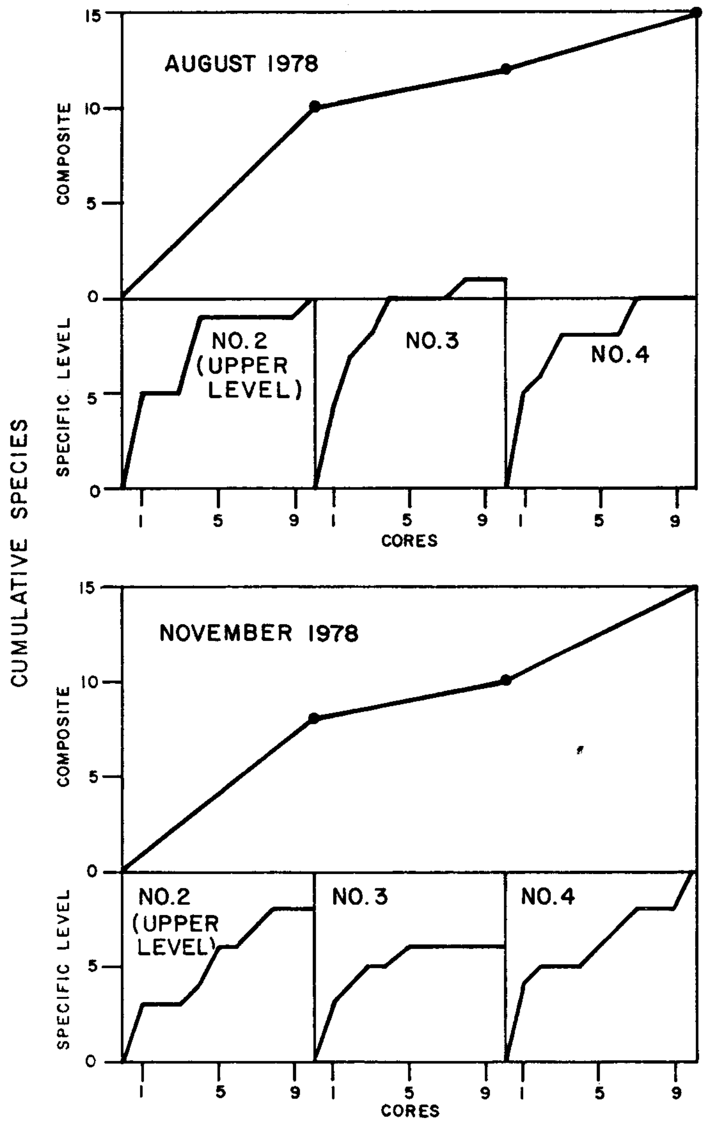


FIGURE 6-18 (3 of 3)

SPECIES/AREA CURVES FOR DEEP CREEK

TABLE 6-59 AVERAGE DENSITY (NO/M^2) OF COMMON SPECIES AT HOMER SPIT SITE

TAXA	17 February 1977 (no./m^2)	%	7 March 1977 (no./m^2)	%	28 July 1977 (no./m^2)	%	11 November 1977 (no./m^2)	%	10 February 1978 (no./m^2)	%	17 August 1978 (no./m^2)	%	16 October 1978 (no./m^2)	%
PLATYHELMINTHES						(0.3)								
NEMERETEA										(0.6)		(0.1)		
ANNELIDA - Oligochaeta										(1.9)				
ANNELIDA - Polychaeta		(76.0)		(87.2)		(77.8)		(79.7)		(88.7)		(48.3)		(89.9)
Eteone nr *longa*	6.4	1.1			3.2	0.3			3.2	0.6	12.7	1.0	4.2	1.4
Magelona sp	12.7	2.1	3.2	0.6					3.2	0.6	4.2	0.3		
Nephtys sp, adult	6.4	1.1	9.5	1.0	3.2	0.3	9.6	0.7	12.7	2.5	17.0	1.3		
Nephtys sp juv					19.1	1.8							8.5	2.9
Scolelepis sp	273.7	45.3	385.2	73.3	547.5	52.3	47.8	34.9	381.9	75.0	585.6	44.1	233.4	79.7
Scoloplos armiger			6.4	1.2					12.7	2.5	4.2	0.3		
ARTHROPODA - Crustacea		(17.9)		(12.7)		(20.6)		(7.0)		(3.2)		(40.3)		(4.3)
Anisogammarus pugettensis											21.2	1.6		
Archaeomysis grebnitzkii	6.4	1.1									34.0	2.6		
Atylus sp											25.5	1.9		
Eohaustorius eous	19.1	3.1	12.7	2.4	28.7	2.7	6.4	4.7	9.6	1.9	25.5	1.9		
Gammaridae, unid., red stripe	38.2	6.3												
ARTHROPODA - Crustacea														
Lamprops carinata					60.5	5.8								
Lamprops quadriplicata					79.6	7.6								
Lamprops sp					3.2	0.3					322.5	24.3		
Paraphoxus milleri	44.6	7.4	50.9	9.7	19.1	1.8	3.2	2.3	6.4	1.3	59.3	4.5	8.5	2.9
ARTHROPODA - Insecta								(2.3)						
MOLLUSCA - Gastropoda		(2.1)												
MOLLUSCA - Pelecypoda		(2.1)		(1.2)		(0.9)		(4.7)		(5.6)		(9.9)		(4.3)
Clinocarium sp											101.9	7.7	4.2	1.4
Spisula polynyma	12.7	2.1	3.2	0.6	6.4	0.6					4.2	0.3	8.5	2.9
Tellina lutea									15.9	3.1	25.5	1.9		
CHORDATA - Pisces		(2.1)		(1.2)		(0.3)								(1.4)
Ammodytes hexapterus	12.7	2.1	6.4	1.2	3.2	0.3						4.2		1.4

Zonation

To examine zonation, the species at each level were assigned to importance categories according to their density and frequency of occurrence (see Chapter 5.0). Species composition was then compared among the sample levels. According to these criteria, Scolelepis dominated all sampling levels; Paraonella was the only other species important at all levels (Table 6-60). The gammarid Eohaustorius was important at the middle levels and Paraphoxus was an important component at the lower levels.

The relationships between elevation and density were examined using unpooled data. The highest densities of Scolelepis were found at the lowest levels during the winter, spring and summer surveys and this pattern proved to be highly significant ($P<0.005$). However, during the fall surveys the pattern did not depart from random (November 1977 $P<0.75$, October 1978 $P<0.25$). Density of Paraonella did not differ significantly between the levels sampled.

Temporal Patterns

Temporal patterns were rather well-defined with overall density increasing during the spring and summer and falling off to the lowest levels in the fall (Table 6-59). The pattern largely reflected the increases and decreases of dominant species such as Scolelepis and seasonally abundant species such as Lamprops. Seasonal fluctuations were highest at the lowest level ($P<0.005$) largely due to the high density of Scolelepis, which fluctuated greatly at this level ($P<0.005$), and taxa like Lamprops that occurred mainly at this level.

Samples were collected immediately following a large storm in March 1977 to examine the effect of that disturbance. Generally, it appeared that the storm had little effect. However, a comparison of species density between the February and March sample 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

TABLE 6-60 IMPORTANT SPECIES AT EACH LEVEL AT HOMER SPIT FOR 1977 - 1978

	SAMPLING LEVEL (m)			
TAXA	30	75	100	135
Polychaetes				
Nephtys ciliata		Frequent		
Paraonella platybranchia	Frequent	Frequent	Sub-Dominant	Frequent
Scolelepis sp	Dominant	Dominant	Dominant	Dominant
Crustaceans				
Eshaustorius eous		Frequent	Frequent	
Lamprops carinata				Seasonal
L. quadriplicata	Seasonal			
Paraphoxus milleri			Frequent	Frequent

Paraonella was reduced significantly ($P<0.05$) and only at the 100-m level (Table 6-59). 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 (Table 6-59).

Strong differences in abundance seem to exist between 1977 and 1978. This was clearly apparent by comparing summer survey densities for the dominant species. Summer and fall densities averaged over 25 percent higher for several crustaceans, e.g. Lamprops spp, and Paraphoxus in 1978 (Table 6-59). However, Scolelepis remained stable and Paraonella declined considerably in 1978.

Biomass

In terms of biomass, the infauna at Homer Spit was strongly dominated by polychaetes, which made up 81.5 to 98 percent of the total biomass during all survey periods (Table 6-61). Of the major polychaetes, Scolelepis was by far the most important, comprising 66.2 percent to 95 percent of the biomass on each survey. Therefore, general patterns in biomass are usually direct reflections of the fluctuations of Scolelepis (Figure 6-19).

Over the two-year study, two trends became fairly clear. Spatially, biomass generally increased with decreasing elevation. This pattern was significant ($P<0.025$ to $P<0.005$) for all surveys except the fall survey in 1978. Temporally, biomass consistently increased from spring to summer and drastically decreased in the fall (Figure 6-19), but the pattern was not always significant when tested by level with unpooled data. In 1977, the increase in biomass from March to July was only significant at the lowest level ($P<0.01$) and the decrease from July to November was significant at the 100-m and the 135-m levels. The increase from April to August in 1978 did not depart from random at any level. The decrease in biomass from the summer survey in August to the fall survey in October was only significant at the lower level.

TABLE 6-61 AVERAGE BIOMASS (g/m^2) OF COMMON SPECIES AT HOMER SPIT SITE

TAXA	7 March 1977 (g/m^2)	%	28 July 1977 (g/m^2)	%	11 November 1977 (g/m^2)	%	10 February 1977 (g/m^2)	%	17 August 1978 (g/m^2)	%	16 October 1978 (g/m^2)	%
ANNELIDA - Polychaeta		(96.5)		(97.8)		(94.4)		(81.6)		(84.7)		(84.8)
Eteone nr longa			T	T			0.01	0.1	0.94	3.1	0.22	6.6
Magelona sp	0.10	0.5					0.02	0.1	0.27	0.9		
Nephtys sp, adult	0.08	0.4	4.21	13.4	0.11	8.9	0.47	2.2	0.56	1.9	0.26	7.8
Nephtys sp juv											0.12	3.6
Paraonella platybranchia	0.02	0.1	0.19	0.6	0.11	8.9	0.04	0.2	0.02	0.1	0.02	0.6
Scolelepis sp	18.03	94.1	26.05	83.1	0.95	76.6	16.80	78.3	23.50	78.3	2.21	66.2
Scoloplos armiger							0.14	0.7	0.11	0.4		
ARTHROPODA - Crustacea		(3.5)		(1.0)		(4.8)		(2.1)		(2.8)		(12.6)
Eohaustorius eous	0.06	0.3	0.13	0.4	0.03	1.6	0.04	1.9	0.14	0.5		
Lamprops sp									0.12	0.4		
Paraphoxus milleri	0.51	2.7	0.19	0.6	0.04	3.2	0.16	0.1	0.28	0.9	0.41	12.3
Paroediceros sp									0.05	0.2		
MOLLUSCA - Pelecpoda						(0.8)		(7.3)		(13.3)		(2.4)
Clinocardium sp									0.30	1.0	0.02	0.6
Spisula polynyma							1.30	6.1	0.18	2.3	0.06	1.8
Tellina lutea									3.01	10.0		
CHORDATA - Pisces												
Ammodytes hexapterus											30.55	*

* not included

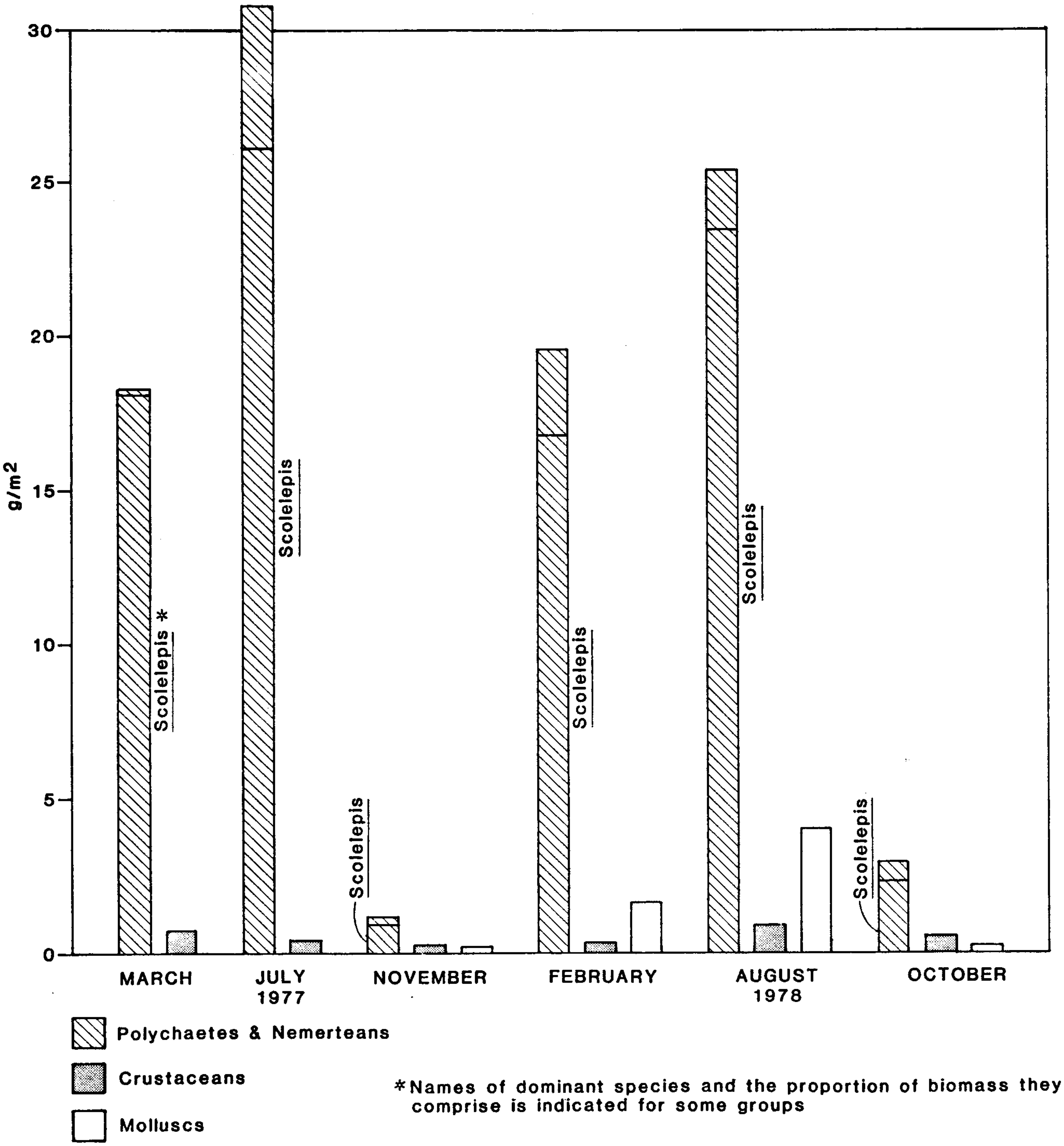


FIGURE 6-19

BIOMASS OF COMMON TAXA AT HOMER SPIT, 1977-1978

Gammarids contributed very little to the total biomass except in October 1978 when _Paraphoxus_ comprised 12.3 percent of the total. The sand-burrowing fish _Ammodytes_ was not included in the analysis of biomass because of its large size and inconsistent distribution in this assemblage. The pink-necked clam _Spisula polynyma_ had a rather patchy distribution pattern but did contribute significantly to the overall biomass.

Size Structure

Size data were collected for the gammarid amphipods _Paraphoxus milleri_ and _Eohaustorius eous_, but sample sizes were too small to provide satisfactory comparisons.

Numerical Parameters

Patterns in the numerical parameters were fairly straightforward and consistent over the two-year period (Table 6-62). Abundance, species richness and diversity increased during the spring and summer and declined during the fall. Evenness parameters (N/S) also followed this general pattern (Figure 6-20).

Increases in abundance from March to July 1977 were significant at all except the -0.6-m level ($P<0.05$). Decreases between the July and the November surveys were significant at all levels ($P<0.005$). In 1978, the increases from February to August were significant at the -0.3-m and -0.9-m levels ($P<0.025$, $P<0.005$, respectively) but not at the -0.6-m level ($P>0.5$). From August to October, the largest decreases occurred at the lower levels ($P<0.025$ at the -0.6-m level and $P<0.005$ at the -0.9-m level) with no significant decrease at the -0.3-m level.

When densities were compared between levels, they were found to increase significantly with decreasing elevation on all surveys except the fall surveys.

TABLE 6-62 SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT HOMER SPIT

Sampling Level (m)	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	Biomass 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	11.40
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	1.15
75	25	2.5 ± 1.6	318.3	6	1.7 ± 0.8	1.60	4.2	0.51	11.40
100	48	4.8 ± 3.0	611.2	8	2.3 ± 1.2	1.58	6.0	0.37	33.23
135	83	8.3 ± 6.3	1056.9	6	2.0 ± 0.8	0.75	13.8	0.28	30.88
Overall	165			12			13.8		
$\bar{x} \pm s$		4.1	525.3		1.7	1.6 ± 0.50		0.4 ± 0.13	19.17 ± 15.49
28 July 1977									
30	64	6.4 ± 5.1	814.9	12	3.3 ± 2.2	2.25	5.8	0.43	3.51
75	47	4.7 ± 2.2	585.7	9	2.9 ± 1.2	2.16	5.1	0.50	19.91
100	75	7.5 ± 2.9	955.0	9	3.0 ± 0.7	1.69	8.3	0.36	77.35
135	144	14.4 ± 5.2	1833.6	10	3.3 ± 1.4	1.26	16.0	0.27	79.62
Overall	300			16					
$\bar{x} \pm s$		8.3	1047.3		3.1	1.8 ± 0.46		0.39 ± 0.10	45.09 ± 39.14
11 November 1977									
30	5	0.5 ± 0.7	63.7	4	0.5 ± 0.7	1.26	1.25	0.60	0.13
75	15	1.5 ± 1.4	191.0	3	1.1 ± 1.0	1.04	5.00	0.69	2.73
100	12	1.2 ± 1.2	152.8	4	1.3 ± 0.7	1.19	3.00	0.57	0.74
135	11	1.1 ± 1.1	140.0	4	1.2 ± 1.2	1.39	2.75	0.66	1.37
Overall	43			7			6.14		4.97
$\bar{x} \pm s$		1.1	136.9		1.0	1.22 ± 0.15		0.63 ± 0.05	1.24 ± 1.11

TABLE 6-62 SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT HOMER SPIT

Sampling Level (m)	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	Biomass Grams wet weight per m^2
10 February 1978									
30	7	0.7 ± 0.7	89.11	5	0.8 ± 0.6	1.15	1.40	0.56	2.97
75	24	2.4 ± 1.7	305.5	7	2.2 ± 1.4	2.03	3.43	0.58	10.04
100	35	3.5 ± 2.3	445.6	6	1.7 ± 0.8	1.06	5.83	0.38	11.43
135	94	9.4 ± 4.5	1196.6	9	2.1 ± 0.7	0.87	10.67	0.20	61.40
Overall	160			13			12.31		85.84
$\bar{x} \pm s$		4.0	509.5		1.7	1.28 ± 0.52		0.42 ± 0.18	21.46 ± 26.88
17 August 1978									
30	61	6.1 ± 3.9	776.5	12	3.4 ± 2.2	2.25	5.08	0.40	7.76
100	29	2.9 ± 2.0	369.2	10	3.0 ± 1.5	2.47	2.90	0.56	2.22
135	223	22.3 ± 6.5	2838.8	15	6.3 ± 2.1	2.14	14.87	0.29	80.02
Overall	313			20			15.65		90.00
$\bar{x} \pm s$		10.4	1328.2		4.2	2.29 ± 0.17		0.42 ± 0.14	30.00 ± 43.41
16 October 1978									
30	47	4.7 ± 5.2	598.3	7	1.4 ± 1.3	0.69	6.71	0.27	6.46
100	12	1.2 ± 1.7	152.8	6	1.2 ± 1.2	1.32	2.00	0.50	2.79
135	10	1.0 ± 1.8	127.3	3	0.5 ± 0.8	0.87	3.33	0.61	0.76
Overall	69			11			6.27		10.01
$\bar{x} \pm s$		2.3	292.8		1.03	0.96 ± 0.32		0.46 ± 0.17	3.34 ± 2.89

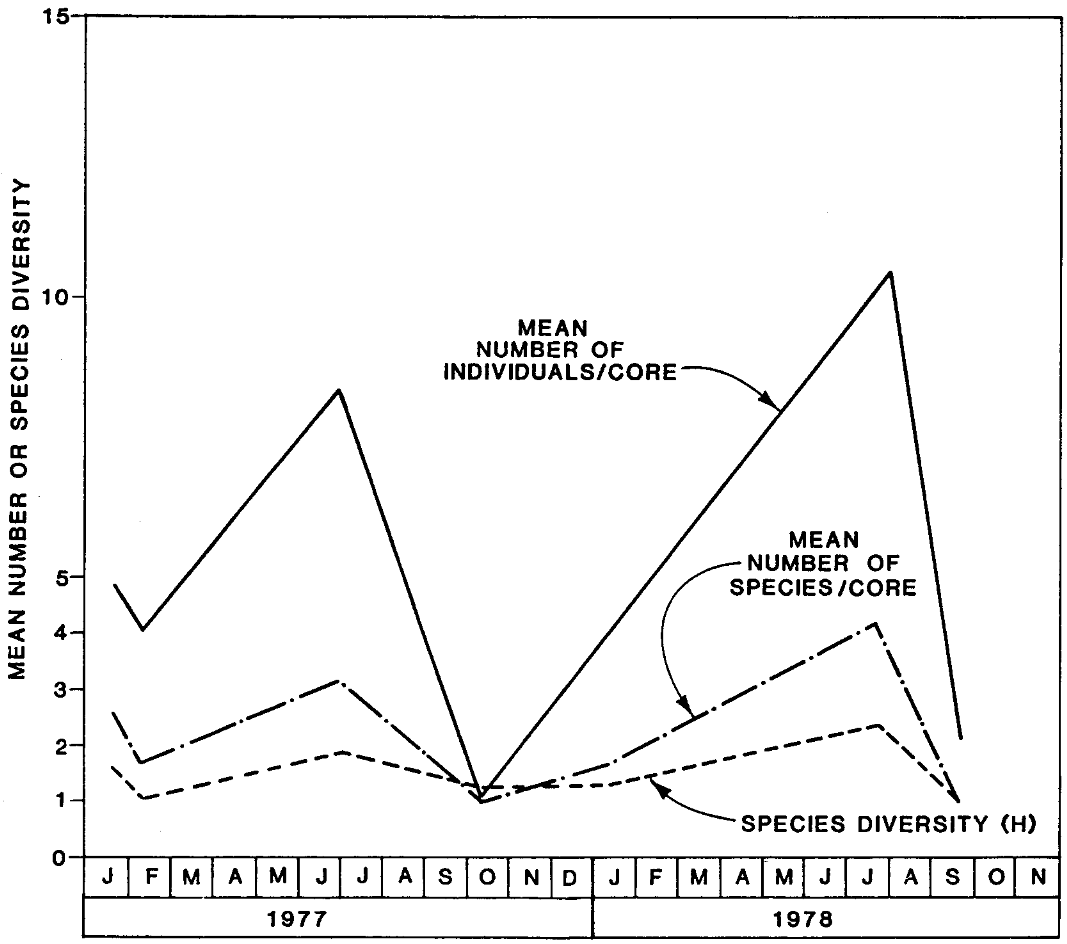


FIGURE 6-20

TEMPORAL PATTERNS IN
NUMERICAL PARAMETERS FOR HOMER SPIT, 1977-1978

Species richness was similarly tested by comparing the number of species per core among levels and surveys. Differences among levels were only significant in March 1977 and February and August 1978 ($P<.005$) but no strong trends were evident.

Seasonal fluctuations by level showed a consistent pattern of significant decreases from summer to fall. There were no significant differences in species richness between the November and February sampling periods.

Species diversity was, on the average, highest during the summer surveys and lowest during the fall and winter. However, this pattern was not statistically significant ($P<0.1$). There was no apparent pattern between species diversity and depth over the two-year period ($P<0.9$).

Evenness parameters (N/S) generally indicated that species were less equitably distributed at the lower levels and during the summer months. However, these patterns were not statistically significant ($P>0.1$ and $P>0.05$, respectively). This increase in N/S with depth is a reflection of the large increase in density at the lower elevations in comparison to the relatively small increase in species. During the fall survey there was a reversal of this pattern, again reflecting the patterns of species richness and density during this period.

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 6-21). However, it appeared that a substantial number of species could have been added by additional sampling at the 30-m and 135-m levels in July 1977, and the 30-m in level in August 1978.

Composite species area curves were constructed for each survey by tabulating by level the cumulative number of species identified. During winter, summer, and fall, the accrual rate was fairly slow and uniform at each level. This seems to indicate a strong gradient in the physical

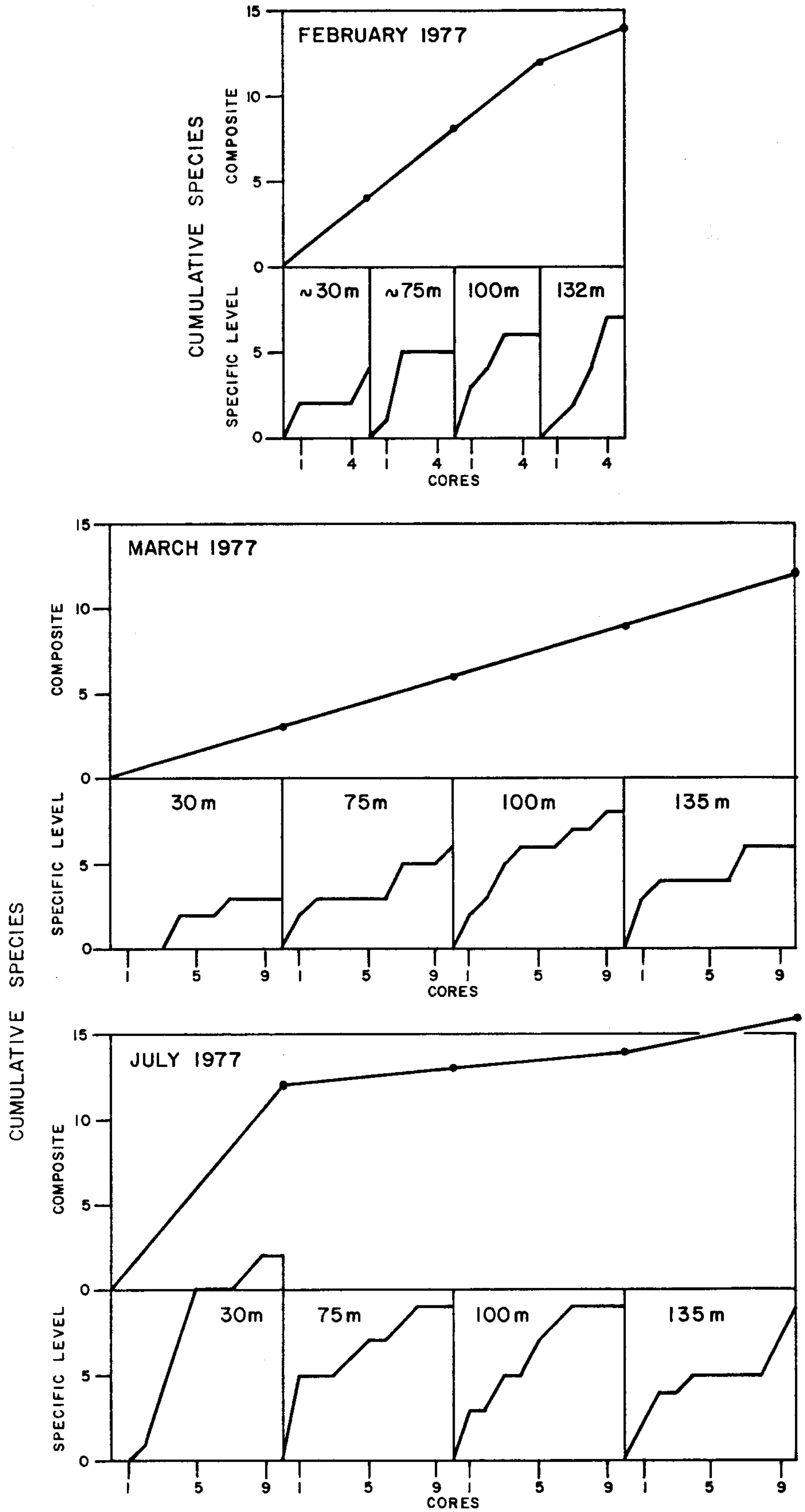


FIGURE 6-21 (1 of 3)

SPECIES/AREA CURVES FOR HOMER SPIT

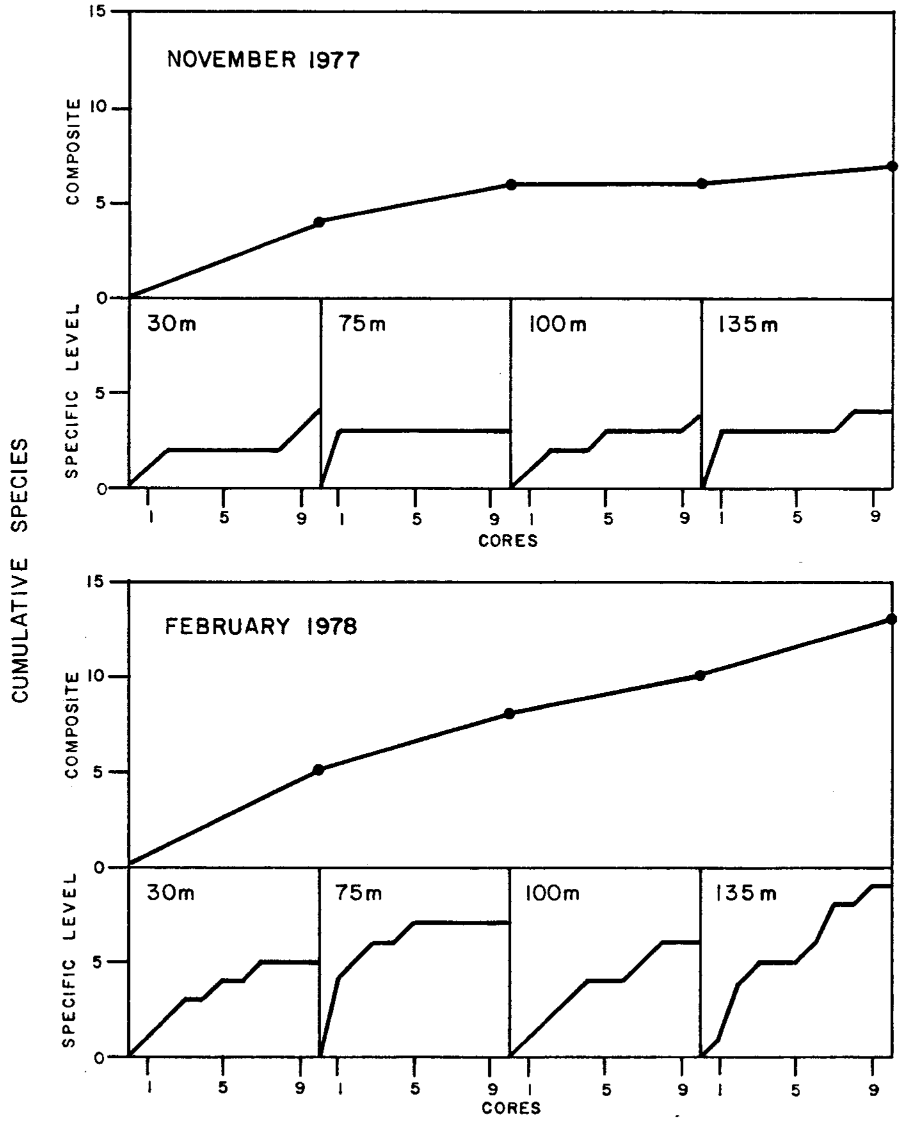


FIGURE 6-21 (2 of 3)

SPECIES/AREA CURVES FOR HOMER SPIT

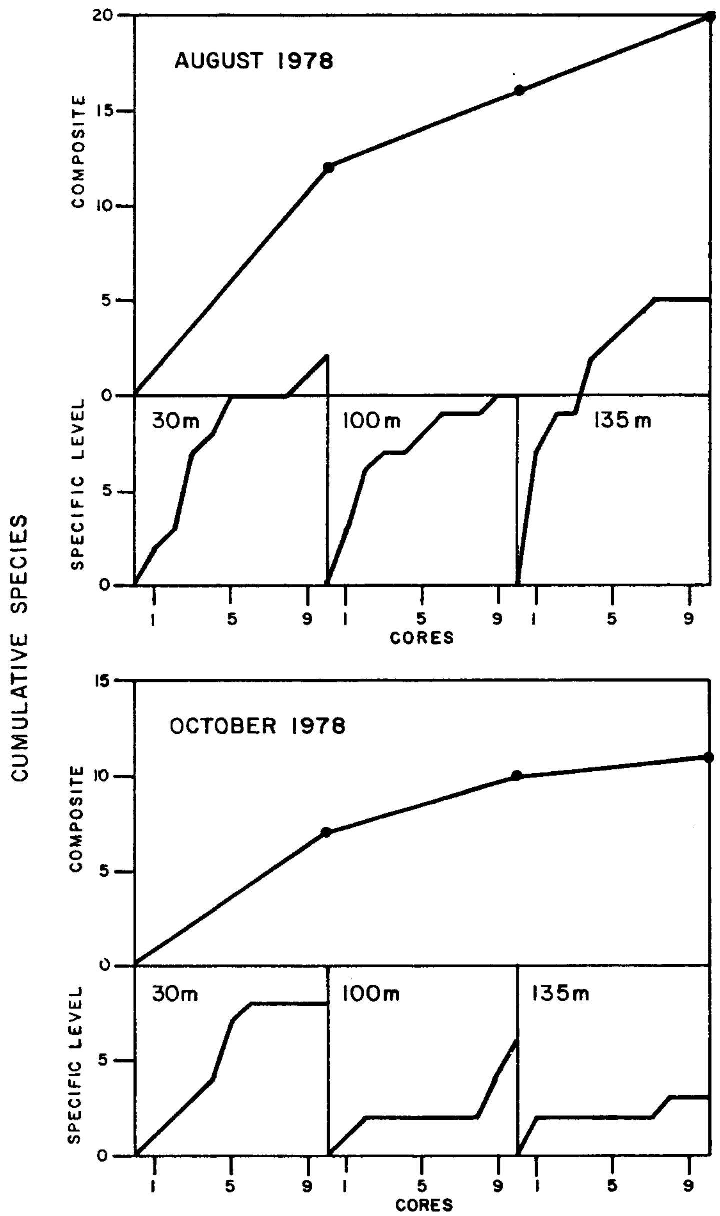


FIGURE 6-21 (3 of 3)

SPECIES/AREA CURVES FOR HOMER SPIT

factors. This interpretation is amplified by the composite curve for July 1977 and August 1978 when conditions were comparatively mild. In this case, the accrual rate is initially rapid, i.e., most of the species were identified at the upper level, and the subsequent accrual rate was considerably slower. Although this suggests that the mild conditions have allowed a number of species previously restricted to the lower levels to expand into higher elevations, examination of the species lists from the different levels does not support this hypothesis.

6.3.1.3 Biological Assemblage of the Sand Beach at Iniskin Beach

The biological assemblage of Iniskin Beach was sampled twice during the course of the study (26 April and 18 August 1978). Twenty-one taxa, including eight polychaetes, eight crustaceans, one insect, three molluscs, and one phoronid, were identified from the core samples (Table 6-63).

The infauna was dominated by polychaetes and razor clams in terms of biomass. The dominant polychaetes were *Scolelepis* sp and *Nephtys* sp (Table 6-63). Gammarids and mysids were numerically dominant; the most commonly occurring species were *Eohaustorius eous* and *Acanthomysis* sp. The razor clam *Siliqua patula* was also an important species on the beach but was excluded from biomass analyses because its patchiness and large size introduced very high variability into the data.

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 Chapter 5.0). Species composition was then compared among sampling levels. According to these criteria, all three levels were dominated by *Eohaustorius eous*, *Scolelepis* sp, and *Nephtys* sp (Table 6-64). *Acanthomysis* was abundant at all levels in August. *Paraonella* was found at the upper levels in both surveys, whereas *Scoloplos armiger*, *Magelona* sp, and *Paraphoxus milleri* were confined to the lower levels. The relationship between elevation and density of these species was examined using unpooled

TABLE 6-63 AVERAGE DENSITY AND BIOMASS OF COMMON SPECIES AT INISKIN BEACH INTERTIDAL SITE

TAXA	26 April 1978 ($no./m^2$)	%	(g/m^2)	%	18 August 1978 ($no./m^2$)	%	(g/m^2)	%
ANNELIDA - Polychaeta	(500.8)	(48.5)	(28.77)	(93.1)	(275.7)	(17.2)	(12.01)	(58.8)
Magelona sp	4.2	0.4	0.08	0.3	4.2	0.3	0.07	0.3
Nephtys sp	110.3	10.7	5.48	17.9	72.1	4.5	0.88	4.3
Paraonella platybranchia	8.5	0.8	T	T	25.5	1.6	0.01	T
Scolelpeis sp	369.3	35.8	22.0	72.0	144.3	8.9	9.79	48.2
Scoloplos armiger	8.5	0.8	0.75	2.4	21.2	1.3	1.24	5.9
ARTHROPODA - Crustacea	(521.9)	(50.6)	(1.12)	(7.0)	(1324.0)	(82.0)		(39.7)
Acanthomysis sp					526.2	32.5	0.25	1.2
Anisogammarus pugettensis					8.5	0.5	0.01	T
Crangon sp			0.06	3.5	17.0	1.1	6.07	29.9
Eohaustorius eous	500.7	48.6	0.88	2.9	691.7	42.8	1.55	7.6
Lamprops sp					59.4	3.7	0.03	0.1
Paraphoxus milleri	17.0	1.6	0.14	0.5	17.0	1.1	0.19	0.9
ARTHROPODA - Insecta						(0.3)		(0.2)
MOLLUSCA - Pelecypoda		(0.8)				(0.5)		(0.7)
Siliqua patula	8.5	0.8	547.81*					
Tellina lutea					8.5	0.5	--	
PHORONIDA		(0.4)		T				

*Excluded from comparison; anomaly

TABLE 6-64 IMPORTANT SPECIES AT EACH LEVEL AT INISKIN BEACH FOR 1978

TAXA	Sampling Level (m) 130	260	386
Polychaetes			
Nephtys sp	Dominant	Dominant	Dominant
Paraonella platybranchia	Sub-Dominant		
Scolelepis sp	Dominant	Dominant	Dominant
Scoloplos armiger		Frequent	Sub-Dominant
Magelona sp			Frequent
Crustaceans			
?Acanthomysis sp	Seasonal	Seasonal	Seasonal
Eohaustorius eous	Dominant	Dominant	Dominant
Lamprops sp	Seasonal		
Paraphoxus milleri		Sub-Dominant	.

data. Eohaustorius was significantly more dense at the upper elevations ($P<0.005$). In August, however, the highest density of Eohaustorius was found at the lowest level ($P<0.005$). Density patterns for Scolelepis during April showed significant increases with depth with the highest density found at the lowest level ($P<0.005$). In August, however, the highest densities of Scolelepis occurred at the middle level, and this pattern was also significant ($P<0.01$). No correlation between density of Nephtys and elevation were evident ($P>0.25$).

Temporal Patterns

Since only two surveys were conducted at Iniskin Beach, seasonal data are not strong but some general patterns were evident. There was an overall increase in density from April to August, largely a result of increased species richness and the appearance of seasonally abundant species such as Acanthomysis (Table 6-63). However, this increase in abundance was only significant at the upper level ($P<0.01$). The dominant polychaete species, Scolelepis and Nephtys, decreased during this period, but the decrease was only significant for Scolelepis at the lowest elevation ($P<0.005$).

Biomass

In terms of biomass, the infauna at Iniskin Beach (excluding the razor clam Siliqua) was dominated by polychaetes during both surveys (Figure 6-22). Specifically, in order of importance, the dominant polychaetes were Scolelepis, Nephtys, and Scoloplos (Table 6-63). The large shrimp Crangon sp was the most important crustacean during the August sampling period. Eohaustorius was the dominant gammarid in both April and August with Paraphoxus the next most important. The mysid Acanthomysis became seasonally important to total biomass in August.

Although this beach was sampled only twice, some general patterns became apparent. Generally, biomass levels were relatively low and strongly affected by large, uncommon species such as Siliqua and Crangon (Table 6-63). Biomass decreased from April to August (Figure 6-22), generally reflecting

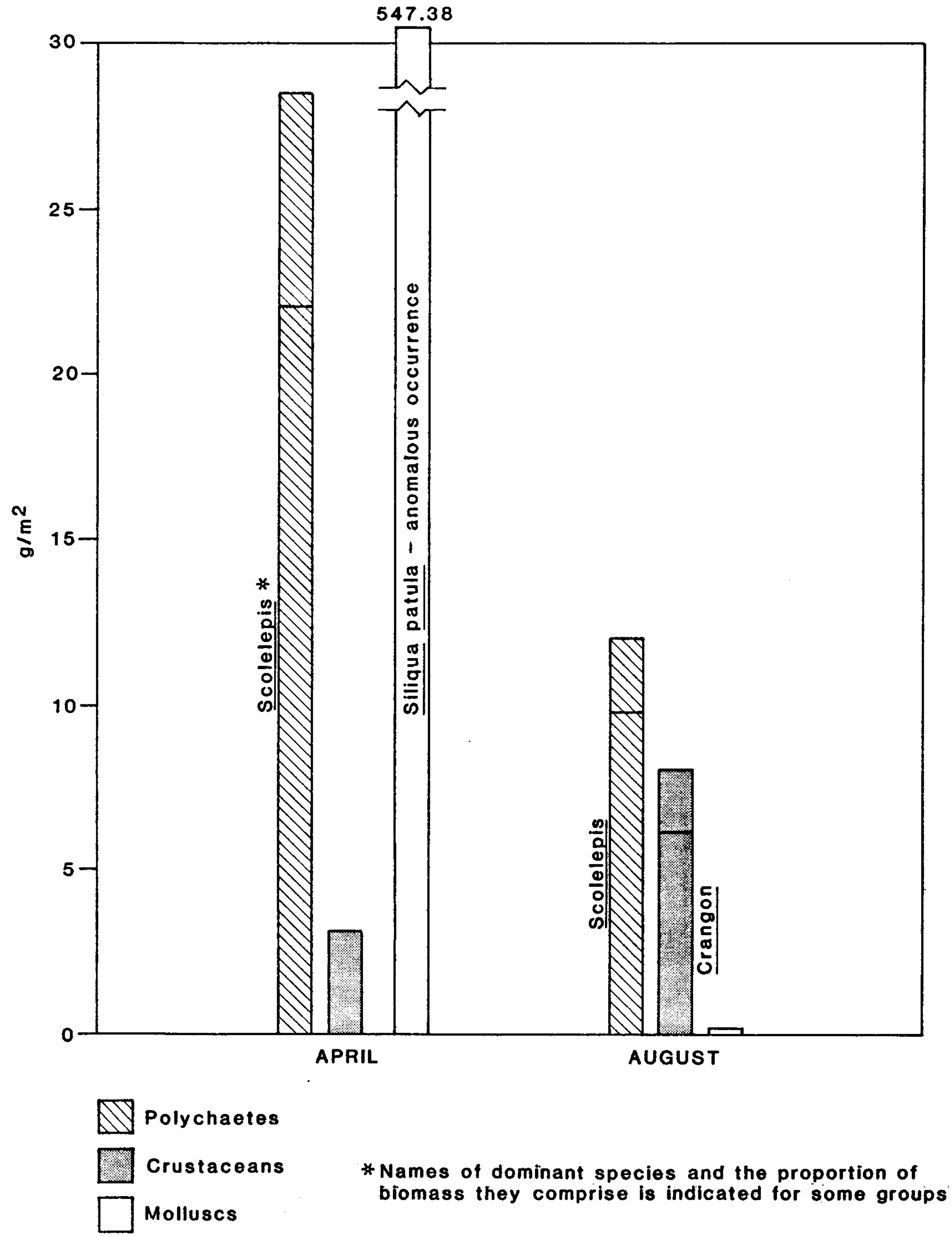


FIGURE 6-22

BIOMASS OF MAJOR TAXA AT INISKIN BEACH, 1978 the large decrease in Scolelepis and Nephtys, which generally overshadowed the appearance of several additional species. For example, crustaceans contributed much more to the overall biomass in August than in April, largely due to the large, uncommon Crangon sp.

Finally, biomass increased with decreasing elevation, again largely reflecting the distribution of the dominant species Scolelepis.

Size Structure

Observations on size structure were attempted for the gammarid Eohustorius eous to determine growth rates and general life cycle. The length-frequency histograms represent pooled samples for all three levels (Figure 6-23). Two age-classes may have been present in April, but in August the length-frequency appears basically unimodal. Furthermore, the average size is small and closer to the mode sizes observed for the 0-year class in April and August at Deep Creek (Figure 6-15). It seems probable that only a single year class was represented at Iniskin beach in 1978.

Size data were also collected for other gammarids, but sample size was rather small. Paraphoxus had an average size of 6.1 ± 0.9 mm in April (n=4) and an average size of 5.6 ± 7.0 in August (n=4).

Numerical Parameters

Patterns in the numerical parameters were rather straightforward. Abundance, species richness and species diversity increased from April to August (Table 6-65). The observed increases in overall abundance were significant only at the 130-m level ($P<0.01$). Abundance varied significantly among levels ($P<0.005$); highest densities were found at the highest levels, and lowest densities at the middle level (Table 6-65).

Species richness, evaluated statistically by comparing the number of species in each core (unpooled data) among levels and surveys, did not vary significantly among levels. The seasonal changes observed were highly

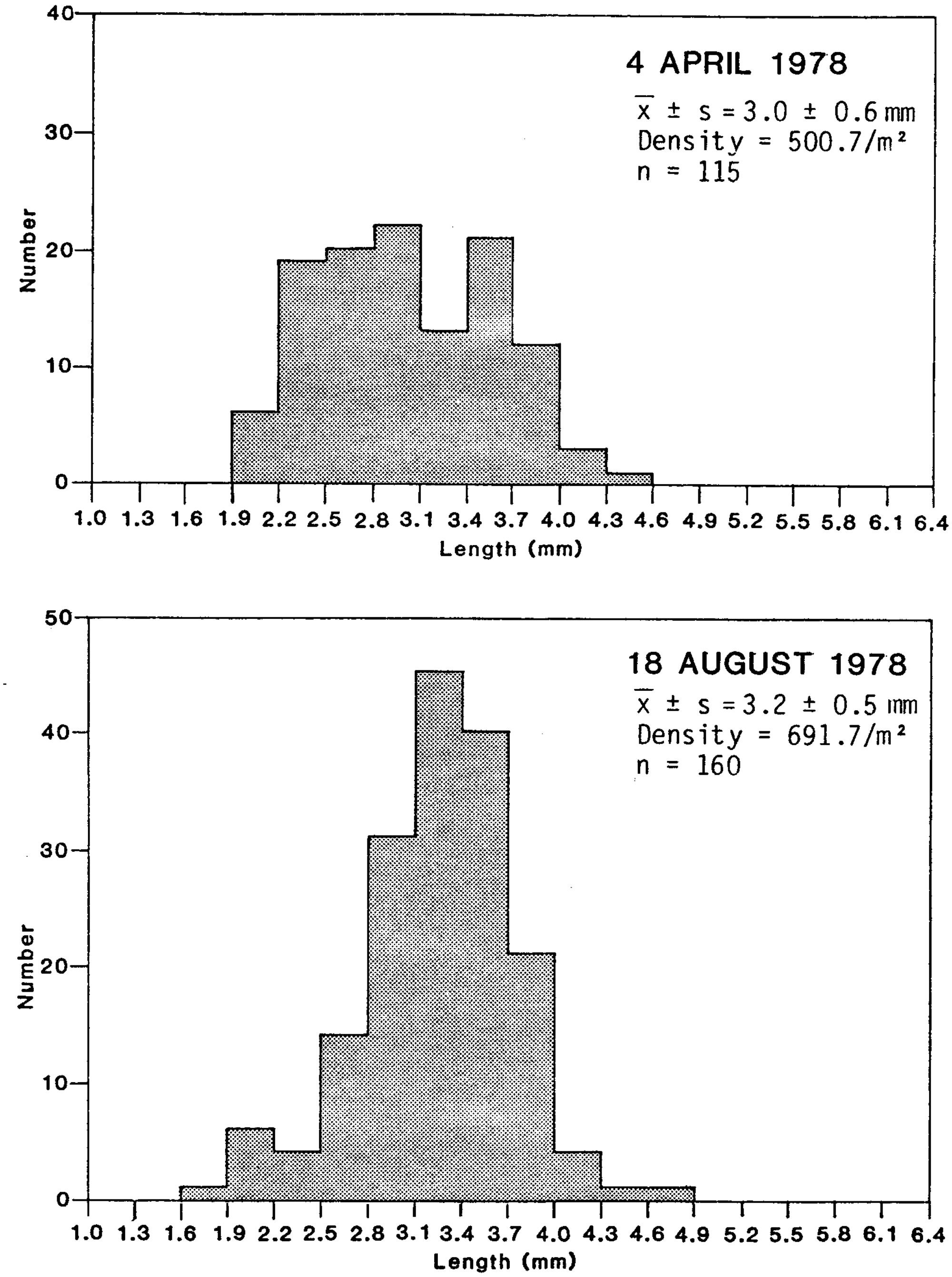


FIGURE 6-23

LENGTH-FREQUENCY HISTOGRAMS
FOR Eohaustorius eous
AT INISKIN BEACH

TABLE 6-65 SUMMARY OF NUMERICAL PARAMETERS FOR THE SANDY INTERTIDAL ASSEMBLAGE AT INISKIN BEACH

	Abundance			Species Richness		Species Diversity	Evenness		Biomass
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
				26 April 1978					
130	134	13.4 ± 3.8	1705.8	4	2.5 ± 0.5	0.85	33.50	0.45	26.86
260	35	3.5 ± 2.9	445.6	6	2.5 ± 1.3	1.57	5.83	0.59	11.01
386	75	7.5 ± 4.1	954.8	9	3.0 ± 1.6	1.26	8.33	0.30	50.60
Overall	244			11			22.18		88.47
$\bar{x} \pm s$		8.2	1035.4		2.7	1.23 ± 0.36		0.45 ± 0.15	29.49 ± 19.92
				18 August 1978					
130	247	24.7 ± 10.8	3144.3	8	4.3 ± 1.2	1.54	30.88	0.36	6.53
260	60	6.0 ± 3.8	763.8	12	3.8 ± 1.4	2.34	5.00	0.46	26.84
386	74	7.4 ± 3.6	942.0	10	3.9 ± 1.0	2.16	7.40	0.45	27.54
Overall	381			18			21.17		60.91
$\bar{x} \pm s$		12.7	1616.7		4.6	2.01 ± 0.42		0.42 ± 0.06	29.30 ± 11.93

*_Siliqua_ not included.

significant at the 130-m level ($P<0.005$) but were not significant at the 260-m and 386-m levels ($P>0.2$ and $P>0.05$).

Species diversity (H) increased at all levels between the April and August surveys; the highest value was found at the middle level during both surveys. Both patterns were significant ($P<0.005$).

Evenness parameters (N/S) showed that species were more equitably distributed at the lower levels and were relatively consistent between the two surveys. The decrease in N/S with depth reflects the decrease in density towards the lower levels accompanied by an increase in species richness.

Species-area curves were constructed for each level and survey to determine rates of species acquisition in the samples and the suitability of the sampling program. In most cases the curve for specific levels showed signs of becoming asymptotic (Figure 6-24). The rate of species acquisition was more rapid during the July survey.

Composite species-area curves were constructed for both surveys by tabulating, by level, the cumulative numbers of species identified. The accrual rate was rather slow and uniform throughout both surveys and seems to indicate a strong gradient for physical factors during both seasons.

6.3.2 Mud Flats

6.3.2.1 Biological Assemblage of the Mud Flat at Glacier Spit, Chinitna Bay

The infaunal assemblage at Glacier Spit, Chinitna Bay, was sampled five times over a period of two years (6 April, 30 July, and 14 November 1977, and on 24 May and 18 October 1978). Fifty-three taxa, including one echiurid, one nemertean, one oligochaete, 26 polychaetes, fourteen crustaceans, three gastropods, six pelecypods, and one fish were identified from the core samples. Of these taxa, only nine species were found on all surveys.

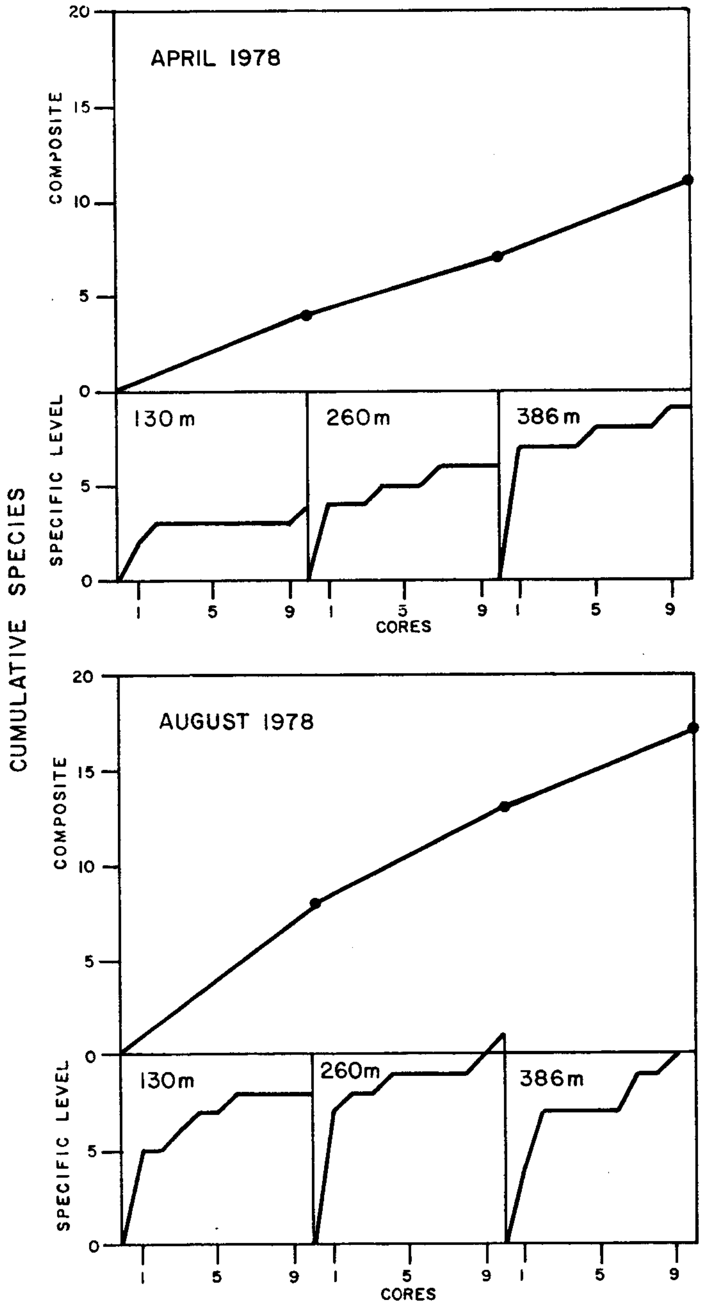


FIGURE 6-24

SPECIES/AREA CURVES FOR INISKIN BEACH

In terms of abundance and biomass, the fauna was dominated by pelecypods, especially Macoma balthica and Mya spp (Tables 6-66 and 6-67). Relative abundance was uniform between surveys. These clams comprised over 97 percent of the total biomass for all surveys except October 1978 when they made up 93.8 percent. The remaining taxa contributed little to overall biomass. Several other species, especially the polychaete worms Nephtys, Laonome, and Gattyana, and the clams Clinocardium and Pseudopythina, contributed at least marginally to density. Crustaceans and gastropods were never of much importance.

Temporal Patterns

Several seasonal patterns are apparent in the Chinitna samples from 1977, but since a summer survey was not completed in 1978, the patterns are not totally clear. Between April and July 1977, two strong trends were apparent. Densities of polychaetes and the caprellid Tritella increased dramatically between the surveys ($P<0.005$; Wilcoxin match-pairs signed ranks T-test). The most dramatic increase was for the polychaete Spio. In contrast, most of the clam species became substantially less abundant ($P<0.005$) during this period (Table 6-66). Between July and November, polychaete abundance and species richness decreased. Clam densities continued to decrease through the winter to May 1978, except for juvenile Clinocardium, which increased at the lower levels. In contrast, polychaete and crustacean abundances showed definite increases by May. In October 1978, polychaete abundance was even higher, especially Nephtys and Polydora. Clam densities also were significantly higher than in May ($P<0.01$); for example, juvenile Clinocardium had increased from 54.6 to 2,596.9/m^2 (Table 6-66).

Densities and species richness were generally higher in 1978 than in 1977. This pattern is highlighted by the October 1978 data. November 1977 data were the lowest for the study, but October 1978 data were the highest. For example, overall abundances for polychaetes and pelecypods were four and two times higher, respectively, in 1978 than in 1977 (Table 6-66). In all data sets where summer surveys were conducted, summer values were the highest for the year. These patterns imply that summer abundance and species richness also must have been considerably richer in 1978 than in 1977.

TABLE 6-66 AVERAGE DENSITY (No./m^2) OF COMMON TAXA AT GLACIER SPIT, CHININTA BAY

TAXA	6 April 1977 (No./m^2)	%	30 July 1977 (No./m^2)	%	14 November 1977 (No./m^2)	%	24 May 1978 (No./m^2)	%	18 October 1978 (No./m^2)	%
ECHIURA		(0.6)*		(0.8)		(1.6)		(0.8)		(0.4)
Echiurus echiurus	38.2	0.6	41.4	0.8	54.1	1.6	27.3	0.8	34.0	0.4
ANNELIDA-Polychaeta	(727.2)	(9.2)	(1547.4)	(31.3)	(496.6)	(15.0)	(932.0)	(26.3)	(2015.5)	(23.3)
Ampharete acutifrons	12.7	0.2	25.5	0.5	0		0		0	
Capitella sp	19.1	0.3	111.4	2.2	0		22.7	0.6	106.1	1.2
Eteone nr longa	38.2	0.6	121.0	2.4	38.2	1.2	45.5	1.3	114.6	1.3
Eteone sp	0		9.5	0.2	0		0		P	
Gattyana treadwelli (adult)	19.1	0.3	63.7	1.3	38.2	1.2	18.2	0.5	8.5	0.1
Gattyana treadwelli (juv)	-		0		0		0		12.7	0.1
Glycinde picta	0		0		130.5	3.9	300.1	8.5	309.7	3.6
Laonome kroyeri	117.8	1.8	251.5	5.1	121.0	3.6	200.0	5.7	110.3	1.3
Nephtys sp, (adult)	108.2	1.6	155.9	3.1	0		100.0	2.8	212.2	2.5
Nephtys sp, (juv)	210.1	3.2	188.1	3.8	0		222.8	6.3	755.3	8.8
Nephyts sp, (?)	0		0		149.6	4.5	0		0	
Paraonella platybranchia	3.2	T	6.4	0.1	0		P		0	
Pholoe minuta (adult)	9.6	0.1	0		0		P		17.0	0.2
Pholoe minuta (juv)	-		0		0		0		50.9	0.6
Phyllodoce groenlandica	15.9	0.2	28.7	0.6	9.5	0.3	4.5	0.1	4.2	T
Polydora caulleryi	15.9	0.2	54.1	1.1	0		0		0	
P. polybranchia	0		0		0		18.2	0.5	191.0	2.2
Prionospio steenstrupi	12.7	0.2	38.2	0.8	0		0		76.4	0.9
Scoloplos armiger	3.2	T	25.5	0.5	0		0		29.7	0.3
?Spio filicornis	9.6	0.1	455.1	9.2	0		0		0	
Spionidae, unid.	0		3.2	0.1	0		0		12.7	0.1
ARTHROPODA	(6.4)	(T)	(248.5)	(5.0)	(6.4)	(0.2)	(90.7)	(1.8)	(458.2)	(5.0)
Anisogammarus pugettensis	0		0		3.2	0.1	27.3	0.8	258.8	3.0
Crangon sp	0		6.4	0.1	0		0		8.5	0.1
Eohaustorius eous	0		0		0		4.5	0.1	4.2	T
Harpacticoida, unid.	0		6.4	0.1	0		13.6	0.4	0	
Insect larva, unid.	0		9.6	0.2	0		9.1	0.2	0	
Lamprops sp	0		0		0		4.5	0.1	42.5	0.4
Tritella pilimana	3.2	T	187.8	3.8	3.2	0.1	4.5	0.1	131.6	1.5
MOLLUSCA - Gastropoda			(6.4)	(0.2)			(9.0)	(0.2)	(55.2)	(0.6)
Aglaja sp	0		3.2	0.1	0		4.5	0.1	8.5	0.1
Cylichna sp	0		3.2	0.1	0		4.5	0.1	38.2	0.4
MOLLUSCA - Pelecypoda	(5929.1)	(89.8)	(3106.2)	(62.6)	(2759.3)	(83.2)	(2492.0)	(70.6)	(6059.4)	(70.3)
Clinocardium spp	238.7	3.6	114.6	2.3	133.7	4.0	54.6	1.6	2596.9	30.1
Macoma balthica	4732.4	71.7	2654.2	53.5	2434.6	73.4	2287.3	64.7	3000.0	34.8
Mya arenaria	47.7	0.7	47.8	1.0	25.5	0.8	18.4	0.5	21.2	0.2
Mya priapus	12.7	0.2	44.5	0.9	12.8	0.4	4.2	0.1	21.2	0.2
Mya truncata	3.2	T	15.9	0.3	9.6	0.3	4.2	0.1	0	0
Mya spp (fragments)	6.4	0.1	22.3	0.4	12.7	0.4	14.1	0.4	12.7	0.1
Mya spp (juv)	738.3	11.0	66.8	1.3	35.0	1.1	13.2	0.4	165.5	1.9
Pseudopythina sp	146.4	2.2	140.0	2.8	95.5	2.9	95.5	2.7	241.9	2.8

* Numbers in parentheses represent total for major taxa

TABLE 6-67 AVERAGE BIOMASS (g/m^2) OF COMMON TAXA AT GLACIER SPIT, CHINITNA BAY

TAXA	6 April 1977 (g/m^2)	%	30 July 1977 (g/m^2)	%	14 November 1977 (g/m^2)	%	24 May 1978 (g/m^2)	%	18 October 1978 (g/m^2)	%
ECHIURA		(1.0)*		(0.8)		(1.3)		(0.7)		(2.9)
Echiurus echiurus	22.83	1.0	31.80	0.8	28.79	1.3	13.97	0.7	56.46	2.9
ANNELIDA - Polychaeta	(38.07)	(1.6)	(78.97)	(0.8)	(40.24)**	(1.7)	(37.17)	(2.3)	(58.83)	(2.9)
Ampharete acutifrons	0.76	T	T	T	0		0		0	
Capitella sp	0.04	T	0.15	T	0		0.31	T	0.17	T
Eteone nr longa	0.55	T	0.73	T	-		0.23	T	0.40	T
Eteone sp	0		0		0		0		0.67	T
Gattyana treadwelli (adult)	0.77	T	8.13	0.2	-		2.56	0.1	0.84	T
Gattyana treadwelli (juv)	-		0		0		0		3.10	0.2
Glycinde picta	0		0		-		3.15	0.7	5.99	0.3
Laonome kroyeri	2.13	0.1	4.86	0.1	-		4.56	0.2	2.52	0.1
Nephtys sp, (adult)	27.22	1.2	58.67	1.4	-		22.92	1.1	42.71	2.2
Nephtys sp, (juv)	0.70	T	1.27	T	0		2.22	0.1	1.31	0.1
Pholoe minuta (adult)	0		0		0		T	T	0.24	T
Pholoe minuta (juv)	0		0		0		0		0.14	T
Phyllodoce groenlandica	1.58	0.1	4.06	0.1	-		1.19	0.1	0.09	T
Polydora caulleryi	0.03	T	0.04	T	0		0		0	
P. polybranchia	0		0		0		0.03	T	0.33	T
Prionospio steenstrupi	T		0.01	T	0		0		0.16	T
Scoloplos armiger	0.01	T	0.03	T	0		0		0.15	T
?Spio filicornis	0.01	T	0.97	T	0		0		0	
ARTHROPODA		(T)		(T)		(T)	(0.16)	(T)	(2.64)	(0.1)
Anisogammarus pugettensis	0		0		0.02	T	0.03	T	1.87	0.1
Eohaustorius eous	0		0		0		0.01	T	0.01	T
Lamprops sp	0		0		0		T	T	0.08	T
Tritella pilimana	0.02	T	T	T	T	T	0.01	T	0.32	T
MOLLUSCA - Gastropoda		(0)		(0)		(0)		(T)	(1.03)	(0.1)
Aglaja sp	0		0		0		0.01	T	0.01	T
Cylichna sp	0		0		0		T	T	0.98	0.1
MOLLUSCA - Pelecypoda	(2261.93)	(97.0)	(3523.98)	(97.6)	(2091.71)	(97.0)	(2035.79)	(97.6)	(1802.38)	(93.7)
Clinocardium spp	1.53	0.1	200.90	5.0	19.30	0.9	289.19	13.9	28.94	1.5
Macoma balthica	502.93	21.7	461.68	11.4	441.19	20.5	302.65	14.5	328.18	17.1
Mya arenaria	1473.2	63.5	1847.7	45.7	966.7	44.8	748.4	35.8	789.6	41.1
Mya priapus	47.8	2.1	592.3	14.7	109.2	5.1	85.5	4.1	377.1	19.6
Mya truncata	77.5	3.3	290.9	7.2	131.5	6.1	26.4	1.3	0	0
Mya spp (fragments)	136.6	5.9	519.0	12.9	416.2	19.3	579.3	27.8	271.7	14.1
Mya spp (juv)	8.1	0.3	19.9	0.5	6.1	0.2	0.1	T	1.3	T
Pseudopythina sp	1.94	0.1	6.60	0.2	1.48	0.1	4.26	0.2	5.60	0.3

* Numbers in parentheses represent totals for major taxa

** Only a composite weight available for polychaetes

Zonation

To examine zonation, the species at each level were assigned to "importance" categories according to their density and frequency of occurrence (see Chapter 5.0). Species composition was then compared among levels. According to these criteria, all levels were numerically dominated by the small, pink clam, Macoma balthica and the polychaete Nephtys (Table 6-68). Additionally, the polychaetes Eteone and Glycinde were important at all levels along with the small commensal clam Pseudopythina, the eastern soft-shelled clam Mya arenaria and small juvenile cockles, Clinocardium. The clam, Mya priapus was important only at the lower two levels whereas Mya truncata was only important at the lowest level. Several other species including the polychaete Laonome and Mya spp (unidentified juveniles) were important at the lower levels. Species that showed seasonal importance were Spio at the lower levels, and Anisogammarus and the caprellid Tritella at the upper levels.

Consistent patterns of vertical distribution of animals in the sediment were evident from field observations for several species (Figure 6-25). The caprellid lives on filamentous algae at the water-mud interface (Benedict, personal communication), whereas most other species live in the sediments. Most of the polychaetes live near the sediment surface. However, Laonome 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. In addition, it probably also inhabits Echiurus burrows. Echiurus (Figures 6-25 and 6-26) 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 Gattyana 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 within the anterior margin of the shell right at the water-mud interface. Macoma and Mya burrow deeper as they grow larger, a trait that provides considerable protection from predators, physical stress and disruption. Adult Macoma balthica (Figures 6-25 and 6-26) generally live within 5 cm of the sediment

TABLE 6-68 IMPORTANT SPECIES AT EACH LEVEL AT GLACIER SPIT, CHINITNA BAY FOR 1977 - 1978

TAXA	ELEVATION (ft) +3.6	+0.9	-1.2
ECHIURA			
Echiurus echiurus	Sub-dominant	Sub-dominant	
POLYCHAETES			
Capitella Capitata		Frequent	
Eteone nr *longa*	Sub-dominant	Sub-dominant	Frequent
Gattyana treadwelli	Sub-dominant	Sub-dominant	Frequent
Glycinde picta	Frequent	Frequent	Frequent
Laonome kroyeri		Dominant	Dominant
Nephtys sp	Dominant	Dominant	Dominant
Phyllodoce groenlandica		Frequent	
Spio filicornis		Seasonal	Seasonal
CRUSTACEANS			
Anisogammarus pugettensis	Seasonal		
Tritella pilimana	Seasonal	Seasonal	
MOLLUSCA			
Clinocardium spp (juv)	Sub-dominant	Dominant	Dominant
Macoma balthica	Dominant	Dominant	Dominant
Mya arenaria	Frequent	Frequent	Frequent
M. priapus		Frequent	Sub-dominant
M. truncata			Frequent
Mya spp (juv)		Sub-dominant	Dominant
Pseudopythina sp	Sub-dominant	Frequent	Dominant

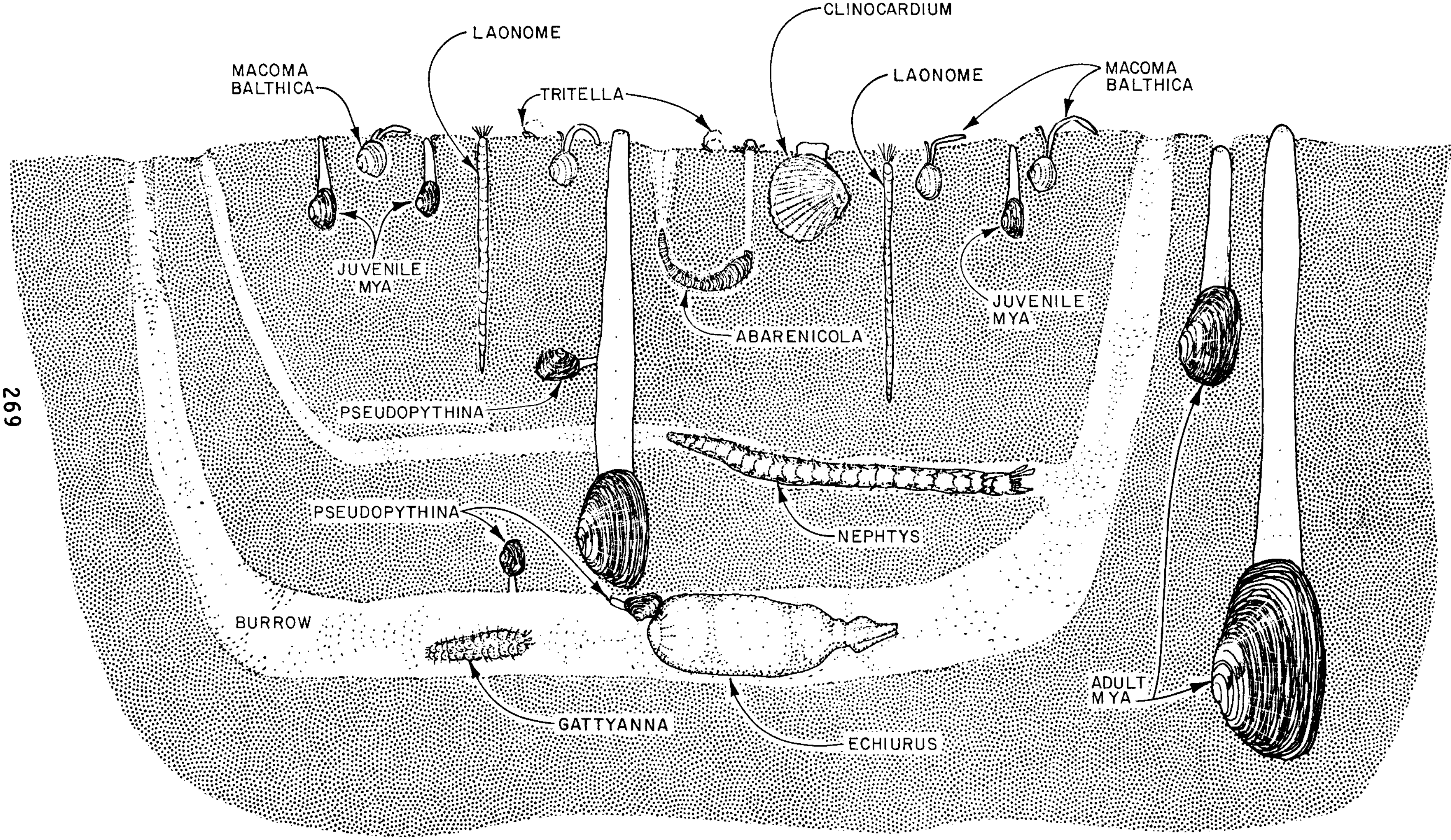


FIGURE 6-25 - DISTRIBUTION OF MAJOR ORGANISMS IN THE FAUNAL ASSEMBLAGE ON THE MUD FLAT AT GLACIER SPIT, CHINITNA BAY

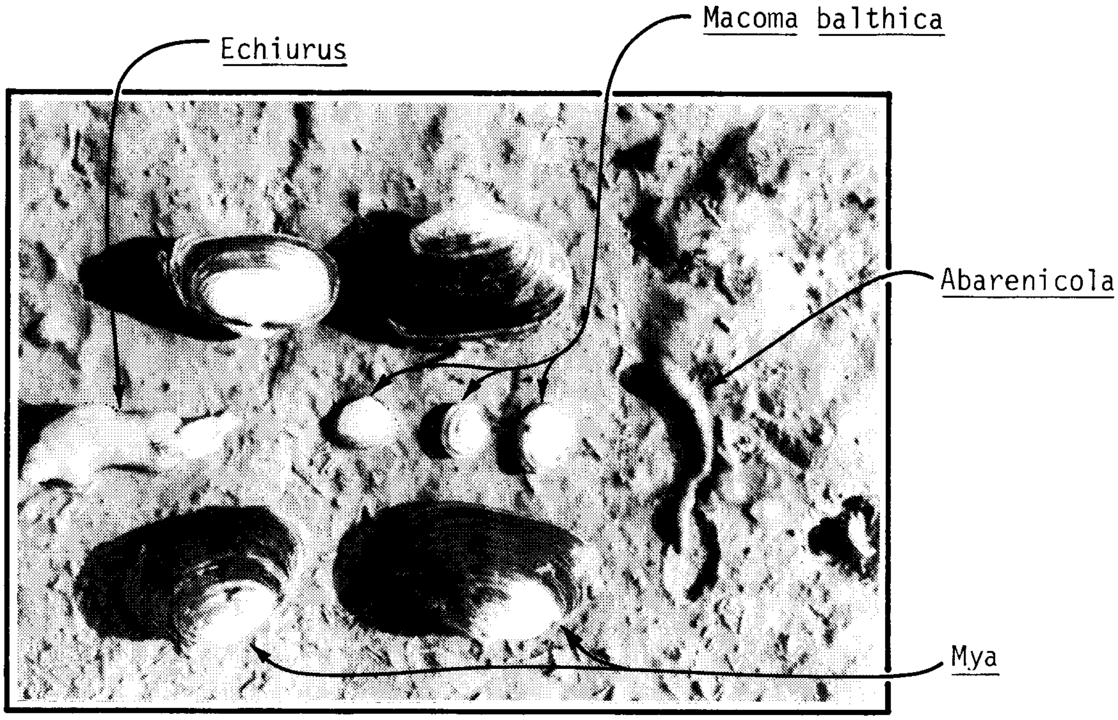


FIGURE 6-26

SEVERAL DOMINANT SPECIES IN THE MUD FLAT ASSEMBLAGE AT GLACIER SPIT, CHINITNA BAY surface. Adults of Mya spp burrow down to at least 30 cm into the sediment and form semi-permanent burrows communicating vertically with the surface (Figures 6-25 and 6-26).

These patterns result in a substantial proportion of the biomass distributed deeply in 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 6-26 and 6-27). In Figure 6-27 the large holes were formed by adult Mya spp, and the smaller holes by Macoma balthica, polychaetes, and Echiurus.

Biomass

During the two-year study period, biomass at Glacier Spit, Chinitna Bay, was heavily dominated by clams; therefore, the distribution of biomass closely followed the distribution of the major clam species (Table 6-67). Mya spp contributed the most to the overall biomass followed by Macoma. Echiurus and polychaetes contributed less than four percent each to standing stocks in all sampling periods. Among the polychaetes, Nephtys was most important and Laonome and Gattyana next. Crustaceans were of little importance on all surveys.

The distribution of biomass, examined using the Friedman X^2 analysis of variance on pooled data, did not vary significantly by elevation ($P>0.4$). Biomass for Mya spp and Macoma were similarly tested and also did not depart from random ($P>0.4$ and $P>0.7$, respectively).

From April to July 1977, biomass definitely increased in average and for most species ($P=0.005$, Wilcoxin T test). Among major species, only Macoma declined. From July to November most species and levels decreased significantly ($P=0.005$).

Although only composite weights were available for polychaete species in November (due to freezing and decomposition before sorting), polychaete biomass clearly declined at all levels except the 0.3-m level where it increased slightly.

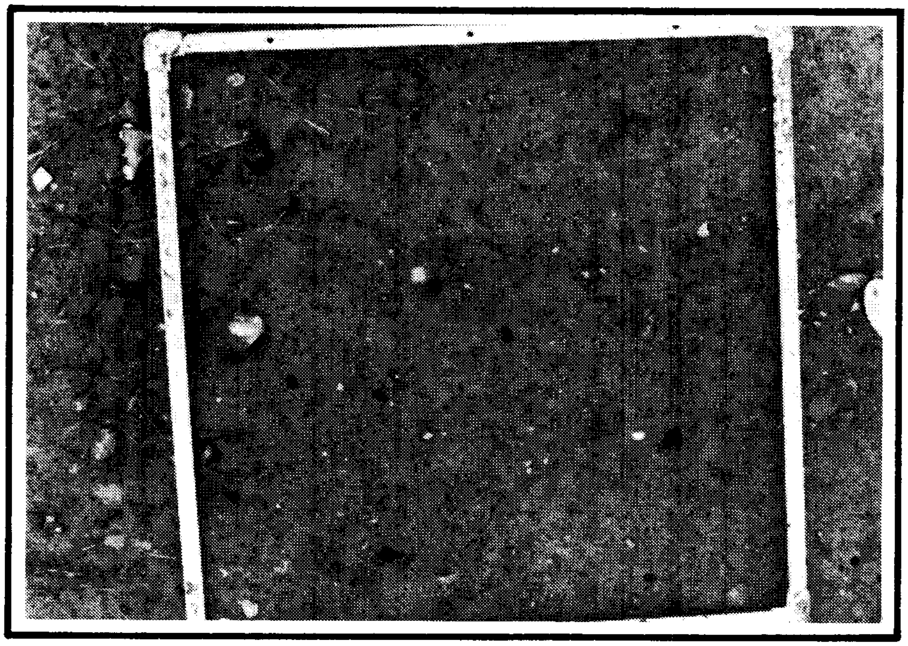


FIGURE 6-27

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

Since there was no summer sampling in 1978, it could only be assumed that the seasonal pattern observed in 1977 was repeated.

Population Biology of Macoma balthica

Size data for *M. balthica* were collected from the Glacier Spit study site in April, July and November 1977, and May and October 1978. Data for the April and July 1977 surveys were presented and discussed previously (Dames & Moore 1979b). Size frequency histograms and summaries of density and biomass for all levels and sampling periods are compared in Appendix G; also included are data from June 1976 (Dames & Moore 1977a). These data indicate the temporal and spatial patterns in some population parameters for Glacier Spit.

Overall mean shell length ranged from 7.26 mm to 10.2 mm (Figure 6-28). Compared to populations described from several other areas (e.g., Ythan Estuary, Scotland, 2.0 to 4.0 mm shell length, Chambers and Milne 1975; Mud Bay in Kachemak Bay, personal observation), the population at Glacier Spit is characterized by large average individual size.

Population parameters appear to vary both considerably by season and year. Myren (personal communication) reports that juvenile recruitment ($\bar{x} \simeq 0.3$ mm) occurs between May and July in Port Valdez and that growth of the 0-year class is rather slow. As a consequence, recruits would not be detected in our samples (1 mm square mesh does not effectively sample clams <2 mm long) until about March. Based on these assumptions, 1976 data indicate that juvenile recruitment failed in 1975 (Appendix H) but was strong in 1976 (Figure 6-28a) and probably 1977 (Figure 6-28d and 6-28e).

Furthermore, the difference in position of the 0-year class modes in the spring samples from 1977 (Mode C) and 1978 (Mode D) suggests either a difference in time of recruitment to the population and/or in rate of growth in the intervening months before recruitment in our samples (Figures 6-28a and 6-28d). Average length of the 0-year class was at least 1 mm larger on 6 April 1977 than on 24 May 1978. In fact, since the October 1978 sample

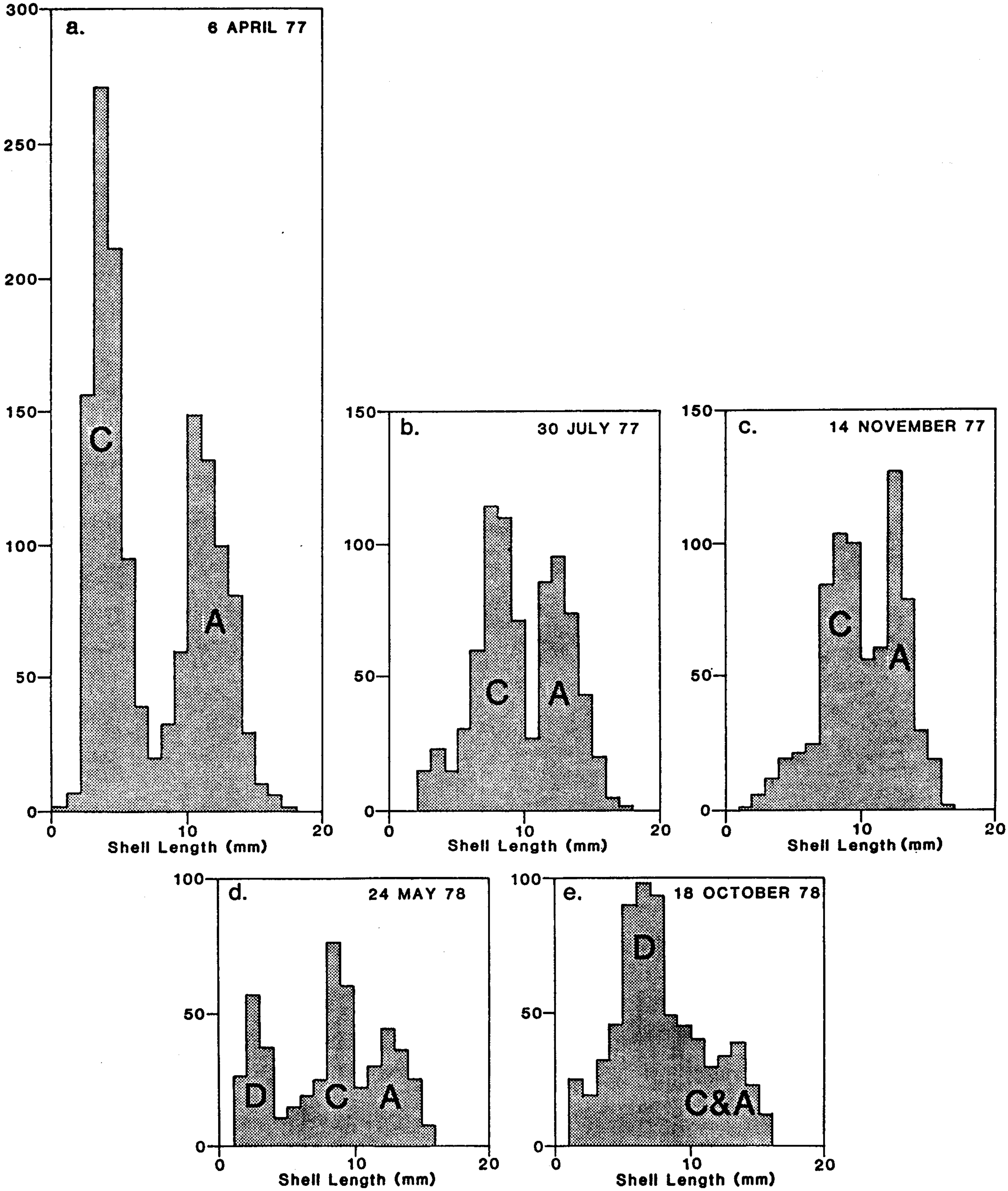


FIGURE 6-28

POOLED SIZE FREQUENCY DATA
FOR Macoma balthica FROM GLACIER SPIT

indicates that recruitment to the 1-year class was as strong in 1978 as it was in 1977, it seems likely that either peak recruitment or attainment of a length of 2 mm occurred about two months later in 1978. This can be deduced by a comparison of the trends for Mode C from April 1977 to November 1978 (Figure 6-28a, b, and c) and Mode D from May 1978 to October 1978 (Figure 6-28d and e).

The apparent absence of recruitment in 1975 (note the absence of Mode B) facilitates the determination of growth rates based on changes in average size of the modes. In the samples from April 1977 to May 1978, Mode A is an aggregate of the clams that recruited before 1975. Mode B represents 1975 recruits; Mode C, 1976 recruits; and Mode D, 1977 recruits. If recruitment had been equal from 1975 through 1977, Mode B would have filled in between Modes A and C, masking the difference in their sizes as finally happened in October 1978 (Figure 6-28e). The changes in mean size of Modes C and D reflect growth (Table 6-69). These data indicate that the 1976 recruits attained an average shell length of about 7 mm in their first year, but probably not much more than 10 mm by the end of their second year. Although growth rates in the 1977 recruits appeared somewhat inhibited, as indicated above, average size agrees closely with that observed for *M. balthica* on Dayville Flats in Port Valdez (Figure 6-29, based on unpublished data, J. Hanson and R. Myren, Nat. Mar. Fish. Service).

These data were combined to construct the "actual" growth curve presented in Figure 6-30. This curve indicates very rapid growth during the first two years of life. In addition, the size data were used in estimating average rates of individual growth and population mortality by a method developed by Ebert (1973). Assumptions of the model are 1) constant rates of growth and mortality; 2) Brody-Bertalanffy growth; 3) a stationary age distribution; and 4) recruitment confined to one month each year. Although assumptions 1) and 3) are very probably not met, Ebert states that the model is sufficiently robust to tolerate "some violations and still produce reasonable estimates." Based on the generally close resemblance between the actual and estimated growth curves up to 8 mm, it appears that the model was accurate up to that point. However, the available size data do not permit further comparison.

TABLE 6-69 MEAN SHELL LENGTH OF IDENTIFIABLE MODES IN SIZE-FREQENCY HISTOGRAMS FOR *MACOMA BALTHICA* FROM GLACIER SPIT, CHINITNA BAY

	MEAN SHELL LENGTH (mm)		
SURVEY	MODE A[a]	MODE C	MODE D
April 1977	11.5	4.0	b
July 1977	12.9	7.4	b
November 1977	12.7	8.0	b
May 1978	12.9	8.3	2.7
October 1978	c	c	c mode ≃ 6.5 mm

[a] Mode A - pre-1975 recruits, Mode C - 1976 recruits, Mode D - 1977 recruits

[b] Below sampling size

[c] Not clearly distinguishable

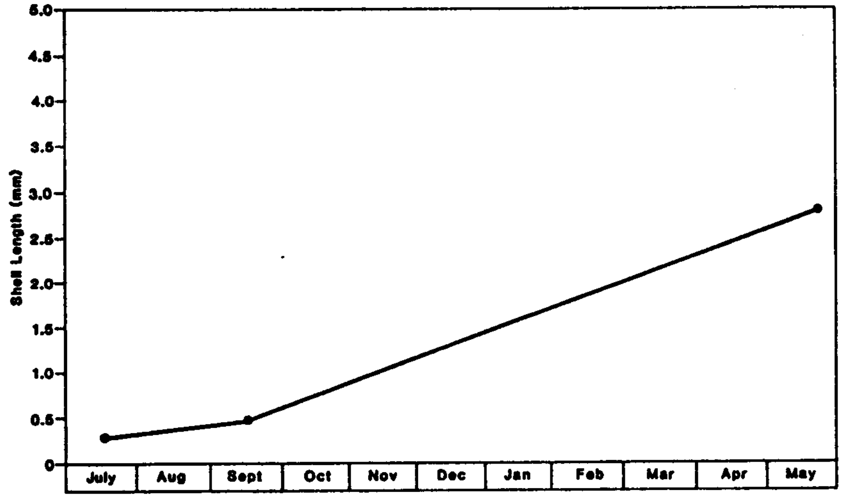


FIGURE 6-29

GROWTH OF 0-YEAR CLASS <u>Macoma</u> <u>balthica</u>
AT DAYVILLE FLATS, IN PORT VALDEZ,

Based on unpublished size data from J. Hanson & R. Myren, NMFS

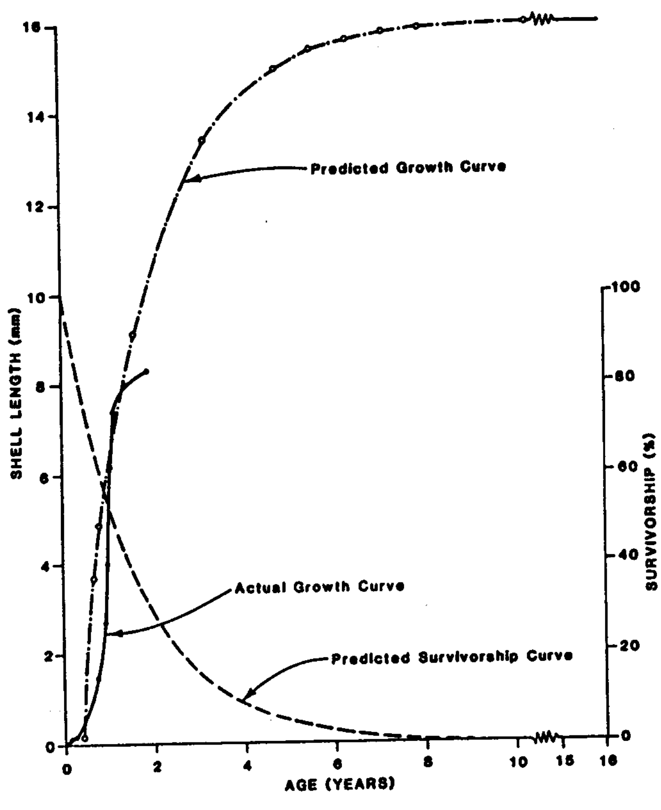


FIGURE 6-30

CURVES FOR ACTUAL AND PREDICTED GROWTH
AND PREDICTED SURVIVORSHIP
FOR <u>Macoma</u> <u>balthica</u> AT GLACIER SPIT

The estimates of growth and mortality rates generated by the Ebert method provide useful insights into the biology of M. balthica at Glacier Spit as well as providing the data necessary for a basic life table. Growth rates are fairly high; specimens apparently attain 75 percent of their growth in less than three years. However, not more than 15 percent of a year-class live that long. In fact, barely half the recruits live a year. However, some individuals may live at least 15 years. Green (1973) reported specimens living 9 to 10 years in Hudson Bay, based on annual rings.

Growth rates at Glacier Spit appear similar to or lower than those reported at other locations. For example, the average size of clams recruiting to this estuary is apparently greater (about 1.5 mm) and it increases to about 6 mm on the first "birthday" and 11 mm on the second (Figure 6-31).

Average density of M. balthica ranged from $4732.4/m^2$ in April 1977 to $2282.3/m^2$ in May 1978, declining steadily through the year (Figure 6-29). Over the period of the study, Macoma density averaged $3008.9/m^2$ and observed survey means varied up to 47 percent from that value. The 95 percent confidence limits for survey means ranged from 3673 to $2207/m^2$, a deviation of about 25 percent from the estimated overall mean. Although this pattern does not initially give the appearance of seasonal changes in density, further consideration indicates that, in fact, strong seasonal variations occur, but that the timing of such changes varies moderately from year to year. The reduction in density at all levels from April to November, tested with the Friedman non-parametric analysis of variance, was significant ($P<0.05$). Variation by the 0-year class in attaining a shell length of 2.0 mm appears to be responsible for lower densities in May 1978 samples than in April 1977 and October 1978. The increase from May to October (Figure 6-28) indicates that strong recruitment occurred in the 0-year class after May.

We examined the hypothesis that a reduction in density variability might be obtained by limiting consideration to large animals (>7.6 mm in shell length), as was done by Myren and Pella (1977). Average density of the larger animals ranged from $1,967/m^2$ in November 1977 to $1,323/m^2$ in October 1978, and averaged $1,708/m^2$ over the period of the study. Observed survey

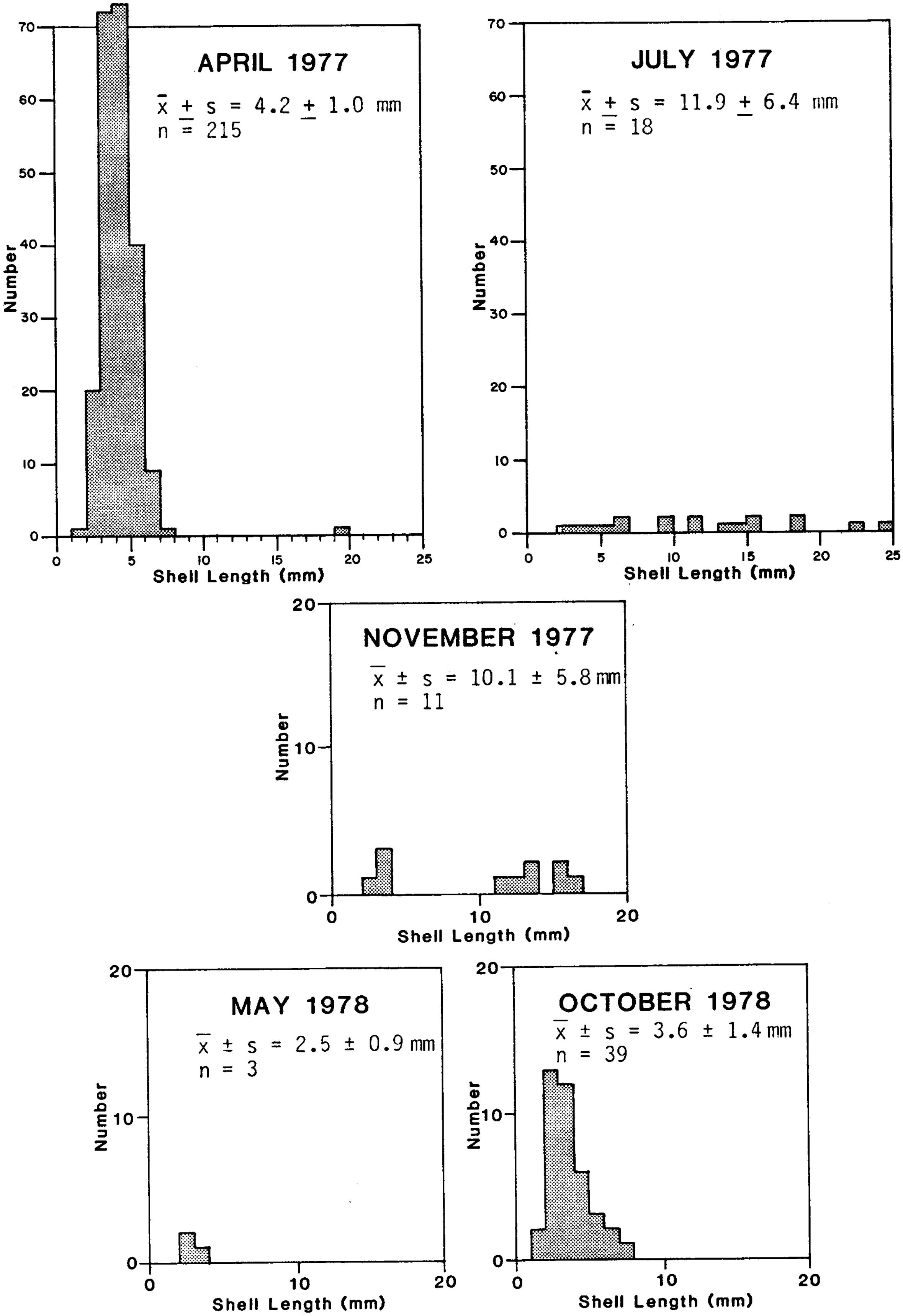


FIGURE 6-31

SHELL LENGTH-FREQUENCY HISTOGRAMS
FOR JUVENILES OF Mya spp.
FROM GLACIER SPIT, CHINITNA BAY

means varied up to 22 percent from the mean, suggesting that annual density variability of the larger animals is somewhat less than that observed in the whole population. The 95 percent confidence limits for survey mean densities range from 2079 to $1336/m^2$, a deviation of about 22 percent from the estimated overall mean for large Macoma. This is a slight improvement over the 95 percent confidence limits for the total population.

The enumeration data for individual cores were used to determine the degree of precision for each level sampled. Relative error (D) in terms of the 95 percent confidence limits was determined by the equation:

$$D = \frac{ts}{\bar{x}\sqrt{n}}$$

Where n = the number of samples

t = the value of Student's t distribution for n-1 degrees of freedom

$\bar{x}$ = the sampling mean

s = its standard deviation

This analysis indicates that, on the average, the estimated mean density for each level (based on 10 core samples) during each survey had a 95 percent probability of being within 20 percent of the true (parametric) mean density for that period and level (Table 6-70).

The same equation was also used to determine how many additional samples it would be necessary to collect at each level to have a 95 percent chance of the estimated mean being within 10 percent of the true mean. Such an improvement of the estimated mean would require increasing the size of the sampling program three to five times. In fact, when the April and July 1977 sample data (40 samples each) for Macoma were pooled for all levels to calculate overall density in the study area in April and July, the resulting means (37.18 and 20.85 clams/core, respectively) were estimated to have a 95 percent probability of being within 8.9 percent and 10.8 percent of the respective parametric means.

TABLE 6-70 DEGREE OF PRECISION (D*) FOR SAMPLES (IN %) OF <u>MACOMA BALTHICA</u> FROM GLACIER SPIT FOR ALL LEVELS AND SAMPLING PERIODS.**

SURVEY	ELEVATION (ft) +4.0	+3.6	+0.8	-1.3	$\bar{x} \pm s$
April, 1977	0.220	0.143	0.165	0.149	0.169 ± .035
July, 1977	0.108	0.191	0.193	0.225	0.179 ± 0.050
November, 1977	0.162	0.225	0.134	0.166	0.172 ± 0.038
May, 1978	0.194	-	0.142	0.185	0.174 ± 0.028
October, 1978	0.144	-	0.217	0.148	0.170 ± 0.041
$\bar{x}$	0.165	0.186	0.170	0.175	0.173 ± 0.004
s	0.043	0.141	0.034	0.032	

$$* \; D = \frac{ts}{\bar{x}\sqrt{n}}$$

** Values in the Table (X_i) indicate that for Sample I, P = 0.95 that the estimated mean was within X_i percent of the true mean for that level at that time.

These data on the observed variability of density at Glacier Spit indicate that Macoma could be useful in detecting disturbances to the environment. In spite of major climatic differences just prior to the study until its completion, seasonal variation of the larger clams from the overall mean was acceptable. Using the April 1977 data as a basis, we estimate that a similar sampling program has a high probability of detecting a change in the mean density of as little as 25 percent.

Whole wet weight of Macoma ranged from 264 g/m^2 at the +0.2-m level in October 1978 to 528 g/m^2 at the same level in April 1977 (Appendix G), and averaged 407.3 $\pm$ 86.3 g/m^2 over the period of the survey. This converts approximately to an average dry tissue weight of 23.4 g/m^2. As with density, differences among surveys were significant when tested by a Friedman non-parametric analysis of variance ($P<0.05$). Generally, biomass was highest in April 1977 and lowest in May 1978. No consistent pattern among sampling levels was noted.

A major proportion of the biomass was attributable to adult clams. Even in April 1977, when juvenile clams were most abundant, clams larger than 7.5 mm long (approximately 43 percent of the population) contributed over 90 percent of the tissue weight (Table 6-71) in the study area.

Small-scale dispersion patterns were examined with the index of dispersion (I)

where $I = s^2/\bar{x}$

$\bar{x}$ = the mean abundance per core

s^2 = its variance

"I" was calculated for each level on each survey and averaged 1.90 $\pm$ 0.98. This tendency toward aggregation was significant ($P<0.05$) in 44 percent of the sample sets. All of the remaining sample sets were distributed randomly. Although patterns relative to tidal height or survey were not observed, there appeared to be a direct correlation between "I" and density, suggesting that at least within the range of densities observed, Macoma became more aggregated at higher densities.

TABLE 6-71 ESTIMATED DISTRIBUTION OF DRY TISSUE WEIGHT AMONG SIZE CLASSES OF MACOMA BALTHICA IN APRIL 1977 AT GLACIER SPIT

Average Shell Length (mm)	Number per m^2	Estimated Average Dry Tissue Weight per Individual (mg)*	Estimated Dry Tissue Weight per Size Class (mg/m^2)
0.5	3	0.001	0.003
1.5	22	0.072	1.574
2.5	483	0.310	149.71
3.5	837	0.769	643.47
4.5	652	1.487	969.75
5.5	289	2.498	722.01
6.5	121	3.830	463.44
7.5	60	5.508	330.49
8.5	104	7.556	785.80
9.5	186	9.99	1858.92
10.5	458	12.84	5882.36
11.5	406	16.12	6545.81
12.5	306	19.85	6073.88
13.5	250	24.04	6010.06
14.5	71	28.71	2612.77
15.5	30	33.88	1016.38
16.5	17	39.56	672.48
17.5	3	45.76	137.28
			34,759.089

* Calculated with the April shell height - dry tissue weight regression equation reported by Chambers and Milne (1975)

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 O-year class (juvenile) mode comprising three species. Specimens smaller than 20 mm are very difficult to assign to species and therefore have been tabulated separately (Figure 6-31). As a consequence, the size of the O-year class for each species is unknown.

Size frequency histograms for each sampling period show significant differences between recruitment and growth for the two-year survey. In April 1977, the O-year class appeared strong (Figure 6-31). The July sample showed a large decrease in density, most likely a consequence of high mortality for this age class. However, it appears that growth of the juveniles was fairly rapid between April and July with the average shell length for the juvenile mode increasing from 4.2 $\pm$ 1.0 mm to 11.9 $\pm$ 6.5 mm. Contrasting the virtual absence of specimens larger than 6.5 mm in April to the fact that 67 percent of the juveniles in July were larger than 6.5 mm supports a hypothesis that the increase in size was due to growth and not solely to differential mortality. November histograms indicate this age class, now about 13.6 mm long, suffered only slight mortality after July and that a new O-year class mode appeared with only four individuals. Size frequency and density observed in the May survey indicate that little mortality occurred throughout the winter. However, the 1-year class animals had disappeared. By October 1978, at least a portion of the O-year class for 1978 had appeared but all individuals from the previous year were absent.

Since no age class could be followed to adult size, recruitment is believed to be rather sporadic.

Distribution of the juveniles appears significantly skewed toward the lower elevations (Friedman X^2 ANOVA on pooled data, $P<0.005$) (Table 6-72).

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

TABLE 6-72 AVERAGE NUMBER OF ADULT AND JUVENILE MYA SPP PER CORE IN THE INTERTIDAL ZONE OF GLACIER SPIT, CHINITNA BAY

	$\bar{x}$ per core																	
	6 April 1977				30 July 1977				14 November 1977				24 May 1978			18 October 1978		
ELEVATION (M):	+1	+0.8	+0.3	-0.4	+1	+0.8	+0.3	-0.4	+1	+0.8	+0.3	-0.4	+1	+0.3	-0.4	+1	+0.3	-0.4
Mya arenaria	0.7	0.5	0	0.3	0.5	0.5	0.4	0.1	0.4	0.3	0.1	0	0.2	0.1	0.1	0	0.4	0.1
M. priapus	0	0.2	0.1	0.1	0.2	0.1	0.6	0.5	0	0	0.2	0.2	0	0	0.1	0	0.1	0.4
M. truncata	0	0	0	0.1	0	0	0.3	0.2	0	0	0.2	0.1	0	0	0.1	0	0	0
Total Adults	0.7	0.7	0.1	0.5	0.7	0.6	1.3	0.8	0.4	0.3	0.5	0.3	0.2	0.1	0.3	0	0.5	0.5
Mya spp (juv)	1.2	1.0	8.8	12.0	0.1	0.4	0.6	1.0	0	0.1	0.4	0.6	0	0.1	0.2	0.5	0.7	2.7
Juvenile/adult ratio	1.7	1.4	88.0	24.0	0.1	0.7	0.5	1.3	0	0.3	0.8	2.0	0	1.0	0.7	0	1.4	5.4

quadrats at each sampling level in April and July 1977 and October 1978 (Table 6-73). Generally, this method produced more conservative estimates of adult density than the core method, probably because the clams become distinguishable to species in core samples before they are large enough to produce readily distinguishable siphon holes. However, the quadrat data are probably more reliable than the core data for the larger clams because of the larger sampling area involved ($0.0625\ m^2$ vs $0.0078\ m^2$), the larger number of samples collected (25 vs. 10 at each level, respectively), and the possibility that the core sampler may not satisfactorily sample large, deeply buried Mya. This interpretation is supported by a comparison of the means ($\overline{x}$) and standard deviations (s) of the two types of data. In all cases for adult Mya spp, s was larger than $\overline{x}$ for core data and smaller than $\overline{x}$ for quadrat data, indicating that quadrat data were less variable.

A comparison of adult Mya densities among sampling levels based on quadrat data (Table 6-72) showed that density was significantly higher at the +0.3-m level in April 1977 ($P<0.05$ in all cases; Mann-Whitney U test). In July, the only significant difference in density was between the + 0.8-m and -0.4-m levels ($P<0.05$) and in October 1978, variations in density were random ($P>0.75$).

Across time, densities of adult Mya showed a slight increase from April to July 1977, but by October 1978, densities had decreased considerably at all levels ($P<0.005$). The decline in the adult population may be a factor of age-related mortality since recruitment appeared rather sporadic.

It appears that M. arenaria is more successful at higher intertidal levels, whereas M. priapus and M. truncata are more successful at lower elevations (Table 6-72). Mya truncata is a common subtidal species in several habitats (personal observation). In all surveys, juveniles were more dense at the lower elevations than upper levels, but this pattern was not statistically significant in May 1978 due to the low density ($P>0.2$).

TABLE 6-73 DISTRIBUTION AND DENSITY OF ADULT MYA SPP BASED ON 25 HAPHAZARD CASTS OF A 1/16m^2 QUADRAT

Number per 1/16m^2 quadrat	Elevation (m) 6 April 1977 +1	+0.8	+0.3	-0.4	30 July 1977 +1	+0.8	+0.3	-0.4	18 October 1978 +1	+0.3	-0.4
0	1	1	0	3	0	0	0	2	4	4	4
1	2	2	0	4	2	4	2	4	7	6	8
2	6	3	3	5	2	2	4	1	6	5	5
3	5	6	3	3	3	1	3	5	5	5	5
4	8	5	4	4	4	2	6	6	1	3	3
5	1	2	3	3	4	6	1	0	2	2	0
6	1	1	3	2	1	3	2	5	0	0	0
7	0	2	3	1	2	1	2	1	0	0	0
8	0	1	1	0	2	2	2	1	0	0	0
9	0	0	1	0	1	2	2	0	0	0	0
10	0	1	0	0	3	1	0	0	0	0	0
11	0	0	2	0	1	0	1	0	0	0	0
12	1	1	0	0	0	1	0	0	0	0	0
13	0	0	2	0	0	0	0	0	0	0	0
$\bar{x}$	3.4	4.2	6.0	2.9	5.5	5.2	4.8	3.6	1.9	2.1	1.8
s	2.3	2.8	3.3	2.0	3.0	3.0	2.7	2.2	1.4	1.5	1.3
No./m^2	53.8	67.8	96.0	46.7	87.7	83.2	76.2	57.6	30.7	33.9	28.8
Overall mean				66.0/m^2				76.4			31.1
Estimated number of adults/m^2, based on core data	101.8	101.8	38.2	63.6	114.8	127.4	216.4	114.7	P	89.1	76.3
Overall mean				74.4/m^2				143.3			55.1

Other Size and Density Data

Average shell length for the juvenile basket cockle *Clinocardium nuttallii*, ranging from 1.9 mm to 4.9 mm, increased from April to July 1977 and then decreased by November ($P<0.001$ in both cases, Kolmogorov-Smirnov two-sample test). Density decreased between April 1977 and May 1978 but then increased tremendously by October 1978 as a result of a significant increase in the 0-year class (Table 6-74). Since densities of most animals examined generally decreased from summer to fall, summer densities might have been considerably more than the $2,596.9/m^2$ found in October. *Clinocardium* densities increased towards the lower levels on the mud flats. It appears that the intertidal population is heavily dominated by juveniles at Chinitna Bay.

Average size of the small commensal clam, *Pseudopythina*, increased from April to July 1977 from 3.2 ± 1.6 mm to 5.0 ± 3.4 mm (Figure 6-32). Over the same period, density remained stable (Table 6-75). Average size and density decreased by November 1977, largely because of the mortality of the larger animals; the smaller mode changed very little (Figure 6-32). Density and average size remained stable in 1978, but by October 1978, density had increased substantially because of a solid 0-year class, and average size had correspondingly decreased (Table 6-75, Figure 6-32).

Overall, density of *Pseudopythina* remained relatively constant throughout the two-year period. 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.

Secondary Production by Mud Flat Clams

In order to document the productivity of a mud flat in lower Cook Inlet and permit comparisons with other parts of the world, secondary production of the clams *Macoma balthica* and *Mya* spp at Chinitna Bay was examined. For *Macoma* this was accomplished using adaptations of methods described by Crisp (1971) and life history data generated with a method for estimating growth

TABLE 6-74 DENSITY OF THE BASKET COCKLE *CLINOCARDIUM NUTTALLII* IN THE INTERTIDAL ZONE AT GLACIER SPIT, CHINITNA BAY

Elevation (ft)	April 1977	July 1977	November 1977	May 1978	October 1978
+1	63.7	38.2	25.5	70.7	2049.5
+0.8	50.9	76.4	63.7	--	--
+0.3	432.9	165.5	241.8	14.1	2749.7
-0.4	345.8	178.2	203.7	76.4	2991.5
$x \pm s$	223.3 ± 195.0	114.6 ± 68.1	133.7 ± 105.2	53.7 ± 34.4	2596.9 ± 489.2

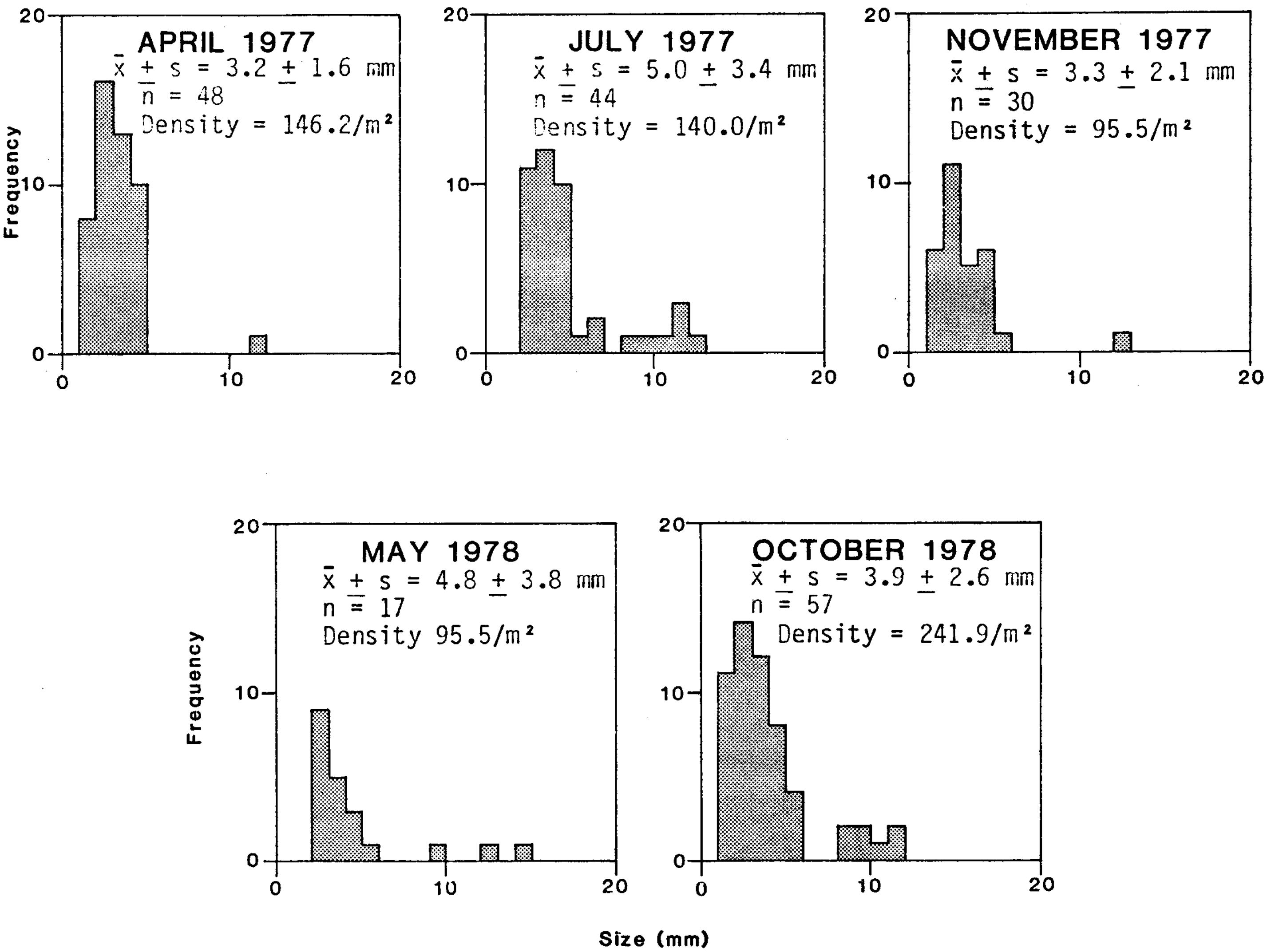


FIGURE 6-32

SIZE-FREQUENCY HISTOGRAMS
FOR Pseudopythina AT GLACIER SPIT

TABLE 6-75 DENSITY OF THE COMMENSAL CLAM *PSEUDOPYTHINA* SP IN THE INTERTIDAL ZONE AT GLACIER SPIT, CHINITNA BAY

Elevation (ft)	April 1977	July 1977	November 1977	May 1978	October 1978
+1	89.1	89.1	76.4	70.7	305.5
+0.8	203.7	114.6	50.9	--	--
+0.3	229.2	216.5	114.6	141.4	407.4
-0.4	56.6	140.1	140.0	76.4	12.7
$x \pm s$	144.7 ± 84.6	140.1 ± 55.0	95.5 ± 39.6	96.2 ± 39.3	241.9 ± 204.9

and mortality rates from size data (Ebert 1973). The data employed were 1) size frequency data from 1977-78 surveys at Chinitna Bay; 2) size data for the 0-year class component of a M. balthica population on Dayville Flats in Port Valdez (J. Hanson, N. Calvin and R. Myren, NMFS, unpublished data); and 3) a set of time-specific shell length-dry tissue weight regressions for M. balthica from an estuary in Scotland (Chambers and Milne 1975). The two productivity estimates calculated used information orginating from data collected at Chinitna. One estimate was calculated from growth and density data obtained by following the 1976 year class (Mode C in Figure 6-28) while the other was based on growth and mortality estimates for a hypothetical "cohort" obtained using Ebert's technique (Table 6-76). In both instances, time-specific dry tissue weights were calculated with regression equations provided by Chambers and Milne (1975). Age and growth data based on annular rings were not collected; therefore, it was not feasible to compute production completely from a time-specific (vertical) life table as was done by Chambers and Milne (1975) and Burke and Mann (1974). In fact, based on the variation observed in recruitment and growth rates between 1976, 1977 and 1978, it appears that the population at Glacier Spit violates the assumption of a stationary age structure specified for this model (Southwood 1966).

In any event, both production estimates were based on age-specific (horizontal) life tables, and were computed by both methods described by Crisp (1971). Details of the computations for the estimates based on the 1976 0-year class and the Ebert growth-mortality curves are presented in Appendices I and J, respectively. The estimates are summarized and compared in Table 6-76. These production estimates are somewhat remarkable for their magnitude, the similarity of the totals, and the high value of the productivity/average annual biomass (P/B) ratio. The similarity of the totals is particularly notable in view of the differences in the respective population parameters (Table 6-76).

In the estimate based on the 1976 0-year class (recruits), only the middle portion of the survivorship curve is based on actual observations. These commenced in April 1977 (age equal to 0.83 years) and continued until nearly June 1978 (age equal to about 1.9 years), after which the year class

TABLE 6-76 SUMMARY OF SECONDARY PRODUCTION FOR MACOMA BALTHICA AT GLACIER SPIT - WEIGHTS REFER TO DRY TISSUE

	1976 0-year Class				Hypothetical "Cohort"			
Age (yrs)	Average Length (mm)	Density (no/m^2)	P (mg/m^2)	E (mg/m^2)	Average Length (mm)	Density (no/m^2)	P (mg/m^2)	E (mg/m^2)
0	0.30	50,000	57	13	0.30	3992	9	2
0.25	0.47	35,732	102	48	0.50	3526	909	67
0.50	0.70	21,464	1153	647	2.6	3060	1443	168
0.67					3.9	2742	834	139
0.75	2.0	7196	35,494	20,500	4.5	2593	2430	244
0.85					5.1	2438	6193	546
0.92					5.8	2276	10,501	1053
1.00	5.5	2000	17	4139	6.11	2127	28,714	18,153
1.25	7.75	1470	2574	1575				
1.50	8.0	1290	-3618	1350				
1.75	8.2	1125	12,536	1832				
2.00	10.0	980	5532	3576	10.6	1133	11,030	17,679
2.25	10.8	815	3897	4246				
2.50	11.6	660	-5211	4086				
2.75	12.0	500	9233	2168				
3.00	13.2	430	2636	2652	13.0	604	3903	12,404
3.25	13.4	350	1209	3698				
3.50	13.85	295	-4961	3114				
3.75	14.2	220	6029	3374				
4.00	14.5	150	23	4521	14.4	322	1107	7617
4.25	14.85	80	14	519				
4.50	15.0	0	0	0				
5.0					15.1	171	347	4321
6.0					15.5	91	118	2360
7.0					15.75	49	39	1323
8.0					15.9	26	0	697
9.0					15.9	14	7	409
10.0					16.0	7	0	176
11.0					16.0	4	0	117
12.0					16.0	2	0	59
13.0					16.0	1	0	59
Total (g/m^2)			66.71	66.73			67.58	67.59
$\bar{P}/B$			3.07				3.11	
$\bar{E}/B$				3.08				3.11

could not be distinguished from older and younger year classes (Figure 6-28). Density estimates for the earlier portion of the life history of this year class are conservative guesses based on observations by Hanson, Calvin and Myren of up to 500,000 juvenile clams/m^2 soon after June recruitment (personal communication). Density estimates for the later years are based on an assumption of a fairly uniform mortality rate until the point of year-class extinction. This assumption probably led to a premature extinction of the year class, making the production estimates slightly conservative. The potential error due to these estimates is probably small, however, as nearly 60 percent of the estimated production occurred during the period of observation. Furthermore, modifying the survivorship curve to extend the length of life to 12 years only increased production by 4.4 percent.

The only direct linkages between the real population of Macoma at Glacier Spit and the production estimate for the hypothetical cohort based on the Ebert growth and mortality rates were 1) observed mean shell lengths for the population at various times of the year; and 2) observed density of the 1976 recruits in April 1977. Otherwise the shapes of the growth and survivorship curves were not closely controlled.

Substantial differences are apparent between several aspects or the two approaches. Although the growth curves are quite similar, the survivorship curves are quite different (Table 6-76). Based on observations by Hansen, Calvin and Myren (unpublished data), the case established for the first year of the 1976 recruits is most pertinent. Nevertheless, these differences appear to result in only minor differences in overall production and its chronology. Over half of the production in the 1976 recruits example occurred during the last quarter of its first year. In contrast, in the hypothetical cohort example, peak production occurred during the second year (Table 6-76).

$P/\bar{B}$ ratios permit assessments of the relationship between average standing crop, actual tissue produced and tissue lost to the population. Average annual biomass for Macoma balthica in the Glacier Spit area was 23.4 g dry tissue/m^2. The $P/\bar{B}$ ratios of over 3, somewhat higher than any previously reported for long-lived bivalves, are probably exaggerated. Burke and Mann (1974) reported a $P/\bar{B}$ ratio of 1.53 for *M. balthica* and Chambers and Milne (1975) reported 2.07. Productivity estimates based on either $P/\bar{B}$ ratio (35.8 and 48.4 $g/m^2/yr$, respectively) are substantially lower than those estimated for Glacier Spit in Table 6-76. In a more recent paper, Hibbert (1976) noted P/B ratios for bivalves ranging from 0.15 to 2.6 and reported ratios as high as 3 only for 1- and 2-year old *Venerupis aurea*. Nevertheless, $P/\bar{B}$ for *M. balthica* at Glacier Spit probably exceeds 2.0 and it is quite clear that secondary production by *M. balthica* is considerable. The tissues so produced are important to numerous predators, particularly several sea ducks, shorebirds and starry flounder.

Sample sizes for adult *Mya* were too small for adequate growth analysis, but estimates of tissue production were derived by multiplying the average dry tissue weight of the standing stock times the P/B ratio obtained by Burke and Mann (1974) for *Mya arenaria* (P/B = 2.54). Estimated annual production of dry tissue was thus calculated to be 319.4 g/m^2 for all species of *Mya* (Table 6-77).

Numerical Parameters

Numerical parameters used to describe the assemblage at Glacier Spit exhibited few strong consistent patterns (Table 6-78). Abundance, species richness and species diversity generally increased from the upper levels towards the lower levels except for October 1978 when all three parameters decreased with depth but did not depart from random. The increase in species richness with depth was only significant in July 1977 ($P<0.025$). This pattern was also reflected in the N/S ratio, which generally increased with depth (Table 6-78).

Between April and July 1977, abundance decreased at all levels, but only significantly at the +1-m and +0.3-m levels ($P<0.005$ and $P<0.025$, respectively). Species richness increased significantly during this same period ($P<0.05$) except at the upper level ($P>0.1$). Species diversity also increased at each level.

TABLE 6-77 AVERAGE BIOMASS (g/m^2), DRY TISSUE WT. AND ESTIMATED TISSUE PRODUCTION FOR MYA SPP AT GLACIER SPIT, CHINITNA BAY

a. Survey Biomass Averages

	g/m^2				
	April 1977	July 1977	November 1977	May 1978	October 1978
Wet Whole Weight (g/m^2)	1743.2	3269.8	1629.7	1439.7	1439.7
Estimated Dry Tissue Weight (g/m^2)*	115.1	215.8	107.6	95.02	95.02

b. Annual Biomass and Production

	Annual Mean Biomass (g/m^2)	Estimated Annual Production $g/m^2/yr$
Whole Wet Weight	1905	4839
Dry Tissue Weight	125.7	319.3

* based on conversion of 6.6 percent for *Mya* published in Thorson (1957)

TABLE 6-78 SUMMARY OF NUMERICAL PARAMETERS FOR THE MUDDY INTERTIDAL ASSEMBLAGE AT GLACIER SPIT, CHINITNA BAY

Elevation (m)	Total per Level	Abundance $\bar{x} \pm s$ per Core	Per m^2	Species Richness Total per level	Species Richness $\bar{x} \pm s$ per Core	Species Diversity H	Evenness N/S	Biomass Grams wet weight per m^2
6 April 1977								
+1	428	42.8 ± 18.1	5448.4	16	4.7 ± 2.6	0.85	26.8	4163.66
+0.8	435	43.5 ± 8.3	5537.5	16	6.6 ± 1.6	1.12	27.2	2975.03
+0.3	648	64.8 ± 18.7	8249.0	15	7.0 ± 1.3	1.41	42.8	1133.08
-0.4	563	56.3 ± 17.3	7167.0	20	6.7 ± 2.0	1.40	28.2	996.46
Overall	2074			25			82.8	
$\bar{x} \pm s$		59.1	6600.5		6.3	1.20 ± 0.27		2319.81
30 July 1977								
+1	250	25.0 ± 6.2	3182.5	20	6.4 ± 2.4	1.81	12.5	3743.89
+0.8	393	39.3 ± 13.7	5002.9	24	9.8 ± 2.5	2.82	16.5	3974.22
+0.3	441	44.1 ± 14.9	5613.9	25	10.1 ± 3.1	2.88	17.6	4858.09
+0.4	475	47.5 ± 13.9	6046.8	25	10.2 ± 3.3	2.54	19.0	3576.88
Overall	1559			36			43.4	
$\bar{x} \pm s$		39.0	4961.5		9.1	2.51 ± 0.49		4038.27
14 November 1977								
+1	200	20.0 ± 5.4	2546.0	11	4.5 ± 1.7	1.4	18.2	2637.29
+0.8	225	22.5 ± 9.2	2864.3	10	5.1 ± 1.9	1.47	22.5	1542.55
+0.3	318	31.8 ± 7.1	4048.1	15	6.4 ± 1.9	1.79	21.2	2952.60
+0.4	299	29.9 ± 6.2	3806.3	14	5.8 ± 1.4	1.52	21.4	1494.63
Overall	1042			21			83.3	
$\bar{x} \pm s$		26.1	3316.2		5.5	1.55 + 0.17		2156.77
24 May 1978								
+1	212	23.6 ± 5.6	2998.6	15	5.9 ± 1.4	1.55	14.1	2511.40
+0.3	302	33.6 ± 5.5	4271.6	18	6.8 ± 2.3	1.94	16.8	1770.75
+0.4	259	25.9 ± 7.6	3297.1	17	6.1 ± 1.7	1.95	15.2	1979.15
Overall	773			25			46.1	
$\bar{x} \pm s$		27.1	3522.4		6.3	1.81 + 0.23		2087.10
18 October 1978								
+1	857	85.7 ± 25.5	10909.6	23	10.7 ± 3.4	2.75	37.3	844.95
+0.3	561	56.1 ± 14.5	7141.5	23	10.0 ± 3.4	2.61	24.4	2903.95
+0.4	614	61.4 ± 10.4	7816.2	23	9.2 ± 2.0	2.52	26.7	2015.10
Overall	2032			34			59.8	
$\bar{x} \pm s$		68.1	8622.4		10.0	2.63 + 0.12		1921.33

With the onset of fall, abundance fell at all levels, but not significantly at the upper level (P>0.1). Species richness followed the same pattern but was significant at all levels (P>0.05). Species diversity decreased at all levels. From November 1977 to the following May, changes in both abundance or species richness at all levels sampled were not significant. In October 1978, high densities, species richness, and diversity were comparable to those observed in July 1977, suggesting that conditions in 1978 were more benign than in 1977.

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 appear to be leveling off, but only the +0.8-m and the +1-m levels in November 1977 and the +1-m level in October 1978, actually became asymptotic after 10 samples (Figure 6-33). However, it seems obvious that additional sampling efforts would have added only uncommon species to the list compiled at each level during the respective sampling periods. The composite species-area curves also showed signs of levelling 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 elevations. The relatively low number of new species added below the upper level suggests a relative homogeneity in composition of the mud flat assemblage in this area.

6.3.2.2 Biological Assemblage of the Mud Flat at Cottonwood Bay

The infaunal assemblage at Cottonwood Bay was sampled twice during the period covered by this study (6 May and 19 August 1978). Forty-four taxa, including one echiurid, nineteen polychaetes, eleven crustaceans, one insect, five gastropods, five pelecypods, one hydroid, and one fish, were identified in the core samples (Table 6-79). Only 32 percent of the polychaetes and 20 percent of the molluscs occurred in both sample sets. One crustacean, Talitroidea, was found in both sampling periods. In terms of biomass, the fauna was dominated by the spoonworm Echiurus. In terms of abundance, the infauna in May was strongly dominated by the small commensal

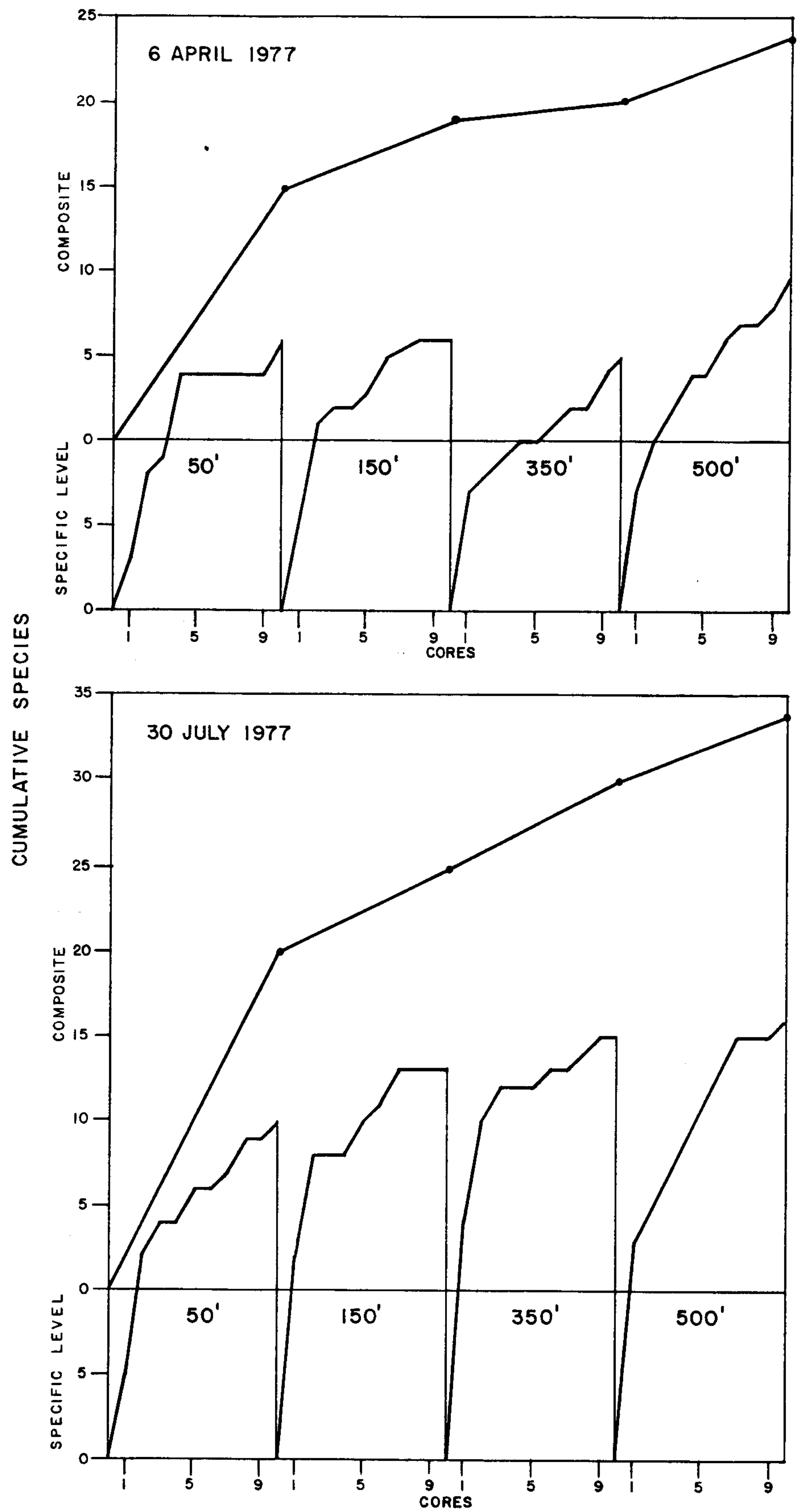


FIGURE 6-33 (1 of 2)

SPECIES/AREA CURVES FOR GLACIER SPIT, CHINITNA BAY

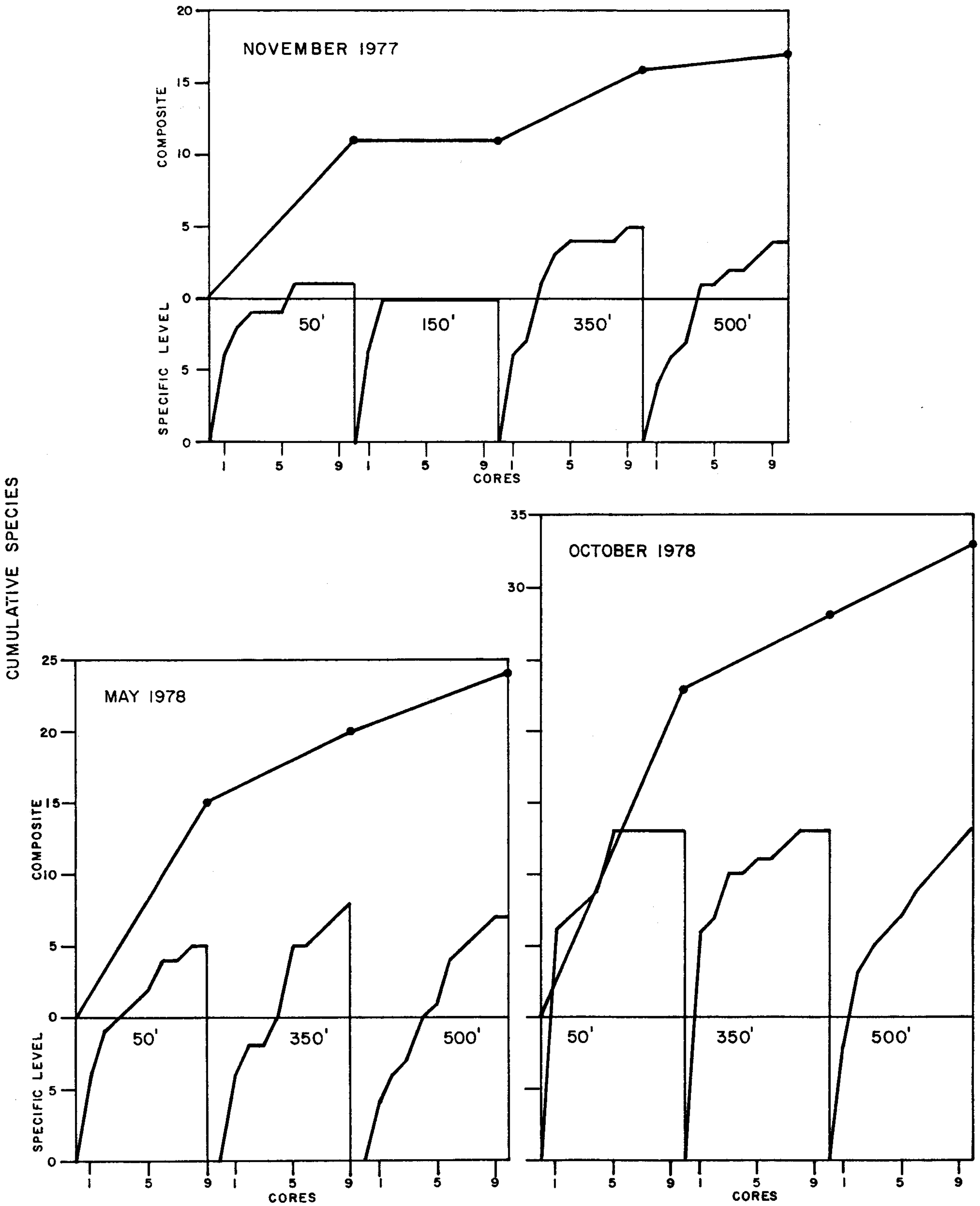


FIGURE 6-33 (2 of 2)

SPECIES/AREA CURVES FOR CHINITNA BAY

TABLE 6-79 AVERAGE DENSITY (no./m^2) FOR BIOMASS (g/m^2) OF COMMON SPECIES AT COTTONWOOD BAY

	6 May 1978				19 August 1978			
TAXA	(no./m^2)	%	(g/m^2)	%	(no./m^2)	%	(g/m^2)	%
ECHIURA		(2.2)		(64.3)		(1.3)	(9.11)	(55.9)
Echiurus echiurus	34.9	2.2	69.47	64.3	34.0	1.3	76.82	55.9
ANNELIDA - Polychaeta		(14.4)						
Capitella capitata	4.7	0.3	T	T	97.6	3.8	0.20	0.1
Eteone nr longa	17.0	1.1	0.98	09				
Eteone sp 1					33.9	1.3	0.51	0.4
Gattyana treadwelli	13.2	0.8	3.14	2.9	13.3	0.5	5.46	4.0
Glycinde picta	4.7	0.3	0.02	T	8.5	0.3	0.13	0.1
Harmothoe imbricata					8.5	0.3	0.17	0.1
Nephtys sp	177.3	11.1	2.53	2.3	1065.1	41.2	5.50	4.1
Phyllodoce groenlandica					12.7	0.5	0.04	T
Polydora sp	4.7	0.3	0.01	T	4.2	0.2	0.02	T
Prionospio steenstrupi					21.2	0.8	0.02	T
Sabellidae, unid	8.5	0.5	0.12	0.1				
Scoloplos armiger					17.0	0.7	0.05	T
Spio filicornis					25.5	1.0	0.13	0.1
Spionidae sp 1					12.7	0.5	0.03	T
ARTHROPODA - Crustacea		(0.9)		(T)		(7.6)		(0.7)
Anisogammarus sp					106.1	4.1	0.14	0.1
Eusiridae, unid.					21.2	0.8	0.16	0.1
Pontogenia sp					8.5	0.3	0.11	0.1
Talitroidea, unid	4.2	0.3	0.01	T	12.7	0.5	0.58	0.4
Tritella pilimana					25.5	1.0	0.05	T
ARTHROPODA - Insecta						(0.2)		(T)
MOLLUSCA - Gastropoda						(5.0)		(0.8)
Aglaja sp					76.4	3.0	0.31	0.2
Cylichna ?alba					25.5	1.0	0.64	0.5
Gastropoda, unid					12.7	0.5	T	T
MOLLUSCA - Pelecypoda		(82.6)		(29.3)		(32.7)		(32.9)
Clinocardium sp					59.4	2.3	0.34	0.2
Macoma balthica	60.8	3.8	15.90	14.7	165.5	6.4	30.29	22.0
Orobitella sp	17.0	1.1	3.17	2.9				
Pseudopythina sp	1240.5	77.7	12.68	11.7	615.3	23.8	11.64	8.5
ECTOPROCTA						(T)		(T)
CHORDATA - Pisces						(0.2)		(0.4)
Liparis sp					4.2	0.2	0.49	0.4

clam Pseudopythina, but with the progression of summer, polychaetes became dominant. The most important polychaete, Nephtys sp, comprised 11 percent of the total density in April and 41 percent in August. The only other polychaete contributing marginally to the overall abundance was Capitella. Gammarids were of negligible importance in May, but became somewhat more abundant by August. This was probably the result of immigration.

Zonation

To examine zonation, the species at each level were assigned, by survey, to importance categories according to their density and occurrence (see Chapter 5.0). Species composition was then compared among sampling levels. According to these criteria, all three levels were dominated by the small commensal clam Pseudopythina, and Macoma was dominant at the upper level and subdominant at the lower two levels (Table 6-80). Nephtys, the most important polychaete, dominated the lower two levels and was a subdominant at the upper level. Echiurus and Capitella were the only other species important at all levels throughout the study period. A large number of seasonal species appeared in August (Table 6-80), suggesting that many species were attempting to colonize the area. Vertical distribution of these species is discussed in Section 6.3.2.1.

Temporal Patterns

Temporal patterns were very apparent at Cottonwood even though only two sample sets were taken. The average number of specimens per core, and thus other abundance parameters, increased from May to August at the 150-m and 350-m levels but showed a significant decrease at the middle level (Table 6-79). This decrease was attributed to the significant decline in Pseudopythina in the August sampling period ($P<0.025$).

Within the general pattern, two trends were discerned. Densities of polychaetes and crustaceans increased sharply between surveys largely due to the addition of seasonally important species and the recruitment of juveniles into the sample (Table 6-79). Densities of molluscs actually decreased; the reduction of Pseudopythina overshadowed an increase in Macoma and the appearance of seven additional molluscan species in August.

TABLE 6-80 IMPORTANT SPECIES AT EACH LEVEL AT COTTONWOOD BAY FOR 1978

	Sampling Level (m)		
TAXA	150	200	350
ECHIURA			
Echiurus echiurus	Frequent	Sub-Dominant	Sub-Dominant
POLYCHAETES			
Capitella capitata	Seasonal	Sub-Dominant	Seasonal
Eteone nr longa	Seasonal		
Eteone sp 1			Seasonal
Gattyana treadwelli	Frequent	Sub-Dominant	
Glycinde pieta		Sub-Dominant	
Harmothoe imbricata	Seasonal		
Nephtys sp	Sub-Dominant	Dominant	Dominant
Phyllodoce groenlandica			Seasonal
Polydora sp		Sub-Dominant	
Prionospio steenstrupi	Seasonal		
Spio filicornis	Seasonal		
Scoloplos armiger		Seasonal	Seasonal
CRUSTACEANS			
Anisogammarus sp		Seasonal	Seasonal
Eusiridae, unid.		Seasonal	
Talitroida, unid.		Seasonal	
Tritella pilimana	Seasonal	Seasonal	
GASTROPODA			
Aglaja sp	Seasonal	Seasonal	
Cylichna ?alba	Seasonal		
Littorina sp	Seasonal		
PELECYPODA			
Clinocardium sp		Seasonal	Seasonal
Macoma balthica	Dominant	Sub-Dominant	Sub-dominant
Orobitella sp			Seasonal
Psuedopythina sp	Dominant	Dominant	Dominant

Biomass

During the two sampling periods, biomass was strongly dominated by the spoonworm Echiurus which made up 64.3 percent and 55.9 percent, respectively, of the total biomass on each survey (Figure 6-34). Biomass for Echiurus varied little during the sampling period. The most important polychaete Nephtys, also increased in biomass slightly between sampling periods (Table 6-79). Crustaceans contributed little to the overall biomass during both sampling periods (Figure 6-34). Macoma was the most important mollusc in terms of biomass and increased considerably from May to August, but again this increase was not significant ($P>0.25$). Pseudopythina, in contrast, decreased slightly in biomass; this clearly was significant at the 200-m level ($P<0.05$). The relationship between biomass and elevation was tested with unpooled data. For Pseudopythina, the difference was significant in May. The highest biomass occurred at the 200-m level ($P<0.05$), but not in August. For Macoma, biomass decreased at lower elevations in both surveys; this pattern was highly significant ($P<0.005$).

Seasonal differences in biomass by level were not significant (Table 6-79). Biomass increased considerably at the 150-m level as a result of large increases in biomass for Echiurus, Macoma, and Pseudopythina.

Size Structure

Length-frequency data for or Pseudopythina and Macoma are presented in Figures 6-35 and 6-36. The Pseudopythina data indicate that the population is basically made up of a single year class. By August, this age class had decreased considerably in density and an older age class was present. The paucity of older specimens indicates that mortality in the younger age class is rather high. Macoma data indicate very low recruitment. The high percentage of very large, old animals suggests that, once established, mortality in adults is rather low. However, the sample size is very small, and Macoma did show significant patchiness.

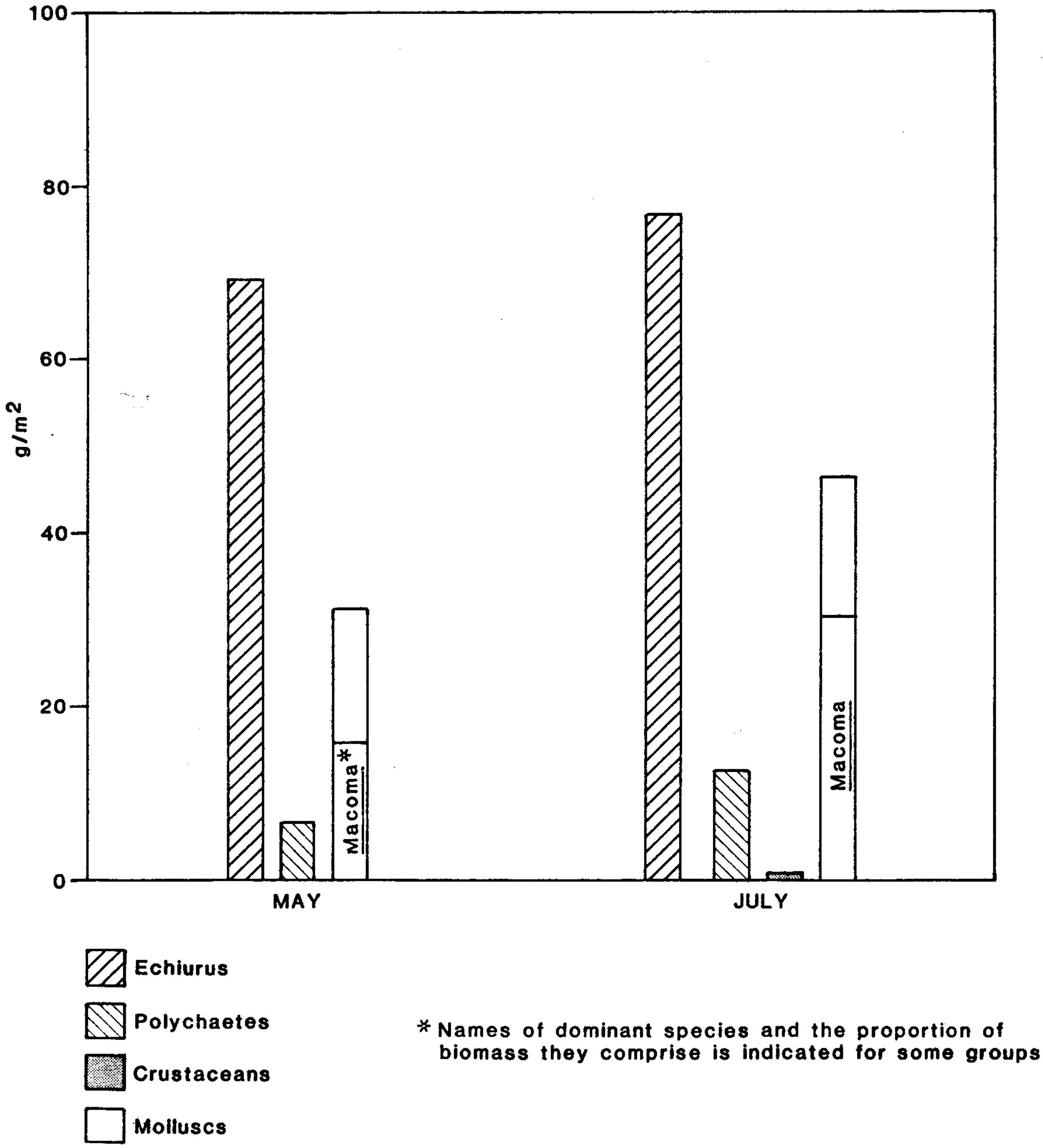


FIGURE 6-34

BIOMASS OF MAJOR TAXA AT COTTONWOOD BAY, 1978

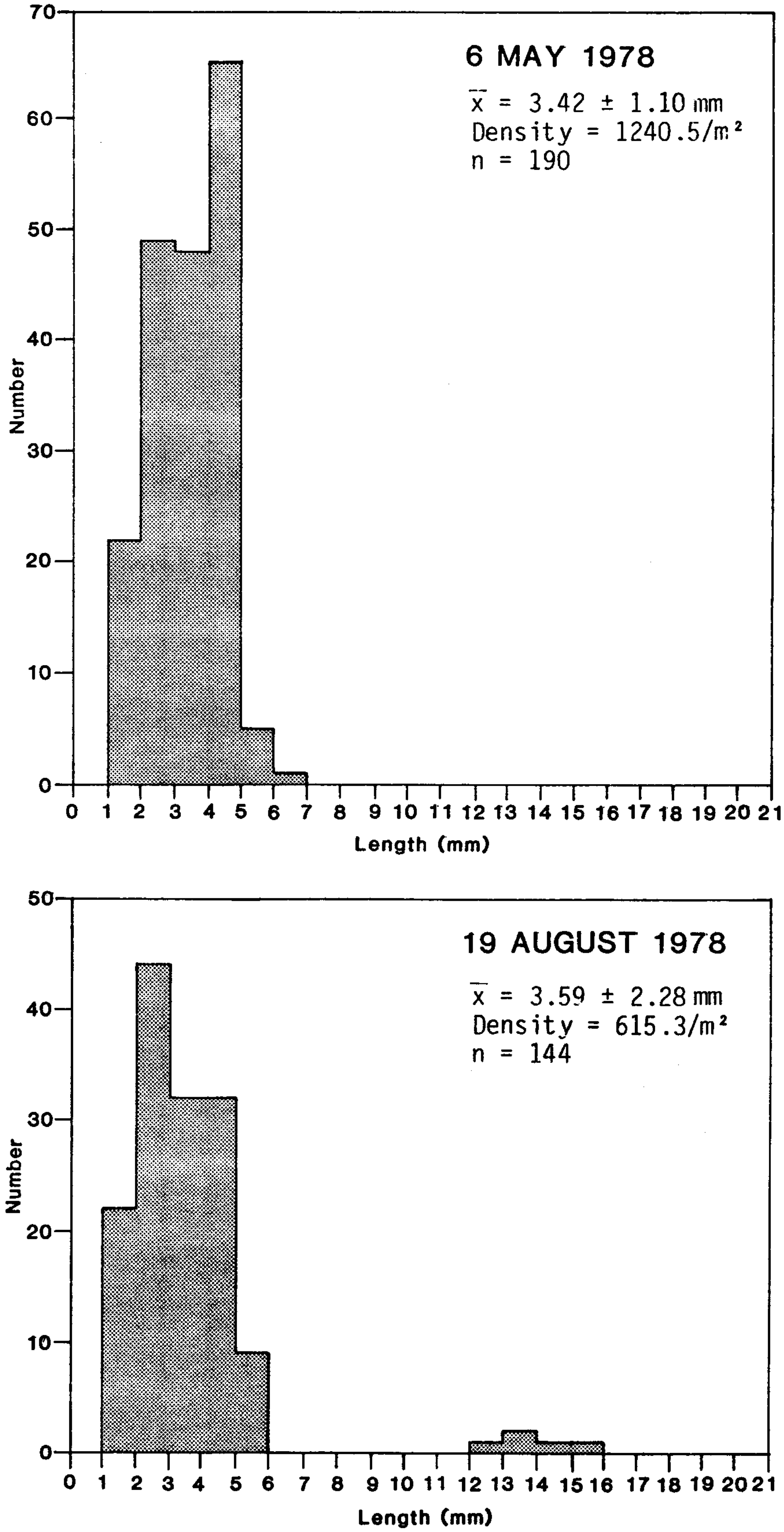
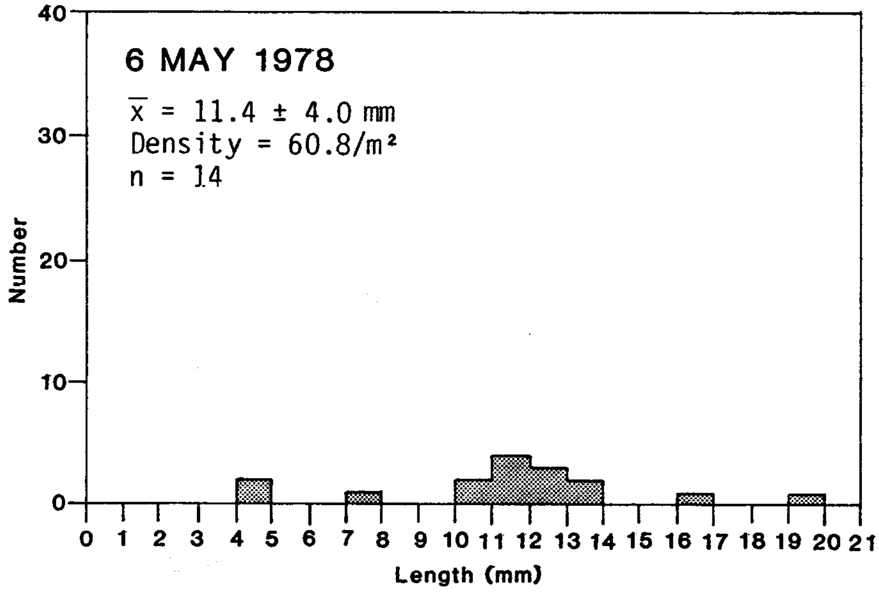


FIGURE 6-35

LENGTH-FREQUENCY HISTOGRAMS
FOR Pseudopythina sp. AT COTTONWOOD BAY



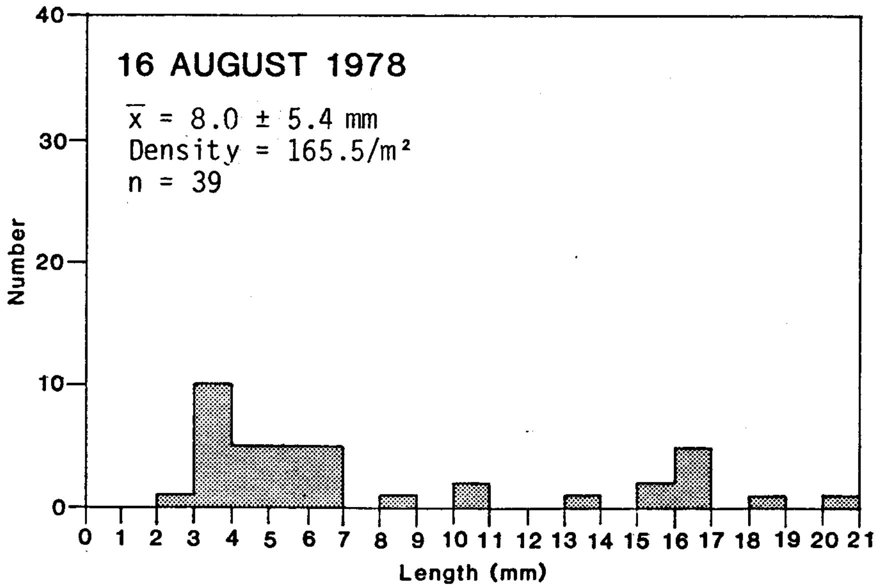


FIGURE 6-36

LENGTH FREQUENCY HISTOGRAMS

FOR Macoma balthica

AT COTTONWOOD BAY

Size data were collected for gammarid amphipods on both surveys, but only one individual was found on the May survey. The most abundant species of gammarid in August was Anisogammarus pugettensis but numbers were too small for accurate analysis. The average size for Anisogammarus in August was 3.1 $\pm$ 0.9 mm (n=22).

Other Density Data

Densities of the spoonworm Echiurus were also estimated with data from random tosses of a 1/16 m^2 quadrat. All echiurid holes were enumerated, and then, since Echiurus lives in a U-shaped burrow with two openings, totals were multiplied by 0.5. Density estimates from the quadrat sampling closely approximated the values obtained from the core samples (Table 6-81). The relationship between density of Echiurus holes and elevation was highly significant ($P<0.005$); highest densities were found at the highest level.

Numerical Parameters

Patterns for numerical parameters were rather straightforward in both surveys (Table 6-82). Generally, abundance, species richness and diversity increased from May to August except for abundance at the 200-m level. In contrast, evenness (N/S) declined over that period.

Increases in abundance parameters were highly significant at the 150-m and 200-m levels but not at the lowest level ($P<0.005$, $P<0.005$, $P>0.05$, respectively). Abundance was similarly examined between levels on each survey. In May, differences among levels were highly significant; highest densities were found at the 200-m level ($P<0.005$). However, in August the slight increase at lower elevations was not significantly different ($P>0.25$).

The increases in species richness from May to August were highly significant at all levels ($P<0.005$, 150-m; $P<0.005$, 200-m; and $P<.025$, 350-m). However, differences among levels during each sampling period were not significant ($P>0.5$ in both May and August).

TABLE 6-81 DISTRIBUTION AND DENSITY OF *ECHIURUS ECHIURUS* AT COTTONWOOD BAY, 19 AUGUST, 1978

	Sampling Level (m)			
Number per 1/16-m^2 Quadrat	150	210	360	410
0	1	2	3	11
1	2	1	4	5
2	5	3	6	2
3	8	6	3	4
4	1	7	2	2
5	1	1	3	1
6	3	4	1	0
7	1	0	1	0
8	1	1	1	0
9	0	0	1	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	1	0	0	0
17	0	0	0	0
18	1	0	0	0
No. of random casts	25	25	25	25
$\bar{x}$	4.5	3.6	3.1	1.4
s	4.3	1.9	2.5	1.6
no. of holes /m^2	71.7	57.6	49.9	21.8
no. of individuals/m^2	35.9	28.8	25.0	10.9
Overall $\bar{x}$			29.9	
Adult density (no./m^2) from core data	50.9	25.5	25.5	--
Overall $\bar{x}$			34.0	

TABLE 6-82 SUMMARY OF NUMERICAL PARAMETERS FOR THE MUDDY INTERTIDAL ASSEMBLAGE AT COTTONWOOD BAY SITE

Sampling Level (m)	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	Grams wet weight per m^2
			6 May 1978					
150	45	4.5 ± 3.7	572.9	8	2.1 ± 1.4	1.81	5.62	80.86
200	191	21.2 ± 15.9	2698.8	9	2.7 ± 1.7	0.91	21.22	128.41
300	119	11.9 ± 19.2	1514.9	8	2.6 ± 1.6	1.05	14.88	114.90
Overall	355			14			41.7	
$\bar{x} \pm s$		12.5	1595.5		2.5	1.26 ± 0.48		108.06
			19 August 1978					
150	190	19.0 ± 13.4	2418.7	25	6.4 ± 2.4	2.79	7.60	197.53
200	199	19.9 ± 13.2	2533.3	22	5.8 ± 1.9	2.46	9.05	111.15
300	220	22.0 ± 23.8	2800.6	23	5.7 ± 3.3	2.36	9.57	103.52
Overall	609	20.3		40			26.2	
$\bar{x} \pm s$			2584.2		6.0	2.54 ± 0.23		137.40

Although species diversity decreased with depth, the difference was not significant (Friedman X^2 test; P>0.2). The increases from May to August were highly significant (P<0.005).

The evenness parameter, N/S, generally increased at lower elevations, reflecting increases in density corresponding with relatively uniform species richness during each survey. From May to August, N/S declined as a result of a great increase in species richness combined with a small increase in overall abundance.

Species area curves were constructed for each level and survey to provide insight into species acquisition in the samples (Figure 6-37). The curves for the May sampling period show definite signs of becoming asymptotic, but the curves for August tend to indicate that additional species could have been found with additional sampling. Decreasing species diversity and an increasing N/S ratio suggests that these additional species would only be uncommon. Composite species-area curves were constructed for each survey by compiling the cumulative number of species by level (Figure 6-37). The rate of "accrual" was fairly slow and uniform in May, a possible result of strong physical gradients, whereas in a milder season (August) the rate of accrual was very rapid at the upper level and then continued on at a steep gradient.

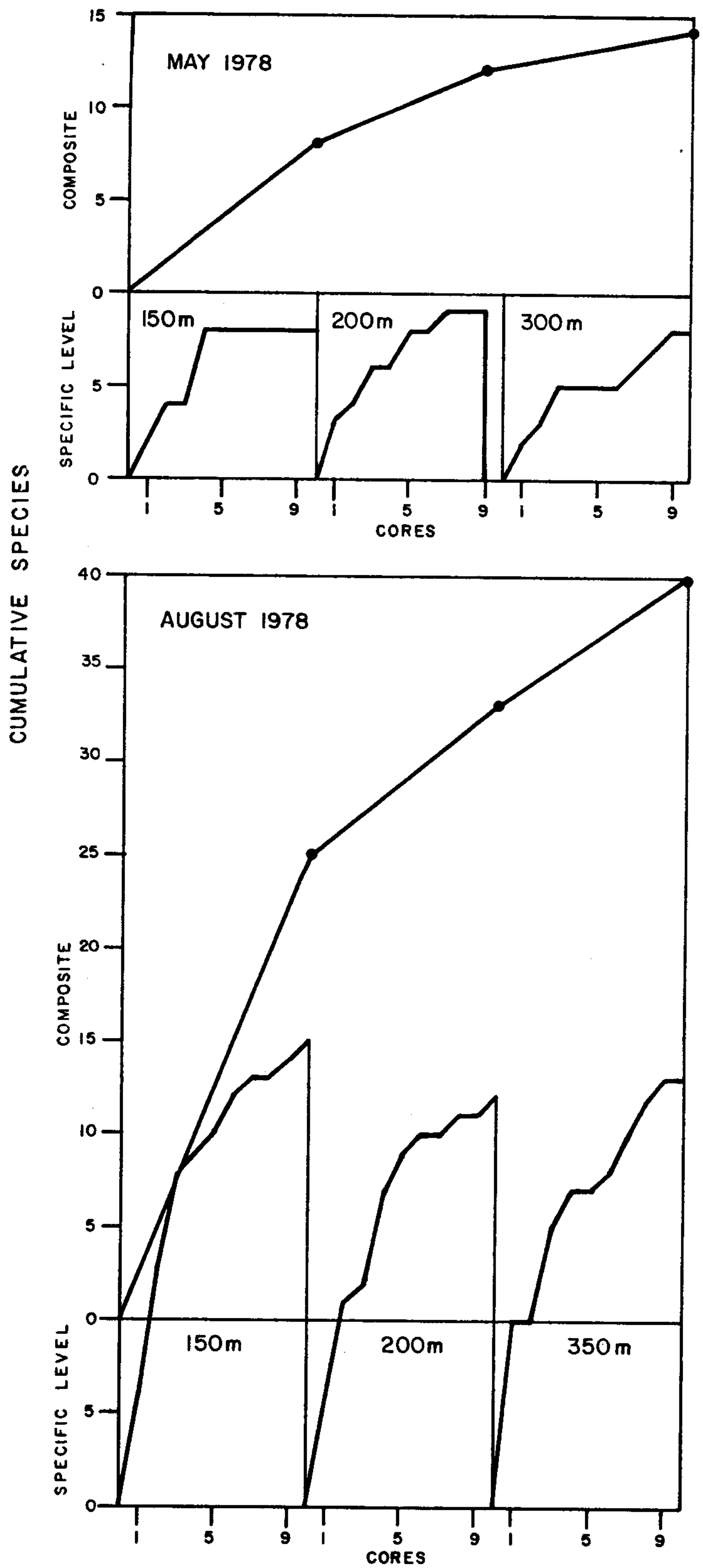


FIGURE 6-37

SPECIES/AREA CURVES FOR COTTONWOOD BEACH

7.0 DISCUSSION

7.1 ECOLOGICAL STRUCTURE AND FUNCTION

7.1.1 Rocky Intertidal Habitats in Kachemak Bay

7.1.1.1 Gull Island

Patterns in zonation at Gull Island are primarily related to differences in elevation, exposure, and slope. The bedrock substrate was of a uniform rock type and 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 experienced by the biota. 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 6-1). 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 1976a). During this period, quantitative data on relative cover were only collected for undisturbed quadrats; thus 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 either through senescence or physical disturbance at these levels, and *A. crispa* failed to develop a canopy in the summer of 1977 or 1978. This was accompanied by a reduction in relative cover of the sponge Halichondria panicea, a frequent associate of B. cariosus and a species that would benefit from moisture retention by the Alaria. A gradual recovery of the B. cariosus population through 1977 and 1978 is clearly demonstrated in Figure 7-1 (0.5- and 0.2-m levels). This trend was accompanied by a trend of increasing overall animal densities and total number of species.

Algal assemblages at all levels exhibited strong seasonal patterns in development, primarily in response to environmental conditions (Figure 7-1). 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 are probably sunlight, nutrient availability, length and time of emersion, air temperature, 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. For example, during the summer of 1978 when densities of these grazers were greatest (Figure 7-1), peak coverage by algae was generally lower than in 1977 (especially at the 0.2-m level).

The main suspension feeders (Balanus spp and Mytilus) were found primarily in the upper portions of the intertidal zone. This was probably a response to limitations imposed by the upward distribution of invertebrate predators (e.g., Paine 1966) whose upward foraging is limited by tidal emersion and the accompanying desiccation. Total number of annual species was relatively constant at each level but tended to increase somewhat through the summer and a decrease in late fall and winter (Figure 7-1).

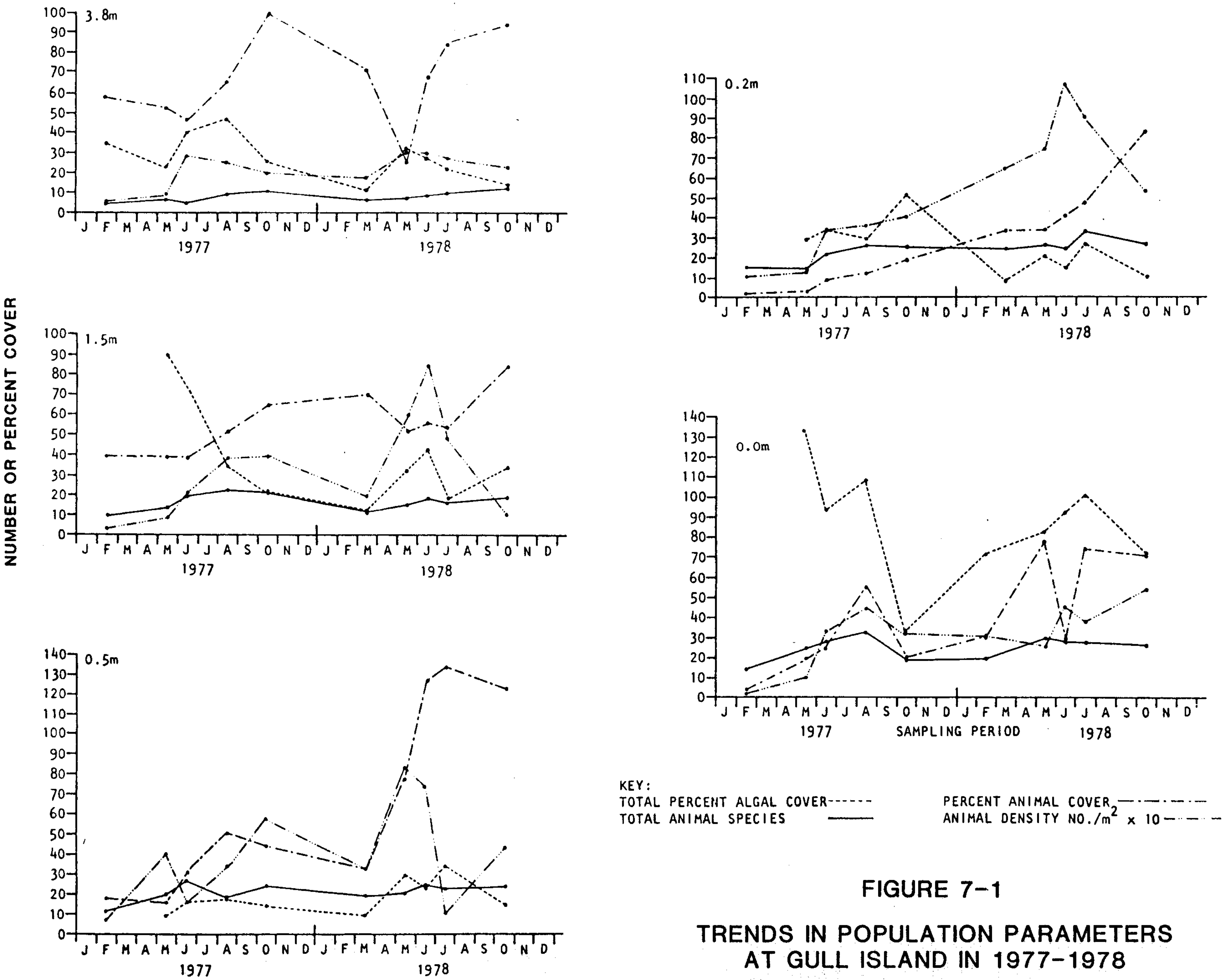


FIGURE 7-1

TRENDS IN POPULATION PARAMETERS AT GULL ISLAND IN 1977-1978

7.1.1.2 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 6.1. Primary productivity was high, as indicated by the strong annual cycle in macrophyte standing crop (Figure 6-6) and the high abundance of microherbivores (limpets, chitons, and pulmonate snails). A major proportion of the macrophyte production is exported to other communities in the form of detached plants, frayed or broken fronds, dissolved or fine-particulate exudates, and metabolites or fecal pellets of macroherbivores (e.g., sea 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 may be carried away by wave action, leaving only some of the stipe, holdfast, or lower frond (e.g., *Katharina* grazing on *Alaria* in October 1978; Section 6.1.1). 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 macrograzers (sea urchins and *Katharina*) may exert some control over algal standing crop, as well as newly settled barnacles and other epifaunal forms. 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 the 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, bryozoans, 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 actively 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 polychaeta Cirratulus cirratus, and perhaps urchins. Hermit crabs (Pagurus and Elassochirus), gammarid amphipods, and isopod scavengers were also present, taking advantage of the natural food trap afforded by these kinds of areas. Overall number of species was generally lowest during the winter and spring with increasing species richness during the summer, peaking between July and October, depending on the year and tide level (Figure 6-6).

7.1.2 Rocky Intertidal Sites in Kamishak Bay

Rocky intertidal sites examined in Kamishak Bay were all composed mainly of bedrock with little boulder cover. As on similar substrates on the east side of Cook Inlet (Gull Island), major patterns in organism distribution were related primarily to differences in slope, elevation, and exposure. However, on the west side of the inlet, exposure to low air temperatures, and ice was perhaps more important than exposure to waves or sunlight. Ecologically, west side sites differed greatly from similar sites on the east side of the inlet in having generally higher algal standing crops in mid- and upper-intertidal zones and a vastly poorer fauna in the mid- and lower zones. In the lowest intertidal ("Laminarian") zone, west side sites appeared to support lower algal standing stocks and faunal density than those on the east side. However, comparability between sample sites was poor and only limited quantitative data were gathered on the west side.

7.1.2.1 Upper Tidal Levels

In addition to the characteristic rockweed (Fucus distichus), the "Fucus" zone on west side transects had significant coverage by encrusting red and brown algae on drier surfaces and by several reds (Gigartina papillata, Rhodomela larix, Odonthalia floccosa, etc.) in pools, moist crevices, and runoff channels. Peak algal standing crop at this level (ranging from just under 1 kg/m^2 at White Gull Island to about 2.3 kg/m^2 at Scott Island) tended to be about half that in the lower "Rhodymenia" zone and occurred in July at all three sites. Algal standing stocks were somewhat higher than the 1978 peaks at the upper levels on the east side (1.5 km/m^2 at +2.0 m at Seldovia Point) but did not match the generally higher standing stocks at Seldovia Point in 1977 (3.1 kg/m^2).

Although no midwinter observations were possible, it is expected that low light levels, freezing temperatures, winter storms, and abrasion by floating ice reduce standing crops of algae to low levels at most locations. During the April sampling at Scott Island, Fucus standing crop was relatively high (1.5 kg/m^2), in fact, exceeding the September level slightly (1.4 kg/m^2). This confirms the pattern seen in more frequent sampling on the east side of the Inlet--that the decline of algal standing crop begins in late summer and continues through the fall with significant new growth by early spring (see Section 6.1.2).

Animal populations in the upper zone at west side sample sites contained few species and were generally low in total animal density compared, for example, to the "Fucus" zone at Gull Island. The maximum (21 species) at Scott Island in September included many found only in the runoff channel, an atypical microhabitat for this tide level on rocky beaches. Only seven organisms, including three filter feeders (Balanus spp, Chthamalus dalli), two grazers (Littorina sitkana, and the limpets), and two predator/scavengers (Pagurus hirsutiusculus and Nucella emarginata), were consistently present and therefore considered typical of the zone. Most individuals were juveniles, although some species apparently overwinter in refugia protected from ice scour.

Numbers of animal species generally increased throughout the summer months; greatest species richness was observed in September at all three sampling sites. This pattern is probably the result of recruitment and growth of young of the year produced by mature individuals residing in areas where overwintering is possible. In many areas these species essentially act as annuals, colonizing large areas each spring but being destroyed by ice each winter. This pattern was also noted on the sandstone benches at the mouth of the Douglas River (Dames & Moore 1977a).

7.1.2.2 Middle Tide Levels

Below the "Fucus" zone, algal cover increased substantially at all west side sites with Rhodymenia palmata and R. liniformis the dominant species. The "Transition" zone at Knoll Head contained a relatively diverse and productive algal assemblage. Fucus cover was roughly half that at the upper zone, but total algal biomass was about double. Coverage by attached animals was reduced and dominance shifted from barnacles to a sponge (Halichondria panicea) and an encrusting bryozoan (Rhynchozoon bispinosum).

These trends continued into the "Rhodymenia" zone at Scott Island and Knoll Head. At these locations, extremely dense growths of algae, especially Rhodymenia spp, Halosaccion, and Gigartina, effectively occupied the available substrate, eliminating most species of animals (especially in the early summer; Tables 6-10 through 6-13). The number of animal species observed in this zone was very low (four) in April but generally increased through the summer to a peak of 21 at Knoll Head. Grazer densities were low; the few grazers present, primarily limpets and the snail Lacuna, succeeded only in keeping very small areas free of macroalgae by grazing on newly attached stages. The scavenging hermit crabs, _Pagurus_ spp, also were generally uncommon but increased substantially in September, probably as a consequence of immigration from the subtidal zone as the late season breakdown of algae increased the availability of acceptable food.

The early summer peak in algal standing stocks (to 5.3 kg/m^2 at Scott Island in June) exceeded peaks at similar tide levels on the east side of the inlet and was comparable to maximum levels measured in the lower intertidal "Laminarian" zone (0.0 m) at Seldovia Point.

7.1.2.3 Lowest Intertidal Levels

The lowest intertidal zone at west side study sites contained only a relatively poorly developed laminarian zone which was systematically sampled only at Scott Island. In general, laminarians (_L. groenlandica_ and _L. saccharina_) were present only in tide channels where the perennial plants are protected from annual freezing, and where ice scour and abrasion by loose gravel may prevent attachment of the more delicate reds. _Alaria_ was far less abundant than on the east side and other species (_Hedophyllum sessile_, _Costaria costata_, etc.) were virtually absent. Haphazard quadrat tosses in lower laminarian beds at Scott Island and Knoll Head indicated mean standing crops of up to 10.8 kg/m^2 in July 1978. Comparable sampling in lower beds at Seldovia Point yielded values as high as 13.6 kg/m^2 in the same month. Solid rock faces on the west side tended to be dominated by _Rhodymenia_ even at lower tide levels where laminarians were abundant on east side study sites.

The general paucity of intertidal animals in west side rocky areas persisted in the "Laminarian" zone although more animals were present here than in the "_Rhodymenia_" zone. This may be partly a consequence of the greater habitat diversity at the lowest level on Scott Island where the sampling area included tide pools and channels as well as solid rock. In contrast, the _Rhodymenia_ zone sample areas were almost exclusively solid rock.

7.1.2.4 Rocky Intertidal Summary

Strong, distinctive differences exist between the intertidal assemblage on rock substrates on the east and west side of lower Cook Inlet. These differences largely seem to be consequences of the more rigorous winter conditions that exist on the west side of the inlet. Because these conditions routinely eliminate virtually all larger, longer-lived species from the rocky shores on the west side of the inlet, they deeply influence the fundamental nature of the intertidal assemblages.

Nearly every year, it appears that the combination of drifting ice and low temperatures kills and removes a large proportion of the plants and animals on the rocks. Perennial plants and animals function as annuals and occur primarily in protected situations. The flora and fauna were strongly dominated by "pioneer" species, i.e., species that disperse rapidly, are highly prolific, and are tolerant of stressed conditions. Thus, laminarian kelps were of far lesser importance in these habitats on the west side of Cook Inlet than on the east side, and red algae were much more important. Moreover, faunal assemblages were impoverished on intertidal rocky habitats on the west side of the inlet. Long-lived sessile animals such as *Balanus cariosus*, *Mytilus edulis*, larger grazers such as chitons and sea urchins, and predators such as sea stars and sculpins were rare or absent on the west side but common on the east side. Limpet densities on the west side were depressed and their populations were strongly dominated by small individuals. Thus, grazing and predation pressure was probably low, especially in the middle and lower levels.

As a result, ecological assemblages in intertidal areas on the west side of the inlet clearly appeared to be physically limited, i.e., distribution patterns were primarily reflections of adaptations to the severity of the physical environment. In sharp contrast, comparably situated assemblages on the east side of the inlet, at least at the middle and lower levels, were largely biologically limited. Herbivory and predation, especially by longer-lived species such as chitons, sea urchins, and sea stars, exerted a strong influence on the species composition and distribution of the assemblage, and replaced ice as a dominant factor.

Several widespread patterns of zonation were apparent generally in the rocky intertidal habitats in lower Cook Inlet. Strong vertical distribution patterns were observed in plants, herbivores, and suspension feeders, and, to a lesser extent, predators. The rockweed Fucus distichus dominated at upper intertidal levels. Kelps such as Laminaria and Alaria dominated at low intertidal levels and contributed substantially to intertidal algal standing stocks. Red algae such as Rhodymenia palmata and R. liniformis dominated in disturbed or stressed areas, generally from mid to lower levels of the intertidal and occasionally contributed substantially to algal standing stocks. Factors important in determining these patterns include desiccation, air temperature and insolation, grazing, and abrasion or scouring by ice, sand, or gravel.

Herbivore distribution patterns seemed fairly closely related to these vegetative patterns. In the Fucus zone, the major grazers were the periwinkle Littorina sitkana, the pulmonate snail Siphonaria thersites and limpets. The two former species were important mainly in the Fucus zone whereas limpets extended across the intertidal zone with various species important at different levels. At mid-intertidal levels, dominant herbivores included limpets and the chitons Katharina tunicata and Schizoplax insignis. At low intertidal levels, dominant forms included limpets, the chitons Mopalia spp and Tonicella lineata and the sea urchin Strongylocentrotus droebachiensis. Herbivores were mostly microherbivorous molluscs. Important factors in the determination of these patterns include desiccation, duration of emersion, predation, and abrasion or scouring by ice, sand, or gravel.

Suspension feeders also partitioned the intertidal zone vertically. Important species at the upper levels included the barnacles Balanus glandula and B. balanoides, and the blue mussel Mytilus edulis. These species can cover considerable proportions of the rock and contribute substantially to the animal biomass at that level. At mid and low tidal levels, dominant suspension feeders included the thatched barnacle B. cariosus and the sponge Halichondria panicea. These species contributed substantially to biomass at the Kachemak Bay sites but were virtually absent at west side sites. At low tidal levels, colonial and solitary ascidians and hydroids were often important. Generally the same factors that influenced the distribution of algae and herbivores were operative with suspension feeders.

Zonation patterns of predators were strongly influenced by emersion-immersion relationships. Important predators included birds such as gulls, which feed during emersion, diving ducks, such as harlequin scoters and oldsquaw (Sanger et al. 1979; Paul Arneson, personal communication) and fish such as Clinocottus acuticeps (Dames & Moore 1979a), which move into the intertidal zone during high tide to feed. Invertebrate predators such as the snails Nucella spp, sea stars (e.g. Leptasterias spp and Evasterias troschelii) and sea anemones (e.g. Anthopleura elegantissima and Tealia crassicornis) either make relatively short migrations up and down slope with each rising and falling tide or are firmly fixed to the substrate. Distribution of the vertebrate predators was closely tied to prey availability but obviously fish and diving ducks exert greater pressure at low tidal levels and birds feeding during emersion will exert more pressure at upper levels. Among the invertebrates the snail Nucella emarginata was a dominant predator on barnacles and mussels at the upper tidal levels. Nucella lamellosa and the sea star Leptasterias hexactis were common at mid-tidal levels. At low tide levels, the sea star Evasterias troschelii was common on the east side on the inlet in more oceanic locations whereas the sea star L. polaris acervata was common in more turbid, estuarine habitats.

Strong seasonal patterns were also apparent, especially in relative cover, biomass, and growth rates of algae. Algal cover and biomass were minimal in winter and maximal in July and August. Growth rates of kelps were maximal between March and April and minimal from about September to January (Dames & Moore 1979b). These seasonal patterns seemed strongly influenced by storms (especially following early morning low spring tides in the summer, when insolation effects cause damage to algal tissues), photoperiod, and nutrient availability.

7.1.3 Rocky Subtidal Assemblages

7.1.3.1 Seldovia Point

Two major types of kelp assemblages dominated the biota off Seldovia Point. Most conspicuous was the canopy of Nereocystis and Alaria fistulosa occurring between depths of about 3 and 11 m. Inshore of the canopy was a moderately dense kelp bed of Laminaria groenlandica. Under and offshore of the canopy (out to a depth of about 25 m) was an understory kelp bed of Laminaria and Agarum; the latter species became relatively more important at the greater depths. Highest biomass and productivity in the kelp assemblages was associated with the canopy. Understory biomass estimates were considerably lower than reported by Calvin and Ellis (1978) for Kodiak.

Seasonal patterns were similar to those described for the intertidal zone, i.e., greatest cover and biomass were observed in July and August, and lowest values were observed in February, before the rapid plant growth period in March through May.

The motile and attached epifaunal invertebrate assemblage was generally rather poorly developed in the subtidal habitats off Seldovia. Seasonal patterns were not well defined. The major motile invertebrates included the chitons Tonicella lineata and T. insignis, the limpet Acmaea mitra, hermit crabs, the sea urchin S. drobachiensis, and the starfish Crossaster pappossus, Henricia leviusculus and H. sanguinolenta. Major attached epifauna species included sponges and the bryozoans Flustrella gigantea and Microporina. The butter clam Saxidomus giganteus was an important infaunal form in sand or gravel patches. Densities or relative cover of most of the species were fairly low (Table 6-24) and, from an overall viewpoint in the kelp bed, invertebrates were much less important than the kelps.

In terms of species composition, the faunal assemblage was relatively uniform from the shallow to the deeper areas. Several patterns in density were apparent, however. Generally, suspension feeders (sponges, hydroids, bryozoans, and sea cucumbers) became more dense at greater depths. In contrast, herbivores became less dense at greater depths (Table 6-29).

The fish assemblage at Seldovia Point was moderately developed (Dames & Moore 1979a) from late spring through early fall, but the fish moved to deeper water during the winter. It was largely dominated by demersal species such as greenling, ronquils, cottids, and rockfish. Fish densities were somewhat higher at greater depths. Examination of food items of a broad range of fish from the kelp beds revealed that, although they consumed a broad range of prey, they tended to concentrate on crustaceans such as shrimp, small crabs, and gammarid amphipods (Dames & Moore 1979a).

7.1.3.2 Jakolof Bay

At Jakolof Bay, a surface canopy dominated by *A. fistulosa* but including *Nereocystis* was present to a depth of about 8 m (Dames & Moore 1976a). The understory of *L. groenlandica* and *Agarum* was well developed throughout the area. The area is subject to considerable tidal flushing and tidal currents are strong, especially directly in the entrance channel to the bay. Kelp development was particularly robust in that area. Seasonal patterns were identical to those described for Seldovia Point (Dames & Moore 1980).

The strong current flow in this area, particularly in the immediate vicinity of the entrance channel, appeared to stimulate the development of the epi- and infaunal assemblages, which were generally the most robust that we observed in south central Alaska. Relative cover, biomass, species richness, and density were very high, and predatory activity indicated that secondary production was also quite high (Dames & Moore 1980).

The main herbivore was the sea urchin *S. drobachiensis*, a macroherbivore. Densities in shallow water under the surface canopy often exceeded $20/m^2$ and the species exerted an important influence on plant distribution in some locations. The chiton *Tonicella lineata* was also common in the area.

The suspension-feeding assemblage was functionally dominant. Important species included the sabellid polychaete Potamilla ?reniformis, the large mussel Modiolus modiolus (average wet tissue weight 7.8 kg/m^2), and the large sea anemone Metridium senile. In addition to Modiolus and Potamilla, many of the common forms lived buried in the cobble/shell debris matrix; these included the clams Saxidomus, Humilaria kennerlyi, and Macoma spp, the sipunculids Golfingia margaritacea and Phascolosoma agassizii and the echiurid Bonelliopsis alaskanus. The large barnacle Balanus nubilus and the large erect orange sponge Esperiopsis ?rigida were also common in these habitats, along with the sea cucumbers Cucumaria miniata and C. vegae, various hydroids, and the brittle star Ophiopholis aculeata. The northern ugly clam Entodesma saxicola was common nestling in the cobble among Modiolus, on ledges and in pockets on bedrock slopes.

Asteroids, fish, and snails were the most common and influential predators in the area and densities were high in response to the high standing stocks of suspension feeders. The more important sea stars included Evasterias troschelii and Pycnopodia helianthoides, which probably consumed about 20 percent of the standing stocks of Modiolus annually, and Dermasterias imbricata, which fed heavily on Metridium. The most important snail was the triton Fusitriton oregonensis which fed on sea urchins and is also a scavenger. The hermit crabs Elassochirus gilli and E. tenuimanus, also important predator/scavengers, were observed feeding on bryozoans, small crustaceans and sabellid polychaetes.

Important fish in the area included rock and kelp greenling, rock sole, and sculpin. The greenling fed most heavily on crustaceans, rock sole on limpets and polychaetes, and one of the sculpins concentrated on sea urchins (Dames & Moore 1979a). Seasonal patterns were clearly defined for the fish; only low densities of cottids remained during the winter.

7.1.3.3 The Northern Shelf of Kachemak Bay

The subtidal benthic assemblages on rock substrate on the northern shelf of Kachemak Bay, extending from Archimandritof Shoals to Anchor Point, has been described and discussed by Dames & Moore (1976a and 1980). The following description is adapted from the latter report.

The northern Kachemak Bay assemblage was characterized by moderate development of a kelp bed consisting of a very spotty, thin canopy and a moderate understory, but well developed assemblages of sedentary invertebrates and predator/scavengers. Canopy development, seldom extending past 10 m, was spatially patchy and temporally inconsistent. Although understory kelps were observed out to 16 m, actual beds generally were not observed deeper than 12 m. Species composition and habitat characteristics of the surface canopy and understory were the same as described for the southern Kachemak Bay assemblage.

The sedentary invertebrate component, mostly comprising suspension feeders, was generally well developed and highly robust; it had high diversity and standing stocks. Species diversity and standing stocks rank among the highest seen in Alaska. Some of the more important species included *Modiolus*, *Flustrella*, *Saxidomus*, the sponge *Mycale* and the sea cucumbers *Cucumaria miniata* and *C. fallax*. Several species, e.g., *Modiolus*, *Saxidomus*, and the sabellid worms *Potamilla* and *Schizobranchia*, and the sea cucumber *C. miniata* formed dense, compact beds of large size. Often these beds were a mixture of two or more species. For instance, at several sites on Archimandritof Shoals, the bottom was a carpet of *Potamilla* tubes overlaying a dense mixed bed of *Modiolus* and *Saxidomus*. Other suspension feeders important at several locations included the arborescent, calcified bryozoans *Microporina borealis* and *Dendrobeania murrayana*, the sponge *Halichondria panicea*, and the barnacle *Balanus rostratus alaskanus*. The development of this component at Troublesome Creek was astounding, and could not be accurately described because of the large number of unidentified species, especially sponges, hydroids, tunicates, and bryozoans observed there.

The micrograzers Tonicella spp and the sea urchin S. drobachiensis, a macrograzer, were generally quite abundant. It has been hypothesized that the poor development of the algal assemblage is due in part to overgrazing, particularly by sea urchins, and in part to low light levels resulting from turbidity (Dames & Moore 1976a). The fact that most sea urchins are exposed rather than cryptic indicates that the population is mainly browsing on attached algae (Lees 1970). This condition probably results from a relative undersupply of drift material.

The predator/scavenger component of this assemblage was diverse and the density of these animals was often high. Again, sea stars dominated the component but snails and crustaceans were important. Although about 15 species of sea star were recorded from the northern shelf, only 5 were considered common. Most important among these seemed to be Leptasterias polaris acervata, Crossaster and Henricia sanguinolenta. Conspicuously sparse were Evasterias, Pycnopodia and Orthasterias. Important predatory snails include Fusitriton, and Neptunea spp. Important crustaceans included the crabs Hyas, Oregonia and Pugettia and the hermit crabs Pagurus ochotensis, P. beringanus, P. trigonocheirus, Elassochirus gilli, and E. tenuimanus. Furthermore, this is probably one of the more important nursery areas for king crab in the southeastern quadrant of Cook Inlet (Sundberg and Clausen 1977); a sizable proportion of the northern shelf has been set aside by Alaska Department of Fish and Game as a juvenile king crab nursery area.

Important fish in the area included rock and kelp greenling, rock sole, a variety of sculpins, and, in some areas, Pacific halibut. Toward Anchor Point, fish diversity became higher than at other locations in Kachemak Bay (Dames & Moore 1979a). Seasonal patterns were not examined.

7.1.3.4 The West Side of Cook Inlet

The subtidal benthic assemblages on rock substrates on the west side of Cook Inlet have been discussed by Dames & Moore (1976b, 1977a, 1979a, and 1980) and this description is synthesized from those reports.

Shallow subtidal benthic assemblages on the west side of the inlet differed strongly from those observed on the east side of the inlet in the poor development of the kelp assemblage. Only understory kelp assemblages were observed; these were dominated by Alaria spp (not the floating A. fistulosa) and L. groenlandica in shallow water and Agarum in deeper water. Maximum depth of kelp bed development was about 3 to 5 m. In contrast to intertidal algal assemblages on adjacent beaches, red algae were not abundant subtidally. The depth limitation, quite uniform among all sites examined, is probably imposed by turbidity; suitable substrate for algal colonization was observed at depth of up to 15 m in several locations.

Microherbivorous chitons and limpets and the macroherbivorous sea urchin, although frequently observed, were generally less abundant than on the east side of the inlet. Surprisingly, they were often common down to depths of at least 10 m, substantially below the lower limits of kelp, and it is probable that the chitons were feeding on a surface film of organic debris and diatoms.

The suspensions feeding assemblage was rather poorly developed in the kelp zone but quite complex and well developed below that level. Within the kelp beds, major suspension feeders included the mussel Modiolus, and the sabellid polychaetes Potamilla and Schizobranchia insignis. The appearance of the assemblage in the kelp bed gave the strong impression that scouring and abrasion, possibly by ice or kelp, severely limited the development of invertebrates. Long-lived encrusting forms generally were encountered only in crevices, depressions, or under ledges.

Below the kelp bed, the appearance and species composition of the suspension-feeding assemblage changed dramatically. A large variety of encrusting invertebrates formed a thin veneer over the rock surfaces. With the exception of locations where Modiolus or Potamilla formed beds, standing stocks appeared low because of the thinness of the encrusting layer. The most important taxa below the kelp beds included the barnacle Balanus rostratus ?alaskanus, the digitate bryozoan Costazia surcularis, laminate head-forming bryozoans such as Bidenkapia spitsbergensis, Terminoflustra membranaceo-truncata and Rhamphostomella sp, encrusting bryozoans such as Costazia nordenskjoldi, the sponges Mycale lingua and Halichondria panicea, and social or colonial tunicates such as Dendrodoa pulchella and Synoicum spp. The combination of barnacles, encrusting and digitate bryozoans, and the silt gave this assemblage a drab, jagged appearance.

The predator/scavenger component of this assemblage was fairly diverse, but densities of most species were low. Sea stars and snails were the most important invertebrate taxa observed. The most important sea stars were Leptasterias polaris acervata, Crossaster papposus and Henricia sanguinolenta and Solaster stimpsoni and L. ?hylodes. Most of the sea stars observed were brooders. The most commonly observed predatory snails were Fusitriton oregonensis and Buccinum glaciale but densities were generally low (Dames & Moore 1980). The fish assemblage in rocky subtidal habitats was poorly developed even though much of the area examined appeared to provide excellent habitat (Dames & Moore 1979a). Whitespotted and masked greenling were the major species on rock.

7.1.3.5 NEGOA

Most of the sites examined in the NEGOA studies were at least partially exposed to the pure oceanic water and power of the northeastern Gulf of Alaska. As a consequence, the benthic assemblages were very rich, colorful, and robust and the algal component was extremely productive. Furthermore, the fish assemblages were quite diverse and productive in the summer and several other types of vertebrates frequented the areas feeding on fish or invertebrates.

The algal assemblage, extending to a depth of about 15 m where substrate permits, exhibited strong patterns of zonation. A surface canopy, formed mainly by Nereocystis, was commonly present from about 5 to 15 m; the beds in some areas (e.g., Latouche Point) were fairly extensive. The understory assemblage, substantially more diverse than observed in lower Cook Inlet, was rather similar to that reported by Calvin and Ellis (1978) for Kodiak Island.

From the intertidal zone out to a depth of about 3 m, the large resilient kelps Laminaria dentigera, L. yezoensis and Pleurophycus gardneri formed dense understories. Below 3 m, L. groenlandica became important and L. dentigera and Pleurophycus declined, disappearing by about 12 to 14 m. Agarum often became important at between 7 and 10 m and eventually replaced Pleurophycus, L. yezoensis and L. groenlandica as the dominant kelp at lower levels. The surface canopy of Nereocystis extended over the bottom from about 3 to 15 m. Primary production of the kelp beds was quite high in some locations, possibly exceeding 70 $kg/m^2/yr$ in dense portions of the kelp bed at Latouche Point. Even so, standing stock estimates out to about 10 m were generally lower than reported by Calvin and Ellis (1978) for the Kodiak area, where L. dentigera apparently inhabits greater depths. Red algae were generally not very abundant although a broad variety of species was identified.

The faunal assemblage was highly diverse and several encrusting or sedentary groups contributed considerably to faunal standing stocks. Micro-herbivores such as the chitons Tonicella spp and the limpet Acmaea mitra were often common but sea urchins were quite scarce and cryptic.

The suspension-feeding assemblage was dominated by colonial ascidians and arborescent bryozoans which covered large proportions of the available hard substrate and contributed substantially to faunal biomass. A large variety of ascidians was involved; some of the major species were Didemnum ?albidum, Ritterella pulchra, Aplidium arenatum, Distaplia occidentalis, and Distaplia smithi. Many important ascidian species could not be identified by taxonomic specialists. Large, long-lived suspension feeders such as clams were very uncommon and well concealed.

Ascidians and, to a lesser extent, bryozoans exhibited considerable annual fluctuation in relative cover and biomass. Peak development was observed in mid to late spring. Regression of the colonies commenced by late summer and minimal development was observed in late winter. Maximal development seemed to be tied to the spring phytoplankton bloom. Toward the lower limit of the kelp beds and below, relative cover in spring often exceeded 50 percent (Table 6-42). It is our impression, based on 4 years observations in the NEGOA area, that the dominant species of ascidian varies considerably between years.

The major species of bryozoans were Microporina borealis and Dendrobeania murrayana, both arborescent forms. These species persisted as the dominant bryozoans over 4 years of observations. Neither contributed as substantially to faunal biomass as ascidians but bryozoans contributed more to relative cover on an annual basis; i.e., exhibited less annual variation in cover.

A broad variety of predator/scavengers was observed at the exposed NEGOA sites, but densities were generally fairly low and the populations were dominated by young animals. Large snails or hermit crabs, for instance, were quite uncommon. Sea stars were the dominant invertebrate predators. Important species included Dermasterias imbricata, Crossaster papposus, Pycnopodia helianthoides, Henricia leviuscula and H. sanguinolenta. Important hermit crabs included Elassochirus gilli, E. tenuimanus and Pagurus beringanus, but few adults were observed. It appears that the large temporal variation in suspension feeders and the paucity of large long-lived suspension feeders may discourage development of a large invertebrate predator population.

In contrast, fish, which are much more mobile than most epifaunal invertebrate predators, form an important predator component during late spring, summer, and probably early fall (Rosenthal 1980). Important groups include greenlings, ronquils, rockfish, and sculpins. Species diversity is moderate and density and biomass are fairly high.

Finally, sea otters and sea lions are important predators in these habitats. Sea otters exert a strong influence on the species composition of the algal, herbivore, suspension-feeding, and predator components of the assemblages by feeding on nearly any large animal of any of these groups.

They influence the algal component by cropping the sea urchin populations (Estes and Palmisano 1974), and probably are largely the cause of the paucity of large clams, snails, and hermit crabs. Sea otters are also heavily dependent upon shallow sublittoral assemblages for food.

Sea lions feed mainly on pelagic fish but undoubtedly also capture unwary demersal fish such as greenling and rockfish. Demersal fish definitely exhibit escape responses when sea lions enter the area. Sea lions probably have little dependence on the fish stocks in shallow rocky habitats, but instead depend on pelagic species such as Pacific herring.

The algal and epifaunal assemblages exhibited strong, consistent zonation patterns at all of the exposed sites. Algal zonation was described above. Generally, invertebrates abundance, relative cover and biomass became greater with increasing depth. In the kelp bed, most of the animals exhibited signs of wear or injury. Most long-lived species such as sea stars or snails were represented only by juveniles or small specimens out to depths of about 20 m. Below that depth, large specimens of sea stars and mature populations of long-lived organisms such as Metridium senile and Cucumaria miniata began to appear (see Sections 6.2.3.3 and 6.2.3.5, and Appendix A). Also, brittle, head-forming bryozoans and massive sponges became common.

These distribution patterns may represent an equilibrium among the effects of (1) physical disturbances related to storm surge, e.g., log damage, scouring and abrasion, etc., (2) competition between encrusting invertebrates and kelps for primary space, (3) light intensity, and (4) predation, similar to the scheme described by Dayton (1971). The effects of storm surge may extend down to at least 25 m, but are probably most acute out to the lower margin of the kelp bed. Above that, surge will rip organisms off of rock, suck them out from under rocks, fracture rocks, resuspend sand, gravel and cobbles, and scour other surfaces with them. The oscillatory action of the waves will cause algae to scour the rock surfaces around them, removing exposed animals. Logs swept through the area during storms will be smashed into rocks considerably below the water level and cause considerable havoc (e.g., Dayton 1971). Such actions will tend to remove any brittle, fragile, exposed, weakly attached or unattached organisms and many exclude most of the encrusting or motile invertebrates. The dominant kelps in the shallower zones are very strongly attached to the rocks, the stipes and holdfasts are very tough and springy, and the blades are virtually shed during fall storms, leaving only a small, crescentic portion of the meristens to permit growth of a new blade (personal observation). Nevertheless, plant mortality is apparently considerable based on the piles of whole kelp plants observed on beaches following storms. At shallower depths, increased light intensity also promotes rapid plant growth several months before the water column stratifies sufficiently to permit the spring phytoplankton bloom, which in turn permits rapid growth of suspension feeders. Thus, encrusting invertebrates probably provide little competition to plants for primary space during that period.

At a somewhat greater depth, plant growth rates are slower because light intensity is lower (Kain 1977), and damage to invertebrates from storm surge, logs, abrasion, and scour by plants, etc., is reduced. Thus, rapidly growing, encrusting invertebrates can compete more successfully for the primary area exposed by winter storms. Nevertheless, motile or long-lived fragile animals do not survive well above 20 m because the probability of elimination is still too high.

Below about 20 m, kelps did not appear to survive, probably because low light intensity reduces (1) photosynthetic rates below the compensation point or (2) growth rates to a point where the plants cannot compete with faster growing encrusting invertebrates. Long-lived animals such as sea anemones, corals, and sea cucumbers, once established, have a reasonable probability of survival and thus become common.

7.1.3.6 Rocky Subtidal Summary

Five distinctly different types of rocky subtidal assemblages were examined. Geographic locations of these different types were (1) the entrances to Prince William Sound, (2) in the entrance to Jakolof Bay, (3) Seldovia Point, (4) on the northern shelf of Kachemak Bay, and (5) on the west side of lower Cook Inlet. Those in the entrances to Prince William Sound and Jakolof Bay and at Seldovia Point had well-developed surface canopies as well as highly productive understories. All were located where strong tidal currents swept the area with relatively clean water. However, at least one of the canopy species, Alaria fistulosa, can tolerate somewhat reduced salinity as it is dominant in the bed at Jakolof Bay and in the entrance channel to Koyuktolik Lagoon (Dames & Moore 1977b).

Rocky subtidal assemblages on the northern shelf of Kachemak Bay and the west side of lower Cook Inlet, where the water is characteristically more turbid, do not support well-developed surface canopies. For example, on Archimandritof Shoals where clarity seldom exceeds 5 m in summer, Nereocystis is temporally and spatially patchy, but generally does not form a dense surface canopy. Nereocystis and A. fistulosa are also temporally and spatially patchy near Anchor Point, possibly in an area where the turbid water leaving Kachemak Bay mixes with clear oceanic water entering the inlet. No surface-canopy species were observed on the west side of lower Cook Inlet, where water clarity seldom exceeds 3 m year round.

The degree of development of the kelp bed formed by understory species (e.g., Agarum, Laminaria, and Pleurophycus) generally correlated well with the development of the surface canopy. Areas supporting well-developed surface canopies also supported well-developed understories. Thus, the most highly developed understories were observed in the entrances to Prince William Sound where five kelp species dominated the understory and algal cover and biomass were very high. In lower Cook Inlet, the understory was dominated by only two species. As with the canopy, algal cover and biomass of beds formed by understory species varied inversely with turbidity; in areas with no canopy, algal cover and biomass were considerably reduced.

Maximum depth to which understory species penetrated also correlated fairly well with canopy development. Development of beds by understory species was observed down to about 20 m in the entrances to Prince William Sound, about 25 m off Seldovia Point, about 12 m on the northern shelf of Kachemak Bay, and about 3 m on the west side of lower Cook Inlet. Kelp stands formed by understory species have been observed to extend to at least 30 m in other areas (e.g., Kain 1971; Mann 1972b). Some of the observed depth limitations are undoubtedly due to reduction in light transmission by turbidity. However, contrasting the occurrence of appreciable stocks of kelps at 20 m at Seldovia Point with the virtual absence of kelps at that depth at Sea Lion Pinnacles, where water clarity always appeared superior, suggests that factors other than light also are involved in establishing the lower limits of kelps at some NEGOA sites. The paucity of herbivores at all NEGOA sites precludes grazing as a consideration. A possible factor is competition for space with encrusting suspension feeders. Poor development of the suspension-feeding assemblage at Seldovia Point may permit the kelp assemblage to extend deeper than at Sea Lion Pinnacles, where the suspension-feeding assemblage is highly developed and can compete intensely for primary space.

Seasonal patterns in algal cover and biomass appeared basically similar in all locations where appropriate data are available. Highest cover and biomass were observed in July or August and lowest values were observed during midwinter.

Differences among the faunal assemblages, especially the suspension-feeding component, were considerably more dramatic than those noted for the kelp assemblage. Considerable variation was observed in the species composition, complexity, relative cover, biomass, stability, productivity, and geographic affinities of the assemblages examined. Along the Gulf of Alaska and on the south side of Kachemak Bay the faunal assemblages had strong affinities with those reported for southeastern Alaska, British Columbia, and Washington. In contrast, on the northern shelf of Kachemak Bay, animals typical of the Bering, Chukchi, and Beaufort Seas become common. On the west side of Cook Inlet, the faunal assemblages are dominated by animals with Arctic affinities and, except for cosmopolitan species, animals with northeastern Pacific Ocean affinities are generally uncommon.

The dominant animals varied sharply among the sites. At the NEGOA sites, the bryozoans Microporina and Dendrobeania and several species of annual colonial tunicate, including Ritterella pulchra, were the dominants, however, cover and biomass were low; the clam Saxidomus gigantea was an important infaunal form. At Jakolof Bay, the large mussel Modiolus strongly dominated a very robust, dynamic suspension-feeding assemblage. Subdominants included Saxidomus and the sabellid polychaete Potamilla ?reniformis. Sea urchins and sea stars were also relatively very abundant. Standing stocks of invertebrates were the highest observed in the study or by these observers. The dominants in the assemblage observed at Archimandritof Shoals and along the north shelf were the same as those described for Jakolof Bay, but, in fact, the assemblage was quite different. The assemblage was not as diverse or productive, except off Anchor Point, and many important species at Jakolof Bay were absent on the shelf; e.g., the major sea stars at Jakolof Bay were absent on most of the shelf. Many animals common on the west side of Cook Inlet also were common on the shelf, e.g., the sea stars Leptasterias polaris acervata, the snails Buccinum glaciale and Beringius kennicotti and the bryozoans Bidenkapia spitsbergensis, Terminoflustra membranaceo-truncata and Costazia surcularis. On the west side of the inlet, Modiolus was also common, but the dominants included mainly the barnacle Balanus rostratus ?alaskensis, the bryozoans C. surcularis and C. nordenskjoldi, the social tunicate Dendrodoa pulchella and several sponges. Although relative cover was high at the deeper levels, biomass was low.

In terms of stability, the NEGOA assemblage appeared to be the least stable and that at Jakolof Bay, most stable. The assemblage at Seldovia Point was moderately stable. Appropriate data are not available for the northern shelf of Kachemak Bay or the west side of the inlet, but we would predict moderate stability.

7.2 PRIMARY PRODUCTION OF MACROPHYTES

7.2.1 Southeastern Quadrant of Lower Cook Inlet

Estimates of primary production from various intertidal and subtidal levels at Seldovia Point (Table 6-49) and intertidal standing stocks of algae (Figures 6-4 and 6-5) were used to compute rough estimates of primary production for the southeastern quadrant of lower Cook Inlet (Table 7-1). The areas within the zones from MLLW to 9 m and 9 m to 18 m were calculated with a planimeter and areas outside those zones were estimated by extrapolation from the adjacent zone based on an assumption of similar slope. Estimated rates of macrophyte production were observed by these methods. In the depth zones between 3 m and 18 m at Seldovia Point, rates are based on Table 6-49. In the shallowest zone (+2 m to MLLW), the estimate was computed by multiplying average biomass of kelps by the P/B ratio for L. groenlandica. In all other zones, the estimates are essentially best guesses based on comparisons with the zones for which data were available. The macrophyte zone along the northern shelf of the bay is attenuated along its shallow and deeper borders. Very little kelp occurs out to about 3 m because of a lack of suitable substrate. Moreover, the density of kelp is quite low below 12 m (Dames & Moore 1977a, 1980). Thus, production was considered negligible. Available data indicate similarities in cover and plant density between the two upper and the lowest macrophyte zones at Seldovia Point and along the northern shelf. Thus, the estimates for production rates for Seldovia Point have been used for the northern shelf. The three middle zones described for Seldovia Point generally appeared to be lacking on the northern shelf.

Annual macrophyte production in each zone was estimated by multiplying the zone-specific production rate by the area of the zone. Basically, these computations suggest that (1) despite less area, Kennedy Entrance and southern Kachemak Bay produce substantially more kelp than the northern shelf and (2) a very large proportion of the kelp is produced between 3 m and 12 m (Table 7-1) Estimated total kelp production in the southeastern quadrant is 82.5 x 10^7 kg/yr. Areal estimates, based on planimeter measurements, are

TABLE 7-1 ESTIMATES OF PRIMARY PRODUCTION FOR MACROPHYTES (WET WEIGHTS) IN VARIOUS ZONES IN THE SOUTHEASTERN QUADRANT OF LOWER COOK INLET

	Kennedy Entrance and South Kachemak Bay: Point Adam to Lancashire Rocks			Northern Shelf: South End of Homer Spit to Anchor Point Light		
Elevation (m)	Estimated Area (m^2)	Estimated Rate of Macrophyte Production ($kg/m^2/yr$)[a]	Estimated Macrophyte Production in Specified Zones ($kg/m^2/yr$)	Estimated Area (m^2)	Estimated Rate of Macrophyte Production ($kg/m^2/yr$)[a]	Estimated Macrophyte Production in Specified Zones ($kg/m^2/yr$)
+2 to MLLW	3.4×10^6	2.1	0.71×10^7	--	--	--
MLLW to -3	10.3×10^6	5.0	5.15×10^7	5.7×10^6	--	--
-3 to -9	20.6×10^6	20.0	41.2×10^7	7.2×10^6	2.1	9.91×10^7
-9 to -12	10.9×10^6	7.1	7.7×10^7	6.9×10^6	5.0	13.45×10^7
-12 to -18	21.9×10^6	0.8	1.75×10^7	3.8×10^6	0.4	2.15×10^7
-18 to -21	10.9×10^6	0.4	0.44×10^7	6.9×10^6	--	--
Total	78.0×10^6		56.99×10^7	70.5×10^6		25.51×10^7

(a) See text for source of estimates.

250 km^2 for the kelp beds in the southeastern quadrant (Table 7-1) and 660 km^2 for Kachemak Bay. Based on these estimates, kelp production is about 3.32 $kg/m^2/yr$ in the kelp beds and contributes about 1.25 $kg/m^2/yr$ of plant tissue to outer Kachemak Bay.

Mann (1972a) reported that dry weight of kelps is about 20 percent of wet weight and that about 30 percent of dry weight is organic carbon. Using these factors, which agree closely with estimates of Westlake (1963), we estimate that kelp production contributes about 4.95×10^7 kg C/yr to the whole of outer Kachemak Bay, or about 75 g $C/m^2/yr$ in the form of plant tissue for the outer bay.

In addition to the plant tissue contributed to detrital food webs by seaweeds, kelps exude part of the carbon fixed through photosynthesis into the water column as dissolved or particulate organic carbon. The importance of this process varies by species (Sieburth and Jensen 1970). Different investigators report highly disparate rates of exudation. Sieburth and Jensen (1970) report that up to 40 percent of the net carbon fixed is lost to kelps by this process whereas others (Brylinski 1977; Fankboner and de Burgh 1977) report exudation levels at less than 1 percent. The particulate exudate is in the form of mucus; it is rapidly colonized by bacteria and flocculates. Occasionally, we have observed dense concentrations of such materials in the water column suggesting that the phenomenon is sometimes important. These particles and the dissolved organic carbon can be utilized by numerous suspension feeders (Fankuboner et al. 1978) and probably also deposit feeders.

The level of carbon production suggested above compares favorably with estimates of Larrance and Chester (1979) for organic carbon from phytoplankton reaching the benthos in Kachemak Bay. Of the approximately 550 g C/m^2 produce by phytoplankton from May to August (the 4-month period of peak production), sediment trap data indicated that about 60 g C/m^2 was delivered to the bottom.

The combined carbon contribution of phytoplankton and macrophytes to the benthos in Kachemak Bay is relatively high compared to probable totals for either Kamishak Bay or the central inlet, where the contribution of carbon input in Kachemak Bay probably exceeds 140 g C/m^2/yr whereas it probably does not exceed 50 g C/m^2/yr in Kamishak Bay or 25 g C/m^2/yr in the central inlet.

Generally, the estimates for macrophyte production are probably fairly conservative. The P/B ratios calculated for Agarum and Laminaria are somewhat lower than those reported by Mann (1972). Moreover, the P/B ratio for Nereocystis is probably low. In addition, blade length-weight regressions were compiled for plants collected in March, when the length-weight ratio is quite low relative to summer and fall values (Mann 1972, Kain 1977).

Estimates of standing stocks and production are generally lower than reported for Nova Scotia by Mann (1972a,b). Only in the Nereocystis bed did standing stock estimates exceed those reported by Mann (1972b). However, he estimated that seaweed production was 1.75 kg C/m^2/yr whereas our estimates translate to 0.2 kg C/m^2/yr.

7.2.2 Comparison of Primary Production

Estimates of primary production by macrophytes in lower Cook Inlet and NEGOA are compared in Table 7-2. Although we acknowledge that the accuracy of the estimates varies from poor to fair, our observations lead us to believe that the order of magnitude probably is generally correct in most cases, and thus the estimates provide the basis for valuable comparisons.

Algal primary production was considerably higher in the NEGOA area than in lower Cook Inlet (Table 7-2). As noted above, maximum production took place in the kelp canopy. However, maximum understory production probably took place inshore of the canopy (Table 6-50). Plant production also varied inversely with depth, as reported by Kain (1977) and others.

TABLE 7-2 COMPARISON OF ESTIMATES OF PRIMARY PRODUCTION ($kg/m^2/yr$ fresh weight) BY MACROPHYTES AT VARIOUS SITES AND DEPTHS IN LOWER COOK INLET AND NEGOA

Depth Zone (m)	Lower Cook Inlet			NEGOA			
	South Side, Kachemak Bay and Kennedy Entrance	Northern Shelf, Kachemak Bay	Kamishak Bay Sites[(a)]	Zaikof Point, Montague Island	Zaikof Bay, NMFS Site, Montague Island	Sea Lion Pinnacles, Danger Island	Latouche Point, Latouche Island
+2 to MLLW	2.1 Fucus and Rhodymenia spp.	Negligible Fucus	4.0 Fucus and Rhodymenia spp.	--[(b)]	--	--	--
MLLW to -3	5.0 L. groenlandica and Alaria spp.	Negligible L. groenlandica	5.4 Rhodymenia spp. and L. groenlandica	15.6 - 23.4 L. dentigera and Pleurophycus	--	--	--
-3 to -6	18.5 Nereocystis and L. groenlandica	2.1 L. groenlandica	<0.1 Agarum	15.5[(c)] Nereocystis and L. dentigera	2.0 - 2.9 Agarum	--	--
-6 to -9	22.0 Nereocystis	5.0 L. groenlandica	0	3.1[(c)] Nereocystis and L. dentigera	1.1 - 1.6 Agarum	7.1 - 10.6 Laminaria spp. and Pleurophycus	--
-9 to -12	7.1 Nereocystis and L. groenlandica	5.0 L. groenlandica	0	3.1 L. groenlandica	1.1 - 1.6 L. groenlandica and Agarum	7.1 - 10.6[(c)] Nereocystis and Laminaria spp.	37.4 - 71.9 Nereocystis and Laminaria spp.
-12 to -18	0.8 L. groenlandica and Agarum	0.4 Agarum	0	<0.1 Desmarestia	Sand bottom	7.6 - 11.4[(c)] Nereocystis and Laminaria spp.	--
-18 to -21	0.4 Agarum	Negligible, Callophyllis	0	Sand bottom	Sand bottom	0.1 - 0.2 Agarum	--

(a) Rough estimates based on biomass data from spring and summer 1978.
(b) -- indicates no data are available.
(c) Nereocystis dominant but productivity estimate does not include its production.

Reasons for this include light intensity, surge intensity, turbulence and probably space competition with encrusting animals.

The influences of turbidity and surge activity on algal productivity and distribution are demonstrated clearly by these data. While the level of surge activity is probably fairly similar at the sites examined in lower Cook Inlet, turbidity differs considerably among them, with Seldovia Point having highest water clarity and Kamishak Bay having highest turbidity. Plant production clearly was higher at Seldovia Point, where light transmission was good (Table 7-2).

The depth at which the canopy formed, although influenced by turbidity, also apparently varied with exposure to turbulence. At Seldovia Point and Jakolof Bay, where tidal currents are strong but surge action is only moderate to slight, moderate canopies formed between about 3 and 12 m. In contrast, at sites such as Sea Lion Pinnacles where surge action is severe, heavier, more robust beds formed between about 9 and 15 m. Kain (1977) observed a similar phenomenon in L. hyperborea and attributed it partially to turbulence, suggesting that increased turbulence exposes the plants to greater quantities of nutrients.

7.3 SOFT INTERTIDAL SUBSTRATES

7.3.1 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 all three sites, including the polychaetes Eteone nr. longa, Nephtys sp, Paraonella platybranchia, Scolelepis sp A, and Scoloplos armiger, and the gammarid amphipods Eohaustorius eous and Paraphoxus milleri (Table 6-54). However, dominance patterns varied substantially among the sites. 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). Age-structure data are not available for any of these species, but most appear to live for two years or less. Reporting on five species of haustoriids, Sameoto (1969a, b) 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 seasonal and elevational patterns observed for numerical parameters were similar for the three beaches (Tables 6-58, 6-62 and 6-65). Levels of density, average number of species, species diversity, evenness and biomass were uniformly rather low (Table 7-3). Sand beaches are generally characterized by low values for these parameters (Dexter 1969, 1972). At all three beaches abundance, species diversity and biomass parameters generally increased from winter to summer (Table 7-3), 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 (N/S) increased from winter to summer and 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, differences in biomass (Table 7-3) and some faunal dissimilarities (Tables 7-4 and 7-5) imply important differences between the areas. Specifically, the fauna at Deep Creek was strongly dominated numerically by crustaceans (Table 7-4), particularly the gammarid amphipods. Eohaustorius, Gammaridae sp A and Paraphoxus (Table 6-55). In contrast, the fauna at Homer Spit was strongly dominated by polychaetes such as Scolelepis; gammarids were only of marginal importance (Tables 6-59 and 7-4). At Iniskin Beach, however, dominance patterns were not clear; both polychaetes and crustaceans were numerically important at different times (Table 7-4). In terms of biomass, the fauna at Deep Creek again was dominated by Eohaustorius whereas at Homer Spit and Iniskin Beach, it was dominated by Scolelepis. The fauna at Homer Spit was somewhat richer than that examined at Deep Creek, biomass was appreciably greater, and the range of organisms was somewhat broader. Although this may also be true for Iniskin Beach, the data base is not adequate to confirm it.

TABLE 7-3 COMPARISON OF OVERALL AVERAGE FOR ABUNDANCE (No./m^2), BIOMASS (g whole wet weight/m^2), AND SPECIES RICHNESS (no. of species/core) AMONG SAND BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	no./m^2			g whole wet weight/m^2			no. of species/core		
Survey Dates	Deep Creek	Homer Spit	Iniskin Beach	Deep Creek	Homer Spit	Iniskin Beach	Deep Creek	Homer Spit	Iniskin Beach
February 1977	515.7	604.8	--	--	--	--	1.6	2.6	--
March 1977	--	525.3	--	--	19.17	--	--	1.7	--
April 1977	585.7	--	--	4.25	--	--	1.5	--	--
July 1977	1263.7	1047.3	--	19.84	31.35	--	3.0	3.1	--
November 1977	388.3	136.9	--	2.59	1.24	--	1.1	1.0	--
February 1978	--	509.5	--	--	21.46	--	--	1.7	--
April 1978	525.1	--	1035.4	6.43	--	29.59	1.9	--	2.7
August 1978	1828.9	1328.2	1616.7	9.96	30.00	20.30	4.1	4.2	4.6
October 1978	--	292.8	--	--	3.34	--	--	1.0	--
November 1978	1336.6	--	--	7.95	--	--	2.6	--	--
$\bar{X}$	920.6	635.0	1326.1*	8.50	17.76	29.95*	2.3	2.2	3.7*
S	552.5	417.2	411.0	6.14	12.89	6.67	1.0	1.2	1.3

*Biased; no winter data

TABLE 7-4 COMPARISON OF ABUNDANCE DATA SUMMARIZED FOR MAJOR TAXA AMONG SAND BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	Density (no./m^2) - Relative Abundance (%)								
	Deep Creek			Homer Spit			Iniskin Beach		
Survey Dates	Polychaetes	Crustaceans	Pelecypods	Polychaetes	Crustaceans	Pelecypods	Polychaetes	Crustaceans	Pelecypods
February 1977	92.9-18.5	423.7-81.9	0	458.4-76.0	108.3-17.9	12.7-2.1	--	--	--
March 1977	--*	--	--	448.9-84.6	66.8-12.7	6.4-1.2	--	--	--
April 1977	79.7-12.9	496.5-84.7	0	--	--	--	--	--	--
July 1977	165.6-13.4	1059.0-84.8	0	812.0-77.8	9.6-0.9	9.6-0.9	--	--	--
November 1977	140.1-36.8	245.1-63.1	0	117.9-79.7	6.4-4.7	6.4-4.7	--	--	--
February 1978	--	--	--	451.9-88.7	28.7-5.6	28.7-5.6	--	--	--
April 1978	105.2-19.9	385.1-74.5	6.4-1.2	--	--	--	500.8-48.5	521.9-50.6	8.5-0.8
August 1978	424.4-23.6	1391.9-77.3	4.2-0.2	640.7-48.3	131.6-9.9	131.6-9.9	275.7-17.2	1324.0-82.0	8.5-0.5
October 1978	--	--	--	263.1-89.4	12.7-4.3	12.7-4.3	--	--	--
November 1978	229.9-17.2	1098.9-82.8	0	--	--	--	--	--	--
$\bar{X}$	176.8 - 20.3	728.6-78.4	1.5-0.2	456.1-77.8	137.8-15.1	29.7-4.1	388.3-32.3	923.0-66.3	8.5-0.7
S	120.5 - 8.1	444.4-7.8	2.7-0.4	228.2-14.0	189.9-12.9	45.6-3.1	159.2-22.1	567.2-22.2	0-0.2

* -- indicates no data

TABLE 7-5 COMPARISON OF BIOMASS DATA SUMMARIZED FOR MAJOR TAXA AMONG SAND BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	Biomass (g fresh weight/m^2) - Percent of Biomass								
	Deep Creek			Homer Spit			Iniskin Beach		
Survey Dates	Polychaetes	Crustaceans	Pelecypods	Polychaetes	Crustaceans	Pelecypods	Polychaetes	Crustaceans	Pelecypods
February 1977	--[a]	--	--	--	--	--	--	--	--
March 1977	--	--	--	18.50-96.5	0.67-3.5	0	--	--	--
April 1977	2.16-50.9	2.08-48.2	0	--	--	--	--	--	--
July 1977	4.47-22.5	15.03-75.8	0	30.74-97.8	0.32-1.0	0	--	--	--
November 1977	1.30-50.8	1.28-49.0	0	1.17-94.4	0.05-4.8	0.01-0.8	--	--	--
February 1978	--	--	--	17.48-81.6	0.21-2.1	1.54-7.3	--	--	--
April 1978	4.03-62.6	1.97-30.6	0.04-0.7	--	--	--	28.77-93.1	1.12-7.0	--[b]
August 1978	5.42-55.7	4.23-44.2	T[c]	25.40-84.7	0.86-2.8	3.49-13.3	12.01-58.8	8.10-39.7	0.14-0.7
October 1978	--	--	--	2.83-84.8	0.42-12.6	0.08-2.4	--	--	--
November 1978	3.70-46.4	3.57-46.0	0	--	--	--	--	--	--
$\bar{X}$	3.51-48.2	4.69-49.0	0.01-0.1	16.02-90.0	0.42-4.5	0.85-4.0	8.07-76.0	4.61-23.4	--
S	1.52-13.7	5.18-14.8	0.02-0.3	11.89-7.0	0.30-4.2	1.43-5.3	9.91-24.3	4.94-23.1	--

(a) -- indicates no data
(b) One large Siliqua patala excluded from comparison
(c) T indicates trace

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 characterizing exposed sandy beaches (Barnard 1969), the importance of another amphipod, *Anisogammarus*, and a mysid *Archaeomysis*, both typically intertidal species (Kozloff 1973). In contrast, the assemblages at Homer Spit and Iniskin Beach were characterized by increased importance of polychaetes, and the consistent appearance of the razor clam *Siliqua* spp and characteristically subtidal forms such as the pinkneck clam (*Spisula*) and the sand lance (*Ammodytes*).

Zonation patterns were not distinct at the sand beaches from the viewpoint of species composition. However, the numerical parameters (abundance, species richness and biomass) generally increased at lower levels, reflecting the influence of gradients in duration of emersion and various physical stresses.

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 (Tables 7-3, 7-4 and 7-5) 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 observed in the winter (Tables 7-3, 7-4 and 7-5). 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 densities of some polychaetes were 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.

Generally, the numerical parameters were fairly predictable seasonally and between the comparable seasons in the two sampling years (Table 7-3). However, abundance, biomass and species richness may have been somewhat higher at Deep Creek and Homer Spit in 1978 than in 1977. This trend can be seen by comparing data from July 1977 and August 1978 or November 1977 and October or November 1978 (Tables 7-3, 7-4 and 7-5).

The precise role of predation in the sand beach assemblages is, at present, still unclear. Predation pressure 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 Scolelepis. Examination of numerous worms indicates it is not a deposit feeder. Pressure from shorebirds appears minimal, even during the peaks of migration. Several species are known to feed on amphipods on sandy beaches (Sameoto 1969a; Dave Erikson, personal communication). Species observed on local sandy beaches include semipalmated 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 large clams. When the low-tide terrace is underwater, several species of diving ducks (e.g., greater scaup (Aythya marila), oldsquaw (Clangula hyemalis), white-winged scoters (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 pelagic and demersal fishes and epifaunal invertebrates, most of them potential predators, have been collected on the low-tide terrace during periods of submergence. The fish included Pacific staghorn sculpin (Leptoccottus armatus), sturgeon poacher (Podothecus acipenserinus) and English sole (Parophrys vetulus), rock sole (Lepidopsetta bilineata, Dolly Varden trout (Salvelinus malma), sand lance (Dames & Moore 1979a) and sandfish (Trichodon trichodon) (personal observation). The epifaunal invertebrates were mainly crustaceans, such as Dungeness, tanner, and helmet crabs and gray shrimp (Crangon sp). Basically the forage species such as sand lance and capelin were feeding on planktonic food items. However, most of the demersal species were feeding mainly on gammarid amphipods and other crustaceans. Pacific staghorn sculpin and some flatfish were feeding on forage fish species. However, although a wide variety of species contained polychaete worms, no species concentrated on them (Dames & Moore 1979a). Our subtidal observations and beach seine collections indicate most of the fish and infaunal invertebrates move into deeper water during the winter months (Dames & Moore 1979a). 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. However, the importance of environmental stress in these habitats must be examined from the viewpoint of adults as well as juveniles 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. Our biomass data (Table 7-5) suggest that the adults may 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 7-2. 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

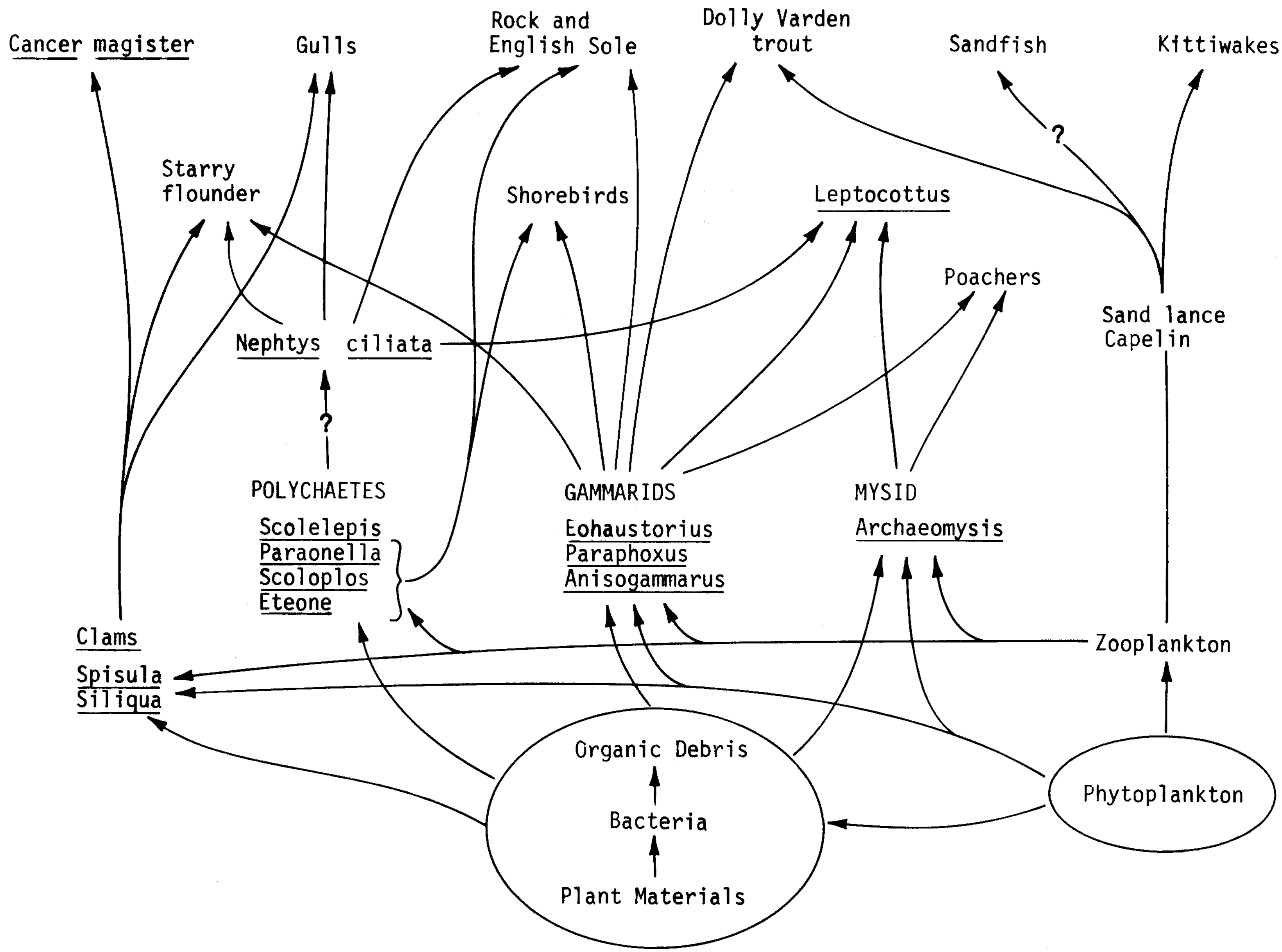


FIGURE 7-2

GENERALIZED FOOD WEB FOR SAND BEACHES AT HOMER SPIT, DEEP CREEK AND INISKIN BEACH

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 fish and birds. 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.

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 7-6). 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.

TABLE 7-6 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
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
Spisul polynyma	6.4	0	0	0	0	0	0
Pisces	(0.3%)						
Ammodytes hexapterus	3.2	0	0	0	0	0	0

Two patterns seem rather well defined. Overall, polychaetes decrease and crustaceans increase in importance on the beaches moving from Homer to Clam Gulch. As noted above, this seems to reflect a gradient in physical energy, with Deep Creek and Clam Gulch 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 ARCO C.O.S.T. well site in the middle of lower Cook Inlet ($\simeq$60 m deep). There is a surprising but definite resemblance between the intertidal sand assemblages and that described for unstable subtidal sand substrates in the middle of the inlet (Table 7-7; Dames & Moore 1978, 1979b, Houghton et al. 1980). Forty-five percent of the species considered important at Deep Creek and eighty percent of those at Homer Spit also were common at the C.O.S.T. well site. The polychaete Scolelepis and a gammarid amphipod Paraphoxus frequently were considered dominants at all locations. Other species that were common at all locations include the polychaetes Eteone nr. longa, Nephtys sp, and Scoloplos armiger. Johnson (1970) reported on a series of related infaunal groupings distributed across a protected sand beach on which the interactions between beach slope and factors related to emersion created a strong physical gradient. He suggested that the increase in species diversity at lower tidal elevations and changes in species composition across the gradient represented different stages in the succession of the assemblage "progressing" toward a more mature assemblage. It is tempting to speculate, in view of the physical gradient, that the faunal differences observed between the various sites represent similar sequences in the successional development of a sandy substrate. Although this could not be shown without experimental manipulation, similar patterns in species composition and diversity were observed.

TABLE 7-7 COMPARISON OF DENSITIES (no./m^2) FOR IMPORTANT SPECIES AT VARIOUS SITES ON UNSTABLE SAND HABITATS IN LOWER COOK INLET

TAXA	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
Polycordius 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
Gammariidae 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

7.3.2 Mud Flat Assemblages

Our studies so far indicate that, in contrast to sand beaches, the mud flats at Glacier Spit, Chinitna Bay, and in Cottonwood Bay, supported large to moderate standing crops of suspension and deposit feeders, had higher species richness, and appeared to be highly productive. However, weather conditions and predation appeared to cause considerable spatial, seasonal, and annual variability. Unfortunately, examination of patterns, species richness, species diversity and biomass is hampered by the absence of summer data at Glacier Spit. Although species composition at the two sites was quite similar, patterns of dominance were quite different, resulting in a great difference in biomass and production.

The fauna at Glacier Spit was heavily dominated by the clams *Mya* spp and *Macoma balthica*, which comprised more than 50 percent of the individuals and 90 percent of the wet biomass in nearly all surveys (Tables 6-66 and 6-67). *Macoma balthica* 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.

Twelve species at Glacier Spit exhibited densities exceeding 100 individuals/m^2 in at least one survey. These included, in order of importance, *Macoma*, *Clinocardium*, *Nephtys*, *Mya* spp, *Laonome*, *Glycinde picta*, *Pseudopythina*, *Spio*, *Eteone*, *Tritella*, *Anisogammarus*, and *Capitella* (Table 6-66). Abundance of *M. balthica* exceeded 2000/m^2 in every survey and eight other species averaged over 100/m^2 during the study. *Tritella* and all of the worms except *Nephtys* and *Glycinde* increased in abundance substantially from April to July, whereas all of the clams became less abundant. The species exhibiting increased abundance in summer are thought to be annuals, at least in this habitat. In contrast, all of the species that declined in abundance from April to July appear to be perennials (Thorson 1957). Also, *Nephtys* is a perennial.

The fauna at Cottonwood Bay was dominated by Nephtys, Pseudopythina, M. balthica, and Echiurus, but only the latter two species were important in terms of biomass (Table 6-79). Echiurus was more important here than at Glacier Spit, but M. balthica was far less important and Mya spp were quite uncommon. Thus, the structures of the assemblages at Cottonwood Bay and Glacier Spit were considerably different. Standing stocks and production were probably much higher at Glacier Spit.

Some of the patterns observed for numerical parameters probably differed between the two sites because of real differences in structure; however, too few surveys were conducted at Cottonwood Bay to be certain (Table 7-8). Abundance apparently decreased at Glacier Spit from April to July whereas it increased over the same general period at Cottonwood Bay. This was due mainly to the differences in dominance patterns. Biomass and species richness increased at both sites over the same period. A comparison of those parameters emphasizes that the assemblage at Glacier Spit is richer than Cottonwood Bay (Table 7-8).

Clams strongly dominated the assemblage at Glacier Spit in terms of abundance and biomass. In contrast, clams and polychaetes dominated in terms of abundance and echiurids and clams dominated in terms of biomass at Cottonwood Bay (Tables 7-9 and 7-10).

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, and 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. However, long-time resident Wayne Byers indicated that adult cockles were abundant at Glacier Spit prior to the uplift resulting from the 1964 earthquake (personal communication).

The contrasting seasonal patterns of abundance for the major clams and the polychaetes seem to indicate differences in reproductive cycles. Density

TABLE 7-8 COMPARISON OF OVERALL AVERAGE FOR ABUNDANCE (No./m^2), BIOMASS (g whole wet weight/m^2), AND SPECIES RICHNESS (no. of species/core) BETWEEN MUD BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	no./m^2		g whole wet weight/m^2		no. of species/core	
Survey Dates	Glacier Spit	Cottonwood Bay	Glacier Spit	Cottonwood Bay	Glacier Spit	Cottonwood Bay
April 1977	6600.5	--	2319.81	--	6.3	--
July 1977	4961.3	--	4038.27	--	9.1	--
November 1977	3316.2	--	2156.77	--	5.5	--
May 1978	3522.4	1595.5	2087.10	108.06	6.3	2.5
August 1978	--	2584.2	--	137.40	--	6.0
October 1978	8622.4	--	1921.33	--	10.0	--
$\bar{X}$	5404.6	2089.9*	2504.66	122.73*	7.4	4.3*
S	2229.6	699.1	869.16	20.75	2.0	2.5

*Biased; no winter data

TABLE 7-9 COMPARISON OF ABUNDANCE DATA SUMMARIZED FOR MAJOR TAXA AMONG MUD BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	Density (no./m^2) - Relative Abundance (%)							
	Glacier Spit, Chinitna Bay				Cottonwood Bay			
Survey Dates	Polychaetes	Crustaceans	Pelecypods	Echiurids	Polychaetes	Crustaceans	Pelecypods	Echiurids
April 1977	727.2-9.1	6.4-T[(a)]	5929.1-89.8	38.2-0.6	--[(b)]	--	--	--
July 1977	1547.4-31.3	248.5-5.0	3106.2-62.6	41.4-0.8	--	--	--	--
November 1977	496.6-15.0	6.4-0.2	2759.3-83.2	54.1-1.6	--	--	--	--
May 1978	932.0-26.3	90.7-1.8	2492.0-70.6	27.3-0.8	230.1-14.4	13.1-T	1318.3-82.6	34.9-2.2
August 1978	--	--	--	--	1362.6-52.3	186.1-7.6	844.4-32.7	34.0-1.3
October 1978	2015.5-23.3	458.2-5.0	6059.4-70.3	34.0-0.4	--	--	--	--
$\bar{X}$	1143.7-21.0	162.0-2.4	4069.2-75.3	39.0-0.8	796.4-33.4	99.6-3.9	1081.4-57.7	34.5-1.8
S	624.5-8.9	192.8-2.5	1771.4-11.0	10.0-0.5	800.8-26.8	122.3-5.3	335.1-35.3	0.6-0.6

(a) T indicates trace
(b) -- indicates no data

TABLE 7-10 COMPARISON OF BIOMASS DATA SUMMARIZED FOR MAJOR TAXA AMONG MUD BEACH STUDY SITES AND SAMPLING DATES IN LOWER COOK INLET

	Biomass (g fresh weight/m^2) - Percent of Biomass							
	Glacier Spit, Chinitna Bay				Cottonwood Bay			
Survey Dates	Polychaetes	Crustaceans	Pelecypods	Echiurids	Polychaetes	Crustaceans	Pelecypods	Echiurids
April 1977	38.07-1.6	T[a]	2261.93-97.0	22.83-1.0	--[b]	--	--	--
July 1977	78.97-0.8	T	3523.98-97.6	31.80-0.8	--	--	--	--
November 1977	40.24-1.7	T	2091.71-97.0	28.79-1.3	--	--	--	--
May 1978	37.17-2.3	0.16-T	2035.79-97.6	13.97-0.7	6.80-6.2	0.01- T	31.75-29.4	69.47-64.3
August 1978	--	--	--	--	12.42-8.9	1.06-0.7	45.24-32.9	76.82-55.9
October 1978	58.83-2.9	2.64-0.1	1802.38-93.7	56.46-2.9	--	--	--	--
$\bar{X}$	50.66-1.9	0.59-0.1	2343.16-96.6	30.77-1.3	9.61-7.6	0.54-0.4	38.50-31.2	73.15-60.1
S	18.15-0.8	1.15- --	680.27-1.6	15.89-0.9	3.97-1.9	0.74-0.5	9.54-2.5	5.20-5.9

(a) T indicates trace
(b) -- indicates no data

of the three main clam taxa at Glacier Spit decreased continuously from April 1977 to May 1978. Moreover, the 0-year class strongly dominated the age structures for Macoma, Mya spp and Clinocardium in April 1977 but was strongly reduced in all cases by July 1977. The latter species recruited strongly in 1978, indicating the importance of annual variation.

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 and Cottonwood Bay. 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. Finally, 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 and Mya spp. A broad variety of predators exploit the mud flats (Figure 7-3). 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 (Erikson 1977) and probably concentrate on Macoma and Mya (Sanger et al. 1979). Dames & Moore (1979c) reported that starry flounder in Port Valdez moved onto the mud flats during high tides and fed heavily on M. balthica; this probably also occurs in lower Cook Inlet. Judging from the reductions of nearly 50 percent and 70 percent in the densities of Macoma and Mya, respectively, between April and July 1977, these predators are fairly effective. The changes in size structure indicate that juveniles, mostly located near the sediment surface (Vassallo 1971), are most frequently utilized, but starry flounder were feeding mainly on adult Macoma. Gulls were observed foraging on the mud flats during both day and night low tides, and their egesta and shell debris indicate that they fed mainly on barnacles,

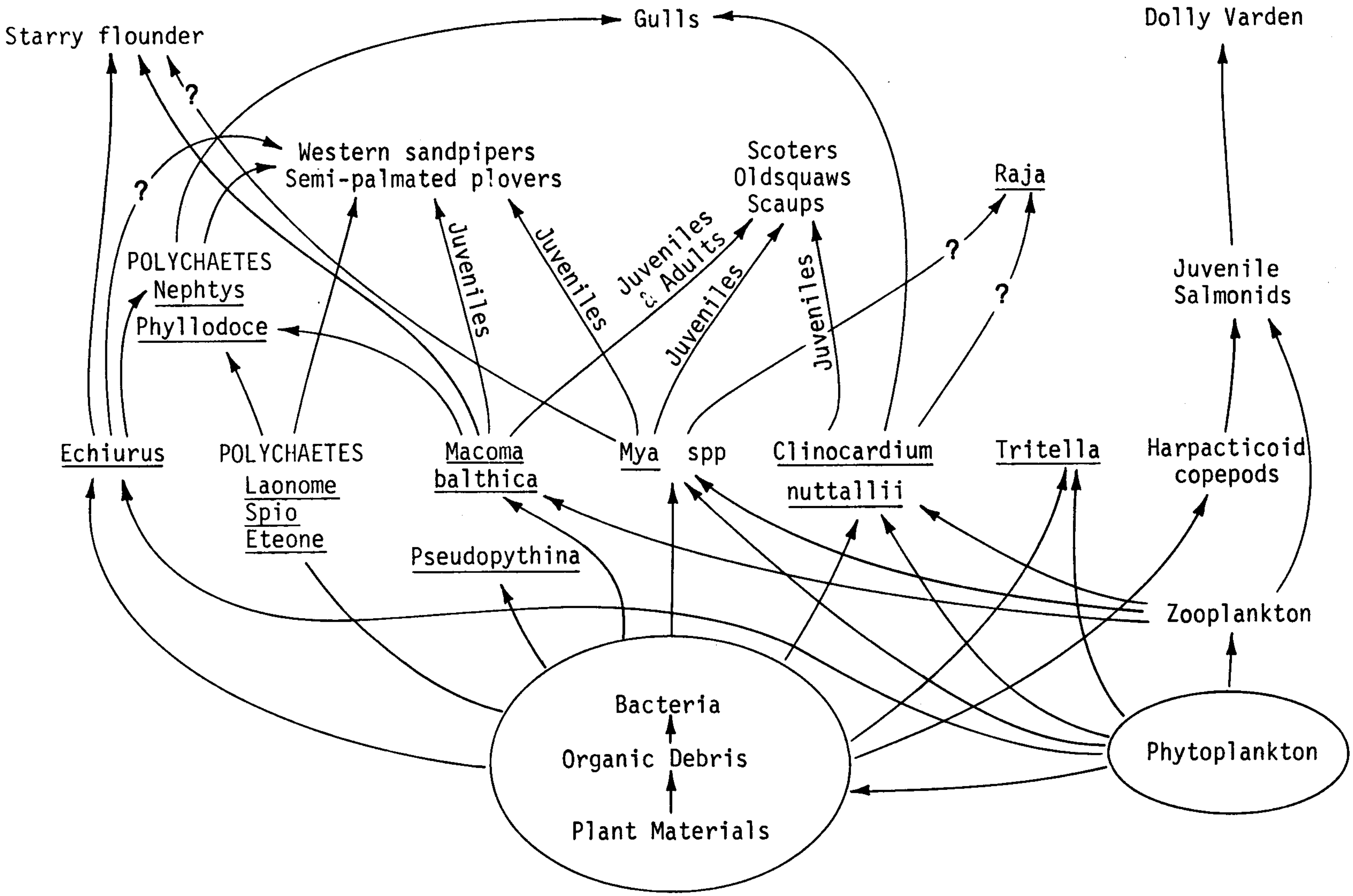


FIGURE 7-3

GENERALIZED FOOD WEB FOR MUD FLAT AT GLACIER SPIT

Clinocardium and crabs; probably large worms such as Nephtys are taken frequently.

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 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 presently are 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 (Dames & Moore 1979a).

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 densely spaced 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 lower Cook Inlet. Most 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. Mud flats observed in lower Cook Inlet generally lack burrowing shrimp (e.g., Callianassa and Upogebia), gammarid amphipods and isopods, deposit feeding or predatory gastropods (e.g., Nassarius, Hydrobia or Aglaja) and commensal fish (e.g., Clevelandia). Some of these groups are present in mud flats in Prince William Sound (Dames & Moore 1979c; personal observation).

Mud flats in lower Cook Inlet supporting high densities of M. balthica and Mya spp bear a fair resemblance to mud flats along the Atlantic coast. However, the presence of the burrow-building Echiurus makes many Cook Inlet mud flats considerably more porous than those on the Atlantic coast. Some of the consequences of increased porosity and the resulting increase in surface area are greater oxygenation of the sediments, larger microbial biomass, and greater microbial oxidation and respiration.

The surface area of the Echiurus and Mya burrows was estimated to permit an assessment of the relative importance of these burrows (Table 7-11). Densities used to calculate surface area are based on the survey data. Dimensions of the burrows are based on recollections from numerous casual field observations. The presumed length of a typical U-shaped Echiurus burrow is based on a depth of 15 cm and a distance of 30 cm between apertures.

These semi-permanent burrows contribute a substantial amount of surface area to the mud flats where these animals occur in moderate densities (Table 7-11). Echiurus contributes considerably more than Mya because of the greater length and diameter of the burrow. In combination, these species increase the potential for gas exchange, microbial respiration, and microbial biomass by 180 percent at Glacier Spit and 130 percent at Cottonwood Bay. Moreover, the burrows retain a sizable volume of water; the volume of burrows

TABLE 7-11 ESTIMATES OF SURFACE AREA OF ECHIURUS AND MYA BURROWS UNDER 1 M^2 OF MUD FLAT AT THE STUDY SITES AT GLACIER SPIT, CHINITNA BAY, AND COTTONWOOD BAY

	Glacier Spit, Chinitna Bay		Cottonwood Bay	
Estimated Parameters	Echiurus	Mya	Echiurus	Mya
Average length of burrow (cm)	60	15	60	15
Average diameter of burrow (cm)	2	1	2	1
Average density (no./m^2)	40	70	35	0
Surface area of burrows (cm^2/m^2 of mud flat)	15,080	3,300	13,195	0
Volume of burrows (cm^3/m^2 of mud flat)	7,540	825	6,600	0
Combined surface area of burrows (m^2/m^2 of mud flat)	1.8		1.3	
Combined volume of burrows (l/m^2 of mud flat)	8.4		6.6	

of larger Echiurus may hold over one liter each. Other burrowers (e.g., Nephtys) also contribute to the porosity of the substrate.

A number of mud flats in lower Cook Inlet support beds of eelgrass (Zostera marina) (e.g., Koyuktolik Lagoon, Mud Bay, and Bruin Bay), but intertidal stands are frequently limited by winter ice (Dames & Moore 1977b). Some of these are quite productive.

The generalized trophic structure proposed for the mud flat appears to be based on detrital material from marine and terrestrial systems (Figure 7-3). It is considerably more diverse than that for sand beaches. Griffiths (personal communications) indicates that the bacterial flora observed in the water column suggests that terrestrial plants may be a major source of organic debris on the west side of the inlet. 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 predation appeared most intense in spring and summer. However, several overwintering duck species are heavily dependent on mud flats. Fish, crabs, and ducks move onto the intertidal flats during high tides, and shorebirds move in during low tides. Commercially, the most important of these interactions appears to be the feeding of juvenile salmon on harpacticoid copepods (Sibert et al. 1977, Kaczynski et al. 1973). The consequence of the abundance of these transient predators is that a very large proportion of the tissue produced on the flats is exploited by predators from other systems and exported. 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 (Dames & Moore 1979d, Section 7.4).

The preliminary assessments of secondary production for Macoma and Mya indicate that large quantities of tissue are produced and cropped each year in the mud flats around Glacier Spit and that production at Cottonwood Bay is substantially lower. Both mud flat assemblages are markedly more productive than the sand beach sites. In addition to the production of Mya and Macoma, production by several other species appeared to be important. However, a large proportion of the production was accounted for by long-lived, burrow-building animals.

7.3.3 Gravel Upper Beach and Scoured Boulder Field Assemblages

Gravel/cobble upper beaches and scoured boulder fields were frequently associated with the soft substrates. They were examined qualitatively to obtain a general understanding 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 support moderate densities of scavengers, mainly the gammarid amphipod Anisogammarus confervicolus, the isopod Gnorimosphaeroma oregonensis and nematodes. 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, the crustaceans 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, such 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 uses these habitats 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), rock and English sole (Lepidopsetta bilineata and Parophrys vetulus). Specific food habits have not been investigated in this area, but some of these fish fed predominantly on benthic crustaceans (Dames & Moore 1979a).

7.4 POTENTIAL FOR IMPACT FROM OCS OIL AND GAS EXPLORATION, DEVELOPMENT AND PRODUCTION

A regional assessment of coastal morphology has been used to predict the behavior of oil arriving in the intertidal zone following hypothetical spills in lower Cook Inlet and to develop a classification of the potential of local coastal environments to retain spilled oil (Hayes et al. 1977). This classification is based primarily on geological features and sediment characteristics as they relate to interactions with crude oil (e.g., physical flushing of oil, potential for incorporation into the sediments). It provides a useful starting point in assessing potential impacts from oil pollution, but it is necessary to temper these assessments with the premise 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 ecological or economic importance, or susceptibility to oil pollution, does not always agree closely with the ranking based on geological characteristics proposed by Hayes et al. (1977). Such an oversight can lead to incorrect priorities and decisions.

Based on their assessment of the shoreline, Hayes et al. (1977) divided the 1216 km of examined shoreline into erosional, neutral and depositional categories (45, 38 and 17 percent, respectively). However, because of their complex structure these beaches are not cleanly divisible into substrate categories such as bedrock, boulder fields, gravel, sand or mud, categories which have more relevance biologically. The upper beach face in lower Cook Inlet (Figures 4-5 and 4-7) is most commonly composed of gravel, or a mixture of gravel, sand, cobbles, and boulders. However, adjacent low-tide terraces may be 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 Hayes 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. Hayes et al. (1977) do not state whether their rankings pertain to the upper or lower portion of the beaches.

This problem is further complicated by assessment of biological susceptibility. The ecological importance and biological productivity of the basic intertidal and shallow subtidal habitat type (rock, sand, mud, boulder, gravel, etc.) are strongly dependent on the degree of exposure to wave action and ice scour among other things. Gravel or mixed sand and gravel beaches in moderate to exposed situations generally support only impoverished assemblages of small crustaceans and are therefore of substantially lower importance than sand beaches which often support important populations of razor clams. Conversely, in protected waters (e.g. MacDonald Spit) gravelly beaches usually support dense populations of hard shelled clams and other organisms; sand flats sometimes support harvestable quantities of cockles. Furthermore, it is important to consider the levels of tolerance or sensitivity 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.

The susceptibility of the assemblages described in this report to deleterious impacts from OCS oil and gas exploration, development, and production activities depends primarily upon the probability of exposure (i.e., the vulnerability of the assemblages to exposure), and the sensitivity of the assemblages and their component organisms in the event that they are exposed to oil or dispersant contamination. The probability of exposure has been predicted in oil spill trajectory analyses for lower Cook Inlet conducted by Dames & Moore (1976b; 1979d). Although some data are available for some of the important species in the major intertidal and subtidal assemblages discussed in this report, in fact, very little is known directly. Thus, predictions must be based mainly upon the physical characteristics of the habitats, apparent degree of development, productivity and stability of the assemblages, and inferences of the sensitivity of the organisms comprising the assemblages based on information for similar species. The whole procedure is highly speculative. The hypothesis of Johnson (1970) regarding the relationship between the stages of succession and biotic assemblages observed at varying levels of stress in a particular habitat should be useful in determining changes that might ensue, especially in the event of chronic pollution.

7.4.1 Vulnerability to Exposure

Oil spill trajectory models indicate that shorelines with the greatest risk of exposure in the event of an oil spill occur 1) between the Cottonwood-Iliamna Bay complex and Chinitna Bay, on the west side of lower Cook Inlet, 2) between Dangerous Cape and Cape Elizabeth, in Kennedy Entrance, 3) on the Barren Islands, and, 4) on Shuyak Island, at the north end of the Kodiak Island archipelago (Dames & Moore 1976b; 1979d). Exposure at these sites would generally occur within one to three days of a spill, and the annual probability of exposure generally is from 3 to 6 percent, assuming the occurrence of a single spill per year for any one of the hypothetical spill sites indicated by Warren (1978). Additional areas of concern are near Harriet Point, Anchor Point and on the NE quadrant of Augustine Island. An important finding of the 1979 trajectory study was that the trajectories from lower Cook Inlet contacted the Chugach Islands and Shuyak Island, and "suggest the possibility of exposure on the eastern side of the Kenai Peninsula as well as Kodiak Island" (Dames & Moore 1979d).

Based on the tendency of spilled oil to attach to suspended sediment particles (Kolpack 1971), turbidity patterns would cause a greater proportion of the spilled oil to come into contact with the benthos in the northern half of the lower inlet in Kamishak Bay and on the northern side of Kachemak Bay and in its inner (eastern) portion (NAS 1975). As a consequence of higher levels of total suspended solids, benthic assemblages on the west side or northern portion of lower Cook Inlet are more vulnerable to exposure than in most of Kachemak Bay. Although shoreline impact is predicted to be critical in Kennedy Entrance and on the north shore of Shuyak Island, the high degree of turbulence and generally high water clarity would tend to minimize the amount and duration of contact.

7.4.2 Sensitivity to Oil

Recent studies by Rice et al. (1979) indicate that intertidal species of fish and invertebrates from Cook Inlet exhibit higher tolerance to the water soluble fraction (WSF) of Cook Inlet crude oil (96-hr static tests) than did subtidal or pelagic forms. This tolerance is probably a function of adaptations to withstand harsh natural conditions in the intertidal zone. They point out however that exposures received by intertidal organisms under actual spill conditions are likely to be far greater than those received by subtidal or pelagic animals except under unusual circumstances. They also suggest a general trend of increasing sensitivity from lower to higher invertebrates; thus in the same habitat polychaetes can be expected to be less vulnerable than amphipods. Different species vary greatly in their vulnerability to purely physical impacts of oiling; many clams can close their shells and remain in virtual isolation for extended periods while organisms such as crustaceans with delicate and exposed feeding or respiratory apparati may become hopelessly fouled with very short term exposure.

A final factor in determining the relative biological impact of oiling in various habitat types is the importance of the assemblage to other assemblages or systems. For example, while there is little direct harvest by man of any species indigenous to rocky or eelgrass habitats, these areas appear to be extremely important as feeding or breeding areas for some exploitable species (e.g., herring) and also as net exporters of organic matter that is incorporated into deep water food chains.

7.4.2.1 Unconsolidated Intertidal Substrates

Sand Beaches

Beaches with sandy low-tide terraces border about 50 percent of lower Cook Inlet (Dames & Moore 1977a). They are concentrated on exposed portions of the lower inlet, especially in its northern portion. Hayes et al. (1977)

indicated that since these beaches are generally flat and hard-packed, they are relatively impermeable to oil and thus have a fairly low susceptibility ranking. However, oil stranding during a falling tide may penetrate into the sediment (especially the toxic water-soluble fractions) and come into contact with the infaunal forms (NAS 1975). Furthermore, extensive burial of stranded oil can occur, increasing the residence time on polluted beaches (Smith 1968). Such burial can induce anaerobic conditions, delaying microbial degradation (NAS 1975), especially if detergents are used to disperse the oil (Smith 1968; Griffiths, personal communication).

The biological assemblages most commonly observed on sand beaches in lower Cook Inlet are dominated by burrowing polychaetes (*Scolelepis*, *Paraonella*, and *Scoloplos*) small crustaceans (the gammarid amphipods *Eohaustorius* and *Paraphoxus* and mysids *Archacomysis*) and clams (*Siliqua* and *Spisula*). Some are probably rather sensitive to crude oil and petroleum products. For example, *Siliqua patula* incurred heavy mortality in Washington after exposure to light fuel oils (Tegelberg 1964). In addition, the crustaceans may suffer heavy mortality from contamination, either from smothering, physiological dysfunction or behavorial problems (Johnson 1971). Haustoriid amphipods held in seawater with oiled sand (10 ppm oil) displayed low levels of burrowing activity after 12 hrs and died in 24 hrs (Sandberg et al. 1972). In contrast, polychaetes may be somewhat resistant to petroleum contamination (Foster et al. 1971; Blumer et al. 1971; Johnson 1971).

Generally, standing stocks of animals on sand beaches are low and the contribution of sand beaches to other systems appears low. However, certain beaches support dense clam populations and are important to sport and commercial clamming enterprises (e.g., Clam Gulch and Polly Creek). Recovery of the worm and crustacean populations probably would be rapid following contamination, but for clam populations, recovery would be very slow, possibly requiring decades.

Gravel and Sand Upper Beaches

Gravel or mixed sand and gravel upper beaches border a large proportion of the shoreline in lower Cook Inlet, as pointed out above. 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 (Hayes ranking of 7 and 6, respectively) to oil pollution. In the Straits of Magellan, crude 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. Hydrocarbons leaching from such "pavements" or relatively raw, unweathered oil incorporated by wave action into the relatively porous gravel and sand could serve as long-term sources of contamination to the more sensitive, biologically productive sand flats at lower tide levels.

The biological assemblage most frequently observed on upper mixed sand and gravel beaches is impoverished. Virutally no animals inhabit the sediments between +0.9-m level and the high tide drift line. Below the +0.9-m level in exposed areas, the fauna mainly includes nematodes, gammarid amphipods (Anisogammarus spp) and an isopod (Gnorimosphaeroma). The effects of petroleum products on nematodes are poorly known. Worwald (1976) reported heavy mortality following a spill of diesel fuel in Hong Kong and found that recovery to "normal" population levels required over a year. As noted above, crustaceans generally are quite susceptible to light hydrocarbon fractions, often exhibiting fatal changes in behavior (Johnson 1971). Thus Anisogammarus and Gnorimosphaeroma could be severely affected. However, since these taxa are all short-lived and fairly motile, they probably could recover fairly rapidly. However, widespread or persistent 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 (Dames & Moore, 1979a).

Protected Sand-Gravel-Cobble-Shell Debris Lower Beaches

Mixed sand-gravel-cobble-shell debris habitats occur sporadically along protected lower beaches in fjords and bays, especially in the southeastern quadrant of lower Cook Inlet. Such beaches are not well-consolidated and are quite porous. Thus, like gravel and sand upper beaches, they are highly susceptible to oil pollution. Since these areas are protected, dispersion and weathering rates of oil would be reduced and oil incorporated into the sediments would persist for a long period.

Such habitats (e.g., the south side of MacDonald Spit, in Kachemak Bay) are often very productive. The faunal assemblages are dominated by the mussel Mytilus edulis or the clams Saxidomus and Protothaca, all highly desirable for food and attractive to large numbers of clammers on low tides in the spring and summer. Both clams are long-lived (Houghton 1973; Feder and Paul 1973; Paul et al. 1976) and recovery of disturbed populations probably would require several decades. In Prince William Sound, such assemblages, often including moderate densities of Echiurus, are still far from recovering from the 1964 earthquake (personal observations). Rice et al. (1979) reported a 96-hr TLM of >6.84 mg/l total aromatics for Protothaca.

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 than sand or exposed gravel beaches, however, because of the high proportion of solid substate. Nevertheless, most of the animals are pioneer species for rock habitats and populations are largely dominated by young organisms. These conditions are a consequence of scouring and abrasion accompanying the importance of sand or gravel in such areas. Juvenile barnacles and mussels are often dominant species and, although production may be moderate, biomass is low. The contribution of this assemblage probably 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).

In some areas, this type of habitat supports an assemblage similar to that described for protected sand-gravel-cobble lower beaches. Where this occurs, standing stocks of mussels or clams can be high, sensitivity on the assemblage may be high and recovery times may be considerable.

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 (Dames & Moore 1977a). The two types of mud flats described are 1) exposed muddy tidal flats, such as are observed primarily in association with the wave-cut sandstone platforms in southern Kamishak Bay, and 2) protected estuarine flats, which are "primarily drowned glaciated river valleys (*rias*)" (Hayes et al. 1977). The latter type of mud flat occurs along the edges of most bays on the west side of lower Cook Inlet (e.g., Bruin, Cottonwood, Iliamna, Iniskin, Chinitna and Tuxedni Bays), along the northern edge of inner Kachemak Bay and at its head, and at the head of many of the bays along the southern edge of Kachemak Bay and in Kennedy Entrance. Because of probable differences in residence time between exposed and protected mud flats, 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 uncommon, the flats indeed appear fairly impermeable. Mud Bay, at Homer, and Dayville

Flats, at Valdez, are examples of this type of flat. Shaw et al. (1977) reported low uptake and rapid loss of crude oil on Dayville Flats. However, Griffiths (personal communication) suggests, based on sediment characteristics , that Shaw's findings may have been influenced by low densities of bacteria and organic debris, which have a direct relationship to uptake rates.

In contrast, where Mya and Echiurus are common, their burrows, extending into the sediment to a depth of at least 45 cm, increases the sediment surface exposed to water or hydrocarbons and supporting aerobic microbial activities, by as much as 2.5 times. As indicated in Table 7-11 the surface area of the burrow walls under 1 m^2 of sediment may be 1.5 m^2 and the volume of the burrows may equal 8 l. Such extensive burrow systems could permit considerable quantities of oil to penetrate deeply into the sediment and be stored under anoxic conditions. Assuming such contamination would kill a large proportion of the populations of Mya and Echiurus, these burrows could then be sealed and microbial activity on the contaminated mud flat would be reduced by 50 to 75 percent. All mud flats observed to date on the west side of Cook Inlet are of this type.

The fauna, dominated by polychaetes and longevous clams, 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 for up to 44 days in response to five daily 5 $\mu l/cm^2$ dosages of Prudhoe Bay crude oil in elegant field experiments on Dayville Flats. Significant mortality was observed whenever oil concentrations in the sediment exceeded 530 μg oil/g dry sediment. 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. Thomas (1978) reported that M. arenaria were smaller and lighter in 1976 in areas contaminated with Bunker C oil (similar to weathered crude oil) at Chedabucto Bay in 1970; initial mortality was heavy. Furthermore, Mayo et al. (1978) observed continuing mortality of M. arenaria five years after sediments had been deeply contaminated with JP4-jet fuel. At that time hydrocarbons had leached out of the upper 5 to 8 cm of sediment and juvenile *M. arenaria* were recruiting the area. However, when adults burrowed to the depth of the upper limits of the hydrocarbons, they died. At that rate of leaching (about 1.5 cm/year), it would take on the order of 30 years for mud flats on the west side of Cook Inlet to recover from such a spill.

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 dependent 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.

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 could require 30 years. The dominant clam species live at least 6-10 years (Chambers and Milne 1975; Feder and Paul 1974). Ducks and starry flounder appear to feed heavily on adult *Macoma*. Shorebirds, in contrast, feed mainly on young-of-year *Macoma*, *Mya*, annual polychaetes and harpacticoid copepods, which could recover fairly quickly after surface sediments were cleansed. Based on the predictions of Hayes et al. (1977), it is probable that the exposed flats would recover in several years, but that the protected mud flats could require several decades.

7.4.2.2 Rocky Substrates

Southern Kachemak Bay Intertidal and Shallow Subtidal Assemblages

The southern Kachemak Bay intertidal and shallow subtidal assemblage are dominated heavily by kelps, which generally are considered quite tolerant to exposure to crude oils (Nelson-Smith 1972; Smith 1968; Straughan 1972).

Furthermore, Smith (1968) observed that the kelp understory may impart some protection from oil impacts to the epifauna. The red algae that occur might be seriously effected, however (Smith 1968). Herbivores, moderately abundant in these assemblages, are fairly sensitive to oil exposure (Rice et al. 1979; Smith 1968; Nelson-Smith 1972); this may be especially true subtidally. Thus, in the event of a large spill, moderate damage to the herbivore component might occur, resulting in a heavy macrophyte bloom. The suspension-feeding and predator/scavenger components, although probably fairly sensitive to oil exposure, are generally poorly developed except at Jakolof Bay. Thus, with that exception, damage to the assemblages would be slight.

At sites like Jakolof Bay, however, suspension-feeding and predator/ scavenger components are exceptionally well-developed and complex. Although little is known about the sensitivity of most species comprising these trophic levels (Sanborn, 1977), subtidal clams, starfish, and snails are probably more sensitive than intertidal species (Rice et al. 1979; Smith 1968; Nelson-Smith 1972) and thus considerable damage could occur in the subtidal zone where significant quantities of hydrocarbons sink to the bottom or become incorporated into the water column.

Recovery times in these systems would vary. The reduction in grazing pressure and reduced competition for space between suspension-feeders and kelps, probably would lead initially to increased plant production. Although development of the herbivore component in these assemblages is substantially less complex than in the one described by North et al. (1964), recruitment appears to be slow in the echinoid populations, which dominate many subtidal areas. Therefore, recovery of the subtidal herbivore populations probably could require between five and ten years. Rocky intertidal areas would probably be cleansed by wave action fairly rapidly and many of the species exhibit moderate tolerance to crude oil. Damage to these areas and the time required for recovery would probably be less (on the order of one to several years).

At sites like Jakolof Bay, where herbivore, suspension-feeding and predator/scavenger components are well-developed, disruption and outright damage might be extensive and recovery might require many years, especially if dispersants were used. Damage to the herbivore component would result in greater development of the kelp assemblage. Damage to the suspension-feeding component also might result in greater development of kelp because of reduced consumption of spores (e.g., North et al. 1964), and reduced competition for suitable substrate. Even if the predator/scavenger component were not damaged directly by oil contamination, it probably would be devastated by the loss of its prey resources, and its recovery would depend upon the recovery of those components. Size structures of several of the dominant species indicate that their populations are dominated by adults and that successful recruitment is sporadic. Thus, recovery would depend not only upon the time required for the habitat to recover to a point at which the natural species could recolonize, but also upon the occurrence of successful recruitment. This could be complicated if the predator/scavenger populations are damaged less by oil than the suspension feeders and herbivores.

We have recently observed the occurrence of an apparently analogous situation in intertidal and shallow subtidal regions of Prince William Sound. The Great Earthquake of 1964 uplifted large tracts of gravel/cobble habitat and killed, in place, dense populations of large clams (Baxter 1971). Thus, it is still possible to examine the density and size structure of the prequake populations. Densities and size structures of pre-earthquake populations, examined in several uplifted areas during the summer of 1979, indicate that, although limited recruitment is occurring in these areas, attainment of the previous high densities and average size has not occurred. This attainment may be strongly limited by the large populations of mobile predators such as sea otters and sea stars which were not as severely damaged by the earthquake. Although 15 years have passed since the Great Earthquake, it appears that many more will pass before these populations have recovered.

Northern Kachemak Bay Assemblage

The kelp component of the northern Kachemak Bay subtidal assemblage exhibits moderate development whereas the suspension-feeding component is moderately to highly developed. Herbivores, especially sea urchins, and predator/scavengers are also common. Based on these patterns, it appears that a large or continuous oil spill in this area could have a severe effect upon the appearance and productivity of the assemblage (as before, assuming that significant quantities of hydrocarbons enter the water column or sink to the bottom). The kelp assemblage probably would not be extensively harmed by exposure to either crude oil or dispersants. However, the herbivore, suspension-feeder and predator/scavenger components probably would suffer moderate to severe damage. Because the overlying waters in this area are characteristically somewhat turbid, a substantial proportion of the oil entering the area could be absorbed and enter the water column; the turbulence characteristic of the area would then tend to bring much of this oil into contact with the substrate and the benthic animals. This is of special concern since this area is an important nursery area for king crab (Sundberg and Clausen 1977). Experiments by Rice et al. (1979) suggest that some of these benthic forms such as king and tanner crab may be moderately sensitive to damage from crude oil especially during molting (Karinen and Rice 1974) and that subtidal animals are more sensitive than their intertidal counterparts. Crustaceans, and, to a lesser extent, sea stars, which constitute a large proportion of the predator/scavenger component of this shelf, appear quite sensitive to oil contamination (Smith 1968; Rice et al. 1979; Nelson-Smith 1972; NAS 1975). As a consequence of the damage to the herbivore and suspension-feeding components, development of the kelp assemblage probably would improve somewhat because of decreases in grazing pressure and competition for space; thus primary production might increase. However, losses in the robust suspension-feeding component could result in reduced secondary production for a considerable period of time. North et al. (1964) reported that the subtidal epifaunal assemblage of a kelp bed was far from recovery seven years after a catastrophic spill of diesel oil in a semi-enclosed bay. Mann and Clark (1978) estimated recovery of a kelp bed assemblage destroyed by sea urchins off Nova Scotia would require at least ten to twenty years. Since many of the important epifaunal animals live at least that many years, and recruitment of many of them appears quite sporadic, it seems probable that recovery from serious disruption might require at least ten to twenty years.

Rocky Intertidal Assemblages on the West Side of Lower Cook Inlet

Rocky intertidal assemblages on the west side of the inlet differ from those in Kachemak Bay and Kennedy Entrance in several important ways. Winter conditions generally severely restrict development of perennial organisms except in protected situations; thus much of the habitat is occupied by juvenile specimens of perennials or by annual (pioneer) species. Annual red algae dominate a large proportion of the intertidal zone. Herbivore, suspension-feeder and predator/scavenger components are poorly developed. The result of these patterns is that the rocky intertidal assemblages have low species diversity and are largely dominated by pioneer algae; animals are uncommon.

The substrate in most of the exposed rocky intertidal areas is composed of bedrock with sand- and gravel-filled surge channels. Boulders and loose rock generally are removed by ice and are thus uncommon. Ice also polishes the rock surfaces. Therefore, the substrate is not complex. In accordance with numerous observations (Smith 1968; Nelson-Smith 1972), Hayes et al. (1977) assigned such habitats a low susceptibility ranking, indicating that retention and penetration of oil in such habitats is low.

Based on the species composition and structure of the biological assemblages in these habitats, it appears that the intertidal biotic assemblages would suffer considerable damage during the first year if contamination occurred in the spring or summer. Smith (1968) reported considerable damage to red algae following the *Torrey Canyon* accident. It is probable, however, that damage to rocky intertidal assemblages would be short-term because of the basically annual nature of the assemblage, the nature of the substrate and the annual scouring of the substrate by ice during the winter. The contamination occurred during winter, damage probably would be minimal and very short-term.

Rocky Subtidal Assemblages on the West Side of Lower Cook Inlet

If the observation is true that a kelp understory provides some protection to the epifauna (Smith 1968), then the subtidal epifaunal assemblages on the west side of the inlet are structurally more exposed and vulnerable than those in Kachemak Bay or in Kennedy Entrance because of the sparseness or absence of the understory kelps. Only in the intertidal and very shallow subtidal zone is the kelp assemblage present on the west side of Cook Inlet. In those habitats, the herbivore component generally is poorly developed, but kelp development is strongly limited by physical factors such as ice scour and turbidity. The suspension-feeding component is moderately developed in the subtidal zone, but composition and appearance differs substantially between very shallow and somewhat deeper substrates. The very shallow levels often support beds of Modiolus and the sabellid polychaete Potamilla whereas the deeper areas are dominated by thin jagged, drab encrustations of barnacles, bryozoans, sponges, and tunicates. The moderately developed predator/scavenger component is dominated by egg-brooding sea stars or snails with direct larval development. Sensitivity to oil for the suspension-feeding component at the upper subtidal level (in the kelp zone) probably is similar to that predicted for Jakolof Bay, but the impact would be less in the event of a spill on the west side of the inlet because of poorer development. As subtidal levels below the kelp zone, damage to the suspension-feeding and predator/scavenger components probably would be great. Because of high turbidity year-round, a large proportion of the oil entering the area following a spill could enter the water column and come into contact with the epifauna. Furthermore, the trajectory models indicate that this oil would not have aged appreciably and would thus still contain a substantial proportion of the lighter, more toxic, fractions (Dames & Moore 1979d). These assemblages lack the protection of a kelp understory and probably the silt layer on the surface of the rocks and epifaunal crusts would become contaminated with oil and oily particles, increasing the amount of contact between the epifauna and oil. The effect of these oiled particles on these types of suspension feeders is unknown, but, considering their feeding mechanisms, they probably are quite sensitive and damage would be great. If a dispersant were used in clean-up efforts, this might increase the damage to the herbivore and predator/scavenger components because they are dominated by echinoderms.

Recovery of the subtidal zone below the kelp would probably require at least 25 years following a major spill. The assemblages are dominated by high arctic species, so growth rates are probably low and many of the species are brooders. This implies that recolonization by many species would require immigration by a benthic (rather than a planktonic) stage. Recruitment for species with planktonic larvae (e.g., Modiolus or the sea urchin) appears to range from fairly reliable to infrequent and thus many of these species would recover slowly.

NEGOA Rocky Subtidal Assemblages

The vulnerability of NEGOA areas in and around the Hinchinbrook Entrance to Prince William Sound is probably at least moderate because of the heavy tanker traffic from Port Valdez and the periodic turbidity of the water from the influence of the Copper River. Although surge activity and strong tidal currents would tend to cleanse, flush, and disperse oil from the area, the oil would also be well mixed in the water column. This would bring it into contact with suspended sediments and causing it to sink (NAS 1975), thus impinging on the benthos. NEGOA areas farther to the west e.g., Montague Strait, Elrington Island, etc., are less vulnerable to oil contamination because of reduced proximity to tanker traffic and reduced influence of the Copper River.

The sensitivity of the biotic assemblages along exposed rocky shores probably ranges from slight to moderate. On rocky subtidal habitats in the NEGOA area, kelps dominated strongly out to a depth of about 15 m. These types of plants have been reported to be fairly tolerant of crude oil contamination (Smith 1968). Annual encrusting epifaunal animals become important at about 10 m and monopolize the available hard surface between 10 m and at least 20 m. These animals generally appear to require water of high quality and probably are quite sensitive to toxic substances. Thus damage could be quite high in areas of contamination to these depths. Because the area between 10 m and 20 m is dominated by annual forms, it is possible that recovery from damage could be fairly rapid in that zone. However, too little is known about the ecology of these assemblages and the biology of the component animals to safely predict the longevity of such events. At greater depths where a decrease in surge activity would permit greater deposition of oil-laden sediments, damage to long-lived encrusting invertebrates could be high and long-lasting.

7.4.3 Specific Activities or Developments

Exploration and development of an oil field involved several different types of activities, installations, and potential perturbations. The major potential impacts from these activities include: 1) acute oil spills, 2) effects from drill cuttings and muds, 3) effects of cooling systems, 4) chronic contamination from formation waters, refinery wastes or ballast-treatment water, and 5) interference with fishing activities. The combination of potential impacts associated with each activity varies to a degree from those of other activities. Therefore, activity-specific impacts for most major activities are discussed below.

7.4.3.1 Drilling Platforms

The projected locations of exploratory drilling rigs in lower Cook Inlet (Warren 1978) are indicated in Figure 7-4. All are located in Federal water a moderate distance from all habitats and assemblages discussed in this report. In view of the turbulent nature of lower Cook Inlet, the most pertinent potential impact of drilling platforms would be from an acute oil spill, i.e. a blowout. The potential impacts of discharged drilling fluids on the

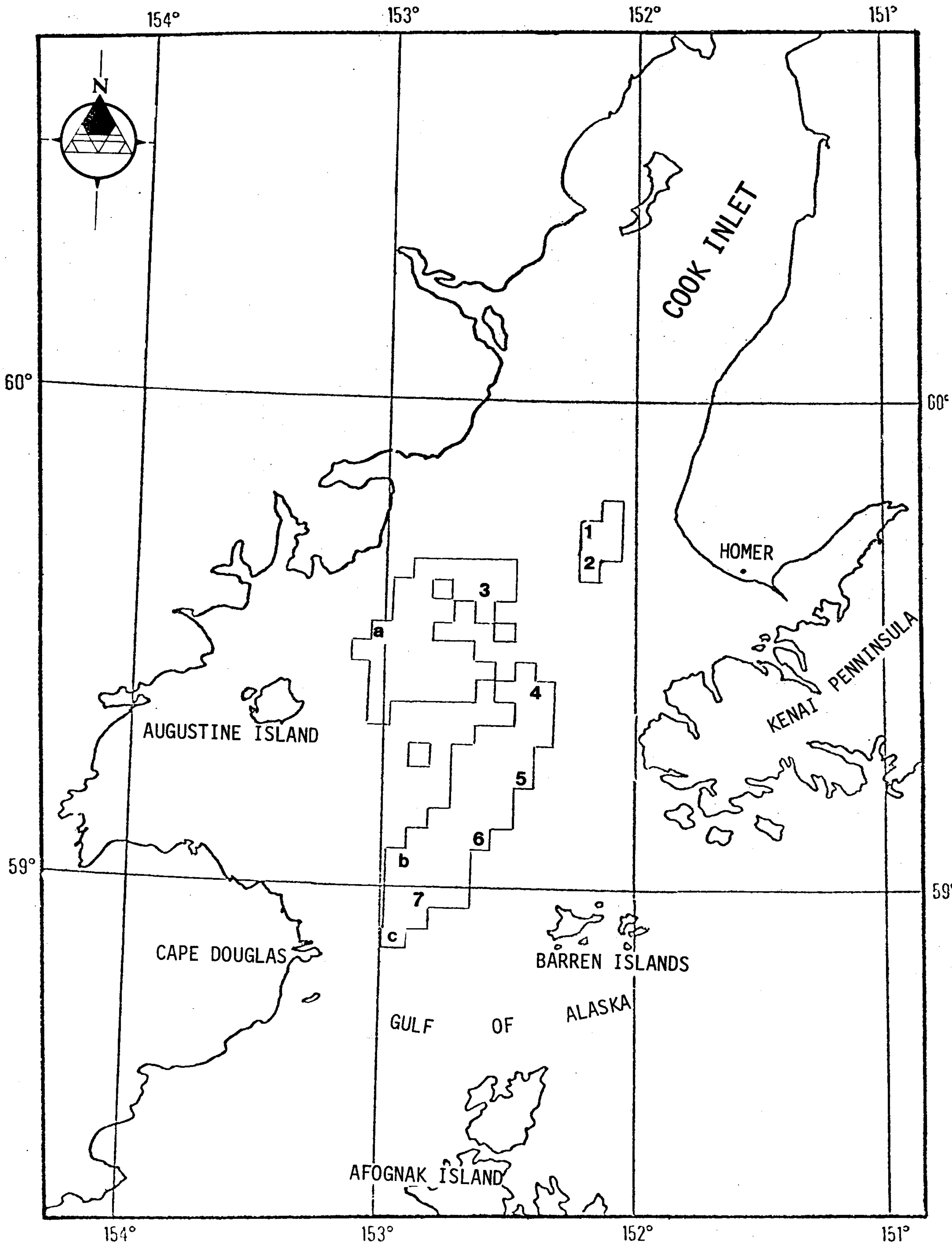


FIGURE 7-4

PROJECTED LOCATIONS OF EXPLORATORY DRILLING RIGS AND POTENTIAL SPILL LOCATIONS IN LOWER COOK INLET THROUGH 1979

(from Warren, 1978)

benthic assemblage associated with sandy substrates in the middle of lower Cook Inlet, and on several other benthic, demersal and nektonic organisms, were investigated by Dames & Moore (1978) and reported by Houghton et al. (1980). These investigators concluded that acute impacts in this area of the inlet would be negligible due to the dynamic nature of both the pelagic and benthic environments. However, an additional OCSEAP research unit is addressing potential long-term effects, critical pathways, and effects in other areas of the inlet. Potential effects of an acute oil spill have been discussed generally for Kennedy Entrance, Kachemak and Kamishak Bays in Sections 7.4.2.1 and 7.4.2.2 above, but a few additional remarks are applicable. The assemblages in Kennedy Entrance and on the southern side of Kachemak Bay probably are quite simlar; key species are kelps, but suspension feeders may be considerably more important in Kennedy Entrance. The assemblage on the northern shelf of Kachemak Bay is intermediate between these and the assemblage described for the west side of lower Cook Inlet; key species are kelps and suspension feeders, particularly the horse mussel *Modiolus* and the sea cucumbers *Cucumaria miniata* and *C. fallax*. This area has been designated a king crab santuary by the Alaska Department of Fish and Game because of its apparent importance to larval (Haynes 1977) and juvenile king crab (Sundberg and Clausen 1977).

Key periods of the year extend from March through September in these rocky habitats. Kelp growth rates are highest from March through early June (Dames & Moore 1979b). King crab enter the shallow habitats in February and remain for several months to molt and breed. Salmon fry move into the marine environment in late April and early May; schools of fry are frequently observed in kelp beds. Larval and juvenile king crab are common in Kachemak Bay in July and August, particularly along the northern shelf between Bluff and Anchor Point (Sundberg and Clausen 1977). Larval and juvenile stages of many of the important epifaunal and infaunal species occur at peak densities from April through August. Several of the demersal fish species, especially greenling, "brood" their eggs in the shallow subtidal rock habitats until at least late September. Large numbers of dungeness crab (*Cancer magister*) often forage in Kachemak Bay in August and September and migrate out of

Kachemak Bay across the northern shelf of Kachemak Bay in September and October. Thus, periods of high activity occur over a large proportion of the year.

Several organisms perceived by regulatory or decision-making agencies as "key" species (e.g., king, tanner and dungeness crabs, salmon species and halibut) occur periodically in the shallow subtidal rocky habitats. In addition, a number of bird species frequent intertidal and subtidal habitats at various periods of the year. Most of these species are somewhat migratory, i.e., they are motile and do not reside in these habitats. Residence time of these migrants varies considerably. However, a major reason they come to a particular area is to feed. The large number and high abundance of the migratory species entering Kachemak Bay in the spring and summer is an indication of its importance and the large amount of food material available and concentrated here. Many of the food species utilized by these migratory species must therefore be recognized as "key" species, but the system is so diverse that it is still impractical to approach this task definitively. Community dominants have been suggested in Sections 7.4.2.1 and 7.4.2.2.

7.4.3.2 Shore-based Facilities and Tanker Terminals

Potential locations of new shore-based facilities and tanker terminals (Warren 1978) are indicated in Figure 7-5. They include a possible support and supply facility at Homer, crude oil terminals and LNG plants in Kennedy Entrance and at Anchor Point, and production treatment facilities in Kennedy Entrance, at Anchor Point, and at Polly Creek, near Tuxedni Bay. No facilities are projected south of Tuxedni Bay on the west side of Cook Inlet. Thus, impacts from these potential facilities on shallow subtidal rocky habitats would mainly occur in Kennedy Entrance, in Kachemak Bay, and near Anchor Point.

The main impacts would arise from acute or chronic oil contamination. Acute spills could occur at all facilities and from tanker accidents. Chronic contamination could occur at the production treatment facilities

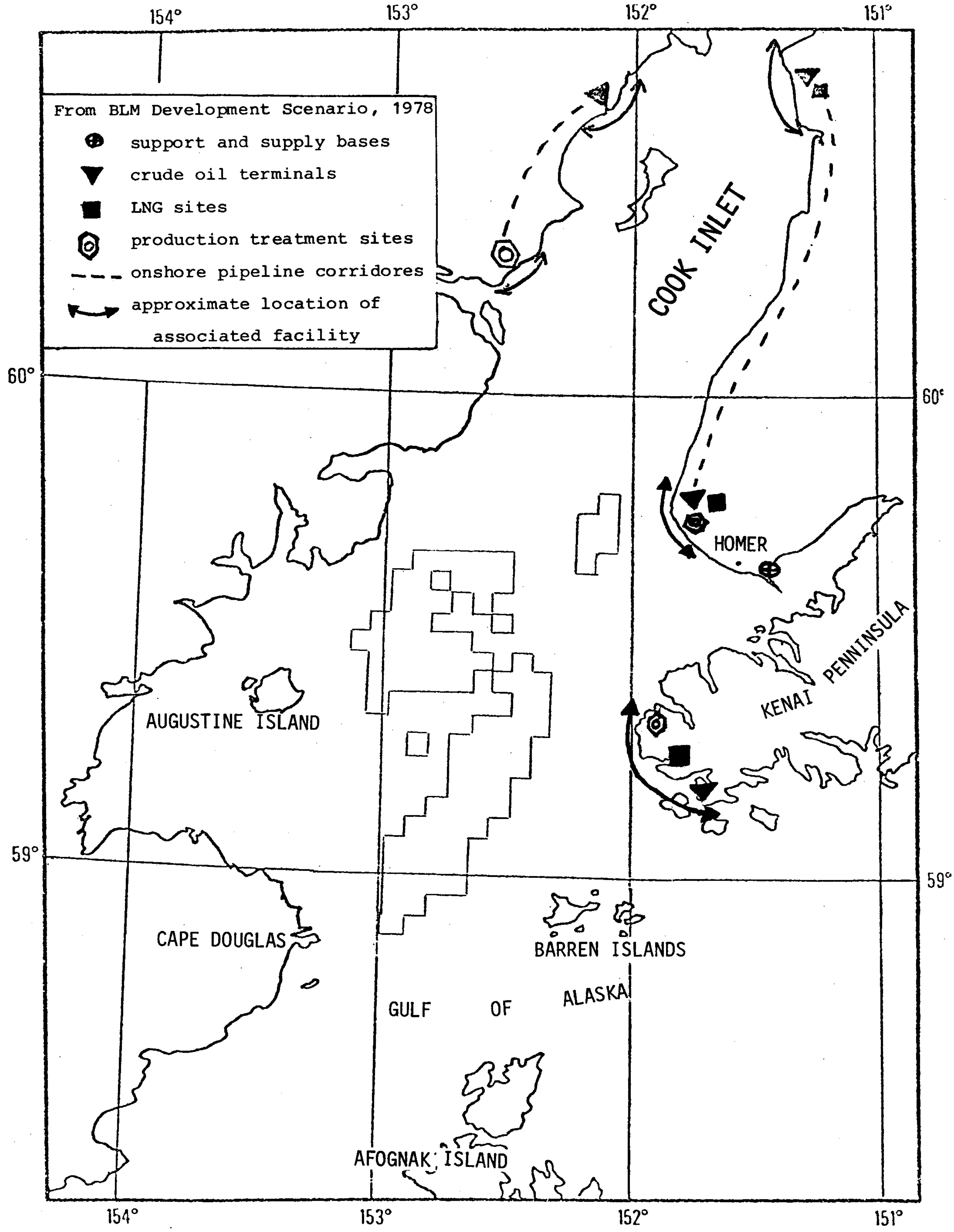


FIGURE 7-5

POTENTIAL LOCATIONS FOR ONSHORE FACILITIES ASSOCIATED WITH OIL EXPLORATION, DEVELOPMENT AND PRODUCTION IN LOWER COOK INLET

(from Warren, 1978)

(disposal of production water) and at tanker terminals (disposal of ballast water and numerous minor spills).

Although the rocky assemblages in Kennedy Entrance are probably somewhat similar to these described for southern Kachemak Bay, descriptions of its shallow subtidal rocky habitats are not adequate to permit a detailed discussion (Dames & Moore 1977b). Furthermore, these assemblages probably would be rather distant from the facilities. It seems probable that routine winter weather conditions would preclude safe, efficient tanker loading operations in the open waters of Kennedy Entrance, and thus would dictate that such facilities be located in its major embayments, i.e., Port Chatham, Koyuktolik Bay, or Port Graham. Thus, the main concern to shallow rocky subtidal assemblages would be acute oil spills, which were discussed in Section 7.4.2.2. The extreme turbulence of this area probably would act to greatly reduce the effects of either acute or chronic contamination by reducing duration of contact and dilution.

Consequences of either acute or chronic contamination in the vicinity of Anchor Point are of greater concern. Circulation studies indicate the presence of a gyre system in northwestern Kachemak Bay, over the northern shelf (Burbank 1977). Residence time of the water mass in this system is not clear. Large concentrations of larvae in the area (Haynes 1977) suggest that the gyre could act to concentrate contaminants. As pointed out above, this area, supporting the northern shelf assemblage, has been designated as a king crab sanctuary and is part of the Kachemak Bay Critical Habitat area. Potential effects of oil contamination have been discussed in Section 7.4.2.2.

7.4.3.3 Pipelines

Pipelines are a potential concern because of the activities associated with laying the pipe and the possibility of breaks or small chronic leaks. Possible pipeline corridors are indicated in Figure 7-6 (Warren 1978). The only areas in which pipelines might affect shallow subtidal rocky habitats

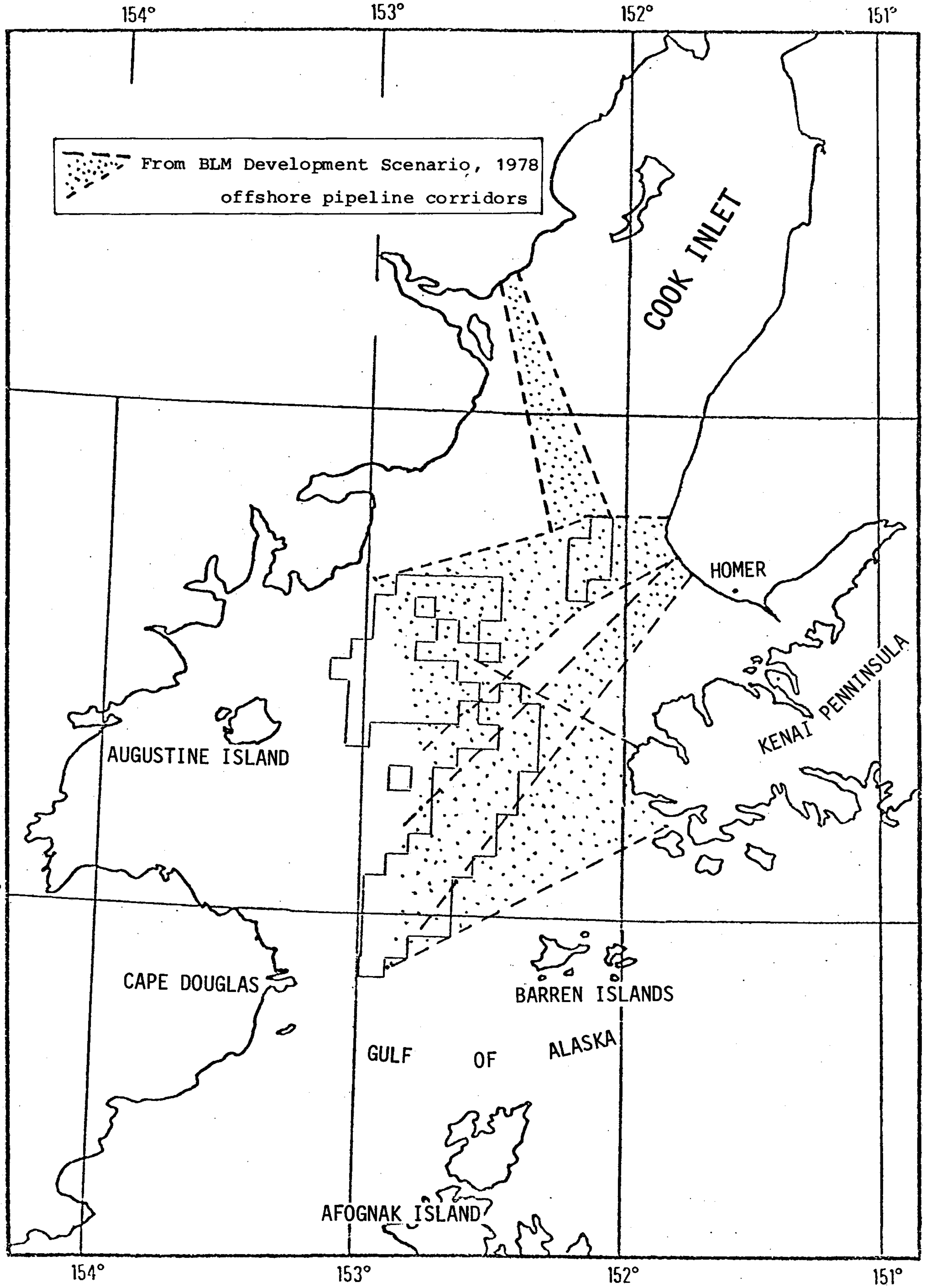


FIGURE 7-6

POTENTIAL OFFSHORE PIPELINE CORRIDORS IN LOWER COOK INLET

(from Warren, 1978)

are in Kennedy Entrance and at Anchor Point, where pipelines would have to cross wide bands of rocky substrate (about 5 km and 10 km, respectively).

Activities associated with laying pipelines (blasting and dredging) would be restricted to pipeline routes and thus would affect rather limited areas.

A rupture in the pipeline would probably create an acute oil spill. The severity of the spill would depend upon the proximity of the break to the habitat, the amount of oil between the rupture and the nearest safety valves, the slope of the pipe, and the amount of time required to stop the flow from the break. If the break occurred in the rocky habitat, it probably would be more damaging than a surface spill because the oil would mix actively with water and sediment particles as it rose to the surface, resulting in a much larger proportion of the toxic fractures being dissolved in the water. This is a special concern at Anchor Point because of the turbidity and the proximity to the king crab sanctuary.

Because of the high degree of turbulence in both locations, small chronic leaks in the pipeline would probably have no widespread effects unless the pollutants were concentrated by the gyre system.

7.4.3.4 Other Concerns

Tanker routes and physical disturbance from boats or aircraft associated with petroleum exploration and development are a concern to some other habitats or vertebrate assemblages, or may interrupt existing activities. However, normal tanker, boat, and airplane activities constitute little threat to conditions in the shallow subtidal habitats discussed in this report, except as they involve access to the onshore facilities discussed above.

8.0 CONCLUSIONS

8.1 ROCKY HABITAT

8.1.1 Southeastern Quadrant of Lower Cook Inlet

Intertidal and shallow subtidal algal assemblages in the southeastern quadrant of lower Cook Inlet (i.e., Kachemak Bay and Kennedy Entrance) generally were dominated by brown algae (i.g., *Alaria* spp, *Agarum cribrosum*; *Laminaria groenlandica* and *Nereocystis luetkeana*). In the mid intertidal zone, *Fucus* was the most important plant. In the low intertidal and shallow subtidal zone, kelps dominated out to a depth of about 20 m. Plant production was moderate, ranging up to 18 kg plant tissue/m^2/yr in dense kelp beds with surface canopies (e.g., Jakolof Bay and Seldovia Point). The algal assemblages exhibited strong seasonal patterns in relative cover, biomass and growth rates. Highest growth rates for kelps were observed in March, April and May. Greatest relative cover and biomass were observed in late summer.

Intertidal and shallow subtidal faunal assemblages in the southeastern quadrant of lower Cook Inlet were diverse and well developed only in areas directly exposed to strong tidal currents; in some likely areas, algal cover may have inhibited the development of faunal assemblages (e.g., Seldovia Point). In areas where faunal assemblages were well developed, the species generally were long-lived. Functional dominants included herbivores (e.g., sea urchins, chitons and limpets), suspension feeders (mussels, clams, polychaetes, bryozoans and sponges) and predators/scavengers (e.g., sea stars, snails, crabs and fishes). Standing stocks of the assemblages were high in areas of strong tidal currents. The assemblages exhibited strong affinities with those in southeastern Alaska, British Columbia and Washington. Rocky intertidal faunal assemblages exhibited strong seasonal variations but subtidal assemblages were substantially more stable. Greatest development was in mid summer and poorest in winter.

The sensitivity to oil contamination of the assemblages on rocky habitats in this area is probably fairly low except in areas with highly developed suspension-feeding assemblages (e.g., Jakolof Bay). Kelps are fairly tolerant to exposure to crude oil, but many of the invertebrate species, especially subtidal suspension feeders are probably very sensitive to oil toxicity.

8.1.2 West Side of Lower Cook Inlet

Mid-intertidal algal assemblages on the west side of lower Cook Inlet were dominated by the brown alga *Fucus* and ephemeral red algae (mainly *Rhodymenia* spp). In the low intertidal and shallow subtidal zones, kelps dominated to a depth of about 3 m. Seaweeds were virtually absent below about 5 m. Plant production was moderate in the seaweed zone, however, the area of that zone is limited. Seasonal patterns were similar to those described for the southeastern quadrant, except winter ice scouring may cause virtual extinction of seaweeds over a large proportion of the mid intertidal zone.

The faunal assemblage in the seaweed zone was rather impoverished, probably as a consequence of ice scour and algal abrasion and battering. Except in protected areas, the fauna was characterized by juvenile specimens of pioneer species. Functional dominants include microherbivores (e.g., limpets and littorines) and predator/scavengers (e.g., hermit crabs). Below the seaweed zone, the faunal assemblage was more diverse and well developed. Although relative coverage was high, biomass was low. Functional dominants included suspension feeders (e.g., barnacles, the mussel *Modiolus*, encrusting bryozoans, social ascidians and polychaetes) and predator/scavengers (e.g., sea stars, snails and crabs). The assemblages exhibited strong affinities with those in the Bering and Beaufort Seas. Seasonal patterns were not examined.

The sensitivity to oil contamination of the biotic assemblages in the seaweed zone in this area is probably quite low and damage would be short term. Because of normal environmental conditions, a large portion of the assemblage is replaced annually. Below the seaweed zone, however, sensitivity to oil contamination may be quite high. A large proportion of the animals are small encrusting suspension feeders in close contact with a film of deposited sediments. In conjunction with oil, this film could be extremely damaging. Many of the animals brood their eggs and larvae and so recolonization would be slow.

8.1.3 NEGOA

Intertidal and shallow subtidal algal assemblages in the NEGOA region generally are dominated by brown algae (e.g., *Alaria* spp, *Agarum cribrosum*, *Laminaria* spp, *Pleurophycus gardneri* and *Nereocystis*). *Fucus* is the most important plant in the intertidal zone. Kelps dominate the low intertidal and shallow subtidal zones out to a depth of about 15 m. Plant production is moderate to high, ranging up to 70 kg plant tissue/m^2/year in dense kelp beds with a canopy of *Nereocystis*, but averaging somewhat lower. Seasonal patterns were similar to those described for the southeastern quadrant of lower Cook Inlet.

Shallow subtidal faunal assemblages varied considerably with depth. Inside the seaweed zone, the assemblage was rather poorly developed, perhaps as a consequence of abrasion by algae and storm surge and competition for space with algae. Between the depths of about 10 and 20 m, ephemeral invertebrates such as colonial ascidians and bryozoans covered a large proportion of the substrate, especially in the spring and summer. Below 20 m, long-lived invertebrates such as sea anemones were common. Clams and motile epifauna such as sea urchins, crabs and snails were never common in the areas observed. Functional dominants at all levels were suspension feeders (e.g., colonial ascidians, bryozoans and sponges). The appearance of the invertebrate assemblage was strongly seasonal as a consequence of the ephemeral suspension-feeding ascidians and bryozoans.

The sensitivity to oil contamination of the biotic assemblages in the seaweed zone in this area is probably low because of the strong dominance by kelps which are fairly tolerant to exposure to crude oil. Damage to that zone probably would be of short-term. Below the seaweed zone, sensitivity probably would be fairly high because of the preponderance of suspension-feeding organisms requiring high water quality. The highly turbulent nature of the water mass probably would bring oil into contact with the benthos down to moderate depths. However, this turbulence would also lead to rapid cleansing on the habitat, speeding recovery.

8.2 SOFT SUBSTRATES

The faunas on soft substrates differed substantially among sites in terms of species composition, dominance patterns and biomass, but did exhibit a certain degree of consistency in species composition among sites with similar substrate characteristics.

8.2.1 Sand Beaches

Faunas on sand beaches were dominated by polychaete worms (e.g., *Scolelepis*, *Paraonella*, *Eteone* and *Nephtys*) and gammarid amphipods (*Eohaustorius* and *Paraphoxus*). Dominance patterns appeared to consistently vary with exposure. *Eohaustorius* and *Scolelepis* dominated at Homer Spit and *Eohaustorius*, *Nephtys* and *Scolelepis* dominated at Iniskin Beach. Species composition was qualitatively quite similar at the beaches surveyed.

Biomass was low in all cases (maximum dry tissue weight was approximately 5 g/m^2) but highest biomass levels were observed at sites where *Scolelepis* dominated. Secondary production appeared low.

Seasonal patterns in abundance, biomass, and species richness were conspicuous; all peaked in summer and apparently were linked to physical stress, especially storms, and reproductive patterns.

Patterns in vertical zonation of the species generally were vague; however, species richness and abundance generally increased at lower levels.

Utilization of the invertebrate resources on sand beaches by birds and fishes appears to be low.

Sand beach assemblages may be moderately resistant to long-term changes arising from exposure to crude oil, but weather conditions during exposure could reduce this resistance severely. Conditions promoting burial of oil in the sand would increase damage and inhibit recovery. Crustaceans are very sensitive to hydrocarbon toxicity. Polychaetes are fairly resistant to hydrocarbons but burial of oil in the sand could lead to anoxic conditions and high polychaete mortality. Relative instability of sandy substrates would promote cleansing of beaches and weathering of the oil and result in relatively rapid recovery.

8.2.2 Mud Beaches

Faunas on mud beaches were dominated by clams (e.g., *Mya* spp and *Macoma balthica*) and an echiurid worm (*Echiurus*). Dominance patterns varied somewhat among beaches but important factors related to the differences are not clear. *Mya* spp and *Macoma balthica* dominated strongly at Glacier Spit whereas *Echiurus* dominated at Cottonwood Bay. Species composition was qualitatively rather similar at the sites surveyed.

Biomass was quite high at sites dominated by *Mya*, moderate at sites dominated by *M. balthica* and low at sites dominated by *Echiurus*. Dry tissue weights exceeded 250 g/m^2 at Glacier Spit, but were less than 10 g/m^2 at Cottonwood Bay. Secondary production also appeared high at Glacier Spit, where *Mya* and *M. balthica* were abundant. Seasonal patterns in abundance, biomass, and species richness were not clearly defined.

Patterns of vertical zonation by species were fairly well defined, especially among *Mya* spp. Numerical parameters (species richness and abundance) were higher at lower elevations.

Utilization of invertebrate resources on mud flats by birds and fishes may be quite high, especially in spring, while shorebirds and ducks are migrating north and salmon smolts are outmigrating from their spawning streams. In addition, several species of crab and other fish feed heavily on mud flat organisms during spring and summer periods of immersion.

Burrowing animals such as the worm Echiurus and the clams Mya spp construct extensive burrows which increase the surface area of the mud flat by about 2.5 times. Increased surface area results in higher microbial standing stocks and oxygenation rates of the sediments. These burrows penetrate the sediment to a depth of at least 45 cm.

Mud flats in lower Cook Inlet probably are highly sensitive to contamination from crude oil. The clams Mya arenaria and Macoma balthica have been shown to be quite sensitive to crude oil and refined products. Numerous burrows would permit large amounts of oil to penetrate deeply into the substrate. Accompanying mortality of the animals constructing the burrows (Echiurus and Mya) would lead to destruction of the burrows and seal the oil in the sediments. Ensuing anaerobic conditions would result in very slow weathering rates for the oil and long-term disruption of the mud flat assemblage. Recovery could require in excess of three decades. Considering the high productivity of the mud flat assemblages and the dependence of many bird and fish populations on these assemblages, such a condition could be devastating.

8.3 FUTURE RESEARCH NEEDS

Based on the findings of this study, the most important habitat for further work would be mud flats. Further studies are needed to establish a better understanding of energy pathways and their relative importance in the lower Cook Inlet system.

The most important research need in this area, and a very logical extension of the findings, is a field investigation of the effects of various types of oil and dispersants of mud flat assemblages. Laboratory studies cannot approach the faunal and structural complexity of the natural mud flats of lower Cook Inlet and thus the findings of such studies, while useful, must necessarily be rather artificial and superficial. Furthermore, such short-term experiments only produce insight on the immediate effects of an oil spill. Immediate effects (mortality), while important, are not of the high importance of long-term effects (inhibition of growth rates, reproduction, recruitment, and production and increases in carcinogenesis and mutagenesis) in such a productive, important habitat. Many of the major species (e.g., Echiurus, Mya, and Macoma) are widespread in Alaska mud flats near areas of potential OCS petroleum development (e.g., Bering Sea); thus, studies of the mud flat assemblage would be widely applicable.

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APPENDIX A ORGANISMS OBSERVED ON RECONNAISSANCE DIVES AT SCHOONER ROCK, MONTAGUE ISLAND IN HINCHINBROOK ENTRANCE

Sheet 1 of 6

TAXA	19 May 1978 North End	11 April 1979 SE Side
ALGAE		
Agarum cribrosum	$8(14.5)92/g/m^2$-12m;	
Alaria marginata	17 m	10 m
Audouinella concrescens		10 m
Callithamnion biseriatum		23 m
Callophyllis crenulata	21 m	11 m, 23 m
?Cirrulicarpis gmelini		17 m
Constantinea rosa-marina		20 m
Desmarestia aculeata	$(25)123g/m^2$ 12 m; 17m; 21m	10 m
Desmarestia sp		17 m
Encrusting coralline alga	(25)-12 m 21 m	10 m, 23 m
Foliose red algae		23 m, 20 m
Hildenbrandia sp	12 m	
Laminaria dentigera	12 m	D-10 m
L. groenlandica	$10(15)105g/m^2$-12 m	to 14 m
L. yezoensis	$2(3)72g/m^2$-12 m	
Nereocystis luetkeana	12 m	
Pleurophycus gardneri	$10(21)504g/m^2$-12 m;	10 m to 14 m
Polyneura latissima	17 m	C-10 m
Rhodymenia pertusa		17 m
PORIFERA		
Cliona celata		14 m
?Speriopsis sp		23 m
Porifera, pustulate chrome-yellow		C-10 m, 23 m
?Suberites sp	17 m	
CNIDARIA		
Abietinaria gigantea	C-21 m	
A. kincaidi	21 m	
A. turgida		23 m
Abietinaria sp		10 m

APPENDIX A ORGANISMS OBSERVED ON RECONNAISSANCE DIVES AT SCHOONER ROCK, MONTAGUE ISLAND IN HINCHINBROOK ENTRANCE

TAXA	19 May 1978 North End	11 April 1979 SE Side
Allopora californica		D-10 m, 23 m
Calycella syringa	17 m	
Campanularia speciosa	17 m	
C. verticillata	17-21 m	23 m
Clavularia sp		23 m
Cribrinopsis ?_similis_		17 m
Epizoanthus ?_scotinus_		17 m
Eucopella compressa	17 m	
Eudendrium vaginatum		10 m
Garveia formosa	21 m	10 m
Gersemia rubriformis	17-21 m	17 m; 14 m
?_Grammaria abietina_	17 m	
Halecium ?_parvulum_	17 m	
Halecium sp	17 m	
Hybocodon prolifer		C-23 m
Hydractinia ?_aggregata_	15 m	
Lafoea dumosa	21 m	
L. fruticosa	17 m	23 m
Metridium senile		C-17 m; 20 m
Ptilosarcus gurneyi	21 m	
Scyphozoa, Scyphistoma, unid.	12 m	23 m
Sertularella albida	17 m	
S. polyzonias var _gigantea_	17 m	
S. robusta	17 m	
S. turgida	C-12 m	10 m
Sertularia cupressoides		C-17 m
S. tolli	21 m	
Sertularia sp A	17 m	
Tealia crassicornis	17 m	23 m
ANNELIDA - Polychaeta		
Crucigera zygophora		10 m, 23 m
Myxicola infundibulum	12 m	17 m, 20 m

APPENDIX A ORGANISMS OBSERVED ON RECONNAISSANCE DIVES AT SCHOONER ROCK, MONTAGUE ISLAND IN HINCHINBROOK ENTRANCE

Sheet 3 of 6

TAXA	19 May 1978 North End	11 April 1979 SE Side
MOLLUSCA		
Acmaea mitra	12 m	
Amphissa columbiana		23 m
Cadlina luteomarginata	12 m	
Calliostoma annulatum		10 m
C. ligatum	17-21 m	23 m
Ceratostoma foliatum	12 m	
Coryphella sp		17 m, 23 m
Cryptochiton stelleri	12 m	
Diodora aspera		17 m, 11 m
Doridacea, unid., white		20 m, 11 m
Epitonium sp	21 m	
Fusitriton oregonensis	17 m	17 m
Hermissenda crassicornis		23 m
Margarites helicinus	17 m	
M. pupillus	17 m	17 m
Musculus vernicosus	12 m	
Natica clausa		23 m
Olivella baetica	12 m	
Placiphorella ?velata		17 m
Puncturella ?multistriata	17 m, 12 m	
Tochuina tetraquetra	15 m	
Tonicella insignis	12 m	
T. lineata	12 m	
Trichotropis cancellata		17 m
Trophonopsis lasius	12 m	
Velutina sp	17 m	
ARTHROPODA - Crustacea		
Balanus nubilus		23 m
Balanus sp	17 m	
Cancer oregonensis	17 m, 12 m	

TAXA	19 May 1978 North End	11 April 1979 SE Side
Caprella borealis	17 m	
C. ?laeviuscula	17 m	
Discorsopagurus schmitti	17 m, 12 m	
Elassochirus gilli	17 m	17 m, 14 m
E. tenuimanus		17 m
Metacaprella kennerlyi	17 m	
Pagurus beringanus	17 m	
P. caurinus	17 m	
P. kennerlyi	17 m	
Pugettia gracilis	17 m, 12 m	
BRYOZOA		
Alcyonidium pedunculatum	17 m	
A. polyoum		23 m
Bientalophora sp	17 m	
Callopora armata	17 m	
Carbasea carbasea	S-17 m	
Costazia surcularis	21 m	
?Caulibugula sp	C-21 m	17 m
Crisia sp	21 m	
Dendrobeania curvirostris	21 m	
D. murrayana	C-17 m	
Eucratea loricata	21 m	
Filicrisia sp	17 m	
Flustrella corniculata		14 m
Heteropora sp	17 m	23 m
Hippodiplosia insculpta	C-17 m	A-17 m; 23 m
Hippothoa hyalina	21 m	
Lichenopora sp	12 m	23 m
Microporina borealis	17-21 m	D-23 m
Myriozoella plana	21 m	
Tricellaria sp		23 m

APPENDIX A ORGANISMS OBSERVED ON RECONNAISSANCE DIVES AT SCHOONER ROCK, MONTAGUE ISLAND IN HINCHINBROOK ENTRANCE

TAXA	19 May 1978 North End	11 April 1979 SE Side
ECHINODERMATA		
Crossaster papposus	17 m	23 m
Cucumaria miniata	15 m	17 m
Dermasterias imbricata	17 m	23 m, 14 m
Evasterias troschelii	12 m	
Henricia leviuscula	21 m	23 m
Henricia sp		17 m
Ophiopholis aculeata	12 m	23 m, 14 m
Orthasterias koehleri	17 m	23 m, 20 m
Pisaster ochraceus	17 m	10 m
Pycnopodia helianthoides	15 m	23 m, 20 m
Solaster dawsoni	15 m	14 m
S. stimpsoni		23 m
Strongylocentrotus drobachiensis		17 m, 20 m
S. franciscanus		11 m
UROCHORDATA - Ascidiacea		
Aplidium arenatum	3-15 m	
A. californicum	3-15 m	
A. ?translucidum		C-10 m, 20 m
Aplidium sp	17 m	
Archidistoma ritteri	3-15 m	
Ascidiacea, unid.	17 m	
?Botrylloides sp	3-15 m	
Chelyosoma productum	3-15 m	
Cnemidocarpa finmarkiensis	3-15 m	
Corella willmeriana	3-15 m	14 m
Cystodytes lobatus	3-15 m	23 m
Didemnum ?albidum	15 m, 12 m	
D. carnulentum	3-15 m	
Distaplia occidentalis		23 m
D. smithi		10 m, 17 m
Halocynthia aurantium	3-15 m	17 m
H. igaboja	3-15 m	
Metandrocarpa taylori	12 m	17 m
Pycnoclavella stanleyi	17 m, 3-15 m	14 m

APPENDIX A ORGANISMS OBSERVED ON RECONNAISSANCE DIVES AT SCHOONER ROCK, MONTAGUE ISLAND IN HINCHINBROOK ENTRANCE

Sheet 6 of 6

TAXA	19 May 1978 North End	11 April 1979 SE Side
Ritterella pulchra	12 m	
Styela clavata	3-15 m	
Synoicidae, unid.		10 m, C-14 m
Synoicum jordani	3-15 m	
CHORDATA - Vertebrata - Pisces		
Anarrhichthys ocellatus	15 m	
Artedius fenestralis		17 m, 20 m
Bathymaster sp	17-21 m	
Cottidae, unid.	17 m	
Hemilepidotus jordani	17 m	
Hexagrammos decagrammus		23 m
H. lagocephalus	17-21 m	
Sebastes melanops	15 m	23 m

APPENDIX B ORGANISMS NOTED ON SAND/SHELL SUBSTRATE IN NW CORNER OF PORT ETCHES, NEAR ENTRANCE TO CONSTANTINE HARBOR ON 11 APRIL 1979; DEPTH 5.5-7.6 m.

PLANTS

- Agarum cribrosum
- Callophyllis crenulata
- C. cristata
- C. ?firma
- C. flabellulata
- ?Cirrulicarpus gmelini
- ?Cystoseira geminata
- Desmarestia sp
- Diatom film
- encrusting red algae
- Laminaria groenlandica
- L. saccharina
- L. yezoensis
- Odonthalia ?lyalli
- Rhodymenia pertusa
- Zostera marina

PORIFERA

- Cliona celata
- ?Suberites ficus

ANNELIDA - Polychaeta

- Cistenides brevicoma
- Crucigera zygophora

MOLLUSCA

- Cadlina luteomarginata
- Clinocardium californiense
- Coryphella sp
- Crepipatella lingulata
- Cryptobranchia concentrica
- Cyclocardia sp
- Hiatella aretica
- Melibe leonina
- Mya sp
- Nassarius mendicus
- Natica clausa
- Olivella baetica
- Pododesmus macroschisma
- Saxidomus giganteus
- Tonicella insignis
- T. ?rubra

ARTHROPODA - Crustacea

- Crangon sp
- Elassochirus tenuimanus
- Pagurus spp
- Pandalus sp

BRYOZOA

- ?Eucratea loricata
- Phidolopora pacifica
- Rhynchozoon sp

ECHINODERMATA

- Dermasterias imbricata
- Evasterias troschelii - juv.
- Henricia leviuscula
- Orthasterias koehleri
- Pycnopodia helianthoides (juv. & adults)

UROCHORDATA - Ascidiacea

- White globose colonial ascidian

CHORDATA - Vertebrata - Pisces

- ?Rathbunella sp

APPENDIX C-1 ORGANISMS NOTED ON MUDDY SAND SUBSTRATE 100 m N OF THE ENTRANCE IN CONSTANTINE HARBOR, PORT ETCHES ON 12 APRIL 1979; DEPTH 4.6-6.1 m.

PLANT

- *Alaria* sp (juv.)
- Ceramiales, unid.
- *Chlorochytrium inclusum*
- *Cymathere triplicata*
- *Desmarestia aculeata*
- Diatom film
- *Fucus distichus*
- *Gomontia polyrhiza*
- *Laminaria saccharina*
- *Monostroma fuscum*
- *Palmaria palmata*
- *Pylaiella littoralis*
- *Rhodomela lycopodioides*
- *Spongomorpha saxatilis*
- *Ulva rigida*
- *Zostera marina*

CNIDARIA

- *Halcampa decemtentaculata*
- *Metridium senile* (juv.)

MOLLUSCA - Pelecypoda

- *Astarte* sp
- *Clinocardium* sp
- *Macoma* sp
- *Mya truncata*
- *Pododesmus macroschisma*
- *Saxidomus giganteus*

MOLLUSCA - Gastropoda

- *Acmaea* sp
- *Dirona albolineata*
- *Gasteropteron pacificum*
- *Hermissenda crassicornis*
- *Melibe leonira*
- *Natica clausa*

ARTHROPODA - Crustacea

- Caprellidae, unid.
- *Pentidotea* sp

ECHINODERMATA

- *Dermasterias imbricata*
- *Pycnopodia helianthoides*

CHORDATA - Pisces

- *Pholis laeta*

APPENDIX C-2 ABUNDANCE DATA FOR TROUBLESOME CREEK SUBTIDAL AREA: 1 August 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 8.0 M BELOW MLLW

TAXA	Frequency					$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta							
Agarum cribrosum	0	1	0	0	1	0.4 ± 0.5	0.2
Desmarestia aculeata	0	1	5	0	0	1.2 ± 2.2	0.5
D. ligulata	0	0	2	0	0	0.4 ± 0.9	0.2
Laminaria groenlandica	0	0	2	0	0	0.4 ± 0.9	0.2
INVERTEBRATA							
Anthozoa, unid., white	0	0	1	3	5	1.8 ± 2.2	0.7
Crossaster papposus	1	0	0	0	1	0.4 ± 0.5	0.2
Cryptochiton stelleri	0	1	0	1	1	0.6 ± 0.5	0.2
Cucumaria fallax	1	0	1	0	0	0.4 ± 0.5	0.2
C. miniata	24	17	14	20	6	16.2 ± 6.8	6.5
Elassochirus gilli	2	0	1	0	0	0.6 ± 0.9	0.2
Evasterias troschelii	0	0	0	0	1	0.2 ± 0.4	0.1
Fusitriton oregonensis	1	0	1	0	0	0.4 ± 0.5	0.2
Hermissenda crassicornis	1	0	1	0	1	0.6 ± 0.5	0.2
Leptasterias ?hylodes	0	1	0	0	0	0.2 ± 0.4	0.1
Neptunea lyrata	0	0	1	0	0	0.2 ± 0.4	0.1
Octopus dofleini	0	1	0	0	0	0.1 ± 0.4	0.1
Strongylocentrotus drobachiensis	43	29	22	32	43	33.8 ± 9.1	13.5
Tealia crassicornis	0	0	2	0	0	0.4 ± 0.9	0.2

APPENDIX D ABUNDANCE AND DISTRIBUTION OF ORGANISMS IN THE VICINITY OF BATHTUB ROCK AND THE SW POINT OF EVANS ISLAND IN 1979

Sheet 1 of 5

TAXA (Facing)	Bathtub Rock W. Side and NW Corner	S Side and SW Corner	SE and E. Side	N Side and NE Corner	SW Point of Evans Island SW	SW
Depths examined (m):	12-15	9-21	11-19	3-18	6	11-13
ALGAE - Rhodophyta						
Ahnfeltia plicata					(1)	
Audouinella sp	9-18 m					
Callithamnion biseriatum	9-18 m					
Callophyllis crenulata	9-18 m					
C. cristata	9-18 m					
C. ?firma	9-18 m					
Callophyllis spp	C-13 m	9 m			(1)	
Constantinea rosa - marina			16 m		P	
Corallina sp					(1)	
Encrusting coralline algae	12 m	9 m; (12)-12 m	16 m		(28)	
Euthora sp	12 m	9 m				
Filamentous red algae	12 m	9 m	16 m			
Hildenbrandia sp	12 m	9 m	16 m		(1)	
Lithothrix aspergillum					P	
Nitophyllum yezoensis	12 m; 9-18 m	9 m; (4)-12 m	16 m			
Opuntiella californica	13 m	9 m, 12 m				P
Platythamnion pectinatum	9-18 m					
?*Platythamnion* sp	9-18 m					
Pterosiphonia gardneri	9-18 m					
Ptilota filicina	12 m; 9-18 m	9 m; 12 m			P	
Rhodymenia pertusa	12 m; 9-18 m	9 m; (80-12 m			(8)	
Rhodophyta, unid.	3% - 13 m	17 m; (13)-12 m			(3)	
ALGAE - Phaeophyta						
Agarum cribrosum	4(22)-13 m	9 m; 18 m; 2(23)-12 m	to 16 m	to 17 m	C	A
Alaria sp					P	
Costaria costata					P	
Desmarestia aculeata	13 m	9 m; (5)12 m				
Dictyosiphon foeniculaceus	9-18 m					
Laminaria dentigera		9 m			A	
L. groenlandica	18.3(3%)-13 m	9 m; 1-14 m			C	D
L. yezoensis	12 m	9 m			C	P
Nereocystis luetkeana	1.7 m-1.3 m	9 m			C	C
Pleurophycus gardneri	6.3 m(6%)-13 m	9 m; 14 m	to 16 m		C	P

APPENDIX D ABUNDANCE AND DISTRIBUTION OF ORGANISMS IN THE VICINITY OF BATHTUB ROCK AND THE SW POINT OF EVANS ISLAND IN 1979

TAXA (Facing)	Bathtub Rock: W. Side and NW Corner	Bathtub Rock: S Side and SW Corner	Bathtub Rock: SE and E. Side	Bathtub Rock: N Side and NE Corner	SW Point of Evans Island: SW	SW Point of Evans Island: SW
Depths examined (m):	12-15	9-21	11-19	3-18	6	11-13
INVERTEBRATA						
Porifera						
Cliona celata		9 m				
Esperiopsis laxa				6 m		
? Esperiopsis sp		9 m;(1)-12 m				
Suberites ?ficus			15 m			
Cnidaria						
Abietinaria spp	13 m	9 m; 21 m; 12 m	15 m		P	
Allopora californica		12 m				
Campanularia verticillata	12 m	9 m; 21 m	15 m			
Clavularia sp	12 m					
Cribrinopsis ?similis		C-9 m	15 m			
Epizoanthus ?scotinus		C-9 m; 21 m		C-17 m		
Halecium sp		12 m		17 m		
Hybocodon prolifer		C-9 m; 21 m	19 m			
Hydroida, unid.	A-13 m					
Lafoea fruticosa	12 m	9 m				
Metridium senile		A-9 m; 78(75)-21 m				
Tealia crassicornis	12 m	9 m	11 m, 15 m			
T. ?lophotensis			15 m			
Tubularia sp				6 m		
Scyphistoma, unid.	12 m	12 m		C-17 m		
Annelida						
Crucigera zygophora	12 m	9 m; 1-12 m	15 m		1	
Myxicola infundibulum	12 m	9 m				
Sabellidae, unid.	12 m					
Terebellidae, unid.	13 m					

APPENDIX D ABUNDANCE AND DISTRIBUTION OF ORGANISMS IN THE VICINITY OF BATHTUB ROCK AND THE SW POINT OF EVANS ISLAND IN 1979

Sheet 3 of 5

TAXA	(Facing)	Bathtub Rock: W. Side and NW Corner	Bathtub Rock: S Side and SW Corner	Bathtub Rock: SE and E. Side	Bathtub Rock: N Side and NE Corner	SW Point of Evans Island: SW	SW Point of Evans Island: SW
	Depths examined (m):	12-15	9-21	11-19	3-18	6	11-13
MOLLUSCA							
Acmaea mitra						1	
Acmaea sp						4	
Amphissa columbiana		C-13m	9 m	15 m			
Austrodoris sp				15 m			
Calliostoma ligata		12 m	9 m	A-11 m			
Chlamys sp		12 m	21 m				
Dirona aurantia			9 m				
Fusitriton oregonensis		13 m	21 m, 0.3-14 m				P
Margarites pupillus		12 m				P	
Musculus vernicosus						P	
Mya sp		12 m					
Natica sp		12 m					
Oenopota sp			9 m				
Placiphorella ?velata			21 m				
Pododesmus macroschisma		12 m					
Saxidomus giganteus						P	
Tochuina tetraquetra			9 m	11 m, 15 m			
Tonicella insignis		12 m	9 m	15 m	17 m	1	
Trichotropis cancellata		12 m	9 m				
Bryozoa							
Alcyonidium pedunculatum		12 m					
Carbasea carbasea			21 m	15 m			
Deudrobeania murrayana		12 m	(3)-12 m			1	
Disporella alaskensis		12 7					
?Eucratea loricata				15 m			
Heteropora sp		12 m	9 m		17 m		
Hippodiplosia insculpta			9 m				
Membranipora membranacea							C
Rhynchozoon ?bispinosum		D-13 m	D-9 m; (25)-12 m; (40)-21 m A-11 m			(8)	A
Tricellaria sp		12 m					

APPENDIX D ABUNDANCE AND DISTRIBUTION OF ORGANISMS IN THE VICINITY OF BATHTUB ROCK AND THE SW POINT OF EVANS ISLAND IN 1979

TAXA (Facing)	Bathtub Rock: W. Side and NW Corner	Bathtub Rock: S Side and SW Corner	Bathtub Rock: SE and E. Side	Bathtub Rock: N Side and NE Corner	SW Point of Evans Island: SW	SW Point of Evans Island: SW
Depths examined (m):	12-15	9-21	11-19	3-18	6	11-13
Arthropoda - Crustacea						
Balanus nubilus	12 m	C-9 m				
Elassochirus gilli		21 m	15 m			
E. tenuimanus		9 m				
Heptacarpus sp	12 m					
Lebbeus grandimanus		C-9 m				
Mysidacea, unid.		A-9 m				
Oregonia gracilis		9 m	15 m			
Pagurus hirsutiusculus					P	
P. kennerlyi			15 m			
Pagurus spp	12 m				3	
Pugettia gracilis		9 m	15 m			
Echinodermata						
Amphipholis sp	12 m					
Crossaster papposus	13 m	9 m, 0.3-14 m	15 m		0.1	
Cucumaria miniata			15 m			
Dermasterias imbricata	12 m	C-9 m; 21 m	11 m		0.03	
Henricia leviuscula	13 m	9 m; 21 m	11 m; 15 m		0.1	0.3
H. sanguinolenta	12 m	-				
Ophiopholis aculeata	13 m	9 m; 21 m				
Orthasterias koehleri	13 m	9 m	11 m; 15 m		0.2	0.1
Pteraster tesselatus			15 m			
Pycnopodia helianthoides	13 m	9 m; 21 m			0.03	0.1
Solaster stimpsoni			11 m; 15 m			
Strongylocentrotus drobachiensis juv.		9 m		6 m		P
Tosiaster arcticus						0.1
TUNICATA - Ascidiacea						
Aplidium arenatum					P	
A. coei	12 m	12 m				
Aplidium sp	12 m	12 m				
Corella willmeriana			15 m			
Didemnum ?albidum	12 m	21 m; 12 m	15 m			
Distaplia occidentalis	12 m	A-9 m	15 m	D-6 m		

APPENDIX D ABUNDANCE AND DISTRIBUTION OF ORGANISMS IN THE VICINITY OF BATHTUB ROCK AND THE SW POINT OF EVANS ISLAND IN 1979

Sheet 5 of 5

TAXA (Facing)	Bathtub Rock: W. Side and NW Corner	S Side and SW Corner	SE and E. Side	N Side and NE Corner	SW Point of Evans Island: SW	SW
Depths examined (m):	12-15	9-21	11-19	3-18	6	11-13
Halocynthia aurantia	13 m		15 m			
H. igaboja			15 m			
Metandrocarpa taylori	12 m					
Polyclinum	12 m					
Ritterella pulchra		C-12 m	A-9 m; (4)-12 m; (4)-21 m			
Styela ?montereyensis				D-6 m	10	C
Synoicum jordani	12 m	A-9 m; (1)-12 m		6 m		
Synoicidae, unid.	12 m	9 m; (5)-21 m		6 m		
CHORDATA - Vertebrata - Pisces						
Bathymaster caeruleofasciatus		9 m		18 m		
Cottidae, unid.		9 m				
Hemilepidotus hemilepidotus					P	
H. jordani					P	
Hexagrammos decagrammus	12 m	C-9 m			P	C
H. lagocephalus				P		P
H. octogrammus					P	
Liparidae, unid.					P	
Myoxocephalus ?polyacanthocephalus	12 m					
Sebastes melanops		9 m, 20 m		18 m		P
S. nebulosus				18 m		
S. ruberrimus				18 m		
Substrate	Bedrock & Talus slope	Bedrock, talus slope, vertical rock wall	Vertical rock wall	Vertical rock wall, large boulder pile at base	Boulder, sand and bedrock flats	boulder and bedrock flats
Dates Surveyed	4 april	5, 7 April	6 April	6 April	6 April	18 July

*P=present, C=common, A=abundant, D=dominant. **The depth at which a species was observed is noted in meters, often in conjunction with a note on relative cover or abundance.** Plain numbers indicate approximate number per m^2, parenthetic numbers indicate relative cover (%). For example, C-13 m indicates the species was common at 13 m and 2(23)-12 m indicates the density and cover of the species were $2/m^2$ and 23%, respectively, at 12 m.

APPENDIX E MENSURAL DATA AND RATIOS USED FOR COMPUTING PRODUCTIVITY AND P/B RATIOS FOR AGARUM COLLECTED AT JAKOLOF BAY, 29 MARCH 1979

Sheet 1 of 2

Stipe Length (SL-cm)	Blade Weight (B_o-g)	Blade Length BL-cm	B_o/BL g/cm of blade A	BW/BL g/cm of blade B	Production g/plant/yr A	Production g/plant/yr B	P/B_o A	P/B_o B
28.2	184.1	55.2	3.34	16.47	192.4	950.2	1.05	5.16
6.5	78.6	50.9	1.54	0.64	89.1	36.7	1.13	0.47
10.0	75.5	44.6	1.69	1.08	97.7	62.1	1.29	0.82
12.8	35.6	30.9	1.15	1.64	66.5	94.5	1.87	2.65
9.0	12.8	26.1	0.49	0.93	28.3	53.4	2.21	4.18
6.2	50.5	37.0	1.36	0.61	78.8	35.1	1.56	0.70
5.7	12.1	20.9	0.58	0.56	33.4	32.6	2.76	2.69
3.1	5.8	20.7	0.28	0.38	16.2	22.1	2.79	3.81
4.1	6.9	21.6	0.32	0.44	18.4	25.6	2.67	3.72
4.4	11.3	22.9	0.49	0.46	28.5	26.8	2.52	2.37
1.0	3.5	15.0	0.23	0.28	13.5	16.1	3.85	4.60
2.7	1.9	13.7	0.14	0.36	8.0	20.8	4.21	10.9
9.9	79.1	41.1	1.92	1.06	111.0	61.2	1.40	0.77
5.5	4.7	8.0	0.59	0.55	33.9	31.6	7.21	6.73
11.2	33.1	31.6	1.05	1.29	60.4	74.3	1.83	2.25
11.2	50.7	43.7	1.16	1.29	66.9	74.3	1.32	1.47
3.3	10.5	17.5	0.60	0.39	34.6	22.7	3.30	2.17
2.2	5.5	17.5	0.31	0.33	18.1	19.3	3.30	3.51
6.3	36.1	36.7	0.98	0.62	56.8	35.7	1.57	0.99
9.4	43.8	49.1	0.89	0.98	51.5	56.7	1.18	1.30
12.0	83.1	49.9	1.67	1.45	96.1	83.8	1.16	1.01
4.5	33.1	42.0	0.79	0.47	45.5	27.2	1.37	0.82
6.5	9.7	20.8	0.47	0.64	26.9	36.7	2.77	3.79
7.0	61.3	37.7	1.63	0.69	94.1	39.6	1.53	0.65
4.7	10.6	24.2	0.44	0.49	25.3	28.1	2.38	2.65
11.2	28.3	25.8	1.10	1.29	63.3	74.3	2.24	2.63
3.0	12.9	24.1	0.54	0.38	31.2	21.7	2.42	1.69
7.0	35.2	35.0	1.01	0.69	58.0	39.6	1.65	1.12
11.5	58.4	33.0	1.77	1.35	102.1	77.7	1.75	1.33
5.0	24.7	34.4	0.72	0.51	41.4	29.3	1.68	1.19
5.5	22.6	36.6	0.62	0.55	35.6	31.6	1.58	1.40
11.2	37.2	43.6	0.85	1.29	49.2	74.3	1.32	2.00
3.0	43.9	35.8	1.23	0.38	70.8	21.7	1.61	0.50
3.2	10.6	20.9	0.51	0.39	29.3	22.4	2.76	2.11
7.0	46.1	36.8	1.25	0.69	72.3	39.6	1.57	0.86
5.9	40.5	37.3	1.09	0.58	62.7	33.6	1.55	0.83
2.2	5.1	20.1	0.25	0.33	14.6	19.3	2.87	3.78
1.5	3.5	17.5	0.20	0.30	11.5	17.4	3.30	4.96

APPENDIX E MENSURAL DATA AND RATIOS USED FOR COMPUTING PRODUCTIVITY AND P/B RATIOS FOR AGARUM COLLECTED AT JAKOLOF BAY, 29 MARCH 1979

Sheet 2 of 2

Stipe Length (SL-cm)	Blade Weight (B_o-g)	Blade Length BL-cm	B_o/BL g/cm of A	BW/BL blade B	Production g/plant/yr A	B	P/B_o A	B
8.0	47.2	46.8	1.01	0.80	58.2	46.0	1.23	0.97
4.8	33.1	32.3	1.02	0.49	59.1	28.5	1.79	0.86
7.6	102.4	73.2	1.40	0.75	80.7	43.3	0.79	0.42
6.2	43.3	37.8	1.15	0.61	66.1	35.1	1.53	0.81
7.5	60.6	32.7	1.85	0.74	106.9	42.7	1.76	0.70
5.0	18.4	30.4	0.61	0.51	34.9	29.3	1.90	1.59
4.5	23.1	38.6	0.60	0.47	34.5	27.2	1.49	1.18
11.5	25.9	26.0	1.00	1.35	57.5	77.7	2.22	3.00
6.0	34.2	41.6	0.82	0.59	47.4	34.1	1.39	1.00
7.5	38.0	26.7	1.42	0.74	82.1	42.7	2.16	1.12
5.5	39.6	39.3	1.01	0.55	58.1	31.6	1.47	0.80
10.5	47.8	33.3	1.44	1.16	82.8	66.9	1.73	1.40
4.1	18.4	34.6	0.53	0.44	30.7	25.6	1.67	1.39
7.5	31.9	42.6	0.75	0.74	43.2	42.7	1.35	1.34
2.2	9.9	28.3	0.35	0.33	20.2	19.3	2.04	1.95
1.8	8.2	22.3	0.37	0.31	21.2	18.2	2.59	2.21
8.3	16.9	22.2	0.76	0.83	43.9	48.1	2.60	2.85
4.5	6.9	11.5	0.60	0.47	34.6	27.2	5.02	3.95
6.2	8.8	18.2	0.48	0.61	27.9	35.1	3.17	3.99
2.0	4.5	18.7	0.24	0.32	13.9	18.7	3.09	4.16
3.7	5.0	23.1	0.22	0.42	12.5	24.1	2.50	4.83
0.7	1.6	8.9	0.18	0.27	10.4	15.4	6.48	9.63
1.5	2.6	12.8	0.20	0.30	11.7	17.4	4.51	6.68
1.7	1.9	25.1	0.08	0.31	4.4	17.9	2.30	9.42
4.5	7.5	14.6	0.51	0.47	29.6	27.2	3.95	3.63
2.3	0.5	8.0	0.06	0.34	3.6	19.6	7.21	39.15
1.6	2.5	12.9	0.19	0.31	11.2	17.6	4.47	7.05
2.5	1.5	8.5	0.18	0.35	10.2	20.2	6.79	13.45
2.7	2.9	13.8	0.21	0.36	12.1	20.8	4.18	7.17
0.5	1.9	11.5	0.17	0.26	9.5	14.9	5.02	7.87
0.6	1.1	7.8	0.14	0.26	8.1	15.2	7.40	13.79
1.7	1.1	7.8	0.14	0.31	8.1	17.9	7.40	16.26
$\bar{x}$							2.68	3.85
s							1.68	5.44
n							70	70
minimum							0.79	0.42
maximum							7.40	39.15

APPENDIX F MENSURAL DATA AND RATIOS USED FOR COMPUTING PRODUCTIVITY AND P/B RATIOS FOR LAMINARIA COLLECTED AT JAKOLOF BAY, 29 MARCH 1979

Sheet 1 of 3

Stipe Length (SL-cm)	Blade Length (BL-cm)	Blade Weight (B_O-g)	BW/BL A	BW/BL B	Production A	Production B	P/B_O A	P/B_O B
31.0	72.2	179.5	2.49	7.87	223.8	707.8	1.25	3.94
13.1	66.4	105.6	1.59	1.03	143.1	92.8	1.36	0.88
14.0	38.4	76.6	1.99	1.14	179.5	102.8	2.34	1.34
15.6	54.9	89.6	1.63	1.37	146.9	123.2	1.64	1.38
18.6	58.9	97.7	1.66	1.92	149.3	173.2	1.53	1.77
13.0	57.2	110.4	1.93	1.02	173.7	91.7	1.57	0.83
14.5	45.7	82.7	1.81	1.21	162.9	108.8	1.97	1.32
18.9	35.4	43.7	1.23	1.99	111.1	179.2	2.54	4.10
13.0	40.9	58.7	1.44	1.02	129.2	91.7	2.20	1.56
14.4	32.6	49.0	1.50	1.19	135.3	107.5	2.76	2.19
19.6	22.1	16.7	0.76	2.16	68.0	194.1	4.07	11.62
8.3	24.7	18.8	0.76	0.60	68.5	53.8	3.64	2.86
16.5	29.7	34.0	1.14	1.52	103.0	136.5	3.03	4.01
8.8	49.0	34.2	0.70	0.63	62.8	56.9	1.84	1.67
10.0	37.8	22.2	0.59	0.73	52.9	65.3	2.38	2.94
2.0	15.2	1.9	0.13	0.29	11.3	26.3	5.92	13.85
1.7	11.3	1.1	0.10	0.28	8.8	25.4	8.00	23.12
9.4	93.4	161.1	1.72	0.68	155.2	61.0	0.96	0.38
10.5	56.5	139.0	2.46	0.77	221.4	69.1	1.59	0.50
15.7	49.1	59.5	1.21	1.38	109.1	124.6	1.83	2.09
13.0	31.0	21.1	0.68	1.02	61.3	91.7	2.90	4.35
16.2	50.5	76.2	1.51	1.47	135.8	131.9	1.78	1.73
17.0	48.0	54.5	1.14	1.61	102.2	144.5	1.88	2.65
15.2	66.7	113.1	1.70	1.31	152.6	117.8	1.35	1.04
13.5	77.3	124.6	1.61	1.08	145.1	97.1	1.16	0.78
15.5	52.9	80.0	1.51	1.35	136.1	121.8	1.70	1.52
14.0	33.5	46.4	1.39	1.14	124.7	102.8	2.69	2.21
13.5	20.5	19.2	0.94	1.08	84.3	97.1	4.39	5.06
8.0	52.3	41.0	0.78	0.58	70.6	52.0	1.72	1.27
9.7	46.4	29.6	0.64	0.70	57.4	63.1	1.94	2.13
8.5	39.0	21.9	0.56	0.61	50.5	55.0	2.31	2.51
10.0	45.8	28.3	0.62	0.73	55.6	65.3	1.97	2.31
12.0	39.4	27.4	0.70	0.91	62.6	81.9	2.28	2.99
15.5	45.5	60.9	1.34	1.35	120.5	121.8	1.98	2.00
14.0	52.5	90.1	1.72	1.14	154.5	102.8	1.71	1.14
15.7	35.8	64.8	1.81	1.38	162.9	124.6	2.51	1.92
10.3	44.8	41.8	0.93	0.75	84.0	67.5	2.01	1.62
11.7	29.7	61.4	2.07	0.88	186.1	79.2	3.03	1.29

APPENDIX F MENSURAL DATA AND RATIOS USED FOR COMPUTING PRODUCTIVITY AND P/B RATIOS FOR LAMINARIA COLLECTED AT JAKOLOF BAY, 29 MARCH 1979

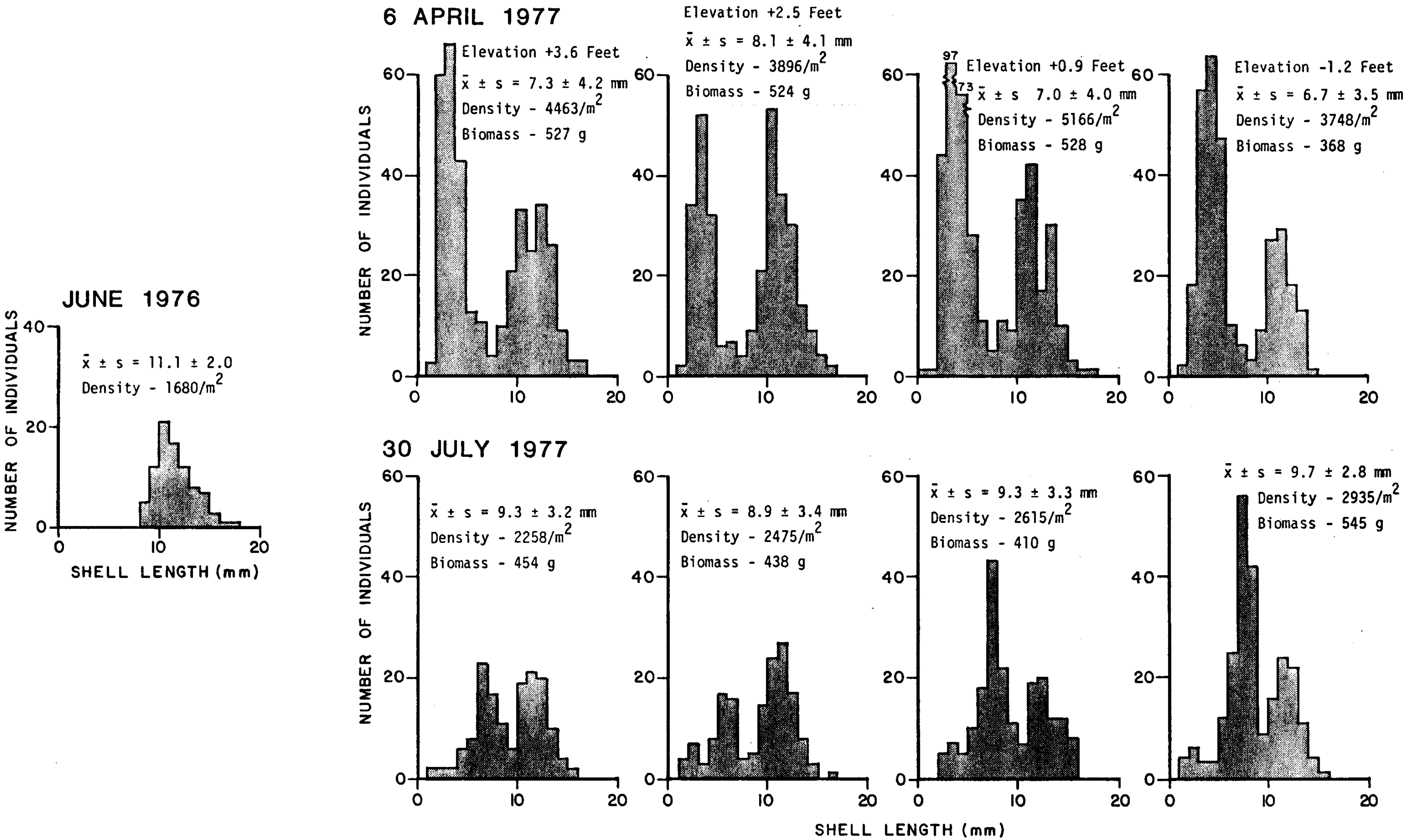
Sheet 2 of 3

Stipe Length (SL-cm)	Blade Length (BL-cm)	Blade Weight (B_O-g)	BW/BL A	BW/BL B	Production A	Production B	P/B_O A	P/B_O B
15.0	52.3	90.5	1.73	1.28	155.7	115.1	1.72	1.27
12.6	39.8	33.2	0.83	0.97	75.1	87.7	2.26	2.64
5.2	37.3	28.7	0.77	0.42	69.2	37.8	2.41	1.32
14.8	33.3	25.1	0.75	1.25	67.8	112.5	2.70	4.48
12.3	13.2	9.2	0.70	0.94	62.7	84.7	6.82	9.21
11.3	44.4	53.7	1.21	0.84	108.9	75.6	2.03	1.41
13.1	36.9	26.2	0.71	1.03	63.9	92.8	2.44	3.54
16.3	57.2	83.8	1.47	1.48	131.9	133.4	1.57	1.59
2.5	17.6	3.9	0.22	0.31	19.9	27.9	5.11	7.14
5.0	32.8	13.5	0.41	0.41	37.0	37.0	2.74	2.74
1.9	13.1	2.1	0.16	0.29	14.4	26.0	6.87	12.39
1.8	16.9	3.6	0.21	0.29	19.2	25.7	5.33	7.15
2.2	18.3	3.9	0.21	0.30	19.2	26.9	4.92	6.90
10.3	36.2	16.2	0.45	0.75	40.3	67.5	2.49	4.17
14.5	37.7	61.1	1.62	1.21	145.9	108.8	2.39	1.78
17.5	69.0	127.1	1.84	1.70	165.8	152.9	1.30	1.20
8.3	23.3	14.9	0.64	0.60	57.6	53.8	3.86	3.61
4.4	26.3	11.1	0.42	0.38	38.0	34.6	3.42	3.11
11.3	45.2	33.6	0.74	0.84	66.9	75.6	1.99	2.25
13.0	24.2	23.1	0.95	1.02	85.9	91.7	3.72	3.97
7.5	43.3	28.5	0.66	0.55	59.2	49.1	2.08	1.72
4.1	28.7	9.8	0.34	0.37	30.7	33.4	3.14	3.41
12.2	50.8	54.6	1.07	0.93	96.7	83.8	1.77	1.53
5.1	36.3	15.7	0.43	0.42	38.9	37.4	2.48	2.38
8.6	17.5	5.3	0.30	0.62	27.3	55.7	5.14	10.50
6.0	42.5	38.3	0.90	0.46	81.1	41.4	2.12	1.08
13.3	60.1	101.6	1.69	1.05	152.1	94.9	1.50	0.93
14.5	47.7	58.6	1.23	1.21	110.6	108.8	1.89	1.86
11.0	52.6	46.5	0.88	0.81	79.6	73.1	1.71	1.57
9.9	21.0	8.8	0.42	0.72	37.7	64.5	4.29	7.33
14.0	31.7	28.1	0.89	1.14	79.8	102.8	2.84	3.66
9.7	56.0	53.8	0.96	0.70	86.5	63.1	1.61	1.17
15.2	56.7	70.7	1.25	1.31	112.2	117.8	1.59	1.67
16.5	56.3	129.0	2.29	1.52	206.2	136.5	1.60	1.06
11.3	31.0	40.5	1.31	0.84	117.6	75.6	2.90	1.87
15.2	18.1	13.1	0.72	1.31	65.1	117.8	4.97	8.99
9.8	15.7	6.3	0.40	0.71	36.1	63.8	5.73	10.13
5.7	31.3	13.2	0.42	0.45	38.0	40.1	2.88	3.03

APPENDIX F MENSURAL DATA AND RATIOS USED FOR COMPUTING PRODUCTIVITY AND P/B RATIOS FOR LAMINARIA COLLECTED AT JAKOLOF BAY, 29 MARCH 1979

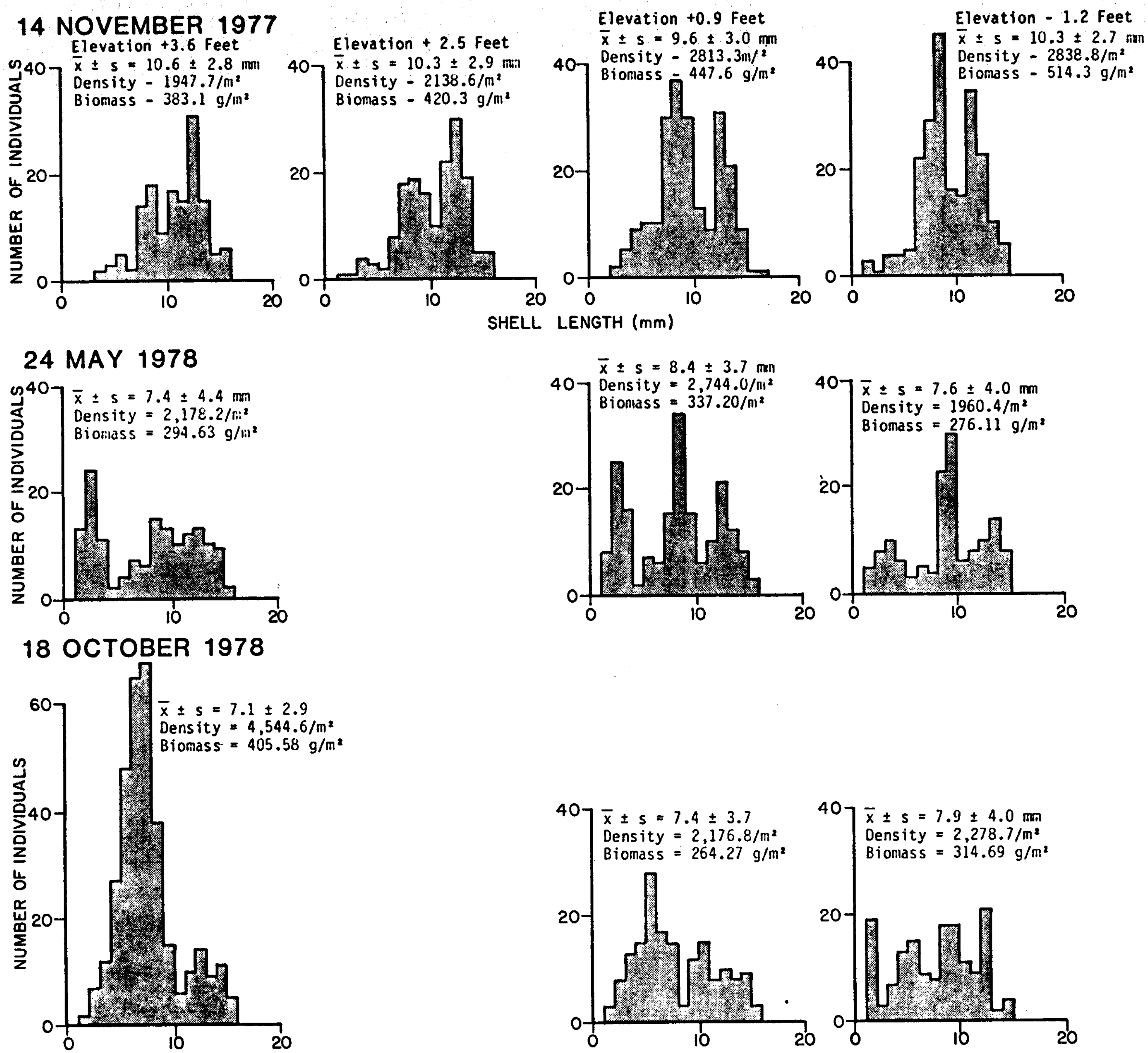
Sheet 3 of 3

Stipe Length (SL-cm)	Blade Length (BL-cm)	Blade Weight (B_o-g)	BW/BL A	BW/BL B	Production A	Production B	P/B_o A	P/B_o B
7.6	19.1	14.0	0.73	0.55	66.0	49.7	4.71	3.55
4.3	27.0	7.0	0.26	0.38	23.3	34.2	3.33	4.88
3.2	21.8	7.7	0.35	0.34	31.8	30.2	4.13	3.92
2.8	30.7	8.0	0.26	0.32	23.5	28.8	2.93	3.60
$\bar{x}$							2.79	3.53
s							1.46	3.63
n							80	80
minimum							0.96	0.38
maximum							8.00	23.12



APPENDIX G (1 of 2)

PATTERNS IN SIZE, ABUNDANCE AND BIOMASS FOR *Macoma balthica*
CHINITNA BAY



APPENDIX G (2 of 2)-PATTERNS IN SIZE, ABUNDANCE AND BIOMASS FOR *Macoma balthica*, CHINITNA BAY

APPENDIX H COMPUTATION OF ESTIMATED PRODUCTION OF THE 1976 0-YEAR CLASS OF <u>MACOMA BALTHICA</u> AT GLACIER SPIT, CHINITNA BAY

	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
Age (years)	0	.25	.5	.75	1	1.25	1.5	1.75	2	2.5	2.5	2.75	3	3.25	3.5	3.75	4	4.25	4.5
Average shell length (mm)	0.3	0.47	0.7	2.0	5.5	7.75	8.0	8.2	10.0	10.8	11.6	12.0	13.2	13.4	13.85	14.2	14.5	14.85	15.0
Density (no/m^2)*	50000	35802	21604	7407	2095	1448	1271	1149	1028	925	822	720	617	514	411	308	206	103	0
$\bar{D}$		42,901	28,708	14,505	4751.0	1771.5	1359.5	1210.0	1088.5	976.5	873.5	771.0	668.5	565.5	462.5	359.5	257.0	154.5	51.5
D		14,198	14,198	14,197	5312.0	647.00	177.0	122.0	121.0	103.0	103.0	102.0	103.0	103.0	103.0	103.0	102.0	103.0	103.0
Average Dry Tissue Wt.	0.00026	0.00159	0.00514	.08562	7.8051	7.815	9.68	6.685	18.59	24.75	30.03	21.045	40.90	47.49	51.13	31.90	64.49	64.69	65.03
$\bar{W}$		0.00092	.00336	.04538	3.8051	7.81005	8.7475	8.1825	12.6375	21.670	27.390	25.5315	30.9725	44.195	49.310	41.52	48.195	64.59	64.86
W		0.00133	.00355	.08048	7.71948	.0099	1.8650	-3.00	11.905	6.160	5.280	-8.9850	19.855	6.59	3.640	-19.23	32.590	0.200	0.340
P(= $\bar{D}$ W) (mg/m^2)		57.06	101.90	1167.40	35,675.25	17.54	2535.47												
E(= $\bar{W}$ D) (mg/m^2)		13.13	47.78	644.26	20,957.75	5053.10	1548.31	+3623.45	12,958.59	6015.24	4612.08	-6927.46	13,273.07	3726.65	1683.50	-6913.19	8375.63	30.9	17.51

P/B̄ = 3.40

E/B̄ = 3.40

P = 73.783

P = 73.796

B̄ = 21.7 g/m^2

P = 38.00 E = 21.66

P = 11.89 E = 9.13

P = 16.97 E = 10.85

P = 6.87 E = 18.82

P = 0.05 E = 13.33

* Initial density is probably a conservative estimate based on observations of Calvin and Myren (personal communication). Dry tissue weights are based on time-specific shell height-dry tissue weight regressions reported by Chambers and Milne (1975).

APPENDIX I COMPUTATION OF ESTIMATED PRODUCTION OF A HYPOTHETICAL "COHORT" OF <u>MACOMA BALTHICA</u>, BASED ON EBERT GROWTH-MORTALITY ESTIMATES

Age (years)	0	0.25	0.50	0.67	0.75	0.83	0.92	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Average shell length (mm)	0.30	0.5	2.6	3.9	4.5	5.1	5.8	6.11	10.6	13.0	14.4	15.1	15.5	15.75	15.9	15.9	16
Density (no/m^2)*	3992	3526	3060	2742	2593	2438	2276	2127	1133	604	3222	171	91	49	26	14	7
$\bar{D}$		3759	3293	2901	2667.5	2215.5	2357.0	2201.5	1630.0	868.5	463	246.5	131	70	37.50	20	10.5
D		466	466	318	149	155	162	149	994	529	282	151	80	42	23	12	7
Average Dry Tissue Wt.	0.0024	0.0048	0.2809	0.7782	1.0910	2.0569	4.6845	9.4543	27.07	39.77	48.20	52.69	55.34	57.02	58.05	58.05	58.73
$\bar{W}$		0.0036	0.1429	0.5296	0.9346	1.5740	3.3707	7.0694	18.2622	33.42	43.99	50.45	54.02	56.18	57.54	58.05	58.39
W		0.0024	0.2761	0.4973	0.3128	0.9659	1.6276	4.7698	17.6157	12.70	8.43	4.49	2.65	1.68	1.03	0	0.68
P(= $\bar{D}$ W) (mg/m^2)		9.02	909.20	1441.67	834.39	2429.72	6193.25	10,500.71	28713.59	11029.95	3903.09	1106.78	347.15	117.60	38.62	0	7.14
E(= $\bar{W}$ D) (mg/m^2)		1.68	66.57	168.40	139.26	243.96	546.05	1053.34	18152.58	17679.18	12403.77	7617.19	4321.20	2359.56	1323.3	696.60	408.73

Age (years)	11.0	12.0	13.0	14.0
Average shell length (mm)	16.0	16.0	16.0	16.0
Density (no/m^2)*	4	2	1	0
$\bar{D}$	5.5	3	1.5	0.5
D	3	2	1	1.0
Average Dry Tissue Wt.	58.73	58.73	58.73	58.73
$\bar{W}$	58.73	58.73	58.73	58.73
W	0	0	0	0
P(= $\bar{D}$ W) (mg/m^2)	0	0	0	0
E(= $\bar{W}$ D) (mg/m^2)	176.19	117.46	58.73	58.73

P = 22,318.96
P = 28,713.59
P = 11029.95
P = 3903.09
P = 1106.78
P = 510.51

E = 2219.25
E = 18,152.58
E = 17,679.18
E = 12,403.77
E = 7617.19
E = 4321.20
E = 2359.56
E = 1323.30
E = 696.60
E = 819.84

P = 67582.88
E = 67592.48

P/B = 3.11
E/B = 3.11

B = 21.7 g/m^2

* Initial density based on extrapolation from observed density of 0-year class in April, 1977. <u>Assumes</u> June recruitment. Dry tissue weights of 0-year class based on time specific shell height-dry tissue weight regressions reported by Chambers and Milne (1975), for later year classes, the June regression was used.

ECOLOGICAL CHARACTERIZATION OF SHALLOW SUBTIDAL HABITATS IN THE NORTH ALEUTIAN SHELF

by

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Fishman Environmental Services

Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 636

July 1986

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Field work was coordinated by Kathy Casson and assisted by Brooke Antrum, Carlos Coriano, Bill Kemp, Ed O'Connor, Val Paul and Greg Roberts. Taxonomic identifications were carried out by: Curt Smecher (sponges); John Ljubenkov (cnidarians); Howard Jones and Eugene Ruff (polychaetes); Mary Bergen, Ann Muscat and Alberto Larrain (echinoderms); Gretchen Lambert (tunicates); Paul Scott (molluscs); William Newman, Peter Slattery and Allan Vogel (crustaceans); William Banta (ectoprocts); and Tom Keegan and Jim Long (fishes). Data analyses and report preparation was conducted by Kathy Casson, Robert Cimberg, Dan Costa, Paul Fishman, Bill Kemp, Williey Knox, Ronald Simmons and Robert Smith.

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SECTION 1.0

SUMMARY

An integrated series of studies was conducted in the North Aleutian Shelf of the Bering Sea in 1982-83 to provide information for the assessment of potential impacts of oil and gas exploration and development on benthic biota-sea otter interactions. Most of the previous studies in the Bering Sea were conducted further offshore, removed from the large sea otter population. The objectives of the study were to determine the distribution of the major infaunal and epifaunal communities, the seasonal distribution and abundance of sea otters, the trophic relationships between sea otters and the benthic communities and the impacts of oil and gas exploration and development on these relationships. Three cruises were conducted during the spring, summer and fall of 1982 to investigate the benthic systems and to collect sea otter scats; four aerial surveys were flown during these same periods, as well as in March 1983, to investigate seasonal changes in sea otter habitat use.

The nearshore, shallow habitat (0-20 m) is homogeneous and consisted of well-sorted sands inhabited by an infaunal community with few species characterized by the razor clam *Siliqua patula*. Deeper habitats were more variable, with areas near the coastal embayments dominated by sand and inhabited by a rich infaunal community dominated by the sand dollar *Echinarachnius parma* and clams. Other deep areas removed from the embayments had greater amounts of gravel and are inhabited by a third, rich infaunal community characterized by polychaetes, particularly *Owenia*. The major epifaunal communities were dominated by yellowfin and rock sole and overlapped more with each other than did the infaunal communities. The distribution of these communities corresponded with substrate type and distance from embayments.

Sea otter abundance varied significantly with season, with the population nearly ten times greater in the summer than the winter. Highest habitat usage was in the Izembek Lagoon region and along the shallow, nearshore areas. Seasonal migration of the population is believed to occur from the Pacific through False Pass and Bechevin Bay into the Bering Sea. Seasonal and spatial distribution and abundance corresponded with the abundance of flatfish and crabs. The population of sea otters is believed to be feeding in the study area primarily on a diet composed of crabs, bivalves, fish and perhaps sand dollars, all of which are abundant in the benthos and are consistent with results from other Alaskan areas. The size of the sea otter population in the summer of 1982 did not differ significantly with results obtained in 1976. The movement of ice into the study area during the winter and spring of 1982 did not appear to affect the population significantly since most of the population was not present in the study area at that time.

A review of the literature indicates that oil slicks and blow-outs pose the most serious threats to the sea otter, particularly by fouling their fur. Additional impacts have been more indirect and involve disturbing feeding activity by blocking foraging areas or tainting prey items and/or sediments. The region off Izembek Lagoon, which was located in the study area, and probably Bechevin Bay and False Pass as well, are considered critical habitats to this population of sea otters. Additional sea otter studies on seasonal migration, population structure, feeding biology and responses to oil are recommended to more accurately determine potential impacts of oil and gas exploration and development.

SECTION 2.0

INTRODUCTION

2.1 Scope of Study

Proposed oil and gas exploration and development in the North Aleutian Shelf area of the Bering Sea has resulted in the need to provide the Bureau of Land Management (BLM) with information needed to make decisions and recommendations regarding oil lease areas; studies providing this information are managed through the Ocean Assessments Division of the National Ocean Services in the National Oceanic and Atmospheric Administration (NOAA).

The North Aleutian Shelf and Bering Sea in general is one of the richest fishery areas in the world and supports large populations of marine mammals, including sea otters. In contrast to the vast amount of information known about the deeper offshore areas, considerably less is known regarding the physical habitats, biota and dynamics of the nearshore system. This study investigated the benthic components of the nearshore ecosystem and their structural and functional interactions with the local sea otter population.

2.2 Specific Objectives

The specific objectives of this study were to describe: 1) the physical environment; 2) the dominant infaunal communities; 3) the dominant epifaunal communities; 4) the local sea otter population; 5) the prey of the sea otters and the dominant epibenthos; and 6) the potential impacts of oil and gas exploration and development on sea otter-benthic interactions.

2.3 Relevance to Petroleum Development

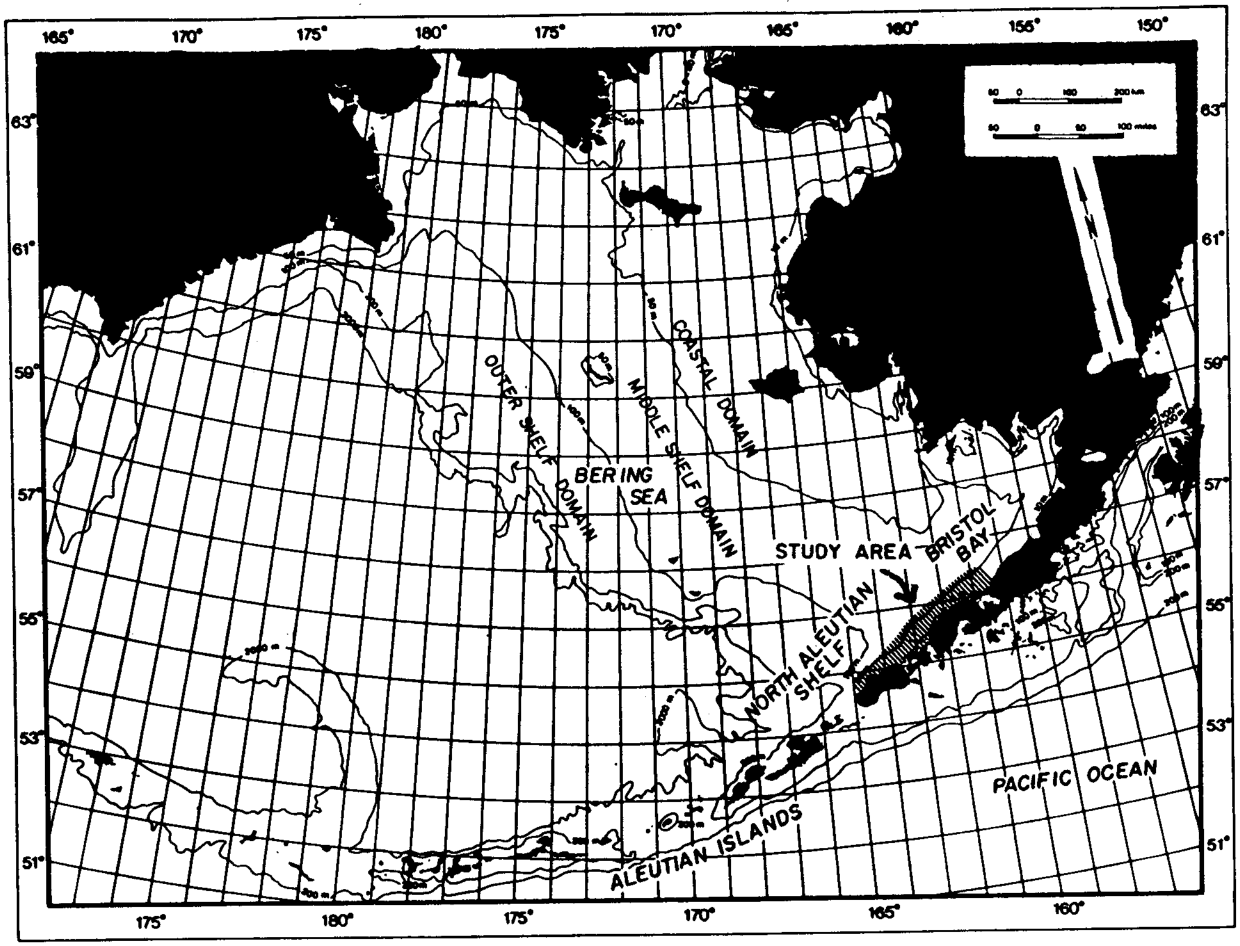
This study provides the first intensive investigation of the dominant and ecologically important bottom communities in the nearshore region and their importance to the sea otter population. This information provides the basis for addressing specific issues regarding impacts of oil and gas exploration and development on the biota. The impacts on the sea otter need to be addressed due to their status as a threatened species and their role as a top carnivore in the area. Studies on the distribution of the dominant epifaunal organisms and communities are important since many of the finfish and shellfish species are commercially important and are prey items of the otters. Investigations of the dominant infaunal communities provide additional information on both prey items of the sea otter and important epifauna. Understanding trophic interactions among the infauna, epifauna and sea otter is important since impacts may occur directly on the otter and/or indirectly on their feeding, an activity that requires approximately 30 percent of their time. Finally, knowledge of the physical environment enables an integration of the physical factors, infauna, epifauna and sea otters and provides an understanding of the forces that drive this system.

SECTION 3.0

STUDY AREA

The study was conducted in the North Aleutian Shelf (NAS) which is located in the southeast portion of the Bering Sea (Figure 3.0-1). This area represents the southwestern extension of the coastal domain, a nearshore hydrographic region defined as the area of the Continental Shelf landward of the 50 m isobath. Other areas of the Bering Sea, the Middle Shelf Domain (50-100 m in depth) and Outer Shelf Domain (100-200 m in depth), have received more attention (see Section 4.0).

The initial study area extended from Cape Mordvinof on Unimak Island to Cape Leontovich on the Alaska Peninsula and included the area from shore to the 50 m contour (Figure 3.0-2). These boundaries marked the highest concentration of sea otters in the area according to Schneider (1976). The study area was later extended west to Cape Sarichef and east to Cape Seniavin, and offshore to 60 m to accomodate field time with other projects. The added area is inhabited by a smaller number of otters and therefore provides a contrasting environment to the original, high dense otter habitat around Izembek Lagoon and Bechevin Bay.



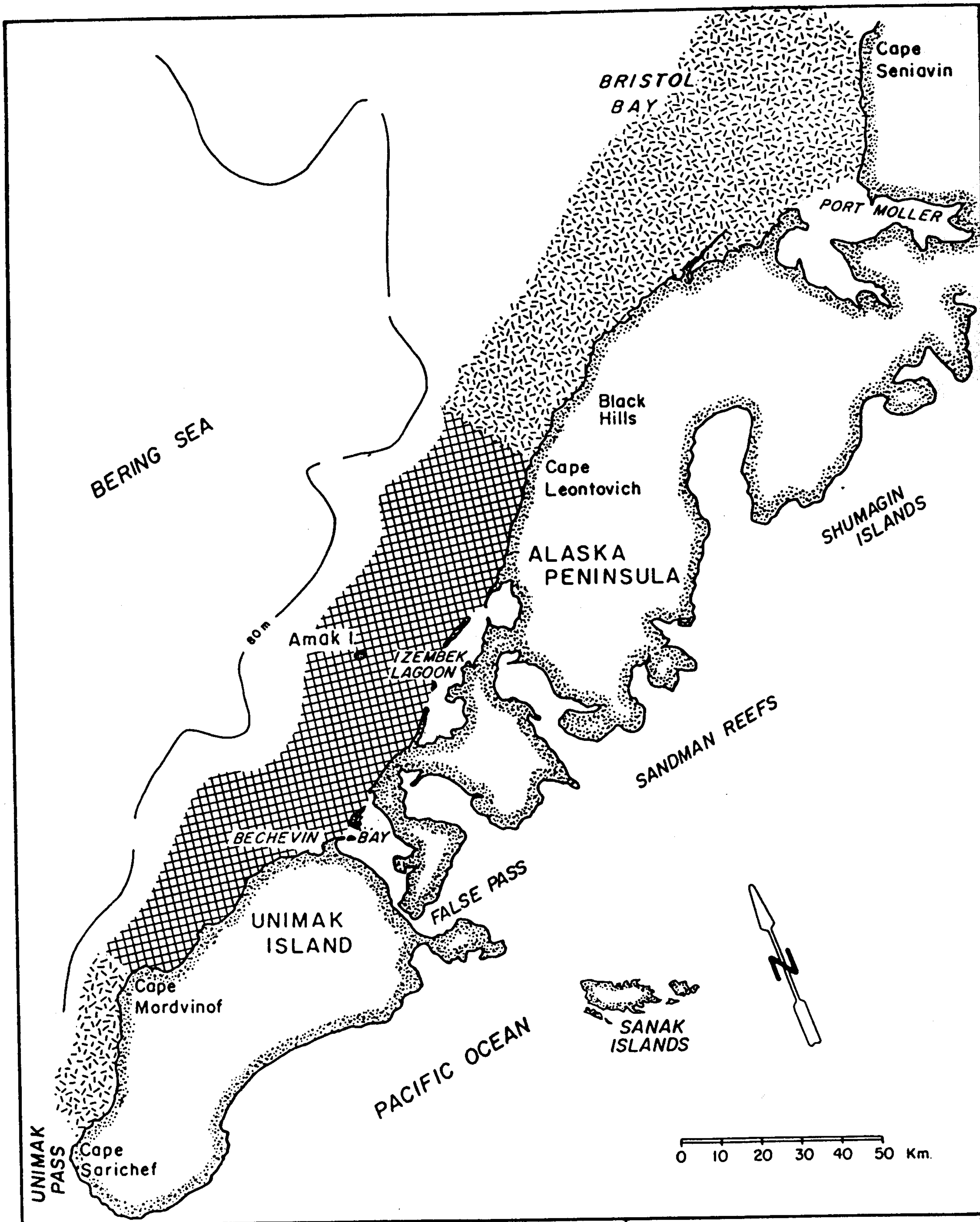
▨ = STUDY AREA

NORTH ALEUTIAN SHELF

LOCATION OF STUDY AREA

Map: Bering Sea

1982-1983	FIGURE 3.0-1



= INITIAL STUDY AREA

= EXPANDED STUDY AREA

vtn

NORTH ALEUTIAN SHELF

MAP OF STUDY AREA

1982-1983

FIGURE 3.0-2

SECTION 4.0

CURRENT STATE OF KNOWLEDGE

The number and scope of studies in the NAS region have increased in recent years as a result of interest in oil and gas exploration and development in the area. Much of this literature has been summarized in the form of review articles (Hood and Calder 1981) and as reports from synthesis meetings (Armstrong, et al. In prep.; Thorsteinson and Thorsteinson 1982). The following discussion highlights the current state of knowledge for the NAS, especially the nearshore area.

Physical Environment. Overall hydrographic conditions and processes on the eastern Bering Sea shelf are dominated by seasonal advances and retreat of ice cover and extensive fresh water discharge during spring and summer (Ingraham 1981). Ingraham (1981) identified three domains with distinct differences in water mass characteristics (Figure 3.0-1). The inner, or coastal domain extends landward from the 50 m isobath, forming a narrow region along the northern shore of the Alaska Penninsula. Water in the coastal domain is well mixed due to hydrographic and climatological events and as a result is hydrographically separated from the vertically stratified regime found seaward. A weak cyclonic circulation is evident around the perimeter of Bristol Bay in the coastal zone (Cline, et al. 1981). Seasonal variability within the study area has not been investigated.

The coastal zone of the NAS has not been extensively sampled for sediment characterization. Results from a small number of stations have been reported by Burrell, et al. (1981), Haflinger (1981) and McDonald, et al. (1981). Results indicate that the nearshore zone has sediments composed primarily of coarse to fine sands as well as silt; gravel areas were found off Unimak Pass and to the northeast of Port Moller. Alongshore and offshore variability in the study area has not been examined.

Benthic Infauna. Most of the information available concerning benthic infauna of the nearshore zone has been reviewed in Hood and Calder (1981). Previous infaunal surveys noted a higher biomass of invertebrates in the nearshore region offshore than at greater depths of the southeast Bering Sea shelf (Feder and Jewett 1981; Haflinger 1981). Specific studies on the distribution and abundance of selected bivalves species were conducted off Izembek Lagoon and Port Heiden (McDonald et al. 1981) and between Port Moller and Ugashik Bay (Hughes and Bourne 1981). Studies have not examined alongshore and offshore variability within the study area.

Benthic Epifauna. The benthic epifauna has been poorly sampled in the nearshore zone of the southeastern Bering Sea. A few stations were sampled between Unimak Island and Port Heiden by Feder and Jewett (1980); results indicate that red king crabs, Tanner crabs and seastars were the dominant organisms. The pelagic fish, bottom fish and shellfish resources of the Bering Sea have been extensively studied in deeper waters in relation to the commercial efforts directed towards a number of important species including:

Paralithodes camtschatica	Red king crab
Chionoecetes bairdi	Tanner crab *bairdi*
C. opilio	Tanner crab *opilio*
Theragra chalcogramma	Walleye pollock
Gadus macrocephalus	Pacific cod
Limanda aspera	Yellowfin sole
Hippoglossus stenolepis	Pacific halibut
Clupea harengus pallasi	Pacific herring
Lepidopsetta bilineata	Rock sole
Hippoglossoides elassodon	Flathead sole
Pleuronectes quadritubercalatus	Alaska plaice
Isopsetta isolepis	Butter sole

The nearshore area is important for the migration of some organisms and perhaps as nursery and rearing area for several species (Bakkala 1981; Best 1981; Favorite and Laevastu 1981; Pereyra et al. 1976; Smith 1981;

Thorsteinson and Thorsteinson 1982; Wespestad and Barton 1981). Salmon are extensively fished in the Bristol Bay area, and the nearshore zone is an important habitat for migrating adults and juveniles (Straty 1981; Thorsteinson and Thorsteinson 1982).

Sea Otters. Information regarding the sea otter population in the area has been reviewed by Kenyon (1969) and Schneider (1976, 1981). They reported that the area supports a large population (over 15,000 otters) including some of the largest pods (1,000 individuals) ever observed. Winter ice is believed to limit the northeast extension of this population in Bristol Bay (Kenyon 1969; Schneider 1976, 1981). Studies regarding their seasonal habitat use have not been conducted.

Trophic Interactions. Knowledge of the feeding biology of otters is limited to gut analyses from three animals in the Bering Sea (Kenyon 1969). The data (volume of stomachs) indicate feeding primarily on clams, hermit crabs and fish. The trophic interaction between the shallow benthic communities and the sea otters has not been previously addressed.

SECTION 5.0

METHODS AND MATERIALS

This study involved the integration of several field programs to address the six objectives. A summary of the methods used is provided in Table 5.0-1 with details of the field and laboratory procedures for each task discussed in the following subsections. An outline of the seven field trips involved in these studies is provided in Table 5.0-2.

5.1 Physical Environment

Physical parameters pertinent to the biota, namely surface and bottom temperatures and salinities as well as sediment parameters, were measured. These were monitored along a sampling grid of 11 transects with four depth contours (10, 30, 50 and 60 m) in June, August and October of 1982 (Table 5.1-1 and Figure 5.1-1).

Temperature and salinity (or conductivity) data were measured using the NOAA vessels CTD system. Sediment samples were taken from 0.25 m^2 Van Veen grab; three replicate core samples were obtained by inserting a 3 cm tube through the grab sample. Contents were transferred to plastic bags, frozen and returned to the laboratory. Grain size analysis followed procedures in Standard Methods for Particle Size Analysis (ASTM 1972) with modifications (see Appendix A). Data for each sample were reduced to calculate percent silt, percent sand, percent gravel, mean phi, geometric mean diameter (Loptspeich and Everest 1981) and sorting index (Krumbein and Pettyjohn 1938).

5.2 Benthic Infauna

Infaunal samples were taken with a Van Veen grab in order to provide comparable data to previous studies (Stoker 1981). An unweighted, 0.25

TABLE 5.0-1

SUMMARY OF METHODS USED FOR PROJECT TASKS

Task/Objectives	Equipment	Sampling Scheme	Data Generated	Products (Analysis)
1. Physical Factors Describe physical environment	0.25 m^2 Van Veen grab CTD	Grid of 11 transects with 4 depth contours in June, August, October 1982	Sediment parameters; surface and bottom temperatures, salinity	Spatial and seasonal means
2. Infauna Determine major infaunal communities	0.25 m^2 Van Veen grab	Grid of 11 transects with 4 depth contours; 1-5 replicates; June, August, October 1982	Densities of infaunal species greater than 1.0 mm	Dominant communities (cluster analysis); population trends (ANOVA/Duncan)
3. Epifauna Determine major epifaunal communities	Trynet trawl	Grid of 11 transects with 4 depth contours; 1-2 replicates; June, August, October 1982	Densities and biomass	Dominant communities (cluster analysis); population trends (ANOVA/Duncan)
4. Sea Otters Determine distribution/ abundance of sea otters	Aerial surveys	Contiguous quadrats (2 x 0.1 miles) along 43 transects	Densities	Population trends (ANOVA/Duncan)
5. Trophic Interactions Determine sea otter food web	Sea otter scats, fish guts	Beach surveys; 1 to 2 species of flatfish on 2 transects at 2 depths	Prey frequency per scat; prey number and volume per fish stomach	Fish, sea otter diets; area food web
6. Impact of Oil and Gas Determine impacts on sea otters and their habitat	Literature	Computer and manual searches	-	Impact-response matrix

TABLE 5.0-2

OUTLINE OF FIELD TRIPS

Dates	Data Collected[(a)] A	T/S	S	I	E	G	SC	O	Vessels or Aircraft
June 6-9, 1982	•								Gruman Goose
June 10 - July 2, 1982		•	•	•	•		•	•	NOAA ship *Miller Freeman*; *Monarch launch*
August 4-9, 1982	•								Gruman Goose; Piper Navaho
August 9-24, 1982		•	•	•	•	•	•	•	NOAA ship *Miller Freeman*; *Monarch launch*
October 15-23, 1982		•	•	•	•		•	•	NOAA ship *Discoverer*
October 23-28, 1982	•								Piper Navaho
March 10-12, 1983	•								Piper Navaho

(a) A = Aerial surveys, sea otters
T/S = Temperature and salinity
S = Sediment cores
I = Infaunal grabs
E = Epifaunal trawls
G = Flatfish guts
SC = Sea otter scats
O = Sea otter feeding observations

TABLE 5.1-1

LIST OF BENTHIC STATIONS, DATES, AND SAMPLES OBTAINED

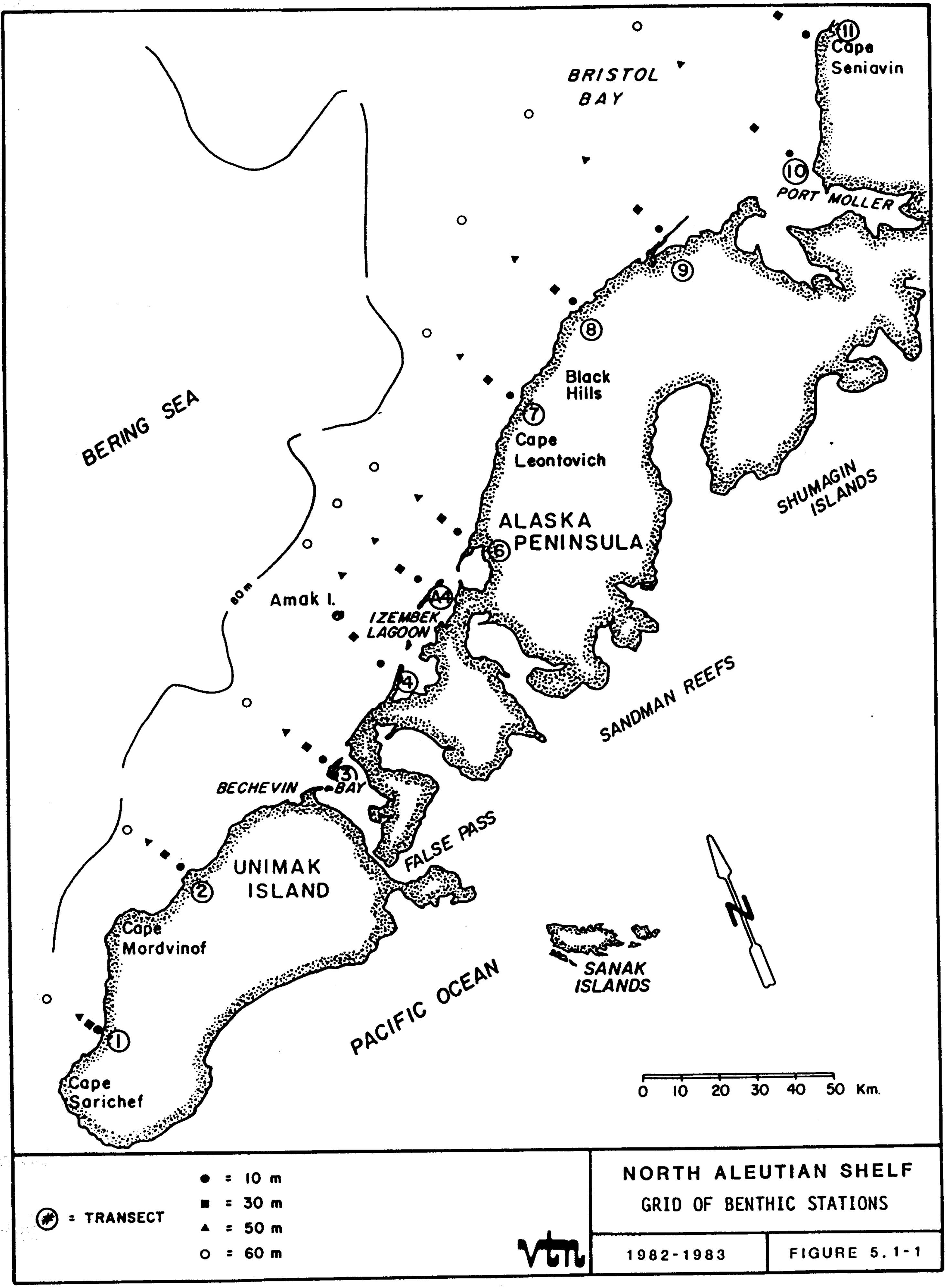
Station Transect	Depth Contour (m)	Location		Samples														
				June					August					October				
		Latitude	Longitude	H	S	I	E	G	H	S	I	E	G	H	S	I	E	G(a)
1	20	54°39.5'	164°45.1'	•	•		•					•						
	30	54°40.2'	164°45.3'				•					•						
	50	54°42.1'	164°49.0'				•					•						
	60	54°44.1'	164°48.8'								•	•						
2	10	54°58.6'	164°06.1'	•	•	•												
	30	55°00.9'	164°09.6'	•	•	•	•							•	•	•	•	
	50	55°05.5'	164°13.9'	•	•	•	•										•	
	60	55°09.0'	164°24.0'								•	•		•	•	•	•	
3	10	55°06.3'	163°26.7'			•												
	30	55°07.2'	163°28.8'	•	•	•	•					•	•			•	•	
	50	55°13.8'	163°33.1'	•	•	•	•										•	
	60	55°20.2'	163°39.9'						•		•	•		•	•	•	•	
4	10	55°17.1'	162°58.0'			•	•											
	30	55°21.2	163°01.8'	•	•	•			•	•				•	•	•	•	
	50	55°28.4'	163°07.8'			•	•											
	60	55°28.9'	163°23.1'						•		•	•		•	•		•	
A4	20	55°25.9'	162°50.2'									•						
	30	55°28.1	162°53.2'									•						
	50	55°34.9'	162°58.2'									•						
	60	55°38.2'	163°04.0'								•	•						
6	10	55°15.4'	163°03.6'	•	•		•											
	30	55°31.8'	162°34.0'	•	•	•	•					•		•	•	•	•	
	50	55°41.8'	162°42.1'	•	•	•			•	•		•						
	60	55°44.4'	162°49.4'								•	•		•	•	•	•	
7	10	55°46.0'	162°07.7'	•	•	•	•					•						
	30	55°46.9'	162°09.8'			•						•		•	•	•		
	50	55°52.6'	162°16.4'	•	•	•						•					•	
	60	56°39.6'	160°27.3'								•						•	

TABLE 5.1-1

(continued)

Station Transect	Depth Contour (m)	Location		Samples														
				June					August					October				
		Latitude	Longitude	H	S	I	E	G	H	S	I	E	G	H	S	I	E	G[a]
8	10	55°54.7'	161°44.5'									•						
	30	55°58.3'	161°46.9'									•						
	50	56°01.6'	161°49.0'	•	•	•	•					•					•	
	60	56°05.4'	161°55.3'								•	•						
9	30	56°05.2'	161°04.9'	•	•	•	•						•				•	
	50	56°11.5'	161°12.2'	•	•	•	•					•		•	•		•	
	60	56°26.5'	161°07.2'				•			•			•				•	
10	10	56°01.7'	160°37.4'	•	•	•												
	20	56°03.5'	160°43.6'									•					•	
	30	56°09.8'	160°45.2'	•	•	•											•	
	50	56°19.5'	160°53.7'	•	•	•											•	
	60	56°26.4'	161°04.0'											•	•		•	
11	10	56°24.0'	160°09.5'	•	•	•										•		
	30	56°29.6'	160°14.5'	•	•	•											•	
	50	56°34.8'	160°20.4'	•	•	•											•	
	60	56°35.1'	160°22.0'													•	•	

(a) H = Hydrography (surface and bottom temperature, bottom salinity)
S = Sediment
I = Infauna
E = Epifauna
G = Guts, flatfish
• = Samples obtained



NORTH ALEUTIAN SHELF

GRID OF BENTHIC STATIONS

1982-1983

FIGURE 5.1-1

m^2 grab was used in place of the desired weighted, 0.10 m^2 grab due to equipment unavailability. Samples were taken along a grid composed of 11 transects and four depth contours to survey the entire study area (Figure 5.1-1). Between one and five grabs were taken per station to compare within and between station variability. Samples were taken in June, August and October to examine seasonal variabiity of the infauna and for comparisons of available prey with sea otter abundance (Table 5.1-1).

Contents of each grab were sieved through a 1.0 mm screen, fixed with 10 percent buffered formalin and stained with rose bengal. Samples with large amounts of gravel were sorted in the field to separate the organisms from the large volume of retained sediments. In the laboratory, samples were sorted to major taxa and identified to the lowest practical taxonomic level and counted. Voucher samples of all species were sent to the California Academy of Sciences and the Smithsonian Institution.

Data analyses involved cluster analysis for community data and analysis of variance (ANOVA) for population data. Cluster analysis using EAP (1982) involved a square root transformation of all data and appropriate standardizations (square root of species means for analysis of sites and square root of species maximum for analysis of species). Dissimilarities or distances among the entities (sites or species) were calculated using the Bray-Curtis index (Bray and Curtis 1957). Formation of the two dendrograms and the two-way matrix of site and species groups involved flexible sorting with the addition of a step across distances re-estimation for the species groupings and the two-way matrix.

Population data were first analyzed using ANOVA (SAS 1982) to determine which environmental factors (depth and area) corresponded significantly ($p<.05$) with abundance values. A general linear model was used since the number of replicates among the different parameters were not equal. A Duncan multiple range test was also conducted on these data to note significant variability among all combinations of factors (e.g., transect 1 - depth 10 m - October with transect 10 - depth 60 m - June).

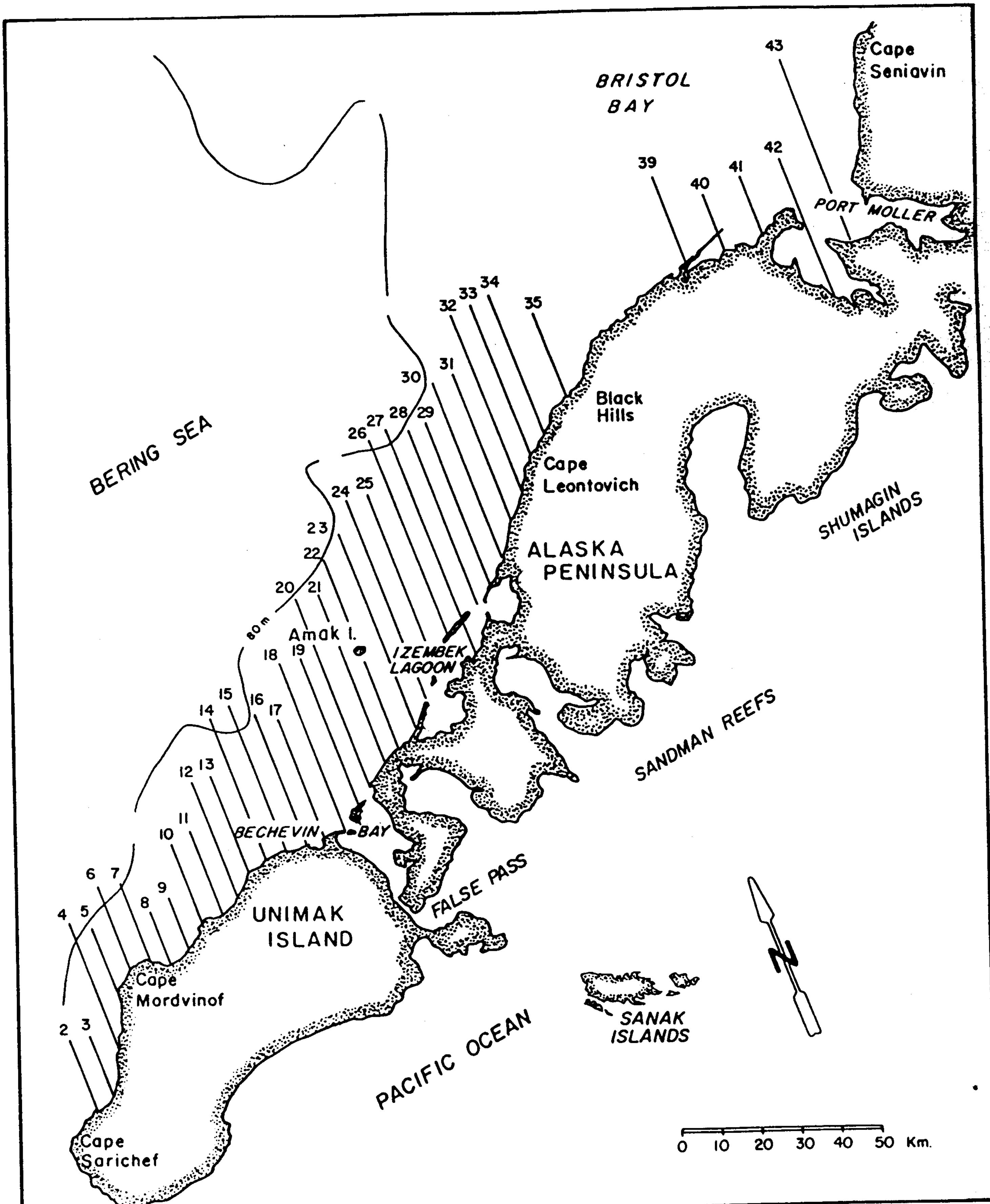
5.3 Benthic Epifauna

Epifaunal samples were taken with a trynet trawl equipped with a tickler chain to pick up organisms in the surface sediments. Originally an eastern otter trawl, fished for one-half to one hour, was chosen to provide results directly comparable to previous offshore studies. Such sampling resulted in over 11,000 pounds of fish caught per trawl and involved over 25 person hours to process. Instead, 20-minute trynet trawls were used since this procedure provided a more discrete sample of the bottom with less chance of sampling multiple habitats. Samples were taken during all three sampling dates and along the same sample grid as the physical data and infaunal samples (Table 5.1-1).

Fish and large invertebrates collected in the trawls were separated by species or the lowest practical taxonomic level, placed in pre-weighed baskets, weighed to the nearest ounce and counted. Smaller organisms were weighed on a triple beam or spring balance and counted. All species were vouchered. Vouchers were identified and/or verified in the laboratory. Data analyses were identical to those conducted for the infauna (Section 5.2) and involved cluster analyses for the community data and ANOVA/Duncan tests for the population data.

5.4 Sea Otters

The sea otter population was monitored using the same aerial transects and procedures established by Schneider (1976). These transects covered the entire study area and provided offshore variability out to 32 miles (Figure 5.4-1). Two observers were seated on each side of the plane. Each observer viewed a 0.1 mile strip of ocean below them using a strip of tape on the window as a guide to surface area. The plane flew along the transects at an altitude of 150-200 feet at 100 miles/hour. The total number of otters and presence of pups was logged along with the time from the beginning of the transect. These transects were flown in 1982 during June, August and October and in March 1983 to establish seasonal variability in habitat use (Table 5.4-1).



NORTH ALEUTIAN SHELF

AERIAL TRANSECTS SURVEYED

vtn

1982-1983

FIGURE 5.4-1

TABLE 5.4-1

LIST OF AERIAL TRANSECTS AND MONTHS SAMPLED

		1982			1983			1982			1983
Transect	Longitude	June	August	October	March	Transect	Longitude	June	August	October	March
2	164°50'		•	•	•	22	163°10'		•	•	•
3	164°45'		•	•	•	23	163°05'	•	•	•	•
4	164°40'		•	•	•	24	163°00'		•	•	•
5	164°35'		•	•	•	25	162°55'	•	•	•	•
6	164°30'		•	•	•	26	162°50'		•	•	•
7	164°25'		•	•	•	27	162°45'	•	•	•	•
8	164°20'		•	•	•	28	162°40'		•	•	•
9	164°15'		•	•	•	29	162°35'	•	•	•	•
10	164°10'	•	•	•	•	30	162°30'		•	•	•
11	164°05'	•	•	•	•	31	162°25'	•	•	•	•
12	164°00'		•	•	•	32	162°20'		•	•	•
13	163°55'	•	•	•	•	33	162°15'	•	•	•	•
14	163°50'		•	•	•	34	162°10'		•	•	•
15	163°45'	•	•	•	•	35	162°00'	•	•	•	•
16	163°40'		•	•	•	39	161°20'	•	•	•	•
17	163°35'	•	•	•	•	40	161°10'	•	•	•	•
18	163°30'		•	•	•	41	161°00'	•	•	•	•
19	163°25'	•	•	•	•	42	160°50'	•	•	•	•
20	163°20'		•	•	•	43	160°40'	•	•	•	•
21	163°15'	•	•	•	•	Bechevin Bay		•	•	•	•
						Izembek Lagoon		•	•	•	•

• = Dates sampled

Data were treated in two manners. One method lumped all values per transect. From these values the population of the area was estimated following the procedures of Schneider (1976). The total number of otters counted was adjusted for the difference in size between the area counted (506 km^2) and the total study area (7,125 km^2). In June, poor weather precluded the sampling of all transects. This treatment resulted in an estimate of the total number of otters per transect per season. Duncan's multiple range test was conducted on these data to determine if there were significant differences ($p<.05$) among seasonal data.

Data were also grouped into contiguous quadrats, 0.1 mile wide by 2 miles long, along the transects. These data were extremely patchy with many quadrats having no otters, while a few quadrats contained many animals. Densities were therefore transformed by ranking each quadrat value; the largest value received the highest rank but only 1 higher than the next largest value regardless of the actual numerical difference. Populational analyses involving ANOVA and Duncan's multiple range tests as described in previous sections were conducted to determine significance of season, depth and along-shore variability.

5.5 Trophic Interactions

Trophic studies were conducted on two dominant species of fish, yellowfin (*Limanda aspera*) and rock sole (*Liopsetta bilineata*), as well as on the sea otters. Gut samples of the fish were taken in August along two transects at two depths to determine if flatfish diet varied in heavily used sea otter areas (transect 3) and depths (30 m) versus areas and depths of less use (transect 9 and 60 m, respectively) (Figure 5.1-1). Ten individuals of each species, covering their entire size range, were sampled. Size and sex were determined for each fish. Stomachs were removed and emptied; contents were sorted to species or lowest identifiable level, counted and volume estimated. All prey vouchers were identified and/or confirmed in the laboratory. Data were reduced to determine mean values per area and depth for each fish species.

Studies of sea otter prey were conducted by collecting scats in haulout areas and fixing them in 90 percent ethanol to prevent decalcification. These samples were sorted in the lab and identified by the same taxonomists who examined the benthic samples. Other methods were tried and proved less successful. Observations from land on Amak Island using sighting scopes were limiting since the sea otters were too far away for scientists to be able to observe prey items being ingested. Observations through binoculars from small skiffs were limited for the same reasons. Direct underwater observations of feeding were not successful during the 80 hours of dives made by scientists. Attempts to collect food scraps using SCUBA or trawl were not successful.

5.6 Impacts of Oil and Gas Development

Information concerning the impacts of oil and gas exploration and development on sea otters was obtained from the literature.

SECTION 6.0

RESULTS AND DISCUSSION

6.1 Physical Environment

Bathymetry. Though bathymetry was not monitored as part of this study, this physical factor is important in evaluating the quality and quantity of the sea otter habitat. Shallow water habitats are needed by the otters in order to forage since these animals cannot dive deeper than 60 m. Depth contours examined from NOAA charts indicate that shallow areas with depths less than 60 m is greater in the eastern part of the study area due to the gradual slope in this region (Figure 3.0-2). In addition, regions at the entrances to the two major embayments (Bechevin Bay-Izembek Lagoon and Port Moller) extend further inland than other areas. As a result, the shallow water areas of potential sea otter habitats are largest off these two coastal embayments.

Hydrography. Water temperatures and salinity values taken during each cruise are listed in the Appendix B. Mean values for each area and depth interval are presented in Table 6.1-1. Variability in the temperature data was noted with season, area and bottom depth. Mean surface water temperature over the study period was 6.6°C with highest temperatures in August (9.0°C), followed by October (6.9°C) and June (6.6°C). Mean bottom temperatures were likewise warmest in August (7.9°C), followed by October (6.9°C) and June (6.1°C).

Among subareas, temperatures of both surface and bottom waters were highest in the Izembek-Black Hills areas and lowest in the more peripheral portions of the study area. This difference could be attributed to warm waters moving from Bechevin Bay and/or Izembek Lagoon. These warm waters would be carried northeast along the counterclockwise gyre into the Black Hills area towards Port Moller (Kinder and Schumacher

TABLE 6.1-1

MEAN TEMPERATURE AND SALINITY VALUES

Area	Transects	June 0-20 (m)	June 21-40 (m)	June 41-60 (m)	August 0-20 (m)	August 21-40 (m)	August 41-60 (m)	October 0-20 (m)	October 21-40 (m)	October 41-60 (m)
Surface Temperatures (%)										
Unimak	1-2	6.0	6.2	-	7.9	7.9	8.4	6.6	6.8	6.8
Izembek	3-6	7.5	6.7	6.0	9.8	9.3	9.0	6.6	7.0	7.0
Black Hills	7-8	-	10.1	9.2	-	10.1	9.2	-	6.7	7.2
Port Moller	9-11	9.3	9.3	8.9	9.3	9.4	8.9	6.7	6.9	7.3
Bottom Temperatures (°C)										
Unimak	1-2	6.1	6.0	-	8.2	7.7	7.2	6.8	6.7	6.8
Izembek	3-6	6.3	6.2	5.0	9.0	8.7	6.6	6.8	6.9	6.9
Black Hills	7-8	7.5	7.1	-	9.5	9.2	7.3	7.0	6.9	7.1
Port Moller	9-11	-	-	-	9.2	9.2	7.5	7.1	6.8	7.3
Stratification (Surface-Bottom Temperatures)										
Unimak	1-2	-0.1	+0.2	-	-0.3	+0.2	+1.2	-0.2	+0.1	0.0
Izembek	3-6	+1.2	+0.5	+1.0	+0.8	+0.6	+0.4	-0.2	+0.1	+0.1
Black Hills	7-8	-	-3.0	-	-	+0.9	+1.8	-	-0.2	+0.1
Port Moller	9-11	-	-	-	+0.1	+0.2	+1.4	-0.4	+0.1	0.0
Bottom Salinities (°/oo)										
Unimak	1-2	-	-	-	-	-	-	31.92	31.76	32.01
Izembek	3-6	-	-	-	-	-	-	31.81	31.76	32.07
Black Hills	7-8	-	-	-	-	-	-	31.72	31.65	31.97
Port Moller	9-11	-	-	-	-	-	-	31.37	31.10	32.26

- = No data

1981). Water temperatures decreased also with depth. This trend was most evident in June and August; October temperatures were more uniform. The decreased stratification could be attributed to fall storms and decreased solar radiation.

Bottom salinity values were calculated for October. Values ranged from 31.10 to 32.26 $^{0}/oo$. Values varied with depth and area. Overall, the deepest depth interval (41-60 m) had the highest salinities. The mid-depth interval (21-40 m) had unexpectedly lower salinities than the shallow depth ranges (0-20 m).

Shallow salinities (0-20 and 21-40 m) each showed an alongshore trend. Salinities were lower along transects closer to Port Moller. This could be attributed to greater surface runoff in this region. The inverse trend occurred at the deeper depth interval (41-60 m). Bottom salinities, with the exception of the Black Hills region, increased at transects closer to Port Moller.

Sediments. Sediment characteristics for each sample are presented in Table 6.1-2. The relationship between sediments and benthic communities presented in the table is discussed in Section 6.2. Most of the study area was composed of well-sorted sands, with gravel and silt components usually comprising a small proportion of the sedments. Variability in these components was noted between areas and depths (Table 6.1-3).

The abundance of sand per area ranged from a low of 33.9 percent at 21-40 m depth interval off Black Hills, to a high of 97.6 percent in the shallowest area off Izembek. Overall the largest percentages of sand (>92%) were found at all depth intervals in the Izembek area and at the shallow (0-20 m) and deep (41-60 m) depths in the other areas. The lowest percentages of sand (<88%) were found at intermediate depths (21-40 m) in the Black Hills, Unimak and Port Moller areas.

The abundance of gravel ranged from 0 percent in the Izembek area at 0-20 m and 41-60 m depth intervals to 64.8 percent in the Black Hills

TABLE 6.1-2

SEDIMENT CHARACTERISTICS AND BENTHIC COMMUNITIES

Transect	Depth (m)	Month	Infaunal Community	Gravel (%)	Sand (%)	Silt (%)	Mean Diameter (d_g)	Mean (Ø)	Sorting Index (S_i)
1	30	June	-	0.6	87.4	12.0	0.15	2.74	1.31
1	50	June	-	0.7	85.7	13.6	0.14	2.84	1.31
2	10	June	I	0.1	93.6	6.3	0.15	2.74	1.27
2	30	June	IIA	36.6	62.7	0.7	2.37	-1.24	3.07
2	30	October	IIA	20.6	78.6	0.8	2.02	-1.01	1.77
2	50	June	IIA	6.8	92.9	0.3	1.24	-0.31	1.64
2	60	October	I	0.0	99.2	0.8	0.39	1.36	1.47
3	30	June	IIB	0.1	93.3	6.6	0.15	2.74	1.21
3	50	June	IIB	0.0	94.5	5.5	0.18	2.47	1.29
3	60	October	IIB	0.0	99.3	0.7	0.76	0.40	1.52
4	10	June	I	0.0	97.6	2.4	0.18	2.47	1.28
4	30	August	-	5.2	94.3	0.5	2.06	-1.04	1.34
4	30	October	I	0.0	95.7	4.3	0.17	2.56	1.36
4	30	June	IIB	0.0	99.3	0.7	0.39	1.36	1.37
4	60	October	IIB	0.0	95.6	4.4	0.17	2.56	1.28
6	10	June	-	0.2	99.7	0.1	0.21	2.25	1.18
6	30	June	IIA	65.9	32.3	1.8	4.91	-2.30	1.98
6	30	October	-	46.0	53.3	0.7	4.20	-2.07	1.98
6	50	June	IIB	0.0	98.1	1.9	0.19	2.02	1.25
6	50	August	-	0.0	97.6	2.4	0.23	2.12	1.37
6	60	October	IIB	0.0	97.6	2.4	0.21	2.25	1.26
7	10	June	I	0.0	93.0	7.0	0.14	2.84	1.21
7	30	October	IIA	82.4	16.0	1.6	5.65	-2.50	1.56
7	50	June	IIA	4.3	95.3	0.4	0.93	0.10	1.90
8	50	June	IIB	0.8	99.0	0.2	0.61	0.71	2.29
9	30	June	IIB	4.5	93.7	1.8	1.11	-0.15	1.88
9	30	June	-	0.0	98.0	2.0	0.24	2.06	1.23
9	60	October	-	0.2	99.4	0.4	0.25	2.00	1.26
9	50	June	IIB	0.0	97.2	2.8	0.22	2.18	1.19
10	10	June	I	0.0	97.3	2.7	0.17	2.56	1.28
10	30	June	IIB	0.1	98.0	1.9	0.19	2.40	1.26
10	50	June	IIB	7.0	92.0	1.0	0.77	0.38	2.64
10	60	October	-	0.0	98.8	1.2	0.21	2.25	1.22
10	60	October	-	0.0	99.3	0.7	0.21	2.25	1.22
11	10	October	IIB	3.9	95.6	0.4	1.63	-0.70	1.48
11	30	June	IIA	8.6	88.3	3.1	1.29	-0.37	1.69
11	30	June	-	42.1	57.4	0.5	2.53	-1.34	3.37
11	50	June	IIB	0.5	96.6	2.9	0.31	1.69	1.38

- = Not sampled

TABLE 6.1-3

SUMMARY OF SEDIMENT CHARACTERISTICS BY AREA AND DEPTH

Area	Transects	Percent Sand by Depth (m)			Percent Gravel by Depth (m)			Percent Silt by Depth (m)		
		0-20	21-40	41-60	0-20	21-40	41-60	0-20	21-40	41-60
Unimak	1-2	93.6	76.2	92.6	0.1	19.2	2.5	6.3	4.5	4.9
Izembek	3-4	97.6	95.6	96.5	0.0	1.8	0.0	2.4	3.0	3.5
Black Hills	6-8	96.4	33.9	97.5	0.1	64.8	1.0	3.6	1.4	1.5
Port Moller	9-11	96.5	87.1	97.2	2.0	11.1	1.3	1.6	1.9	1.5

Area	Transects	Mean Diameter by Depth (m)			Mean Phi (Ø) by Depth (m)			Sorting Index(So) by Depth (m)		
		0-20	21-40	41-60	0-20	21-40	41-60	0-20	21-40	41-60
Unimak	1-2	0.15	1.51	0.59	2.74	0.16	1.30	1.27	2.05	1.47
Izembek	3-4	0.18	0.92	0.37	2.47	1.41	1.81	1.28	1.32	1.36
Black Hills	6-8	0.18	4.92	0.43	2.56	2.29	1.46	1.20	1.84	1.70
Port Moller	9-11	0.90	1.10	0.32	0.93	0.65	1.79	1.38	1.89	1.50

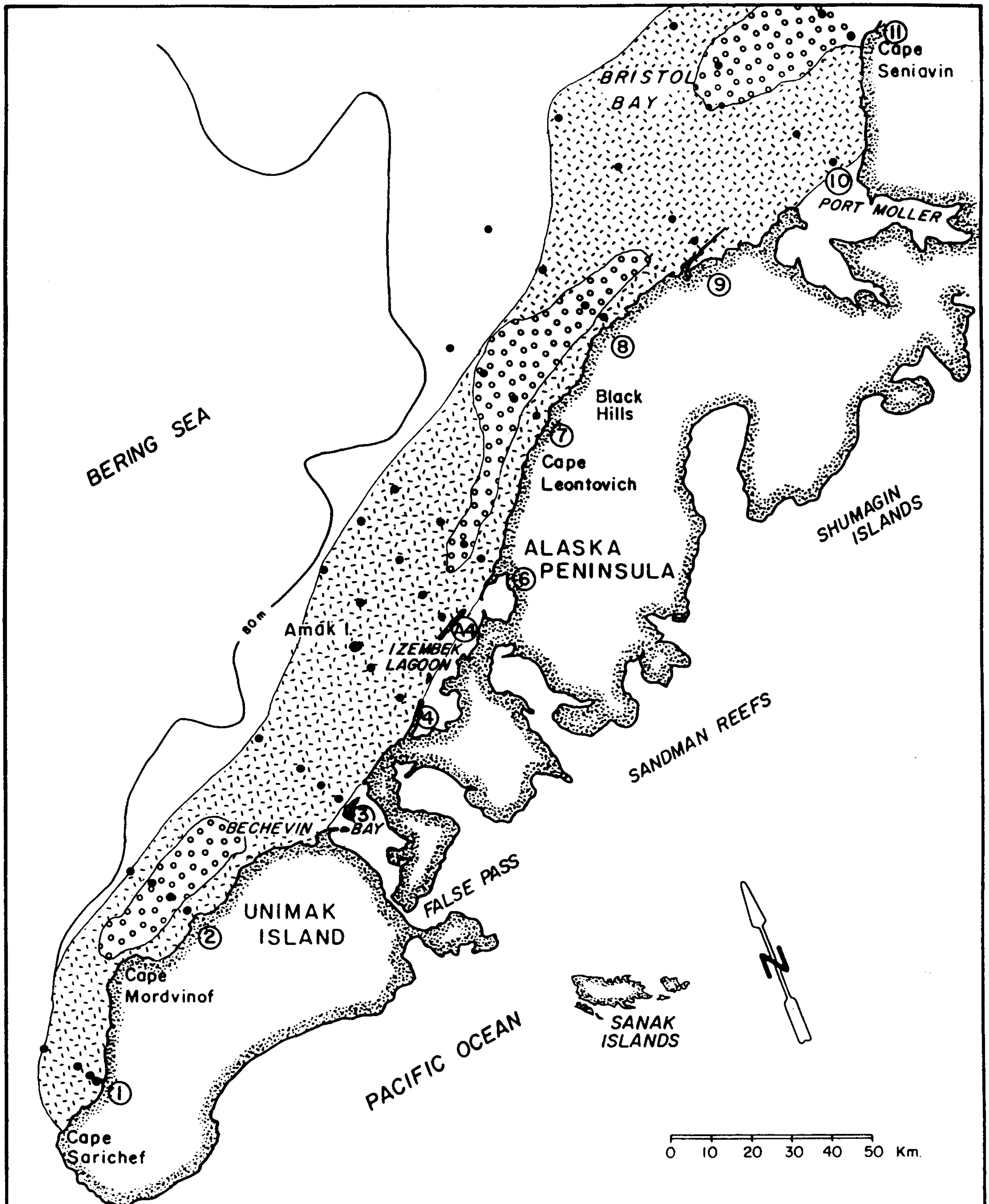
region at the 21-40 m depth interval. Overall, the Unimak and Black Hills areas had the highest gravel composition at the 21-40 m depth interval.

Silt composition per station ranged from 0.1 percent on transect 6 at 10 m to 12.0-13.6 percent on transect 1. Overall, the largest percentages were found in the Unimak area for all depth intervals, whereas the lowest percentages were found in the Port Moller area. The small percentage of silt east of Cape Mordvinof could be attributed to swifter currents which prevent most of these smaller particles from settling to the bottom.

Phi size provides a good index of overall grain size, with larger grain sizes having a smaller phi value. All sediment samples had a phi less than 3.0, indicating sandy substrates (Table 6.1-2). Previous studies along the Bering Sea shelf at depths less than 60 m also reported sediments with phi sizes less than 3.0 (Sharma 1979). Phi size varied with area and depth. The smallest phi values (less than +0.65) occurred at the 21-40 m depth interval in all areas except Black Hills. Conversely, the shallower (0-20 m) and deeper (41-60 m) intervals had a larger phi (>+1.30), or smaller grain size.

The variability of grain sizes within a sample was computed using a sorting coefficient (S_i). A perfectly sorted sample with no variability in grain size has a S_i of 1. The S_i values among individual samples ranged from 1.19 to 3.37. Sorting index values varied with area and depth. Well-sorted values (<1.71) occurred in the shallower (0-20 m) and deep (41-60 m) intervals for all areas as well as the 21-40 m interval for Izembek. The other areas (Unimak Island and Black Hills) had poorer sorted samples, particularly at 30 m. This trend is due to the mixed sand and gravel components in these areas.

Sediment composition was plotted for the entire study area in Figure 6.1-1; variability with depth and location can be noted along the shore.



• = STATION
(#) = TRANSECT
= SAND
= SAND AND >1% GRAVEL

NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF SOFT SEDIMENT TYPES

1982-1983

FIGURE 6.1-1

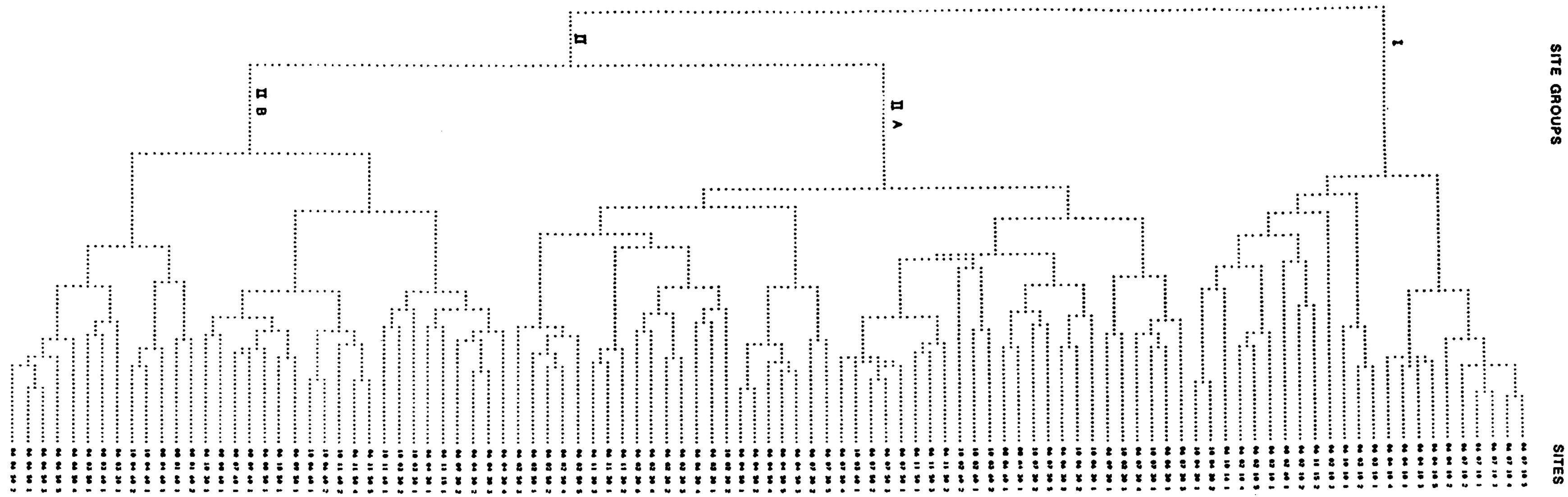
Substrates dominated by sand (93-99.4%) with low percentages of gravel (<1%) were found at all shallow water (10 m) and at deep water stations (50-60 m) near the two embayment systems, Izembek Lagoon-Bechevin Bay and Port Moller. Areas with sand (16.0-92.9%), but with greater amounts of gravel (1.0-82.4%), were found primarily at 30 m off central Unimak Island, Black Hills and Cape Seniavin, areas removed from these embayments.

The major components of the sediments were sand and gravel. The lack of silt, the large phi size and low sorting coefficient is attributed to a high energy environment. Water movement is strong enough to prevent the fine and medium sands from settling. Sharma (1979) noted that winter and summer surface waves have sufficient energy to move sediments at depths as deep as 40-60 m.

6.2 Benthic Infauna

A taxonomic species list of all organisms identified from the infaunal grabs is provided in Appendix C. This list indicates that species composition of the area is dominated by polychaetes, crustaceans, molluscs and echinoderms.

Raw data from each grab during the three cruises is presented in the Appendix D. Classification analysis of these data resulted in the generation of a dendrogram that grouped the sites (Figure 6.2-1). Inspection of this figure indicates the presence of two major site groups (I,II), with one composed of two subgroups (IIA, IIB). Site groups represent different assemblages of organisms in different habitats and are therefore referred to as communities. The distribution of these three groups was compared with physical parameters (season, depth, transect location and grain size) to determine which one(s) corresponded best with and therefore could separate the three site groups. Results indicate that depth and percent gravel are the key physical factors separating communities (Figure 6.2-2). Such comparisons are not available for each sample since sediment samples were not taken for each biological grab.



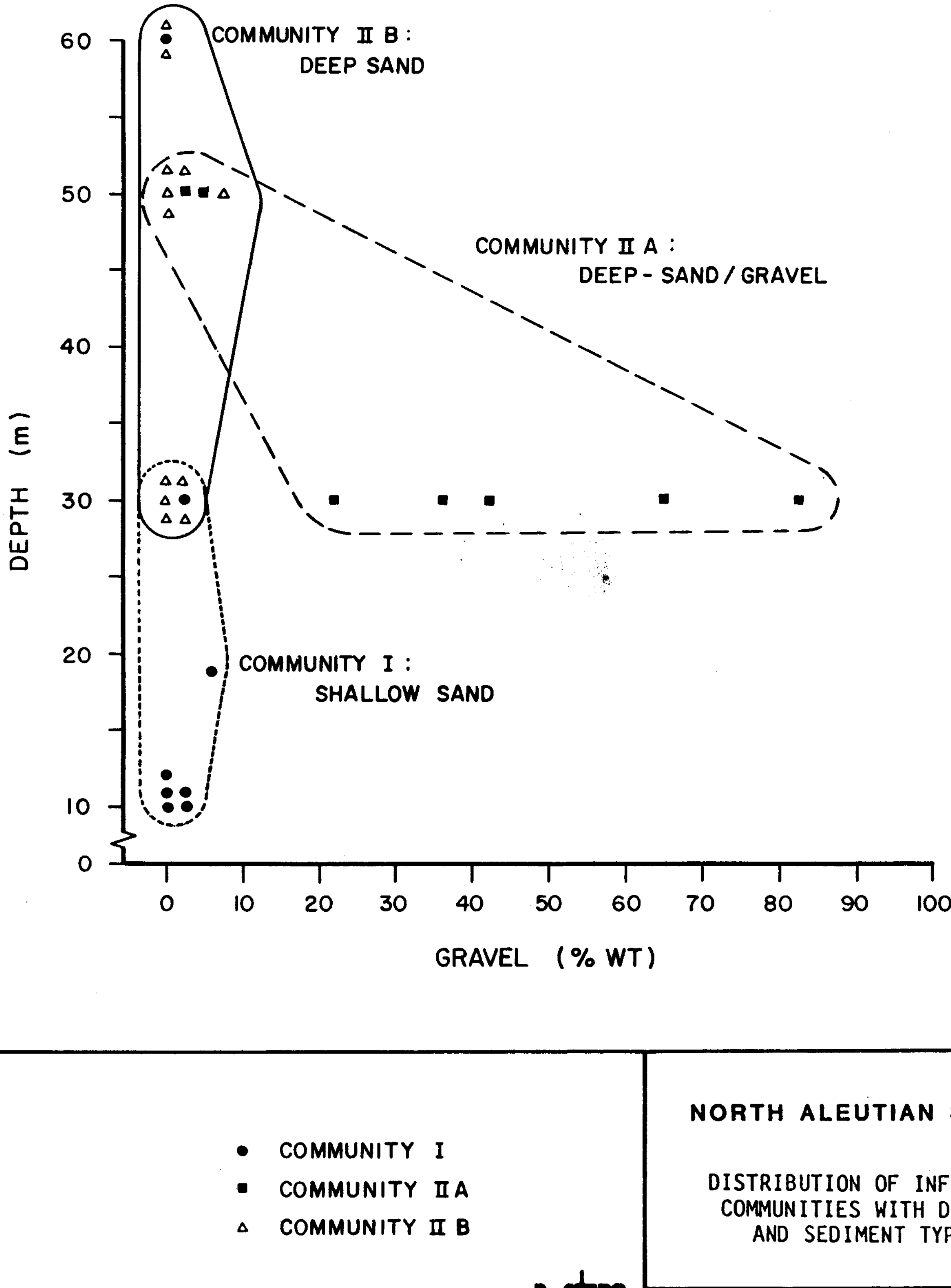
SITES MONTH-TRANSECT-DEPTH-REPLICATE

NORTH ALEUTIAN SHELF

SITE DENDROGRAM FROM INFAUNAL SAMPLES

1982-1983

FIGURE 6.2-1



NORTH ALEUTIAN SHELF

DISTRIBUTION OF INFAUNAL COMMUNITIES WITH DEPTH AND SEDIMENT TYPE

1982-1983

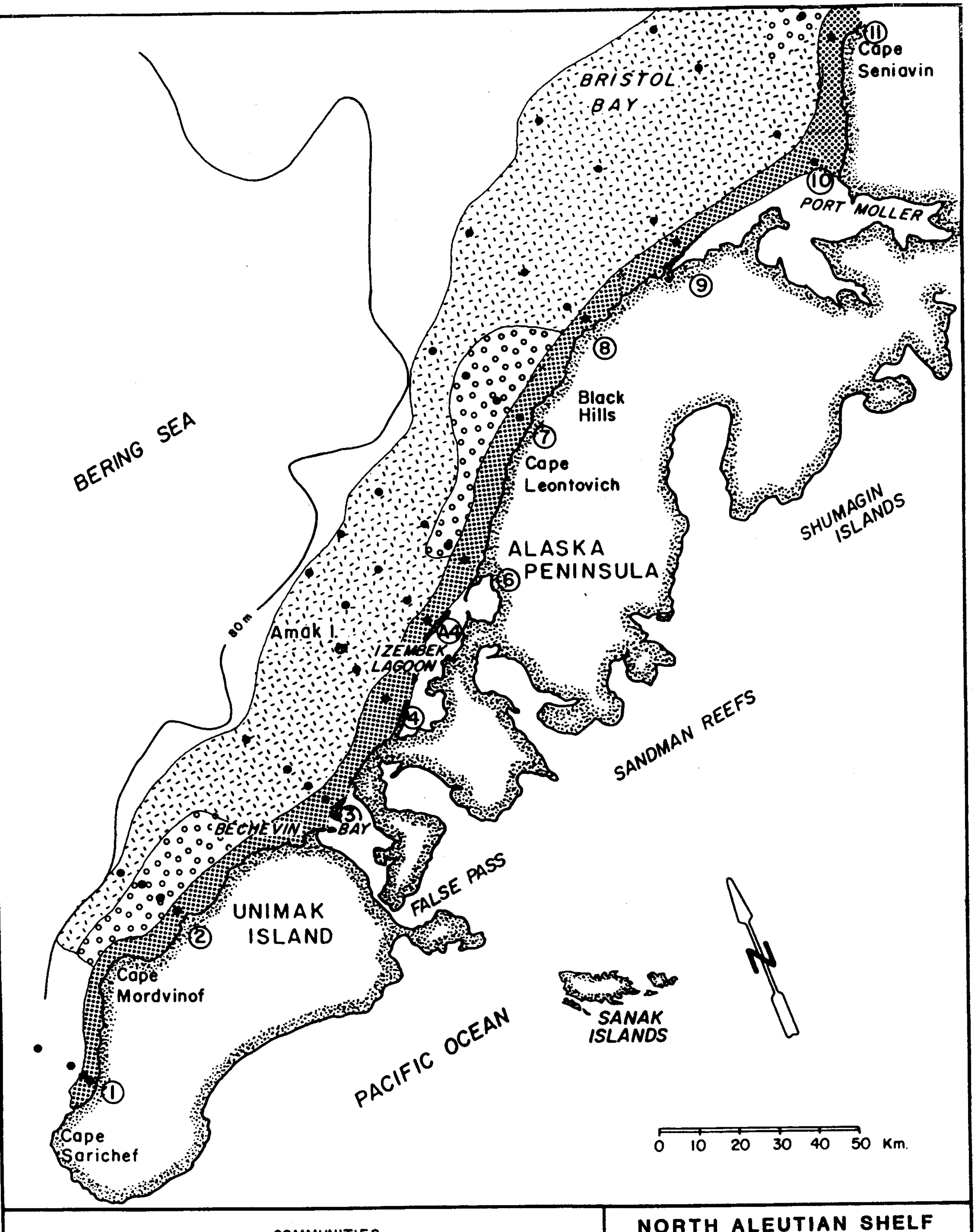
FIGURE 6.2-2

The major communities differed in depth; community I was found primarily in shallower waters (10-30 m) than community II (30-60 m) (Figure 6.2-2). Environmental differences between the minor groups within community II were associated with gravel content of the sediments. Community IIA inhabited sediments with higher percentages of gravel (4.3-82.4%) than community IIB (0.1-7.0%).

An aerial map displays the distribution of the three infaunal communities (Figure 6.2-3). The nearshore shallow region (10 m depth) was homogeneous, composed predominantly of sand (93-99%) and inhabited by a single infaunal community. Deeper waters (30-60 m) were also composed predominantly of sand, but were more heterogeneous. Areas of larger gravel content, usually at 30 m, was inhabited by a community (IIA) different from the one at the same depths with less gravel (IIB). The sand/gravel community (IIA) was found off Unimak Island, Black Hills and Cape Seniavin. Areas near the coastal inlets (Bechevin Bay, Izembek Lagoon and Port Moller) were inhabited by the communities associated with sand in both deep (IIB) as well as shallow (I) waters.

Replicate samples (Figure 6.2-1) indicate that some local, small-scale variability did exist with two different communities sometimes found within the same station, but this was rare. No large-scale seasonal shifts in community distributions were noted.

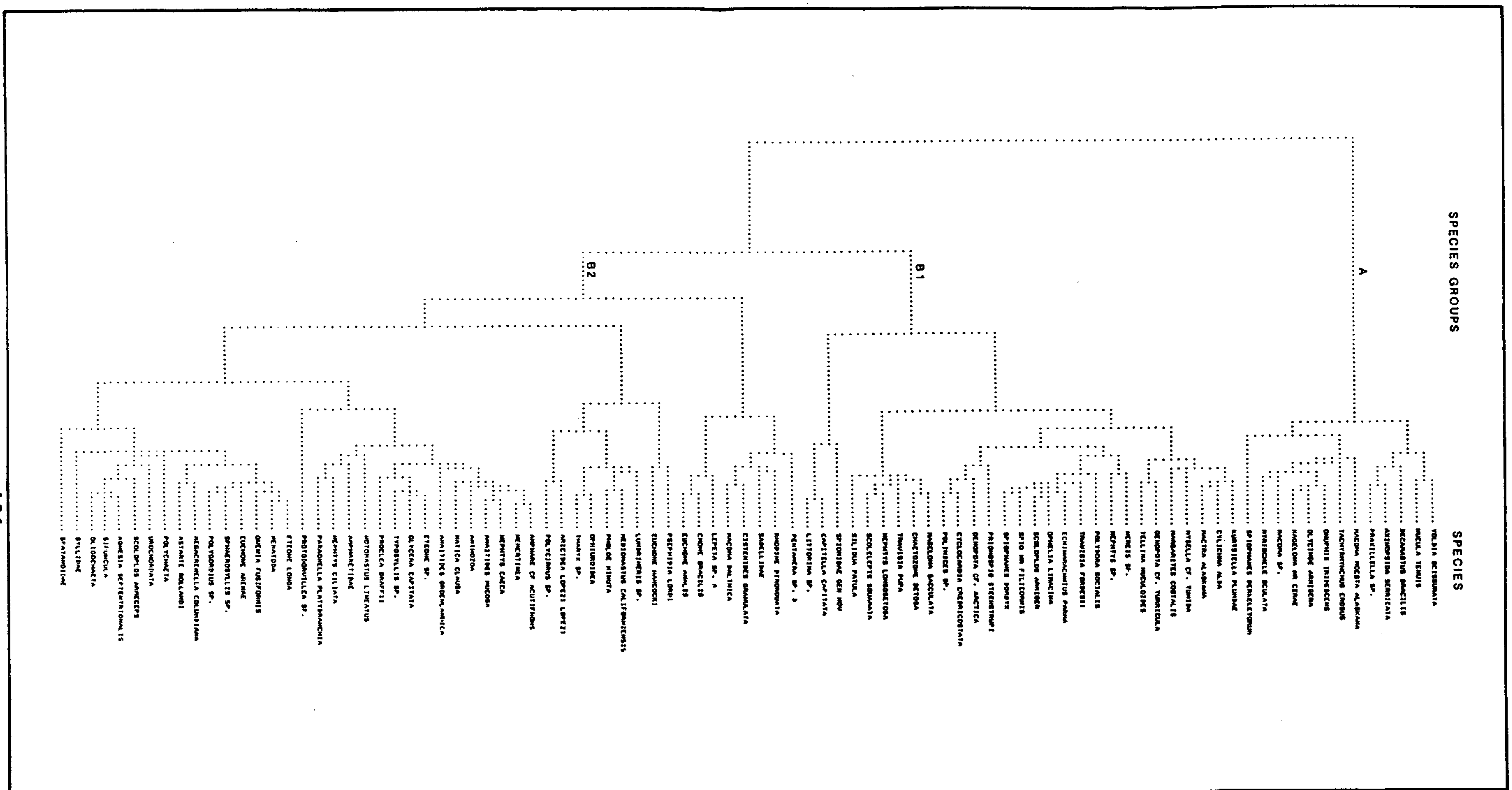
Inspection of the species dendrogram (Figure 6.2-4) indicates the presence of three major species groups (A, B1 and B2). The two-way matrix (Figure 6.2-5) shows the relationship among sites and species. Species groups differed primarily by their distribution between high and low gravel areas and secondarily with depth. Species group A inhabited sandy sediments having lower gravel content than did species group B. Subgroup B1 was found in both shallow and deep waters, while subgroup B2 was restricted to deep waters.



NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF INFAUNAL COMMUNITIES

1982-1983	FIGURE 6.2-3

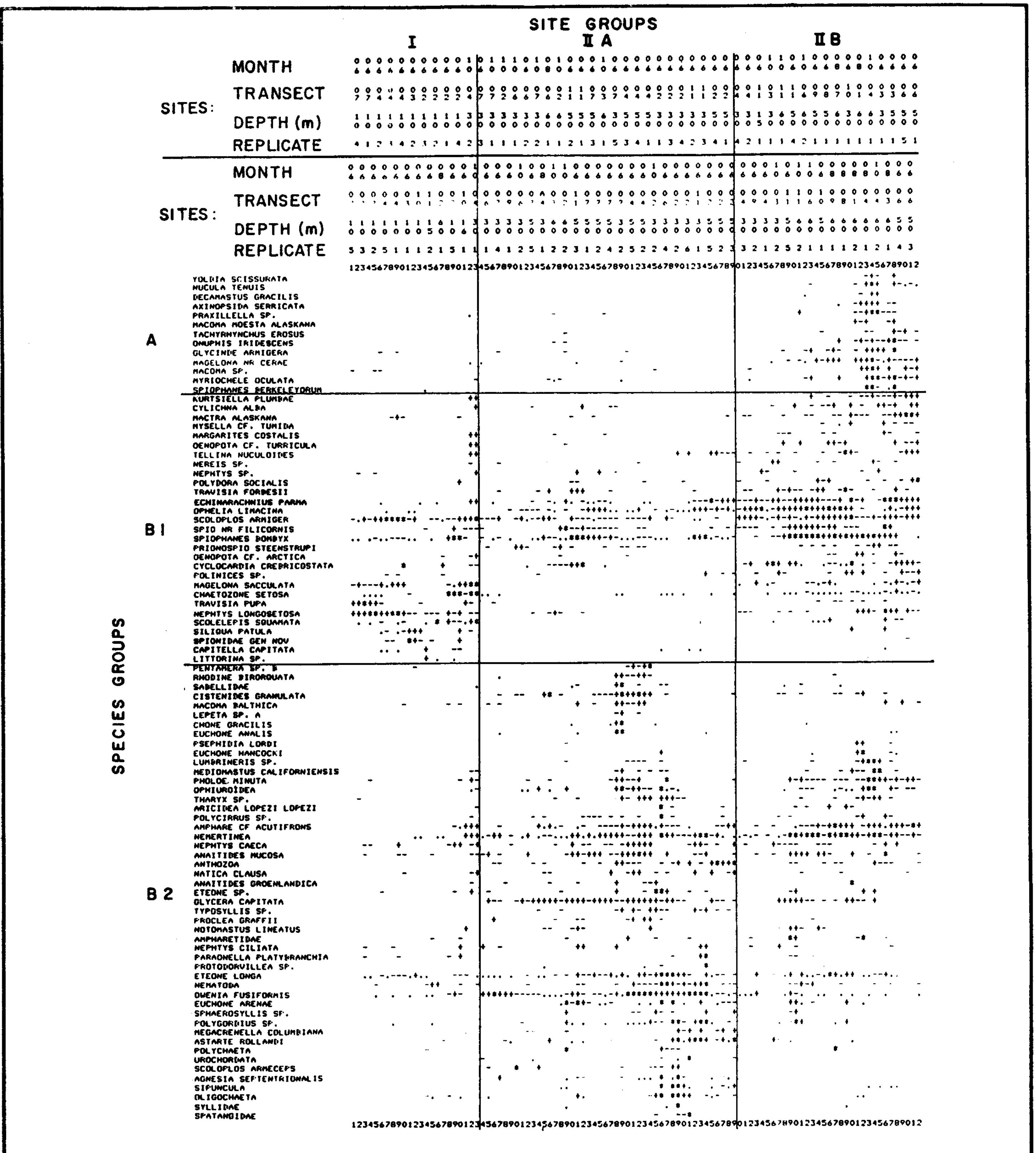


NORTH ALEUTIAN SHELF

SPECIES DENDROGRAM FROM INFAUNAL SAMPLES

1982-1983

FIGURE 6.2-4



ABUNDANCE VALUES :

• = $(\sqrt{x} / \sqrt{\bar{x}}) \leq 0.5$

- = $(\sqrt{x} / \sqrt{\bar{x}}) > 0.5 \leq 1.0$

+ = $(\sqrt{x} / \sqrt{\bar{x}}) > 1.0 \leq 2.0$

* = $(\sqrt{x} / \sqrt{\bar{x}}) > 2.0$

vtn

NORTH ALEUTIAN SHELF

TWO-WAY SITE AND SPECIES MATRIX FROM INFAUNAL SAMPLES

1982-1983

FIGURE 6.2-5

The two-way matrix also indicates which species groups and species were found in each community. The shallow water sand community (I) is composed essentially of species group B1. These were ubiquitous species within the study area and were found at all depths and in sediments with both high and low gravel content. The characteristic species were the bivalve Siliqua patula, along with the polychaetes Capitella capitata, Magelona sacculata, Nephtys longosetosa, Scolopus armiger and Travisia pupa.

The deep sand/gravel community (IIA) also had many of the ubiquitous species in group B1 including the polychaetes Scolopus armiger and Spiophanes bombyx, as well as species in group B2 which inhabited gravel substrates, particularly the polychaetes Owenia fusiformes, Eteone longa, Glycera capitata, Megacrenella columbiana and Polygordius sp. The deep sand community was characterized by the sand dollar Echinarachnius parma as well as species from group B1, including the polychaetes Ophelia limacina, Scolopus armiger, Spio nr. filicornis and Spiophanes bombyx.

Further analysis was conducted on the two-way matrix to examine trophic differences among the three communities. Comparisons were made among different feeding types of polychaetes and their "preferred" habitat among the three communities (Table 6.2-1). A habitat preference was established if the given species was twice as common in any given community, otherwise the species was considered ubiquitous in the study area. This information was reduced into a matrix to examine the distribution of feeding types (Fauchald and Jumars 1979) among the three communities (Table 6.2-2). This analysis indicates that the number of polychaete species increased with depth, with the greatest number of species in the deep sandy areas. The relative abundance of feeding types (in descending order), namely selective deposit feeders, predators, non-selective deposit feeders, filter feeders and others, remained constant in the three communities. Filter feeders were found only in the deep habitats, particularly in the sand/gravel stations

TABLE 6.2-1

HABITAT PREFERENCE, BASED ON FREQUENCY OCCURRENCE, AND FEEDING TYPES FOR POLYCHAETE SPECIES

Species	Community I (Shallow) Sand Frequency (%)	IIA (Deep) Sand/Gravel	IIB (Deep) Sand	Preferred[a] Habitat	Feeding Type[b]
Decamastus gracilis	0	0	12	Deep sand	Non-selective deposit
Praxillella sp.	4	2	27	Deep sand	Non-selective deposit
Onuphis iridesiens	0	4	36	Deep sand	Scavenger
Glycinde armiger	9	4	36	Deep sand	Predator
Magelona nr. cerae	4	2	64	Deep sand	Selective deposit
Myriochele oculata	4	9	42	Deep sand	Selective deposit
Spiophanes berkeleyorum	4	0	15	Deep sand	Selective deposit
Nereis sp.	4	4	24	Deep sand	Omnivore
Nephtys sp.	13	7	15	Ubiquitous	Predator
Polydora socialis	4	9	30	Deep sand	Selective deposit
Travisia forbesii	0	17	48	Deep sand	Non-selective deposit
Ophelia limacina	13	70	88	Deep	Non-selective deposit
Scolopus armiger	91	67	100	Ubiquitous	Selective deposit
Spio nr. filicornis	22	35	61	Deep sand	Selective deposit
Spiophanes bombyx	70	83	76	Ubiquitous	Selective deposit
Prionospio steenstrupi	0	26	30	Deep	Selective deposit
Magelona sacculata	70	0	55	Sand	Selective deposit
Chaetozone setosa	48	24	76	Sand	Selective deposit
Travisia pupa	39	2	18	Sand	Non-selective deposit
Nepthys longosetosa	87	11	48	Sand	Carnivore
Scolelepis squamata	57	2	24	Sand	Selective deposit
Spionidae gen. nova	30	0	3	Shallow sand	Selective deposit
Capitella capitata	26	9	3	Shallow sand	Non-selective deposit
Rhodine birorquata	0	17	3	Deep gravel	Non-selective deposit
Sabellidae	4	15	9	Deep	Filter
Cistenides granulata	0	41	24	Deep	Selective deposit
Chone gracilis	0	11	3	Deep	Filter
Euchone analis	0	11	6	Deep	Filter
Euchone hancocki	0	2	15	Deep sand	Filter
Lumbrineris sp.	0	13	24	Deep	?
Mediomastus californianus	9	13	24	Ubiquitous	Non-selective deposit
Phloe minuta	17	22	67	Deep sand	Predator
Tharyx sp.	4	26	24	Deep	Selective deposit
Aricidea lopezi lopezi	4	7	15	Deep sand	Non-selective deposit
Polycirrus sp.	4	26	18	Deep	Filter

TABLE 6.2-1

(continued)

Species	Community I (Shallow) Sand	Community IIA (Deep) Sand/Gravel	Community IIB (Deep) Sand	Preferred[a] Habitat	Feeding Type[b]
	Frequency (%)				
Ampare cf. *acutifrons*	22	61	73	Deep	Selective deposit
Nephtys caeca	35	41	36	Ubiquitous	Predator
Anaitides mucosa	26	52	39	Deep	Predator
Anaitides groenlandica	4	2	3	Ubiquitous	Predator
Eteone sp.	13	20	12	Ubiquitous	Predator
Glycera capitata	0	83	42	Deep	Predator
Typosyllis sp.	0	33	0	Deep gravel	Predator
Proclea graffii	0	22	3	Deep gravel	Filter
Notomastus lineatus	4	13	15	Deep	Non-selective depoist
Ampharetidae	9	9	18	Deep sand	Selective deposit
Nephtys ciliata	13	15	12	Ubiquitous	Predator
Paraonella platybranchia	17	7	9	Ubiquitous	Non-selective deposit
Protodorvillea sp.	0	9	0	Deep gravel	Predator
Eteone longa	65	76	67	Ubiquitous	Predator
Owenia fusiformis	35	98	45	Deep gravel	Selective deposit
Euchone arenae	0	41	18	Deep	Filter
Sphaerosyllis sp.	0	17	6	Deep gravel	Selective deposit
Polygordius sp.	9	41	15	Deep gravel	?
Scolopos armeceps	0	17	0	Deep gravel	Selective deposit
Syllidae	0	7	3	Deep gravel	?

(a) If frequency was twice as much as in any other community(ies)

(b) From Fauchald and Jumars (1979)

TABLE 6.2-2

DISTRIBUTION OF POLYCHAETE FEEDING TYPES WITH THEIR PREFERRED HABITATS

Community / Species	Preferred Habitat[a]			
	I (Shallow) Sand	IIA (Deep) Sand/Gravel	IIB (Deep) Sand	I,IIA, IIB[b] Obiquitous
Non-selective deposit	1	2	5	3
Selective deposit	7	11	17	3
Filter	0	6	4	0
Predator	7	10	10	7
Scavenger	0	0	1	0
Omnivore	0	0	2	0

(a) From Table 6.2-1
(b) Also accounted for in individual habitats

(possible indicator of greater water movement) than the strict sandy habitats. Predators were the least selective (most ubiquitous) in terms of habitat preference.

With the exception of McLaughlin's (1963) qualitative survey, no ecological investigations have been conducted in the shallow, nearshore areas of the Bering Sea. Studies by Haflinger (1981) in deeper waters indicated that differences between site groupings corresponded with depth. The nearshore study area with its high energy environment, coarse grain size and dominant species, Siliqua patula (razor clam) and Echinarachnius parma (sand dollar), are more similar to other high energy sandy habitats along the Pacific Coast than other areas of Alaska. In such habitats the primary distribution of infaunal communities occurs in zones from onshore to offshore with wave action being a primary factor regulating the break between zones (Jon Kastendiek, Univ. S. Calif., personal communication) and Oregon (Howard Jones, Oregon State Univ., personal communication).

6.3 Benthic Epifauna

A listing of all organisms collected in the epifaunal trawls is provided in Appendix C. A total of 185 epifaunal taxa were identified including 58 fish taxa, 121 invertebrate taxa and six plant taxa. Raw data from epifaunal samples from each cruise are provided in Appendix E. The taxa that occurred in 10 percent or greater of the trawl samples are listed in rank order in Table 6.3-1; the total and mean weight of each taxon are also presented in the table. The 27 taxa listed represented almost 92 percent of the total sample biomass and include 14 fish taxa, 12 invertebrate taxa and one plant taxon. Two species of flatfish, Limanda aspera (yellowfin sole) and Lepidopsetta bilineata (rock sole), were the most frequently captured taxa, occurring in at least 85 percent of the samples; two invertebrate taxa, Hippolytidae (shrimp) and Asterias amurensis (sea star) each occurred in more than 70 percent of the samples. Five taxa represented >6 percent of the total biomass

TABLE 6.3-1

RANKED ABUNDANCE DATA FROM EPIFAUNAL TRAWLS

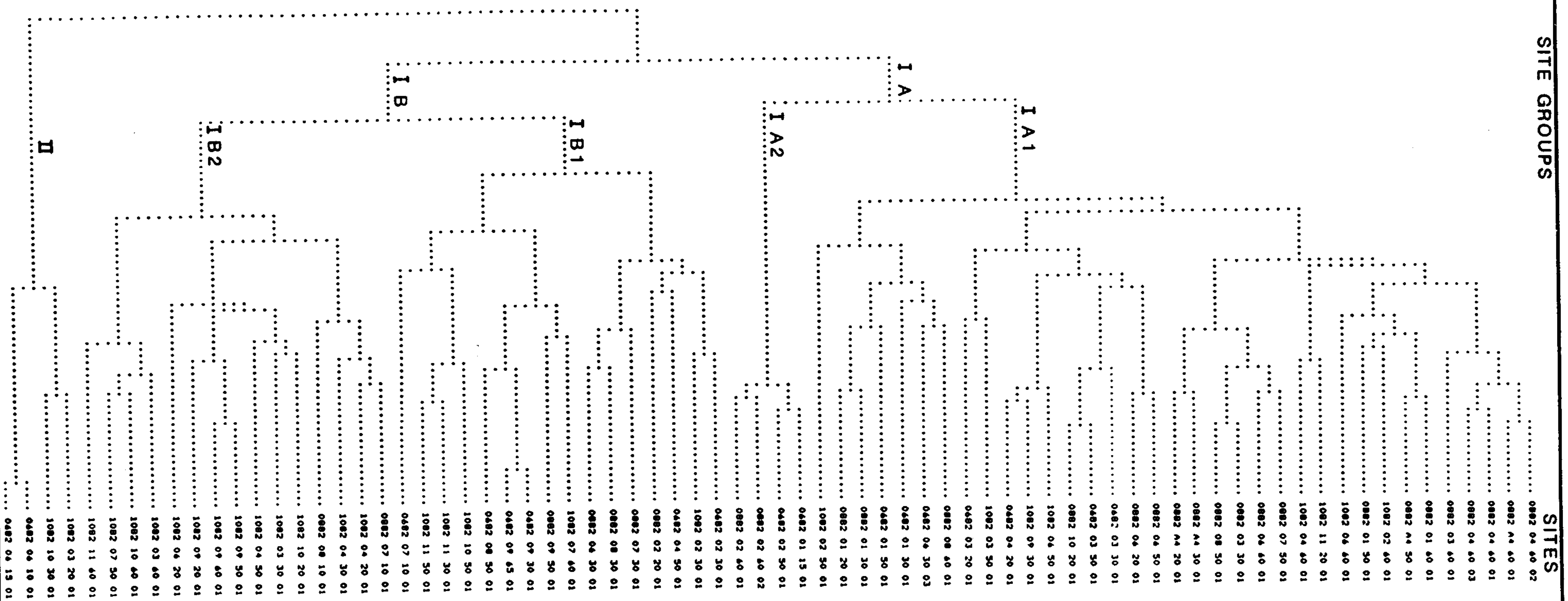
	Taxon	Number of Occurrences	Percent Frequency Occurrence	Total Weight(g)	Mean Weight(g)	Percent Weight	Cummulative Percent
1.	*Limanda aspera*	70	89	788,890.0	9,985.9	32.3	32.3
2.	*Lepidopsetta bilineata*	67	85	415,579.0	5,260.5	17.0	49.4
3.	*Hippolytidae*	62	78	12,558.1	159.0	0.5	49.9
4.	*Asterias amurensis*	56	71	371,518.0	4,702.8	15.2	65.1
5.	*Paguridae*	45	57	8,797.3	111.4	0.4	65.5
6.	Gadidae, juv.	43	54	28,832.7	365.0	1.2	66.6
7.	Cottidae	38	48	43,693.0	553.1	1.8	68.4
8.	*Boltenia ovifera*	30	38	207,689.0	2,629.0	8.5	76.9
9.	*Pleuronectidae*, juv.	28	35	8,660.5	109.6	0.4	77.3
10.	Agonidae	28	35	3,787.6	48.0	0.2	77.4
11.	Natica *clausa*	25	32	924.8	11.7	<0.1	77.5
12.	*Hippoglossoides elassodon*	24	30	15,842.3	200.5	0.7	78.1
13.	*Echinarachnius parma*	23	29	11,306.6	143.1	0.5	78.6
14.	*Pleuronectes quadrituberculatus*	22	28	30,967.1	392.0	1.3	79.9
15.	Phaeophyta (drift?)	21	27	6,983.5	88.4	0.3	80.2
16.	*Gadus macrocephalus*	20	25	78,211.0	990.0	3.2	83.4
17.	*Theragra chalcogramma*	18	23	7,194.7	91.1	0.3	83.7
18.	*Ammodytes hexapterus*	16	20	1,847.7	23.4	0.1	83.7
19.	*Hippoglossus stenolepis*	15	19	7,589.7	96.1	0.3	84.0
20.	Porifera	14	18	8,648.5	109.5	0.4	84.4
21.	*Chionoecetes bairdi*	14	18	3,104.4	39.3	0.1	84.5
22.	*Cancer oregonensis*	14	18	1,892.9	24.0	0.1	84.6
23.	*Potamilla reniformis*	12	15	164,662.0	2,084.3	6.6	91.3
24.	*Liparis* sp.	11	14	371.6	4.7	<0.1	91.4
25.	*Microgadus proximus*	10	13	5,750.2	72.8	0.2	91.6
26.	*Ophiuroidea*	10	13	2,809.9	35.6	0.1	91.7
27.	Ectoprocta	10	13	1,538.1	19.5	0.1	91.8

sampled; these were: Limanda aspera, Lepidopsetta bilineata, Asterias amurensis, Boltenia ovifera (tunicate) and Potamilla reniformis (marine worm), in descending order by weight. The combined biomass of these five species equalled 73 percent of the total biomass sampled.

The results of cluster analysis on abundance data (weights) are presented in separate site and species dendrograms as well as a two-way site by species matrix. Sites were clustered into two widely distributed groups (IA and IB) and a localized group (II) (Figure 6.3-1). The spatial distribution of the major site groups is shown in Figure 6.3-2. These site groups overlap considerably. Such overlap is attributed to a combination of the patchy nature of the substrate and the sampling procedures. The substrate in the study area included sand, gravel, boulders and large rocky outcroppings. Epifaunal samples involved 10 minute trawls which covered a large area, thereby increasing the chances of sampling more than one habitat. In spite of this problem, some basic patterns were evident (Table 6.3-2). Group IA occurred more extensively in the Unimak and Izembek areas, while group IB was more extensive in the Black Hills and Port Moller areas. Group IB also occurred in areas closer inshore where the two groups were contiguous. The mean sample depths were 43 m (group IA) and 37.5 m (group 1B).

The species used in cluster analysis fell into two major species groups (Figure 6.3-3). Group A contains 12 taxa, many of which are characteristic of soft sediments. Species group B contains 23 taxa, many of which, especially those in group B2, are characteristic of hard substrates. Many of the most frequently caught taxa, and all five of the taxa that dominated trawl samples by weight, are in group B.

The site by species matrix (Figure 6.3-4) shows the abundance distribution of species within samples. Species group B1 contains the most ubiquitous species and are found in all site groups. Site group IA is composed primarily of soft-bottom organisms in species group B1. Site group IB is also composed of soft-bottom organisms in species group B1 and hard-bottom organisms in species group B2.

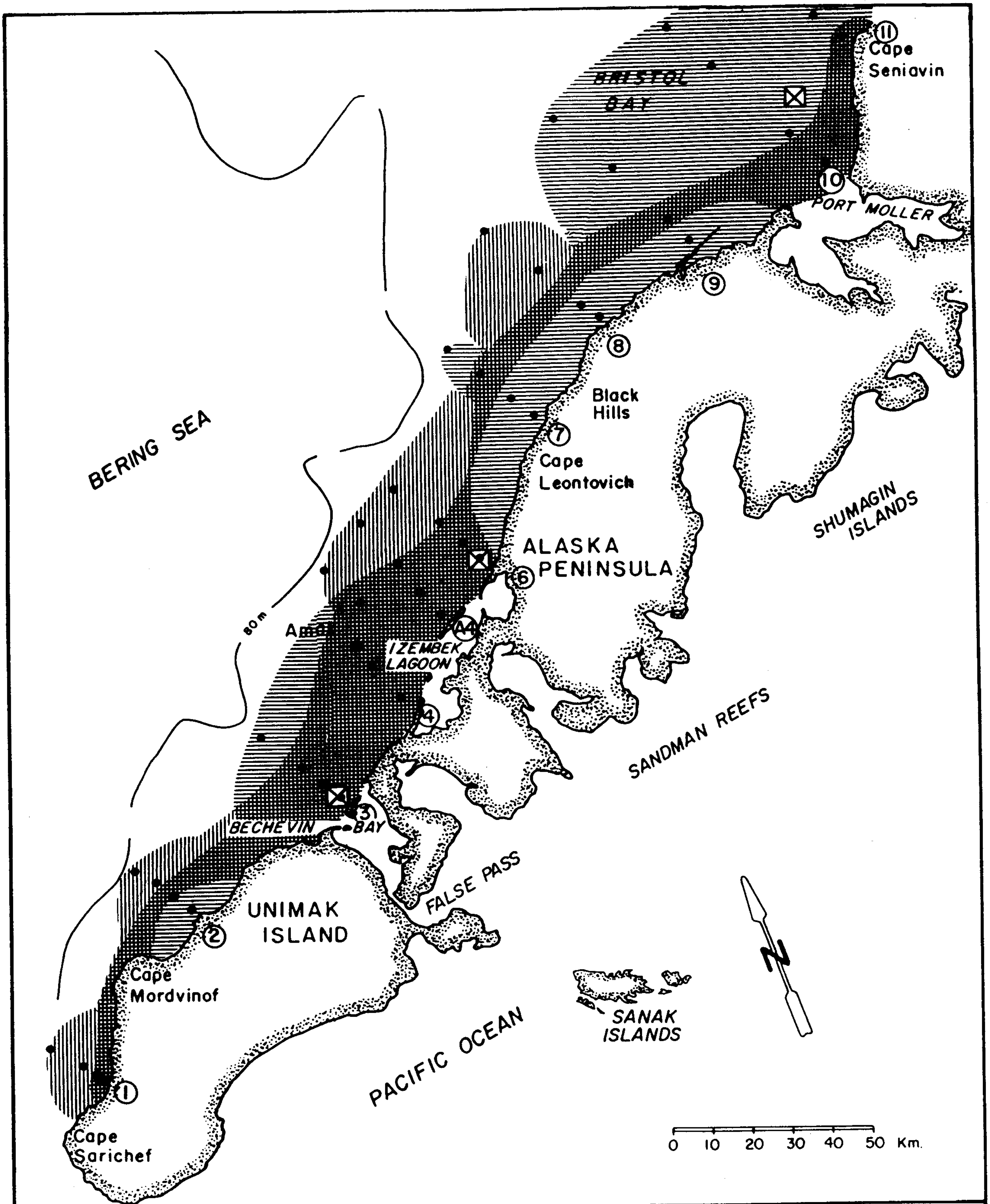


SITE IDENTIFIERS = DATE/TRANSECT/DEPTH(m)/REPLICATE

NORTH ALEUTIAN SHELF

SITE DENDROGRAM FROM EPIFAUNAL SAMPLES

1982-1983 | FIGURE 6.3-1



• = STATION

(#) = TRANSECT

=SITE GROUP IA – SOFT-BOTTOM ORGANISMS

=SITE GROUP IB – HARD-BOTTOM ORGANISMS

=SITE GROUP II

vtn

NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF MAJOR EPIFAUNAL SITE GROUPS

1982-1983

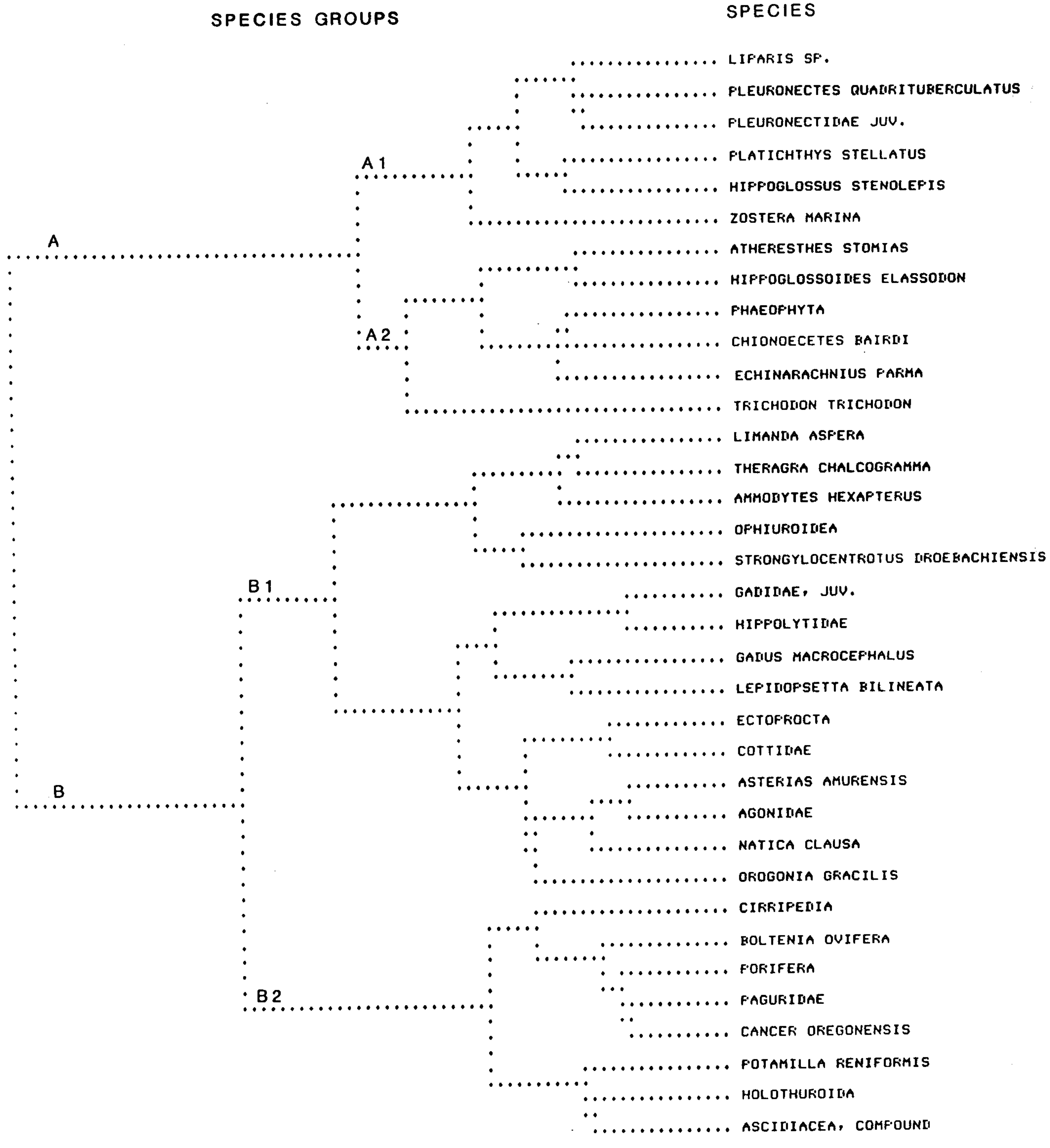
FIGURE 6.3-2

TABLE 6.3-2

SITE GROUP CHARACTERISTICS FOR EPIFAUNA DATA

Site Group	Number of Samples	Bottom Depth(m)		Number of Samples Per Month			Number of Samples Per Transect[a]									
		Mean	Range	Jun	Aug	Oct	1	2	3	4	6	7	8	9	10	11
I	70	41	10-65	15	29	26	7	8	8	13	8	6	5	7	4	4
IA	39	43	15-60	9	21	8	7	5	6	9	6	1	2	1	1	1
IA1	35	43	20-60	7	19	8	6	2	6	9	6	1	2	1	1	1
IA2	4	46	15-60	2	2	0	1	3	0	0	0	0	0	0	0	0
IB	31	37.5	10-60	6	7	18	0	3	2	4	2	5	3	6	3	3
IB1	16	38	10-60	6	5	5	0	3	0	1	1	3	2	3	1	2
IB2	15	37	10-60	0	2	13	0	0	2	3	1	2	1	3	2	1
II	4	19	10-30	2	0	2	0	0	1	0	2	0	0	0	1	0
Total I + II	74			17	29	28	7	8	9	13	10	6	5	7	5	4

[a] Transects 1,2 = Unimak area
Transects 3,4 = Izembek area
Transects 6,7,8 = Black Hills area
Transects 9, 10, 11 = Port Moller area

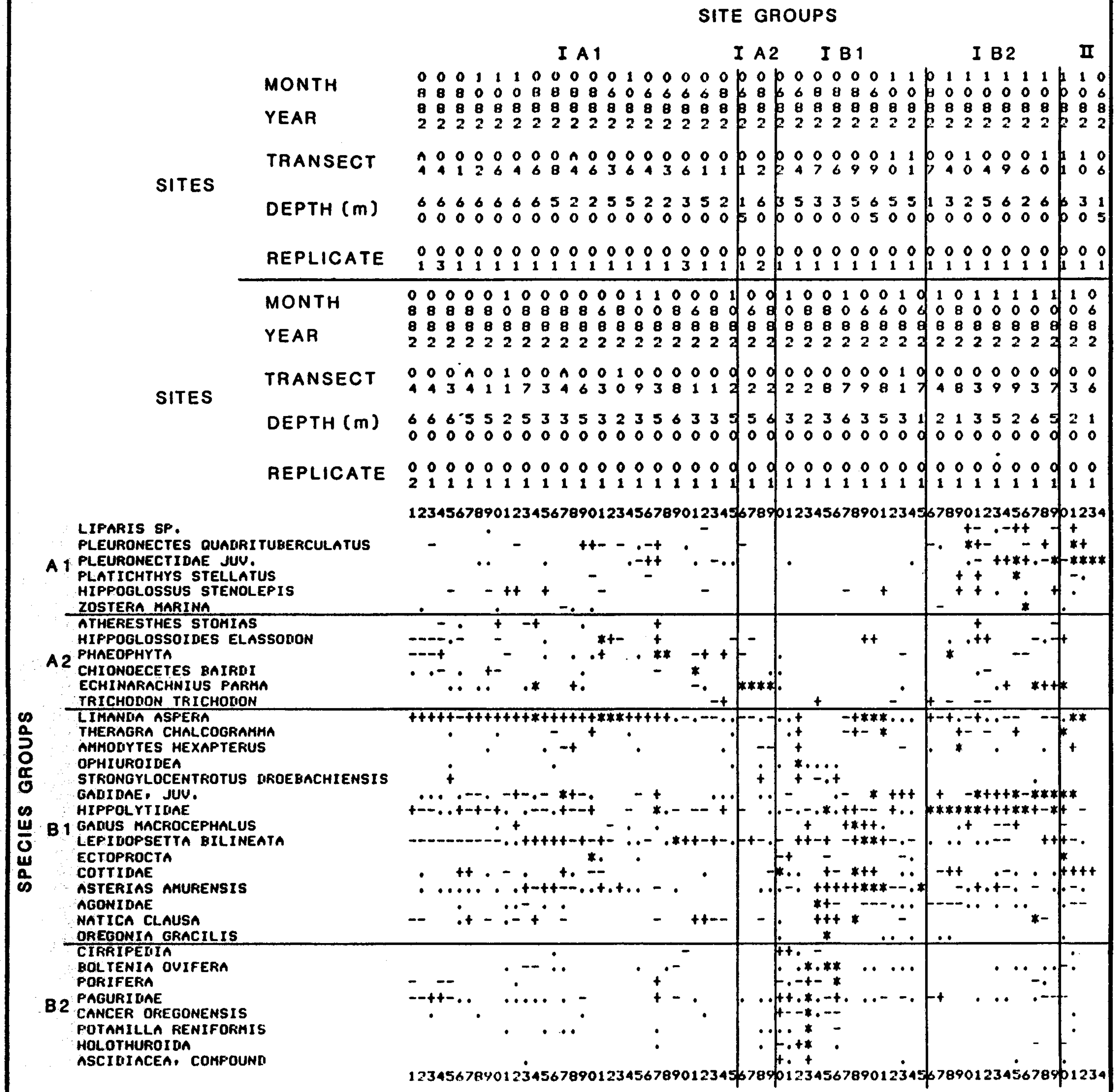


NORTH ALEUTIAN SHELF

SPECIES DENDROGRAM FROM EPIFAUNAL SAMPLES

1982-1983

FIGURE 6.3-3



ABUNDANCE VALUES :

- • = $(\sqrt{x}/\sqrt{\bar{x}}) \leq 0.5$
- − = $(\sqrt{x}/\sqrt{\bar{x}}) > 0.5 \leq 1.0$
- + = $(\sqrt{x}/\sqrt{\bar{x}}) > 1.0 \leq 2.0$
- ✱ = $(\sqrt{x}/\sqrt{\bar{x}}) > 2.0$

vtn

NORTH ALEUTIAN SHELF

TWO-WAY SITE AND SPECIES MATRIX FROM EPIFAUNAL SAMPLES

1982-1983

FIGURE 6.3-4

The species characteristic of the five site groups are listed in Table 6.3-3. These species were the most abundant (biomass) and together represented 90 percent of the total biomass within each sample group. Site groups IA1 and IA2 were dominated by the flatfishes *Limanda aspera* and *Lepidopsetta bilineata* (Figure 6.3-5), which together represented 65 to 80 percent of the biomass of these samples. Group IA1 was further characterized by much smaller amounts of the seastar *Asterias amurensis*, the tunicate *Boltenia ovifera* and the flatfish *Pleuronectes quadrituberculatus*. Group IA2 was further characterized by the sand dollar *Echinarachnius parma* and an unidentified fish species.

Greater numbers of taxa characterized groups IB1 and IB2, as shown in Table 6.3-3. While the flatfishes *L. aspera* and *L. bilineata* were important in these groups, they did not dominate the total biomass as in group IA samples. The group IB1 species assemblage was dominated by invertebrates: the seastar *A. amurensis*, the tunicate *B. ovifera*, the colonial, reef-building polychaete worm *Potamilla reniformis* and pagurids (hermit crab) (Figure 6.3-6). This species assemblage was found primarily in samples from the area between Izembek Lagoon and Port Moller (Figure 6.3-7). Stations of the central coast of Unimak Island were also characterized by this species assemblage.

Group IB2 samples were dominated by the flatfish-sea star group characteristic of group IA, but also had a number of other taxa represented. Drift eelgrass, *Zostera marina*, was an important component of this group, as were juvenile and adult codfishes (Gadidae), other flatfishes, including starry flounder (*Platichthyes stellatus*) and Alaska plaice (*P. quadrituberculatus*), and Hippolytid shrimp. This species assemblage was not represented in June samples and was found only in the area between Bechevin Bay and Port Moller (Figure 6.3-7).

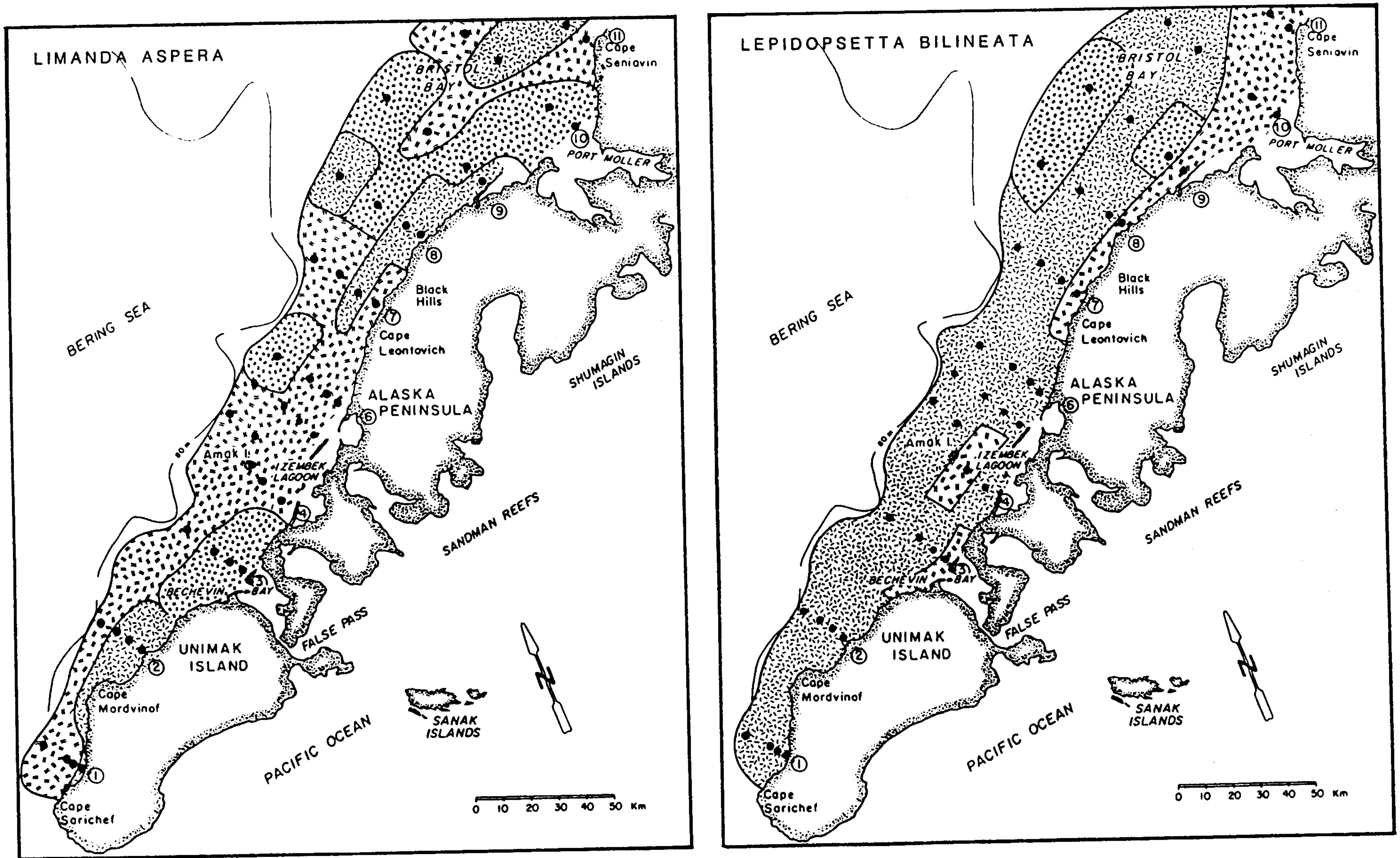
The four samples in group II were characterized by the highest mean biomass of *L. aspera* and the presence of juvenile flatfishes (Pleuronectidae). These samples were found only in shallow areas off Bechevin

TABLE 6.3-3

CHARACTERISTIC TAXA OF SITE GROUPS[a]

		Taxon	Frequency of Occurrence	Mean Weight(g)	Percent of Total Weight	Cummulative Percent
GROUP IA1						
No. of Samples = 35	1.	*Limanda aspera*	100.0	12,344	56.5	56.5
No. of Species = 59	2.	*Lepidopsetta bilineata*	94.3	5,137	23.5	80.1
	3.	*Asterias amurensis*	65.7	1,660	7.6	87.7
	4.	*Boltenia ovifera*	22.9	331	1.5	89.2
	5.	*Pleuronectes quadrituberculatus*	28.6	326	1.5	90.7
GROUP IA2						
No. of Samples = 4	1.	*Lepidopsetta bilineata*	100.0	5,425	43.6	43.6
No. of Species = 23	2.	*Limanda aspera*	100.0	2,723	21.9	65.5
	3.	*Echinarachnius parma*	100.0	2,020	16.2	81.7
	4.	*Osteichthyes*	25.0	1,702	13.7	95.4
GROUP IB1						
No. of Samples = 16	1.	*Asterias amurensis*	93.8	15,388	24.1	24.1
No. of Species = 60	2.	*Boltenia ovifera*	68.8	11,300	17.7	41.8
	3.	*Potamilla reniformis*	25.0	10,211	16.0	57.8
	4.	*Lepidopsetta bilineata*	81.3	8,162	12.8	70.6
	5.	*Limanda aspera*	68.8	7,290	11.4	82.0
	6.	*Gadus macrocephalus*	37.5	2,996	4.7	86.7
	7.	*Cirripedia*	25.0	1,438	2.3	89.0
	8.	*Zooantharia actiniaria*	25.0	1,311	2.1	91.1
GROUP IB2						
No. of Samples = 15	1.	*Limanda aspera*	86.7	4,005	23.5	23.5
No. of Species = 51	2.	*Lepidopsetta bilineata*	66.7	2,773	16.3	39.8
	3.	*Asterias amurensis*	66.7	1,473	8.7	48.5
	4.	*Zostera marina*	20.0	1,419	8.3	56.8
	5.	*Gadidae, juvenile*	80.0	1,294	7.6	64.4
	6.	*Platichthys stellatus*	20.0	1,233	7.2	71.6
	7.	*Gadus macrocephalus*	40.0	1,111	6.5	78.2
	8.	*Pleuronectes quadrituberculatus*	46.7	615	3.6	81.8
	9.	*Hippolytidae*	100.0	552	3.2	85.0
	10.	*Boltenia ovifera*	40.0	449	2.6	87.6
	11.	*Cottidae*	60.0	397	2.3	90.0
GROUP II						
No. of Samples = 4	1.	*Limanda aspera*	50.0	18,536	66.7	66.7
No. of Species = 23	2.	*Pleuronectidae*, juvenile	100.0	1,697	6.1	72.8
	3.	*Pleuronectes quadrituberculatus*	50.0	1,619	5.8	78.7
	4.	*Zooantheria actiniaria*	25.0	1,375	5.0	83.6
	5.	*Cottidae*	75.0	1,360	4.9	88.5
	6.	*Asterias amurensis*	50.0	1,120	4.0	92.5

(a) Taxa comprising 90% of total group biomass are ranked by weight.



• = STATION
= TRANSECT

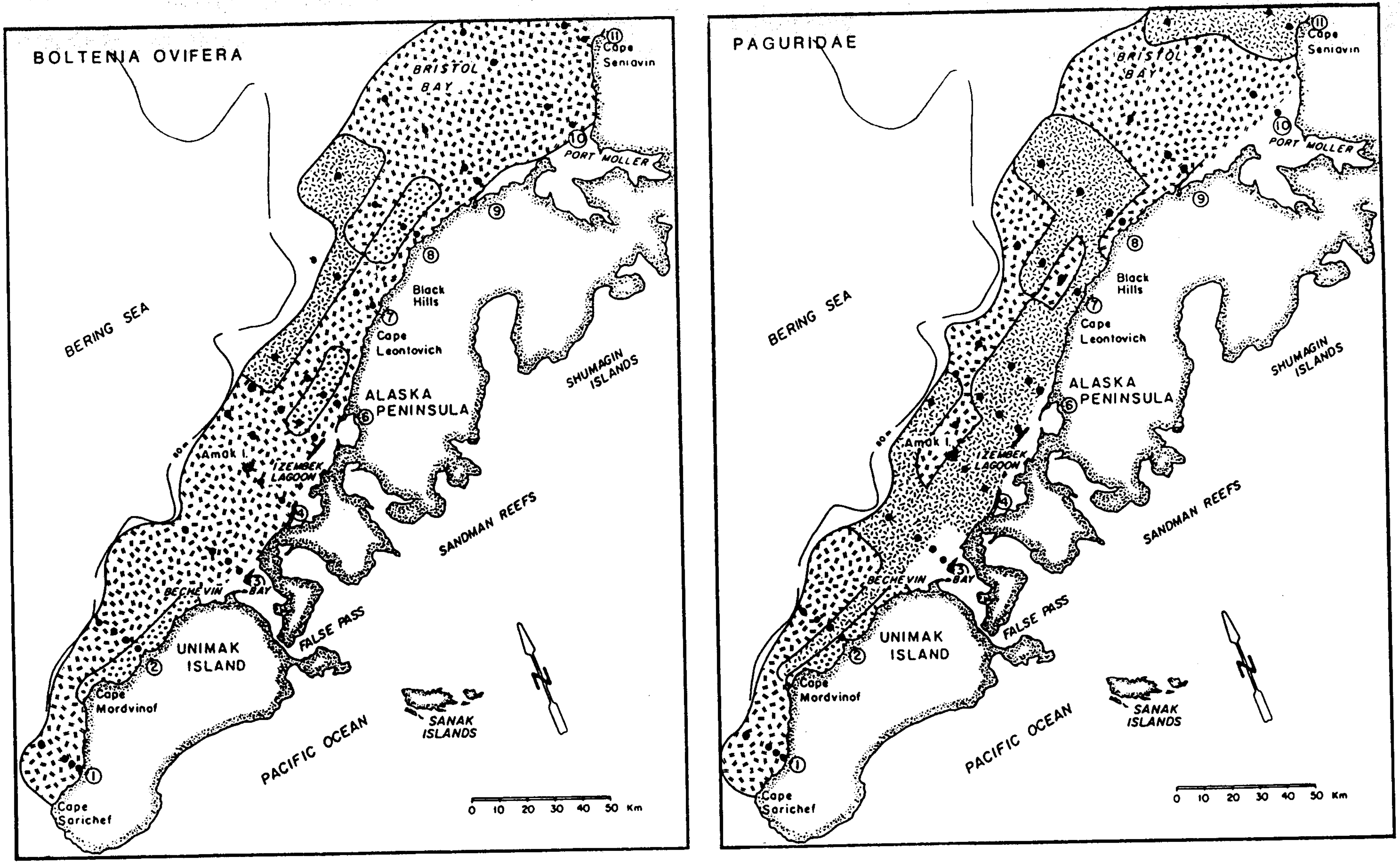
ABUNDANCE

= HIGH $(\sqrt{x} / \sqrt{\bar{x}}) > 2.0$
= MEDIUM $(\sqrt{x} / \sqrt{\bar{x}}) \leq 1.0$
= LOW $(\sqrt{x} / \sqrt{\bar{x}}) \leq 0.5$

NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF SELECTED SOFT-BOTTOM EPIFAUNAL SPECIES.

vtn 1982-1983 FIGURE 6.3-5



• = STATION

(#) = TRANSECT

ABUNDANCE

= HIGH $(\sqrt{x} / \sqrt{\bar{x}}) > 2.0$

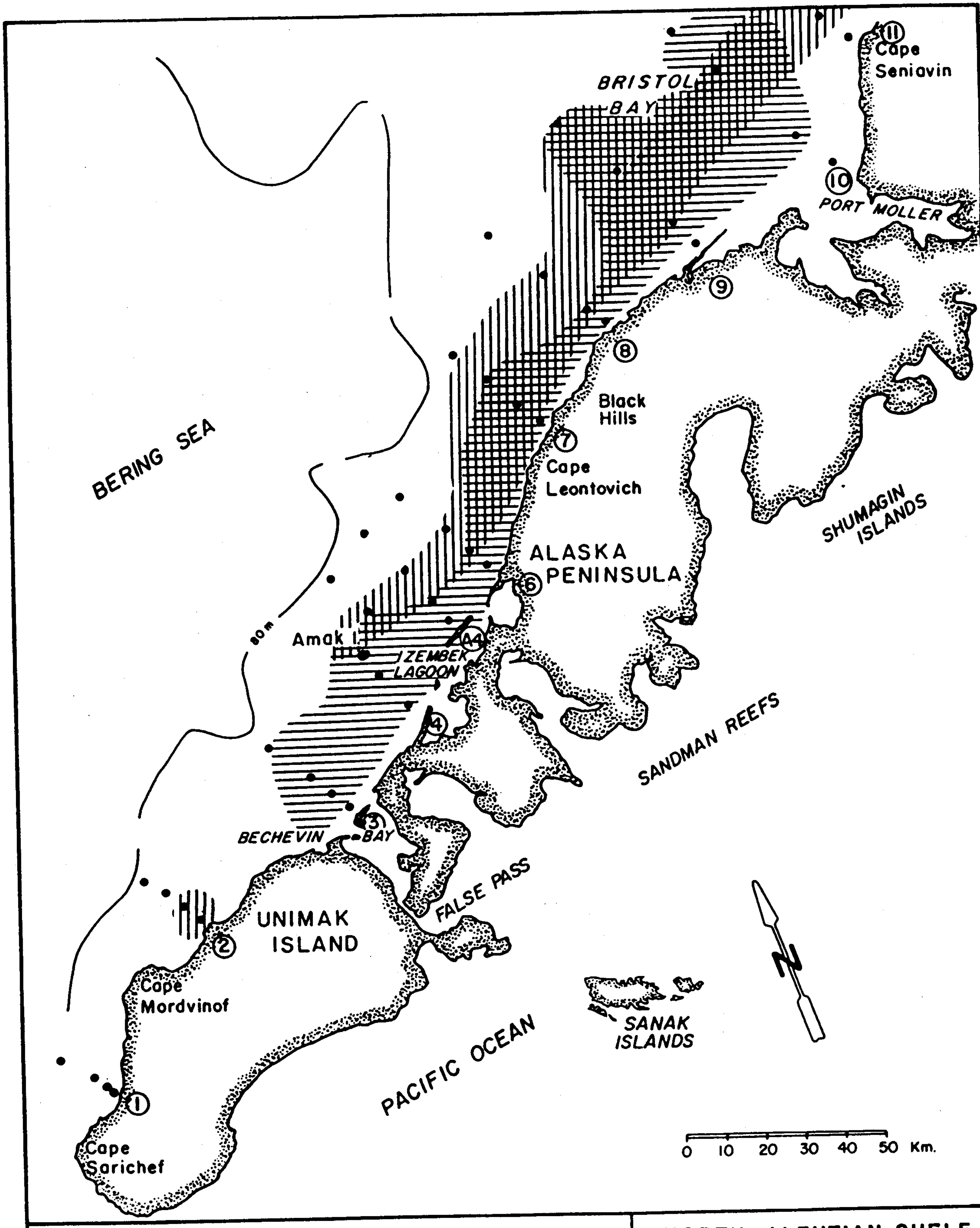
= MEDIUM $(\sqrt{x} / \sqrt{\bar{x}}) \leq 1.0$

= LOW $(\sqrt{x} / \sqrt{\bar{x}}) \leq 0.5$

NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF SELECTED HARD-BOTTOM EPIFAUNAL SPECIES.

1982-1983 | FIGURE 6.3-6



• = STATION

(#) = TRANSECT

|||| = SITE GROUP IB1 - YELLOW FIN & ROCK SOLE, SEA STARS, SCULPINS, HARD-BOTTOM INVERTEBRATES

☰ = SITE GROUP IB2 - JUVENILE COD & FLATFISH, SNAILFISH, SHRIMP

VTN

NORTH ALEUTIAN SHELF

SPATIAL DISTRIBUTION OF MINOR EPIFAUNAL SITE GROUPS

1982-1983

FIGURE 6.3-7

Bay, Izembek Lagoon and Port Moller. The other small (distribution) sample group, IA2, was characterized by Echinarachnius parma (sand dollar) and was abundant in the Cape Mordvinof area.

Previous epifauna studies of the nearshore area between Unimak Island and Port Moller are limited to a small number of stations sampled during studies of the central Bering Sea (Feder and Jewett 1980; Pereyra et al. 1976). The nearshore region of the North Aleutian Shelf (NAS), is generally considered to be more productive than deeper offshore areas of the eastern Bering Sea in terms of infuana and invertebrate epifauna biomass (Armstrong et al. 1982). Biomass values from trawls in the present and previous studies of the NAS are dominated by demersal fish, although invertebrates appear to be more important in the shallower areas associated with more rocky substrates. Trawl samples from Bristol Bay (NMFS Bering Sea subarea 1) during 1975-1976 were composed of 70 percent fish by weight (Pereyra et al. 1976), whereas trawl samples in the present study were 59 percent fish. This difference may be attributed to the type of trawl used. The 1975 studies utilized large otter trawls, which usually capture larger fish than the trynet used in this study. The relative abundance of the fish families from these two studies are presented in Table 6.3-4. Pleuronectids represented about 85 percent of the fish caught in both studies. The average biomass of fish caught per area in nearshore samples during this study was about one half the biomass reported for all of Bristol Bay.

The relative importances of invertebrate groups sampled during three studies are presented in Table 6.3-5. Crabs dominated the invertebrate epifauna sampled in 1975, representing 50 to 58 percent of the invertebrate biomass, followed by echinoderms at 22 to 29 percent. The 1982 sample biomass was dominated by echinoderms (primarily Asterias amurensis) at 48 percent and ascidians (primarily Boltenia ovifera) at 26 percent. Crustaceans represented only 3.4 percent of invertebrate biomass from 1982 nearshore samples. The mean invertebrate biomass per unit area for 1982 nearshore samples was about two-thirds the inverte-

TABLE 6.3-4

RELATIVE IMPORTANCE OF FISH FAMILIES FROM SOUTHEASTERN BERING SEA STUDIES

Family	Percent of Total Fish Catch By Weight 1975[a]	1982[b]
Gadidae	7.7	8.1
Pleuronectidae	85.0	85.2
Cottidae	4.0	0.3
Zoarcidae	0.3	<0.1
Rajidae	<0.1	2.4
Agonidae	0.3	0.3
Other fish	2.4	3.7
Mean biomass per area (g/m^2)	9.121	4.297

(a) Samples from NMFS subarea 1 (Bristol Bay) (Pereyra et al. 1976)

(b) This study

TABLE 6.3-5

RELATIVE IMPORTANCE OF INVERTEBRATE GROUPS FROM SOUTHEASTERN BERING SEA STUDIES

Taxa	Percent of Total Invertebrate Catch		
	1975[a]	1975[b]	1982[c]
Porifera	1.1	14.1	1.2
Coelenterata	3.9	1.7	0.1
Mollusca	6.5	3.4	0.6
Crustacea	58.0	50.3	3.4
Paralithodes camtschatica	21.1	29.5	<0.1
Chionoecetes opilio	19.9	18.8	0.1
C. bairdi	10.8		0.3
Echinodermata	22.0	29.2	48.2
Asteroidea	-	9.1	-
Asterias amurensis	17.9	-	46.3
Echinoidea		5.4	0.5
Ophiuroidea		0.3	-
Holothuroidea		0.1	-
Ascidacea	8.5	1.3	25.9
Annelida (Polychaeta)	<0.1	-	20.1
Mean invertebrate biomass per area (g/m^2)	3.338	3.874	2.493

(a) Samples from <80 m on the middle shelf and coastal areas (Feder and Jewett 1980)

(b) Samples from NMFS Subarea 1 (Bristol Bay) (Pereyra et al. 1976)

(c) This study

brate biomass during 1975 reported for Bristol Bay. Crustacean biomass from 1982 trawls averaged 0.085 g/m^2, compared to 1.936 g/m^2 and 1.949 g/m^2 from 1975 trawls (Feder and Jewett 1980; Pereyra, et al. 1976, respectively). Echinoderm biomass was higher during 1982 (1.202 g/m^2 compared to 0.734 g/m^2 and 1.131 g/m^2 for 1976), as was ascidian biomass (0.646 g/m^2 compared to 0.284 g/m^2 and 0.050 g/m^2 for 1976). Polychaete biomass from 1982 samples averaged 0.501 g/m^2 compared to <0.334 g/m^2 during 1976 (Feder and Jewett 1980).

Based on the limited number of comparable studies, total epifaunal biomass per unit area in the nearshore Unimak Island to Port Moller region appears to be less than epifaunal biomass per unit area for the middle shelf and coastal domains of the southeastern Bering Sea. The biomass of certain invertebrate taxa, primarily echinoderms, ascidians and colonial, reef-building polychaetes, however, appears to be greater per unit area in the nearshore region.

6.4 Sea Otters

Results from aerial sea otter surveys are presented in Appendix F. Analyses indicate that sea otter abundance had significant ($p<.05$) seasonal and spatial variability (Table 6.4-1). Spatial variability occurred alongshore, offshore and with depth; these three factors also had interacting components. Trends regarding sea otter abundance with each physical variable will be presented, followed by a discussion of the dynamics of all variables and possible causal factors driving this system.

Data were analyzed in two manners. First, totals from individual transects surveyed in this and Schneider's study (1976) were analyzed to determine seasonal and long-term fluctuations. Results of ANOVA indicate significant variability ($p<.05$) with time (Table 6.4-1). During 1982-83, sea otters were significantly more abundant ($p<.05$) in August (10,325) than either March (1,454), June (1,880) or October

TABLE 6.4-1

VARIABILITY OF THE SEA OTTER POPULATIONS

A. Seasonal Comparisons, using densities per transect

1. ANOVA

Variable	Degrees Freedom	p[a]
Date	3	$p<.0125$

2. Duncan Multiple Range Test[b]

Season	Total
July 1975	17,365^{a}
August 1982	10,325^{a}
October 1982	4,737^{b}
June 1982	1,880^{b}
March 1983	1,454^{b}

B. Spatial Comparisons, using ranked abundances per quadrat

1. ANOVA

Variable	Degrees Freedom	p[a]
Area	3	$p<.0001$
Depth	2	$p<.0001$
Season	3	$p<.0010$

2. Duncan Multiple Range Test[b]

Area	Aerial Transects	June 1982			August 1982		
		0-20 (m)	21-40 (m)	41-60 (m)	0-20 (m)	21-40 (m)	41-60 (m)
Unimak	1-15	1490^{cde}	1251^{ff}	1196^{ef}	1386de	1522^{cd}	1221^{ef}
Izembek	16-30	1351^{def}	1280^{def}	1239^{ef}	1733^{ab}	1362^{ef}	1208^{f}
Black Hills	31-35	1522^{bcd}	1235^{ef}	1156^{f}	1273^{def}	1156^{ef}	1183^{f}
Port Moller	39-43	1250^{ef}	1274^{def}		1380de	1217^{ef}	

Area	Aerial Transects	October 1982			March 1983		
		0-20 (m)	21-40 (m)	41-60 (m)	0-20 (m)	21-40 (m)	41-60 (m)
Unimak	1-15	1622^{bc}	1424^{ff}	1221^{ef}	1352^{def}	1203^{ef}	1221^{ef}
Izembek	16-30	1616^{bc}	1460^{cde}	1253^{ef}	1333^{def}	1249^{ef}	1233^{ef}
Black Hills	31-35	1329^{def}	1315^{def}	183^{f}	1335^{def}	1399^{cde}	1212^{ef}
Port Moller	39-43	1391de	1226^{ef}		1262^{def}	1286^{def}	

[a] Significance of variable(s)

[b] Significance among cells

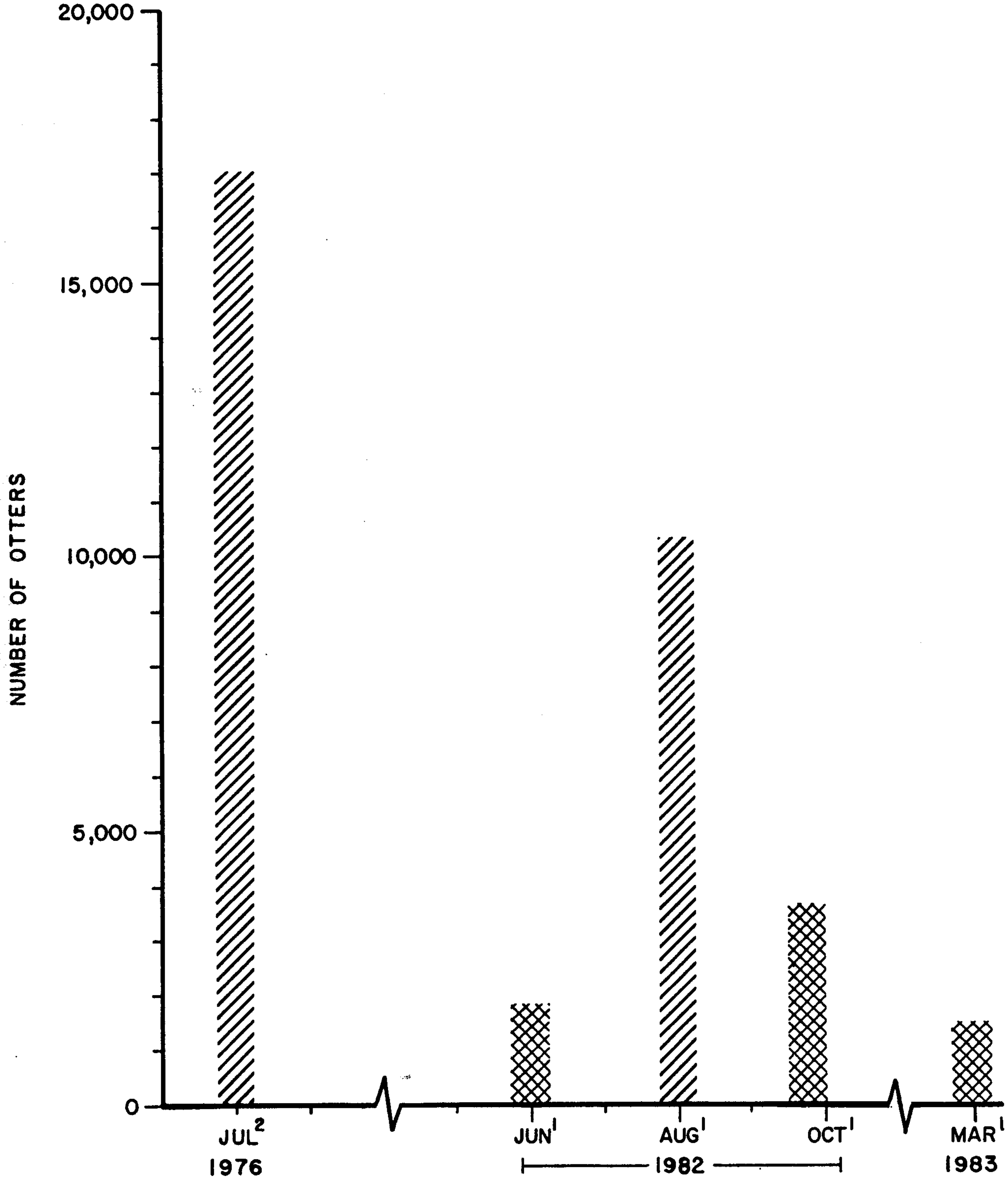
a,b,c,etc. = Values with same letter(s) are not significantly different ($p<.05$)

(4,737), which were not significantly different ($p<.05$) from each other (Figure 6.4-1). Summer values (July 1976) collected by Schneider (1976) were greater but not significantly different ($p<.05$) from August 1982 levels. These results indicate two different seasons, a summer period of high abundance (July-August or September) with over seven times as many sea otters as during the winter (October-June). Additional data in the area from Schneider (1976), not conducted along the transects, also indicates a large (12x) increase in the population during summer months.

Data were also analyzed by dividing the transects into contiguous quadrats, each one measuring two miles long by a tenth mile wide. Density values per quadrat were transformed into rankings. ANOVA analyses indicates significant variability ($p<.05$) with depth, area and season (Table 6.4-1). Abundance values were highest nearshore in waters between 0-20 m deep. Abundance values in each depth interval were highest in August, indicating all depths underwent changes in seasonal usage. Schneider (1976, 1981) also indicated in his figures that abundance was greatest closer to shore. Alongshore variability in otter abundance was also significant ($p<.05$). Otters were more abundant in the Unimak and Izembek areas than in the Black Hills-Port Moller area. These results are consistant with Schneider (1976).

The three factors of season, depth (or offshore location) and alongshore variability have strong interactive components. Ranked abundance values per area were plotted for all four seasons (Figure 6.4-2). By looking at the abundance values per area and total abundance for the whole study site, the interrelationship among variables can be better understood and the demographic dynamics of the population can be developed.

Between March and June the total population size did not change significantly ($p<.05$), but some net movement occurred from deeper to shallower areas off Black Hills. Between June and August the largest net influx of animals occurred into the study area. The largest increase occurred in the Unimak and Izembek areas and into the Port Moller area.



1 = THIS STUDY

2 = SCHNEIDER 1976

SAME PATTERNS = NOT SIGNIFICANTLY DIFFERENT ($p<.05$)

DIFFERENT PATTERNS = SIGNIFICANTLY DIFFERENT ($p<.05$)

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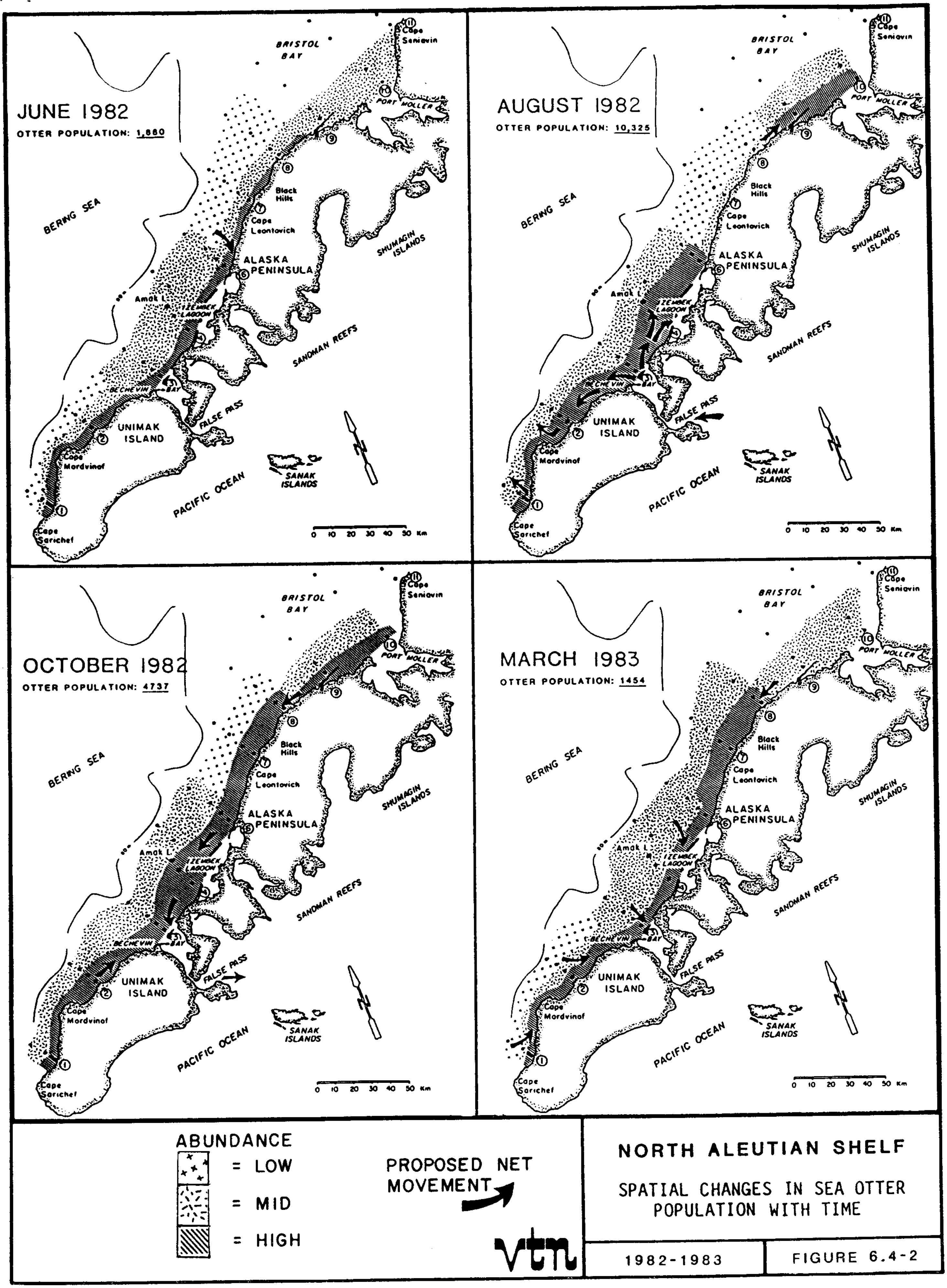
NORTH ALEUTIAN SHELF

SEASONAL CHANGES IN
SEA OTTER POPULATION

1982-1983

FIGURE 6.4-1



NORTH ALEUTIAN SHELF

SPATIAL CHANGES IN SEA OTTER POPULATION WITH TIME

1982-1983	FIGURE 6.4-2

The animals were most likely migrating from Bechevin Bay via False Pass from populations in the Pacific. Lensink (1958) also suggested that the population might undergo seasonal migrations. Such migration is possible since: the route traveled is shallow, allowing continuous feeding as apparently is necessary; the area of highest concentration was in the Bechevin Bay-Izembek Lagoon area where the otters would first enter the area; and observations of large numbers of otters have been made in and around False Pass (John Sarvis, USFWS, Personal Communication).

Migration from further east is unlikely since ice limits the eastern distribution of the animals (Schneider 1976), and/or from further west, either through or across Unimak Pass, is possible but unlikely since otters usually do not migrate along or across deep trenches where they are unable to feed (Kenyon 1969). Sea otters in California also undergo seasonal migrations (Estes and Jameson 1983). In addition, animals released at distances 72 km from their home site returned, often to the same kelp bed (Wild and Ames 1974). These seasonal movements may be related to migration patterns of bottom fish and shellfish (see Section 6.5).

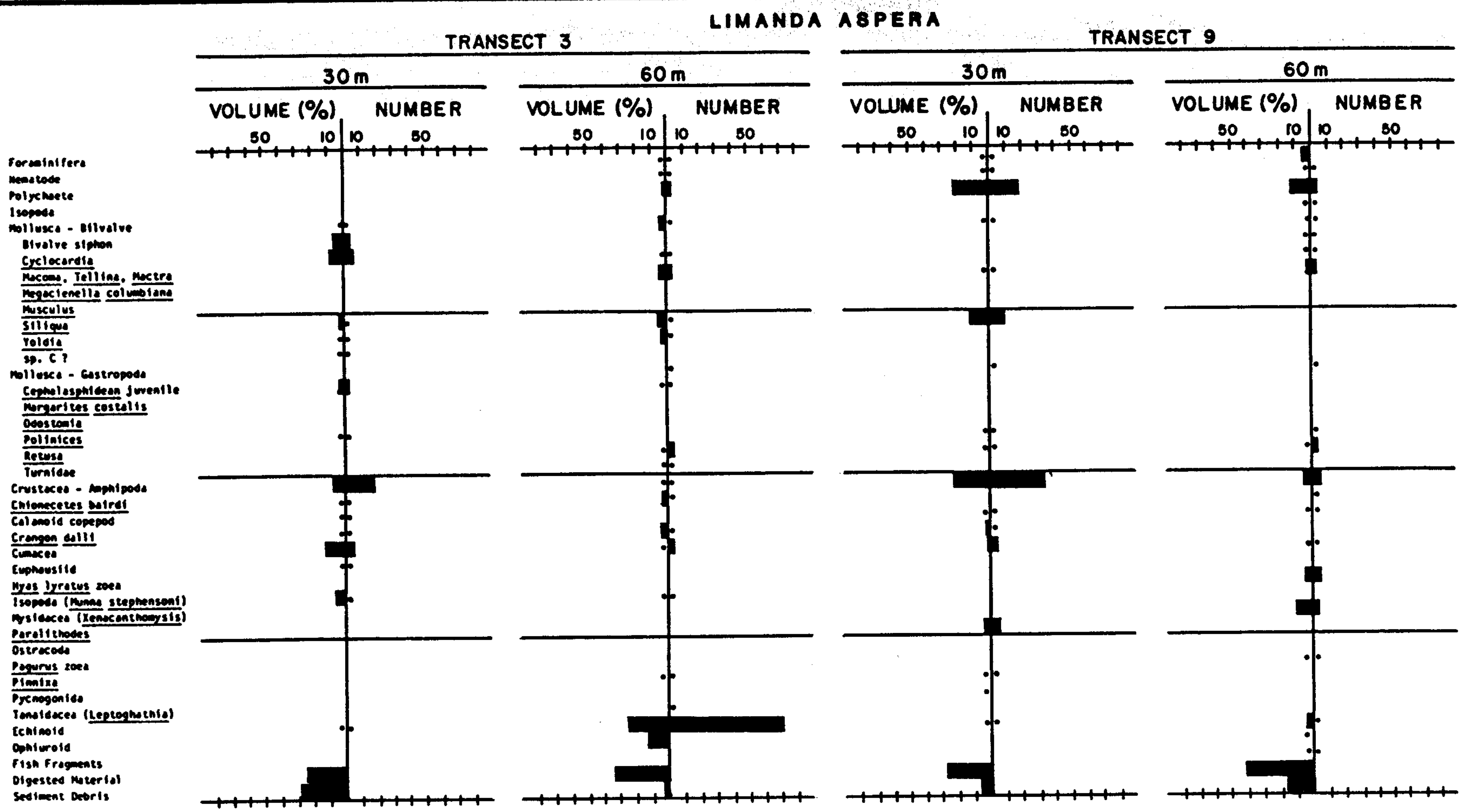
Between August and October the sea otter population decreased significantly ($p<.05$) to near its winter minimum. Net movement occurred from areas deeper and areas removed from Bechevin Bay. Between October and March, the otter population decreased slightly with animals in deeper waters and in areas removed from Bechevin Bay moving back toward this area.

Comparisons between summer surveys conducted in 1976 (Schneider 1976) and this study indicate no significant differences ($p<.05$) (Figure 6.4-1), suggesting that the summer population has been stable between these years. The stability of the population was maintained in spite of the movement of ice into the study area during the winter and spring of 1982 when many sea otters were observed surrounded by or walking on the ice (John Sarvis, USFWS, Personal Communication). Ice is not likely to regulate the summer population. The impact of ice would most likely occur during the winter and early spring when only 10 percent of the summer population is present. Ice probably only affects the distribution and abundance of the winter population on its eastern edge. Ice apparently prevents sea otters from feeding by covering their foraging areas. The otters seek refuge on the ice (Schneider and Faro 1975) or on land where they have been seen walking many miles from the coast (John Sarvis, USFWS, Personal Communication). The number of carcasses noted on the beaches in the late spring of 1982 after the ice retreated did not appear to vary from previous non-ice years (John Sarvis, USFWS, Personal Communication).

Ice could be an important factor if the winter population, as suggested for southern California populations, is composed primarily of pregnant females (Mike Bonnell, UCSC, Personal Communication). Mothers and pups have been observed in the study area, but their relative abundance in the winter is not known.

6.5 Trophic Interactions

Flatfish Feeding Habits. Feeding habits were examined for the two dominant fish species, *Limanda aspera* and *Lepidopsetta bilineata*, in high and low density sea otter areas during August. Results for yellowfin sole (*L. aspera*) are summarized in Figure 6.5-1 and reveal several trends. *L. aspera* taken at shallow stations were smaller than those from deeper stations. The ages of these fish were estimated from published age-length data (Bakkala 1981; Pereyra, et al. 1976). Fish collected at 30 m along both transects averaged three to four years, while the fish from 60 m averaged five to six years on transect 3, and eight to 10 years on transect 9. Smaller fish ate fewer prey taxa (16 and 17), than the larger fish (21).



	Transect 3, 30m	Transect 3, 60m	Transect 9, 30m	Transect 9, 60m
NUMBER OF SAMPLES	10	10	10	10
FISH SIZE, $\bar{x}$ (mm)	156.6	192.0	141.3	258.7
FISH SIZE, RANGE (mm)	90-199	118-235	60-108	204-319
NUMBER OF PREY TAXA	16	21	17	21
FULLNESS, $\bar{x}$	2.2	2.5	3.1	2.1
DIGESTION, $\bar{x}$	3.0	1.7	2.0	2.5
SEX	9M, 1F	4M, 6F	6M, 4F	2M, 8F

■ = ABUNDANCE VALUES

• = <1.0

NORTH ALEUTIAN SHELF

SUMMARY OF GUT ANALYSES FOR YELLOWFIN SOLE

1982-1983 FIGURE 6.5-1

The major items in the diets of L. aspera were polychaetes, crustaceans, bivalve molluscs and echinoderms; the use of these items varied with transect and depth (Table 6.5-1). Fish collected along transect 9 at both depths utilized polychaetes to a greater extent, both in terms of numbers and volume, than fish from transect 3. Fish along both transects at 30 m used more crustacean taxa than those from 60 m. The number and volume of crustaceans used along transect 9 were greater than from transect 3. A greater number of bivalve taxa were utilized at transect 3, and, although total bivalve densities per stomach were approximately the same, bivalve volumes were greater from transect 3. Greater numbers of bivalves were eaten at 30 m than 60 m on both transects. Echinoderms were of minor importance at all stations except at 60 m on transect 3. Echinoderms, primarily small, whole sand dollars (Echinarachnius parma) represented 30 percent (by volume) and 71 percent (by number) in the guts of these fish.

Stomach analysis results for L. bilineata are summarized in Figure 6.5-2 and Table 6.5-1. These fish were also smaller at shallower (30 m) than deeper (60 m) stations. L. bilineata age averaged approximately two years at shallow stations, and three to four years old at deeper stations. The smaller fish generally utilized fewer prey taxa than larger fish.

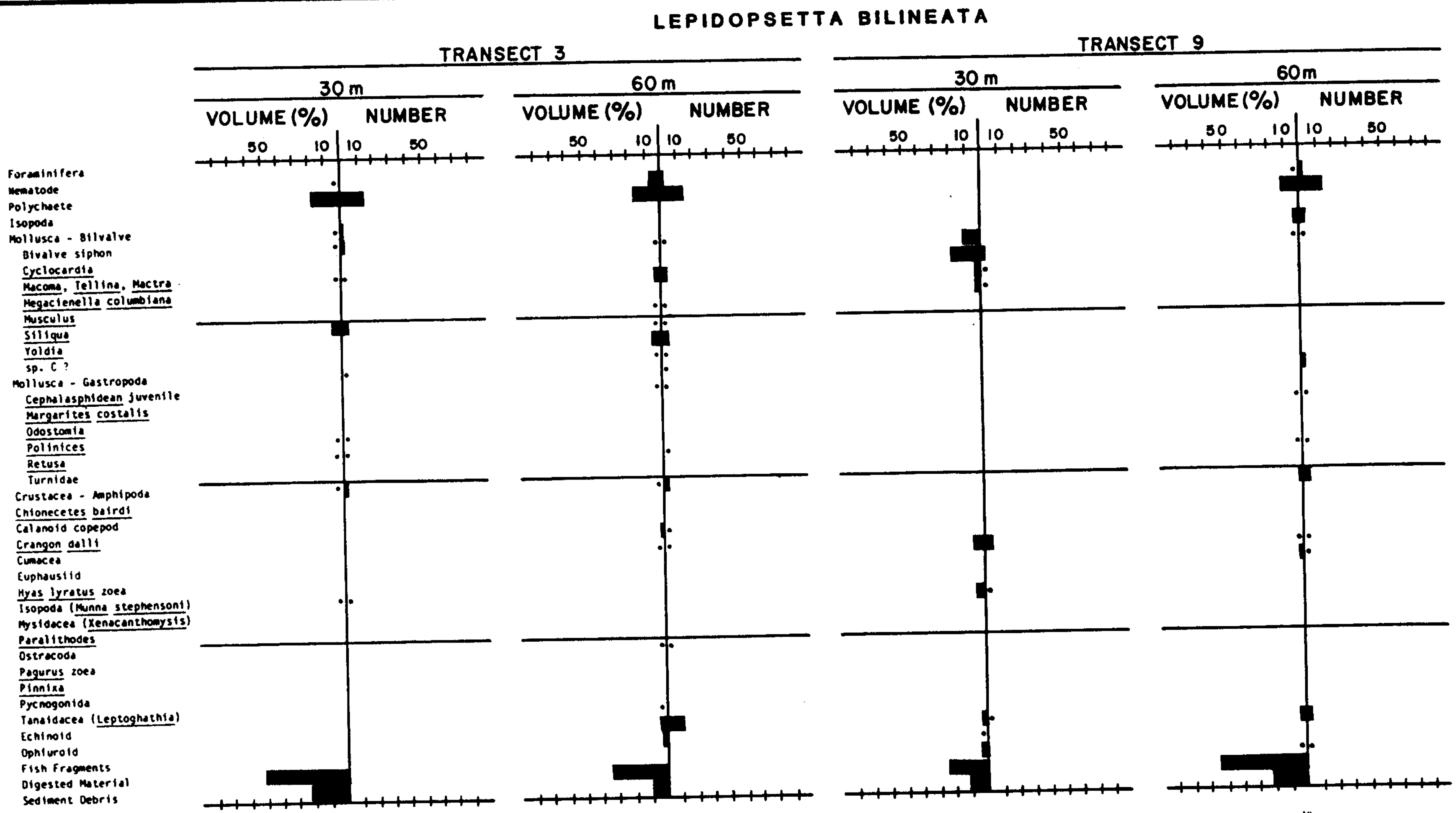
L. bilineata diets were dominated by polychaetes, followed by bivalves and crustaceans; variations by station and transect were evident. Polychaete abundance in fish diets was approximately the same at the three stations where they were utilized, ranging from 12 to 18 percent of the diets. No polychaetes were found in stomachs of fishes collected at the 30 m station along transect 9. Bivalve molluscs, primarily Cyclocardia sp. along with unidentified bivalve siphons, were the major diet item from the 30 m station on transect 9, representing 34 percent of the stomach contents of these fish, by volume. Bivalves were less abundant in guts at the other three stations, ranging from 3 to 11 percent by volume. Crustaceans were of minor importance with the

TABLE 6.5-1

COMPARISON OF PREY ITEMS BETWEEN YELLOWFIN AND ROCK SOLE

	Mean Number								Mean Volume (%)							
	L. aspera				L. bilineata				L. aspera				L. bilineata			
	Transect 3		Transect 9		Transect 3		Transect 9		Transect 3		Transect 9		Transect 3		Transect 9	
Taxon	30m	60m	30m	60m	30m	60m	30m	60m	30m	60m	30m	60m	30m	60m	30m	60m
Foraminifera	0	0.4	0.1	0	0	0	0	0	0	0.4	0.1	5.9	0	0	0	0
Nematoda	0	0.4	0.1	0	1.1	0.8	0	1.3	0	0.4	0.1	0.5	0.5	6.4	0	0.8
Polychaeta	0	1.2	19.7	2.5	14.8	13.8	0	14.8	0	1.3	20.8	12.6	18.4	18.4	0	11.7
Bivalvia	10.9	4.7	10.0	2.2	2.5	8.4	5.5	2.3	17.2	17.9	12.0	2.1	4.6	11.4	33.7	3.0
Gastropoda	2.0	2.0	0.9	0.5	0.8	1.4	0	1.5	2.3	0.8	0.8	0.9	0.5	0.6	0	0.9
Crustacea	26.9	3.1	44.2	11.0	1.1	3.6	4.5	6.4	27.2	7.6	29.8	18.1	2.5	2.7	11.1	3.2
Echinodermata	0.5	71.5	0.2	0.8	0	9.6	0.3	1.4	0.2	36.1	0.5	1.2	0	4.7	1.9	3.3
Cordata	0	0	0	0.2	0	0	0	0.2	0	0	0	0.1	0	0	2.5	0.1
Detritus	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0.3
Digested Material	-	-	-	-	-	-	-	-	23.6	32.5	28.6	40.7	51.9	35.7	27.3	55.1
Sediment Debris	-	-	-	-	-	-	-	-	26.5	1.3	6.6	15.8	23.7	10.0	11.2	20.4

- = Not determined



	Transect 3, 30 m	Transect 3, 60 m	Transect 9, 30 m	Transect 9, 60 m
NUMBER OF SAMPLES	10	9	9	10
FISH SIZE, $\bar{x}$ (mm)	161.2	194.2	158.4	237.0
FISH SIZE, RANGE (mm)	115-204	155-263	112-268	164-330
NUMBER OF PREY TAXA	11	18	9	12
FULLNESS, $\bar{x}$	2.8	2.7	2.7	2.6
DIGESTION, $\bar{x}$	3.6	2.6	3.2	3.7
SEX	10M	5M, 4F	8M, 1?	2F, 8?

• = <1.0

▬ = ABUNDANCE VALUES

• = < 1.0

NORTH ALEUTIAN SHELF

SUMMARY OF GUT ANALYSES FOR ROCK SOLE

1982-1983 FIGURE 6.5-2

exception of fish at 30 m on transect 9 where cumaceans were abundant in the guts. Echinoderms, primarily small sand dollars, were abundant in guts from fish at the 60 m contour along transect 3.

These two flatfish species had large differences in their diets. Limanda aspera is considered an opportunistic feeder which utilizes a wide variety of prey items (Pereyra, et al. 1976). Small specimens (100-200 mm) in the Bering Sea have been reported to feed primarily on amphipods and polychaetes (Bakkala 1981; Pereyra, et al. 1976); whereas small specimens of Lepidopsetta bilineata feed primarily on polychaetes, followed by molluscs, and then crustaceans (Pereyra, et al. 1976). The relative importance of major prey taxa in the diets of these two species as examined during this study is shown in Table 6.5-2. The main dietary difference was the greater use of crustaceans (primarily amphipods) by L. aspera. L. bilineata consumed more polychaetes, while L. aspera used more echinoderms. These results generally agree with previous studies cited. The use of small sand dollars was not important in the diets of fish in other reports; the use of this prey in the present study occurred primarily at one station.

Sea Otter Feeding Habits. Results of scat analyses indicate that crustaceans (crabs, shrimp and amphipods), molluscs (clams and mussels), echinoderms (sand dollars) and chordates (fish) were the most frequent food items (Table 6.5-3). The small sample size and collection period limits the ability to develop a diet for this sea otter population solely on these results. The sample size was small (9) and samples were collected from only one site (Glazenap Island near Izembek Lagoon) over a two-day period. A generalized picture of sea otter diet can be derived, however, by considering additional information from other studies.

A data base of sea otter prey from scat and stomach content analyses, and dive observations from this study and other eastern Pacific investigations is summarized in Table 6.5-4. Species were lumped into ecologi-

TABLE 6.5-2

RELATIVE IMPORTANCE OF FLATFISH PREY TAXA[a]

Major Prey Taxa	Flatfish Species	
	Limanda aspera	Lipidopsetta bilineata
Polychaetes	8.7	12.1
Bivalves	12.3	13.2
Crustaceans	20.7	4.9
Echinoderms	9.5	2.5
TOTAL	51.2	32.7

(a) Values are mean percent of total stomach volume

TABLE 6.5-3

ORGANISMS IDENTIFIED FROM SEA OTTER SCATS

Prey Items	Samples									Percent Frequency	
	1	2	3	4	5	6	7	8	9	Taxa	Phyla
Phylum Cnidaria (Total)										-[a]	11
Hydroid						P[b]				11	-
Phylum Nemertina (Total)										-	11
Nemertean								1[c]		11	-
Phylum Mollusca (Total)										-	67
Bivalve*[d]	P						P			22	-
Macoma balthica		1								11	-
*Mytilus edulis**			P	P	P					33	-
Phylum Arthropoda (Total)										-	77
Amphipod				P				P		22	-
Brachyura										-	-
Brachyura*	22			1+					1+	33	-
?*Chionoecetes*						1			1	22	-
?*Cancer*								1+		11	-
?*Erimissus*		1								11	-
Oregonia gracilis						1				11	-
Carid										-	-
?*Crangon*		7								11	-
Crangon alaskensis								1+		11	-
Crangon dalli				1						11	-
?*Pandalid*		1								11	-
Phylum Echinodermata (Total)										-	44
Echinarachnius parma	P	P			P	P				44	-
Phylum Chordata (Total)										-	22
Pleuronectid*	5+									11	-
(?*Limanda aspera*)								2		11	-
Scorpaeniform								2		11	-

(a) - = Not calculated
(b) P = Present
(c) Values represent numbers of animals per scat
(d) * = Important prey items (see text)

TABLE 6.5-4

SEA OTTER PREY ITEMS FROM OTHER EASTERN PACIFIC STUDIES

Sample	ALEUTIAN ISLANDS: Amchitka, AK Dives (%F)	Amchitka, AK Scats (%F)	Amchitka, AK Sp. 1962 Stomachs (%F)	Amchitka, AK Fall 1962 Stomachs (%F)	Amchitka, AK Sp. 1963 Stomachs (%F)	Attu, AK Dives (%F)	BERING SEA/PRINCE WILLIAM SOUND: N. Aleutian, AK Scats (%F)	Bering Sea Stomach (%V)	Bering Sea Scats (D)	Shumagin, AK Scats (%F)	Shumagin, AK Stomach (%V)	Green Is, AK Dives (%F)	Sheep Bay Dives (%F)	OREGON/CALIFORNIA: Oregon Dives (%F)	Piedras Blancas, CA Dives (%F)	Buchon, CA Dives (%F)
Division Phaeophyta	3														<1	
Phylum Cnidaria						<1	11								11	
Phylum Annelida/ Nemertina			5+		5		11									
Phylum Echiuroida												3				
Phylum Mollusca																
Abalone															2	3
Clam	4	1	1		3+	2	33	68+	20+	8	99	44	70	2	2	
Mussel/scallop	<1	21+	28+	12+	24+	3	33	<1	7	77+	1	40	22	3	2	<1
Octopus		1	12	4	14	4								1	6	
Snail/chiton	<1	6+	10+	5+	10+	1				5				2	13	10
Phylum Arthropoda																
Amphipod			5		6		22									
Barnacles															1	
Crabs - Brachyura	1	18	5+	5+	5+	4	66	7	1	16		2	2	5		13
- Hermit			3	3	9			24	3						31	
Isopods			6		3											
Shrimp			1		1		33									
Phylum Echinodermata																
Brittle star			1		13											
Sand dollar							44									
Sea cucumber	<1		17	4											<1	<1
Seastars			29+	2	28+	1								1	1	
Sea urchins	47	95	71	17	92	74				4				64	1	52
Phylum Chordata																
Tunicates			4	1	6											
Fish	12	15	22+	4+	87+	<1	22	50	1	10						
Sample Size	580	422	107	20	182	563	9	2	2	75	2	420	251	425	820	567
Reference	(1)	(2)	(2)	(2)	(2)	(2)	(3)	(2)	(2)	(2)	(2)	(1)	(1)	(4)	(1)	(1)

%F = Percent Frequency
%V = Percent Volume
D = Density
(shaded) = Important prey

References: (1) Estes, et al. 1981
(2) Kenyon 1969
(3) This Study
(4) Estes, et al. 1982

cally equivalent prey items (e.g., clams), so different geographical areas could be compared. As a result, where several species occurred in one of these taxa, the largest value was taken to represent the minimum frequency level. A precise level could not be determined for such prey without the original data since the distribution of all the prey items in that taxon was not provided.

Arthropod crustaceans were the most frequently found organisms in the scats from the present study. These prey included brachyuran crabs, shrimp and amphipods. Brachyuran crabs were identified as otter prey items in almost all of the studies cited (Table 6.5-4) and were found in 66 percent of the scats examined for this study. Crabs in the study area are large, should be easy to catch and in general have a high caloric value (Kenyon 1969). For these reasons crabs are considered to be an important sea otter prey item in the study area.

Shrimp and amphipods were found in 33 and 22 percent of the scat samples from this study, respectively. Even though both organisms are abundant throughout the study area, they were small, were not found in otter stomachs during other Bering Sea studies and have rarely been found in the guts or feces in any other area. For these reasons, shrimp and amphipods are not considered important prey items.

Molluscs constituted the second most frequent prey items in this study. Clams (Macoma balthica and bivalves) were found in 33 percent of the scats. These organisms have been found in the stomachs of other Bering Sea otters and have been identified as prey items in all other reported studies of eastern Pacific otters. These organisms are found throughout the study site, with epifaunal mussels attached to more stable substrates and infaunal clams inhabiting soft sediments. They are easy to capture, and caloric value is moderate to high (Kenyon 1969). Mussels and clams can be considered as important prey items to the otter population in the study area.

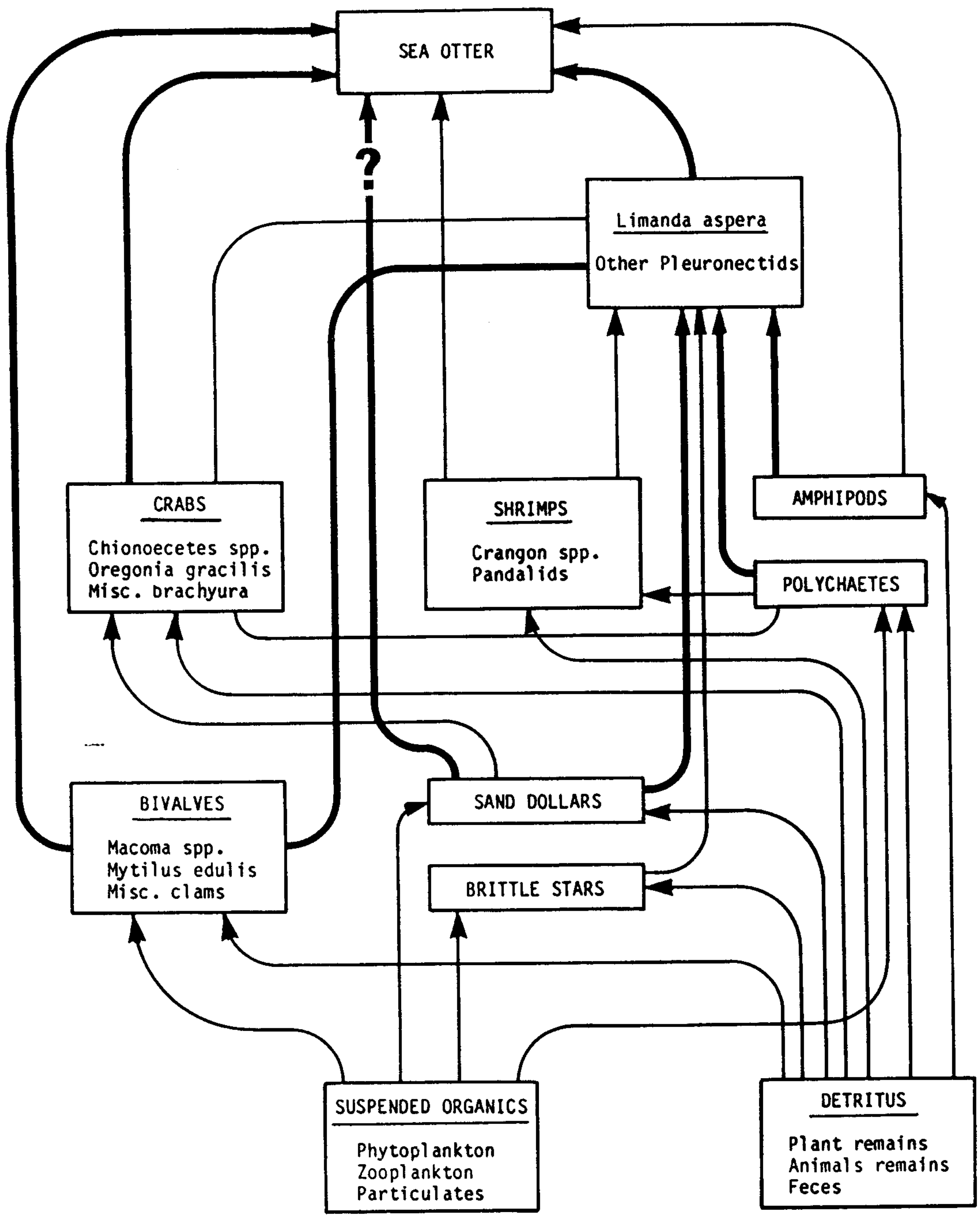
Sand dollars were the third most frequent food item. This organism was abundant in the study area, being collected in high abundance both in epifaunal and infaunal samples, as well as in the guts of flatfish. Whether the otters directly ingested the sand dollars or ingested fish which had eaten them is not certain. Since three of the four scats with sand dollars did not have any fish parts, direct ingestion may occur. If otters are feeding on sand dollars, the organisms might be on important prey item due to their high frequency in the scats, high abundance in the area and their ease of capture and ingestion. Sand dollar coloric value, however, is probably low compared to other prey items. These results provide the first known report of sand dollars possibly being a sea otter prey item, probably since sand dollars, inhabiting the open coast sandy areas, and sea otters, living in rocky regions with kelp or protected embayments, rarely co-occur.

The fourth most frequent prey item in the scats were fish, particularly flatfish (Pleuronectids). These prey items, particulary yellowfin and rock sole, are extremely abundant in the study area (see Section 6.3) and comprised 50 percent by volume of the sea otter stomachs sampled in the Bering Sea (Kenyon 1969). Fish have been reported to be important prey items in all other areas of the Aleutians, and otters are reported to prefer them over sea urchins (Kenyon 1969). Flatfish are easy to capture, easy to ingest (the presence of five lower jaws in all scats sampled indicates they may eat the entire animal) and are high in calories (Kenyon 1969). Finally, the seasonal and spatial distribution of the flatfish and crab populations within the study area corresponds with and could be an important factor regulating the temporal and possibly spatial distribution of the sea otters. For these reasons fish are considered an important prey item to the sea otters.

Several species which have been found to be common prey items in other areas, but not the Bering Sea, are sea urchins, gastropods (limpets and chitons) and hermit crabs. Sea urchins are usually found on rocky, stable habitats often associated with kelp. Sea urchins were collected in low abundance in trawls off Unimak Island and observed during dives in rocky areas off Amak and Unimak Islands. Although no sea urchin tests and/or spines were recorded from the scats in the Bering Sea, other evidence indicates that otters are feeding to some degree on these prey. Several of the sea otter skulls examined near the entrance to Izembek Lagoon were stained purple, evidence of sea urchin predation (Kenyon 1969). Sea urchins are not considered an important prey item in the study area, but would be more important if these animals are seasonally migrating into the Pacific during the winter where kelp beds and sea urchins may be abundant. Hermit crabs or their mollusc shell homes were not found in these scat samples even though they have been reported in other Bering Sea studies and were extremely abundant in the epifaunal surveys.

A preliminary sea otter food web was developed from the results of sea otter scat analyses and fish guts examined in this study and information obtained from other investigations (Figure 6.5-3). These results suggests that flatfish are important prey items and could be competitors for prey with sea otters, but more likely these predators might partition the common resources based on prey size.

Comparisons were made of abundance of sea otter prey items in different areas as determined with epifaunal trawls. The mean biomass values per sample for these taxa, organized by the epifaunal site groups discussed in Section 6.3, are presented in Table 6.5-5. The greatest number of otter prey taxa was found in site groups IA1 and IA2; the highest biomass values for two of the prey taxa, Cancer spp. and Limanda aspera, were found in site group II. The distribution of site group IA, as shown in Figure 6.3-2, includes all depths sampled in the Bechevin Bay-Izembek Lagoon area, intermediate and greater depths east and west of the lagoons, and the shallow depths in the Port Moller area. Group II sites were at the mouths of Bechevin Bay, Izembek Lagoon and Port Moller (Figure 6.3-2).



SOURCE: Present Study; Feder and Jewett 1980

ENERGY PATHWAYS

Major Importance

Minor Importance

vtn

NORTH ALEUTIAN SHELF

PROPOSED SEA OTTER FOOD WEB

1982 - 1983

FIGURE 6.5-3

TABLE 6.5-5

COMPARATIVE ABUNDANCE OF SEA OTTER PREY IN EPIFAUNAL COMMUNITIES

	Mean Biomass[a] by Epifauna Site Groups[b]				
	Group IA1	Group IA2	Group IB1	Group IB2	Group II
Otter Prey Taxa[c]					
*Bivalve	0.1	5.2	0.0	0.0	0.0
Mytilus edulis	0.0	39.8	0.0	0.0	0.0
(*Siliqua patula*)(d)	0.1	3.5	0.0	0.0	0.0
(*Cyclocardia* sp.)(d)	<.1	0.0	0.0	0.7	0.0
**Chionoecetes* spp.	157.4	0.3	0.0	3.2	0.0
**Cancer* spp.	0.4	88.8	0.0	18.0	152.5
**Oregonia gracilis*	0.0	92.8	0.0	6.0	0.0
**Echinarachnius parma*	29.4	2,020.0	0.0	129.5	0.0
**Limanda aspera*	12,344.0	2,723.0	7,240.0	4,005.0	18,536.0
Otter Prey Taxa[e]					
Snails	10.5	2.5	199.0	30.3	0.0
Hermit crabs	59.2	5.5	306.6	74.6	0.0
Shrimps	56.2	7.0	68.8	552.4	10.0
Sea cucumbers	0.3	1.0	44.3	7.0	0.0
Seastars	1,660.0	2.0	15,388.0	1,473.0	1,120.0
Sea urchins	0.7	10.3	5.6	0.1	0.0
Tunicates	331.4	0.0	11,300.0	448.6	40.0
Flatfishes(f)	18,337.0	8,375.0	16,135.0	9,202.0	22,731.0

(a) Grams per trawl

(b) Groups from samilarity analysis

(c) Taxa found only in otter scats and epifaunal samples, this study

(d) Not specifically identified from otter scats

(e) Taxa reported from other studies and found in epifaunal samples, this study

(f) Including *Limanda aspera*

* = Major prey items

Sea otter prey items found in other studies are also listed in Table 6.5-5, with corresponding mean biomass values for epifaunal site groups determined during the present study. The greatest mean biomass values for most prey taxa occur in site group IB1. The distribution of this site group is primarily in areas not occupied by site group IA, namely deeper stations off Izembek Lagoon and Port Moller, and shallow stations between Izembek Lagoon and Port Moller as well as the central Unimak Island coast (Figure 6.3-4).

The data available from this and other studies indicate that sea otters in the areas offshore from the coastal lagoons and bays have large food resources of flatfish, crabs and clams available, and that areas between the lagoons and bays contain a greater variety of invertebrate food resources. The seasonal aspects of sea otter food resources are not clearly understood for the North Aleutian Shelf study area. Adult red king crabs (Paralithodes camtchatica) move into the area during summer from deeper wintering grounds; adult yellow fin sole migrate east into Bristol Bay during the summer (Bakkala 1981).

Comparisons in the abundance of selected infaunal and epifaunal parameters were made among areas and depths of high and low otter abundance to assess the relative importance of otters versus other environmental variables on these organisms (Table 6.5-6). Most values correspond primarily with physical factors. For instance, the low abundance of organisms in shallow depths (0-20 m) in all areas is attributed to the apparent harsh inshore conditions. Large clam and flatfish abundance was high in all sandy areas, regardless of depth. Seasonally, the abundance of clams was greatest in June and decreased through the summer. This trend could be attributed to otter or fish predation. Total epifaunal biomass and yellowfin/rock sole biomass was higher in August and October in shallow habitats and lower in deeper waters. This distribution and abundance corresponded with the abundance of sea otters. The seasonal movement of flatfish (an apparent primary prey item of the otters) to shallower waters and co-occurrence with otter

TABLE 6.5-6

COMPARATIVE ABUNDANCE OF BENTHIC INFAUNA AND EPIFAUNA

Area	Transects	June 0-20 (m)	June 21-40 (m)	June 41-60 (m)	August 0-20 (m)	August 21-40 (m)	August 41-60 (m)	October 0-20 (m)	October 21-40 (m)	October 41-60 (m)
Infaunal Species (mean/0.25 m^2)										
Unimak	1-2	15	30	26	-	-	31	-	14	32
Izembek	3-6	12	18	40	-	-	46	-	27	34
Black Hills	7-8	10	25	25	-	-	26	-	10	32
Port Moller	9-11	8	18	29	-	-	33	-	-	33
Infaunal Specimens (mean/0.25 m^2)										
Unimak	1-2	384	445	116	-	-	231	-	93	158
Izembek	3-6	102	115	407	-	-	364	-	339	304
Black Hills	7-8	49	243	152	-	-	300	-	68	1,988
Port Moller	9-11	48	344	526	-	-	502	-	-	301
Diversity (H)										
Unimak	1-2	1.20	2.37	2.50	-	-	2.20	-	1.42	-
Izembek	3-6	1.73	2.06	2.00	-	-	2.88	-	2.15	2.69
Black Hills	7-8	1.76	1.94	2.37	-	-	2.03	-	1.51	0.48
Port Moller	9-11	1.70	1.78	1.55	-	-	1.66	-	-	1.78

TABLE 6.5-6

(continued)

Area	Transects	June 0-20 (m)	June 21-40 (m)	June 41-60 (m)	August 0-20 (m)	August 21-40 (m)	August 41-60 (m)	October 0-20 (m)	October 21-40 (m)	October 41-60 (m)
Large Clams										
Unimak	1-2	2.6	12.4	15.8	-	-	9.3	-	2.5	9.0
Izembek	3-6	18.1	11.4	5.2	-	-	5.0	-	29.1	2.8
Black Hills	7-8	0.0	2.8	18.0	-	-	13.3	-	0.0	1.0
Port Moller	9-11	1.3	23.8	17.7	-	-	8.0	-	-	0.5
Total Epifaunal Biomass (kgms/trawl)										
Unimak	1-2	10.3	24.8	17.8	137.0	11.0	8.1	-	10.3	5.6
Izembek	3-6	20.8	67.3	41.9	28.0	-	17.4	30.2	27.5	11.9
Black Hills	7-8	9.8	11.7	99.3	18.2	64.7	35.6	22.1	-	18.9
Port Moller	9-11	-	130.4	137.0	60.8	35.9	52.4	16.0	20.5	13.5
Yellowfin and Rock Sole (kgms/trawl)										
Unimak	1-2	8.5	9.0	11.6	8.9	10.0	5.9	-	-	5.3
Izembek	3-6	18.5	45.6	35.2	-	19.5	16.1	18.8	17.0	6.6
Black Hills	7-8	-	9.2	40.6	9.5	-	27.9	-	-	14.3
Port Moller	9-11	-	60.9	61.3	37.5	22.6	28.3	5.1	17.0	6.4

- = Not determined

abundance in sandy areas suggests that the presence of flatfish and crabs might be the ultimate factor regulating the seasonal movement of otters between the Pacific Ocean and the Bering Sea.

These results suggest that the distribution of communities, abundance indices and most selected prey is regulated primarily by environmental factors, namely sediment and depth, not by sea otter predation. In turn, the seasonal and spatial distribution of otters appears to be regulated primarily by season (possibly triggered by higher temperatures and seasonal abundance of flatfish and crabs), secondarily by habitat (sandy areas with flatfish, crab and clams) and thirdly by distance from the source of migrating animals (Bechevin Bay).

Sea otters in the Kurile Islands of Russia were also reported to feed on fish, crab and octopus during the summer and sea urchins and molluscs during the winter (Shitikov 1971 cited by Estes et al. 1981). Results from this study indicate that sea otters migrate from the Pacific Ocean, where they feed (on urchins and molluscs?) in the winter, to the Bering Sea in the summer where they feed on fish, crab and clams. The movement of these sea otters correspond with the movement of crabs (Armstrong et al. 1983) and yellowfin sole (Bakkala 1981) to shallow waters in late winter-early spring. The migration of these otter prey items has been attributed to warmer temperatures and perhaps increased food supply. While the ultimate factor regulating the seasonal sea otter migration may be to feed on flatfish and crab, the proximal factor may be temperature. Results of this study indicate a warm temperature plume in the study area centered off the Izembek Lagoon. The migration of flatfish to deeper waters in the fall occurs with decreasing temperatures (Bakkala 1981). By October, most of the otters have also left the area even though they are able to survive throughout the year at much lower temperatures. The overall high abundance of sea otters in the area is attributed to the high quality (abundance of prey items) and quantity (broad, shallow shelf for feeding) of the habitat.

6.6 Impacts of Oil and Gas Exploration and Development

Introduction. Determination of impacts includes evaluation of a series of interacting processes, namely those among the various phases of oil and gas exploration and development and the biological processes associated with the the sea otter's life history. Since there is a varying degree of knowledge in each step, there is an even greater uncertainty in the resulting projected impacts. This discussion follows the four major phases of oil development outlined by Geraci and St. Aubin (1980) in their review of impacts of oil on marine mammals (Table 6.6-1).

Exploration. Exploration involves seismic and drilling surveys, as well as air and vessel support. Seismic surveys produce shock waves which are known to injure and kill sea otters, depending on the strength and distance of the explosion, the nature of sea floor and water depth (Geraci and St. Aubin 1980). Sublethal affects may include avoidance of areas for feeding. Drilling, air support, vessel support and construction also result in increased noise and visual disturbances. Sea otters will likely react to noise, depending on level, by diving and swimming away. Such activity could reduce valuable feeding time. Some behavioral or physiological adaptations may occur with time as the animals become more exposed to the potential hazards. Maximum impacts would occur in the Izembek-Bechevin area where maximum otter densities and apparent migration occurs. Drilling also involves potential hazards of a blowout, thereby releasing oil. The potential hazard of oil spills will be discussed later.

Production. Production includes drilling, air support, vessel support and construction which all involve potential noise hazards as addressed earlier. Production also involves risks of oil spills. Factors regarding the potential impacts of an oil spill on sea otters are the location of the spill, size of the spill, season and local weather conditions. The location of the spill and weather conditions are major factors that

TABLE 6.6-1

SUMMARY OF SEA OTTER VULNERABILITY TO OIL AND GAS EXPLORATION AND DEVELOPMENT

Project Phase	Physical Factor	Biological Response[a]	Important Considerations
Exploration			
Seismic expolosions, drilling, air and vessel support	Noise	Possible mortalities; disturbance	Depends on decibles, environmental conditions, location of otters
Production			
Drilling, air and vessel support	Noise	Possible mortalities; disturbance	Depends on decibles, environmental conditions, location of otters
Drilling and vessel support	Oil spills	Probable mortalities (fouled fur and possible toxicities); probable disturbance (decreased feeding, slick, tainted prey, sediments)	Depends on physical and chemical characteristics and location of spill
Transportation			
Vessels	Noise	Possible mortalities; disturbance	Depends on decibles, environmental conditions, location of otters
Pipeline emplacement	Sediment disturbance	Possible mortalities; disturbance	Depends on location, size of area and period of disturbance
Onshore Facilities	Noise	Possible mortalities; disturbance	Depends on decibles, environmental conditions, location of otters
	Oil spills	Probable mortalities (fouled fur and possible toxicities); probable disturbance (decreased feeding, slick, tainted prey, sediments)	Depends on physical and chemical characteristics and location of spill

(a) Represents short-term impacts which may lead to mortalities. Subsequent implications of mortalities on long-term status of population are too variable to address at this time.

would determine the trajectory of the spill. Distance offshore and atmospheric conditions will also determine the size and shape of the slick as well as the concentration of toxic components. Any spill near the center of the sea otter distribution, nearshore of the Izembek Lagoon and Bechevin Bay, would have the greatest impact on the otter population. The type of oil spilled is critical. Crude oil may damage the fur more, while refined oils may be more toxic. Much of the oil handled in the area would likely be crude. Finally, season is critical since oil spills, which are more likely to occur during the winter months because of rough weather, would only impact 10 percent of the total population, but if females and/or pups are present or if the oil settles to the benthos, longer-term impacts may occur.

Impacts of an oil spill on the sea otter depend critically on the ability of otters to avoid the spill. Both field and laboratory studies on sea otters have been conducted but are limited. Additional information has been extrapolated from studies on other marine mammals.

Otters would be susceptible to oil slicks since they spend much time on the surface feeding, cleaning, rafting and moving from place to place (Schneider 1981). Results of laboratory studies concluded that otters do not avoid oil (Siniff et al. 1982). These results are hard to extrapolate to field conditions due to the small size of the pool. Additional evidence indicates that otters can not avoid oil slicks. Otters often swim on their back with their head looking toward their tail (Danial Costa, UCSC, personal observation; Kenyon 1969). This swimming behavior may preclude visual observations of objects in front of them as is the case when otters are captured in tangle nets which extend down from the surface. Not all otters can be captured in this way; many see the net and either swim under or around it. Sea otters may respond to an oil slick in a similar way, with some animals swimming into it and being fouled while others might avoid it. The shape and size of the slick may modify their avoidance success.

Some evidence suggests that otters may avoid oil slicks. Barabash-Nikiforov, et al. (1947) indicate that Japanese poachers used petroleum products to herd otters away from the shore; sea otters apparently possess a highly developed sense of smell (Kenyon 1969) and may detect the petroleum odor, and thereby avoid the slicks.

Direct contact with oil is the most obvious and potentially damaging consequence of oil contamination to sea otters. Apparently, no oil spills have occurred in a sea otter population that has been closely monitored to determine impacts on the otters. Kenyon (1969) stated that the Shumagin Island population, south of the Alaska Peninsula, "was certainly reduced when a tanker and a freighter were wrecked and spilled oil in this area during World War II," and that "many sea otters and ducks were killed by oil on the water (Kenyon 1964)". Kenyon did not indicate the number of mortalities nor the means of assessment.

The most common impact of oil contamination upon sea otters reported thus far is the loss of thermal insultation from fouling of the fur. Thermal homeostasis in sea otters is dependent upon the presence of an air layer entrapped in the very dense underfur (Costa and Kooyman 1982). When oil comes into contact with the fur this air layer is destroyed and results in a loss of heat. Otters have the highest heat production of any mammal of equal size (Costa and Kooyman 1982; Iversen and Krog 1973; Morrison et al. 1974). A large decrease in thermal insulation, as a result of fouling of the fur by oil, is likely to require a corresponding increase in heat production that could not be maintained for an extended period (Costa and Kooyman 1982).

Oil fouling of 30 percent or more of the sea otter's fur surface is estimated to result in death from hypothermia or pneumonia (Costa and Kooyman 1979). Otters coated with oil on up to 10 percent of their body surface survived at least 20 days. In a similar study, Siniff et al. (1982) found that sea otters survived between four days and three weeks after the application of 25 mls of crude oil. In both studies, increases in oil exposure increased the time spent grooming, specifically the oil-fouled fur. However, these studies were conducted during the summer when the weather is mildest and the animals could forage in areas where prey availability was high. In rough weather when tanker or other oil development accidents could be more likely, the otters foraging ability might be reduced, making the animals more susceptible to ramifications associated with spills.

The sensitivity of sea otters to oil toxicity has not been directly examined due to the more profound thermoregulatory consequence of reduced thermal insulation due to oil-fouled fur. However, toxic effects may prove to be important when otters are exposed to quantities of oil insufficient to cause immediate death from hypothermia or pneumonia. Several studies have shown that sea otters can survive small amounts of crude oil (10% of the body surface covered, Costa and Kooyman 1979; 25 mls, Siniff, et al. 1982). However, the oil was removed by the otters grooming activities, which included licking of the oil-fouled area. Therefore, as the fur is groomed, oil is ingested and could result in acute or chronic systemic toxicity.

Analysis of other studies does not firmly establish if ingested oil is toxic to sea otters. Sea otters ingest and process the largest material and fluid volume of any marine mammal of its size, and therefore could be ingesting large quantities of potentially toxic compounds. However, this large fluid intake could also help to flush ingested oil compounds out of their system, thereby preventing accumulation to toxic levels.

Sea otters exposed to oil under laboratory conditions did not exhibit noticeable toxicity from oil ingestion (Costa and Kooyman 1982). However, these otters were exposed to oil for only 12 hours in three experiments and six days in one experiment. Such brief periods could have precluded the ingestion of significant amounts of oil. Free-ranging sea otters that were oiled and followed via radio-transmitters for two to three weeks in the field did not exhibit obvious toxic effects (Costa and Kooyman 1979). In addition, Siniff et al. (1982) did not rule out the possibility of death due to oil toxicity in one otter that died after swimming in an oil-coated pool for 12 hours.

Little is known concerning the indirect effects of crude oil, but these may include environmental contamination that may result in reduction or avoidance of prey items and habitat. Oil uptake by prey organisms could result in the death of the prey due to oil toxicity or to its becoming tainted and unpalatable to sea otters. Sediments tainted with oil might also inhibit feeding. The turbulent nature of the area and relatively unstratified water column of the North Aleutian Shelf (Schumacher et al. 1979) increases the chances of oil being transferred to the benthos (Curl and Manen 1982). Impacts of oil are known to have long-term impacts on benthic organisms, such as clams (Armstrong et al. 1982) which are important sea otter prey.

Further indirect effects could result from general habitat loss as the sea otters move out of the area to avoid slicks. Time lost from feeding is critical to sea otters; otters are estimated to use 30 percent of their time feeding (Loughlin 1977, Shimek and Monk 1977) and adults ingest 23 to 29 percent of their body weight per day (Kenyon 1969). Starved animals loose 10 percent of their weight per day and a weight loss of 23 to 24 percent (2 to 3 days time) would be lethal (Miller 1974). In Alaska, many animals starve to death during the winter (Miller 1974) and during years of low food abundance (Kenyon 1969). Females will abandon their pups in late winter and early spring when food is scarce (Miller 1974). Time lost from feeding due to the oil spill would be critical, especially at times of additional stress such as low winter temperatures, low food availability and other ramifications of oil and gas exploration and development, such as cleaning oiled fur.

Transportation. This phase involves transport vessels and pipeline emplacement, involving potential noise and other hazards discussed previously. Pipeline emplacement can also disturb the bottom and impact potential prey items. However, this impact would be local and therefore minimal.

Transportation also involves onshore support in which potential onshore activities may affect the sea otters. Since most potential onshore facilities (Cold Bay and Port Moller) are removed from major otter populations, onshore activity would not pose a problem to the otter population in general. If Bechevin Bay and False Pass are major routes for migrating otters, onshore activies in those regions could be of consequence.

All phases of the development of inshore operation that might intersect migration routes could impact otters. Such impacts could include boat collisions and disturbances. The major impact again would occur in the otter area of greatest abundance.

Summary. Recovery rates of the sea otter population following impacts is necessary to assess long-term impacts of oil pollution. Estimates of recovery rates depend upon the cause, duration and resulting impacts as well as responses of the surviving population. Recovery from direct impacts due to toxicity or fouling of fur would vary. Minimal recovery time would occur if impacts occurred during the winter on a male dominated population. In such a case, only a few animals would be affected and recovery would be relatively fast. Longer recovery times would occur if impacts occurred either during the summer when most of the population would be present or in winter if the population consists of females and pups. In addition, there is the possibility that if most of the animals are seasonally migrating to the area, recovery may take longer if the animal's seasonal migration route is affected. Recovery following indirect effects may take even longer if the cause of the impact (oil) persists. If prey or sediments are tainted or contaminated by oil, thereby preventing feeding, animals would either starve or leave the area and possibly not return for a long time.

The range of scenarios of possible oil spills (size, kind, area, etc.) and lack of additional information on the population biology of the local population (seasonal migration route, population structure of winter and summer animals), vulnerability to oil (avoidance, toxicity) and ability to recover makes it difficult at this time to predict impacts more accurately. Sea otters are extremely vulnerable to oil spills under certain conditions that would result in major impacts if: oil comes into contact with the fur; noise, oil slick, odor, tainted food or sediments disrupt feeding; large numbers of females are killed; or seasonal migratory patterns are changed. If none of these events occur or if they are only minor, impacts would be considerably less.

SECTION 7.0

CONCLUSIONS

A series of field studies was conducted on nearshore biotic systems along the North Aleutian Shelf with emphasis on the distribution and abundance of the dominant infaunal and epifaunal communities, the resident sea otter population, the trophic interactions among these biotic systems and the impact of oil and gas development on the sea otters.

Nearshore bathymetry indicates a large shallow water shelf at depths less than 60 m where otters can forage. Areas around the embayments (Izembek Lagoon, Bechevin Bay and Port Moller), where the otter abundance is often highest, had the largest shelf areas.

Surface and bottom water temperatures ranged from 6.0 to 10.1°C and 5.0 to 9.5°C, respectively, with August values at the surface (9.0°C) and bottom (9.3°C) higher than in June (7.6 and 6.3°C) or August (6.9 and 6.9°C). Peak temperatures in August corresponded with the highest abundance of sea otters. Within the study area, a thermal plume originates in the Izembek area and dissipates with the current to the northeast. These results suggest that warm waters either enter the area via False Pass and Bechevin Bay, or are generated within the shallow coastal embayments, and then mix with the cold counter-clockwise gyre moving towards Port Moller. Such a thermal plume may affect sea otter seasonal migration.

Soft sediments in the area are primarily sand with varying amounts of gravel and silt. Shallow waters (10 m) are homogeneous and characterized by well-sorted sands, deeper waters (30-60 m) are more heterogeneous, characterized by poorly-sorted sand and gravel. Areas removed from the embayments (Unimak Island, Black Hills and Cape

Seniavin) have the highest gravel content (10-80%). Areas near the coastal embayments and in shallow waters, where the highest abundance of otters have been reported, are composed of sand with little gravel.

Infaunal samples were dominated in terms of species composition by polychaetes, molluscs, crustaceans and echinoderms. Cluster analysis resulted in the identification of three communities whose distribution corresponded with depth and gravel content of the sediments. Community I was a shallow (0-20 m) community in the sandy substrates along the nearshore areas of the study site characterized by the clam *Siliqua patula*. Community IIA was a deeper community (usually at 30 m) inhabiting the sediments of high gravel content off Unimak Island, Port Moller and Cape Seniavin and characterized by the polychaete *Owenia*. Community IIB was the deep (30-60 m) community found in sandy substrates characterized by the sand dollar *Echinarachnius parma*. Highest otter abundances were associated with the two sandy communities (I and IIB).

Epifaunal samples were dominated (by weight) by yellowfin sole (*Limanda aspera*), rock sole (*Lepidosetta bilineata*) and seastars (*Asterias* and *Evasterias*). Cluster analysis resulted in the identification of major communities whose distribution and species composition varied in substrate type and geographical location. Site group IA was characterized by adult flatfish inhabiting soft sediments. Site group IB was characterized by a mixture of hard-bottom organisms such as barnacles, hermit crabs and tunicates. These two communities overlapped spatially more than the infaunal communities. This can be attributed to the less discrete nature of the epifaunal trawls and patchy nature of the two substrate types. The seasonal and spatial distribution and abundance of the sea otters corresponded with the abundance of flatfish and crabs.

Sea otter abundance varied significantly ($p<.05$) with season, depth and area. Results indicated two seasons: a summer period (July-September) of high otter abundance, and a winter period (October-June) with 90 percent fewer otters. Otters were more abundant in shallow waters (0-20 m) in the Izembek area. Results strongly suggest that the otters migrate in early summer from the Pacific via False Pass to the study area. The seasonal and spatial abundance of otters corresponded with and, is hypothesized to be a result of, the movement of crabs and flatfish, important prey items. Most of the otters migrated out of the area by October, well before winter ice.

Scat sugdies indicate that sea otters fed primarily on crabs, bivalves, fish and possibly sand dollars. Such results suggest that otters are feeding on some of the most available prey in terms of abundance and accessibility. Sea urchins and hermit crab, common sea otter prey in other areas, were not common prey in this study. Fish could be the most important prey item based on their usage in other Alaskan areas, abundance in the study area and their close correspondence with the distribution and abundance of sea otters.

Potential impacts of oil and gas exploration and development on sea otters were determined from the literature. Particular attention was paid to the impacts of oil and gas development on benthic habitats. Studies indicate that oil spills and blowouts potentially pose the most serious large-scale and long-term effects; sonic booms, noise, visual disturbance, and boat traffic all would probably have local, short-term effects. Oil spills could result in direct mortalities due to fouling of the fur inducing pneumonia or toxicities. Indirect impacts, that include avoidance of feeding areas due to surface slicks or tainting of prey, may lead to starvation and may be just as damaging.

The greatest impacts would occur: seasonally, in the summer (approximately July-September) when the largest number of animals are present, or in the winter, if the remaining population is composed primarily of females; and spatially, near Izembek Lagoon and Bechevin Bay, where most of the otters were found. Outside the study area, the Bechevin Bay/ False Pass region may be an additional critical habitat if the summer population migrates through this area. Long-term impacts could occur for years following the initial incidents: if the summer sea otter population is not able to avoid oil slicks; if oil slicks prevent feeding; if oil contaminates prey items or sediments and inhibits feeding. Such impacts would either reduce the reproducing population and/or create an uninhabitable environment for the sea otters.

SECTION 8.0

SUGGESTED STUDIES

Results from this investigation indicate the need for additional studies to address specific issues. This discussion is presented according to the six study objectives.

Physical Factors. Substrate type was found to be a primary factor regulating the distribution of both the infauna and epifauna. Results indicate a patchwork or mosaic of habitat types distributed on small and large scales. Since samples of soft substrates were taken at discrete stations within and between habitats, the scale of variability needs resolution. The use of side scan sonar in the area could provide a more continuous distributional map of types of infaunal, epifaunal, and sea otter prey habitat.

Infauna. These studies described the major infauna communities. Many large clams which are believed to be present in the study area were not collected with the Van Veen grab. Many are located below the 16 cm sediment depth that the grab penetrates. Therefore, studies of the distribution of large clam species which may be important sea otter prey items would be helpful.

Epifauna. Studies using the small trynet in the deeper (20-60 m) portions of the study area adequately described the epifauna, with the possible exception of larger fish. Seasonal studies in shallow waters which could not be sampled during the fall and winter are needed to fill in the data gaps regarding habitat usage by flatfish and other species as well as the availability of prey to sea otters.

Sea Otters. Results strongly suggest the seasonal movement of otters in and out of the study area, probably through False Pass. Studies are needed to determine the specific role of the various areas on the population biology of the sea otters. This information is necessary to critically evaluate short-term and long-term impacts of oil on the otters.

Trophic Interactions. Results from the limited otter feeding data collected are consistent with other studies in the area and other parts of Alaska. Additional studies from different areas and seasons would help to clarify seasonal and spatial variability in otter feeding habits. This could be accomplished through additional scat collections and/or stomach analyses.

Impacts of Oil and Gas. Results generated from a review of the literature indicate that otters are potentially highly susceptible to impacts from oil and gas exploration and development. However, their actual susceptibility is largely dependent on three unknown variables: their ability to avoid oil slicks, impacts of oil slicks on feeding behavior, and the impacts of contaminated or tainted prey on feeding. These three field studies would be needed to more accurately determine short-term and long-term impacts. The results of these studies along with the information generated from the sea otter population studies suggested above will provide a more precise estimate of impacts.

SECTION 9.0

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SECTION 10.0

APPENDICES

Appendix A	Modifications of sediment analysis from ASTM (1982)
Appendix B	Hydrography data
Appendix C	Taxonomic list of organisms identified
Appendix D	Raw data from infaunal samples
Appendix E	Raw data from epifaunal samples
Appendix F	Raw data from sea otter surveys

APPENDIX A

MODIFICATIONS OF SEDIMENT ANALYSIS FROM ASTM (1972)

Homogenization was accomplished by kneading the sample bag for several minutes. Following digestion of organics, the samples were wet sieved on a No. 230 sieve. Material passing through the sieve was then transferred to a settling chamber; the remainder was dried at 103°C, cooled, weighed and placed on a nest of sieves of varying sizes (Nos. 5, 7, 10, 14, 18, 25, 35, 45, 60, 80, 120, 170 and 230). The material retained on each sieve was then weighed. Approximately 30 grams of the material which passed through the No. 230 sieve was transferred to a settling chamber; 5 ml of sodium hexametophosphate was added and diluted to 1 liter with deionized water. The samples were allowed to soak for 12 hours. A settling cylinder was then thoroughly mixed, returned to vertical position and 25 ml aliquots withdrawn at specified times and depths. The aliquots were placed in a tared 50 ml beaker which was covered and dried in an oven at 90°C. The beakers were reweighed after cooling for one hour.

APPENDIX B

HYDROGRAPHY DATA

June 1982						
Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
1	20	0	6.0	-	31.61	-
1	20	17	5.8	-	31.46	-
1	30	0	5.9	-	31.51	-
1	30	24	5.8	-	31.48	-
2	30	0	6.4	-	31.80	-
2	30	25	6.3	-	31.83	-
3	30	0	6.5	-	31.83	-
3	30	21	6.0	-	31.50	-
3	50	0	6.3	-	31.59	-
3	50	36	5.7	-	31.29	-
4	30	0	6.8	-	32.14	-
4	30	30	6.8	-	32.14	-
4	50	0	5.7	-	31.20	-
4	50	49	5.0	-	31.70	-
6	20	0	7.5	-	32.75	-
6	20	18	7.1	-	32.42	-
7	30	0	10.3	-	34.83	-
7	30	31	9.5	-	34.38	-
7	50	0	9.1	-	34.18	-
7	50	51	7.1	-	32.59	-
8	30	0	9.8	-	34.35	-
8	30	32	9.1	-	33.96	-
8	50	0	9.4	-	34.39	-
8	50	48	8.4	-	33.62	-
9	30	0	9.3	-	33.99	-
9	30	26	9.1	-	33.81	-
9	30	0	9.7	-	34.28	-
9	30	26	9.2	-	33.94	-
9	50	0	9.1	-	33.93	-
9	50	44	8.0	-	33.08	-
9	60	0	9.1	-	34.08	-
9	60	53	7.4	-	32.69	-
10	20	0	9.3	-	33.35	-
10	20	22	9.3	-	33.35	-
10	30	0	9.2	-	33.52	-
10	30	26	9.2	-	33.52	-
10	50	0	8.6	-	33.33	-
10	50	50	7.2	-	32.10	-

APPENDIX B

(continued)

			August 1982			
Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
1	20	0	7.9	-	33.16	-
1	20	16	7.7	-	33.06	-
1	30	0	7.9	-	33.15	-
1	30	25	7.6	-	33.05	-
1	50	0	8.3	-	33.37	-
1	50	44	7.5	-	32.95	-
1	60	0	8.5	-	33.54	-
1	60	54	7.3	-	32.89	-
2	60	0	8.4	-	33.67	-
2	60	58	6.9	-	32.68	-
3	60	0	8.8	-	34.10	-
3	60	58	6.6	-	32.33	-
3	60	0	8.9	-	34.14	-
3	60	58	6.5	-	32.19	-
4	20	0	9.6	-	34.38	-
4	20	15	9.6	-	34.36	-
4	50	0	8.9	-	34.03	-
4	50	35	8.5	-	33.78	-
4	50	0	9.0	-	34.04	-
4	50	36	8.9	-	34.03	-
6	20	0	9.9	-	34.62	-
6	20	16	9.9	-	34.61	-
6	30	0	9.3	-	34.25	-
6	30	32	8.9	-	34.01	-
6	50	0	9.3	-	34.31	-
6	50	44	7.8	-	33.16	-
7	30	0	10.3	-	34.83	-
7	30	31	9.5	-	34.38	-
7	50	0	9.1	-	34.18	-
7	50	51	7.1	-	32.59	-
7	60	0	9.0	-	34.02	-
7	60	58	6.9	-	32.44	-
8	30	0	9.8	-	34.35	-
8	30	32	9.1	-	33.96	-
8	50	0	9.4	-	34.39	-
8	50	48	8.4	-	33.62	-
8	60	0	9.1	-	34.23	-
8	60	56	6.4	-	32.02	-

APPENDIX B

(continued)

August 1982 (continued)

Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
9	30	0	9.3	-	33.99	-
9	30	26	9.1	-	33.81	-
9	30	0	9.7	-	34.28	-
9	30	26	9.2	-	33.94	-
9	50	0	9.1	-	33.93	-
9	50	44	8.0	-	33.08	-
9	60	0	9.1	-	34.08	-
9	60	53	7.4	-	32.69	-
10	20	0	9.3	-	33.35	-
10	20	22	9.3	-	33.35	-
10	30	0	9.2	-	33.52	-
10	30	26	9.2	-	33.52	-
10	50	0	8.6	-	33.33	-
10	50	50	7.2	-	32.10	-

October 1982

Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
1	60	0	6.9	31.94	32.38	25.092
1	60	59	6.9	31.96	32.44	25.112
1	60	0	6.9	31.95	32.39	25.104
1	60	59	6.9	31.96	32.44	25.112
2	10	0	6.6	31.69	31.95	24.927
2	10	29	6.6	31.70	31.96	24.936
2	30	0	6.8	31.80	32.21	24.996
2	30	35	6.8	31.81	32.22	24.998
2	50	0	6.8	32.05	32.42	25.192
2	50	50	6.8	32.08	32.45	25.212
2	60	0	6.8	32.10	32.49	25.222
2	60	62	6.7	32.22	32.55	25.332
3	20	0	6.8	31.74	32.15	24.940
3	20	15	6.8	31.72	32.15	24.928
3	30	0	6.9	31.76	32.20	24.951
3	30	27	6.9	31.76	32.22	24.953
3	50	0	6.9	32.07	32.56	25.190

APPENDIX B

(continued)

October 1982 (continued)						
Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
3	50	45	6.9	32.07	32.57	25.186
3	60	0	6.9	32.05	32.52	25.179
3	60	59	6.9	32.06	32.56	24.184
4	20	0	6.3	31.35	31.36	24.698
4	20	15	6.6	31.49	31.72	24.772
4	50	0	7.0	32.02	32.54	25.145
4	50	0	7.0	32.02	32.54	25.145
4	50	48	7.0	32.05	32.58	25.171
4	60	0	7.0	32.11	32.60	25.216
4	60	61	7.0	32.10	32.62	25.210
6	20	0	6.9	31.46	31.91	24.725
6	20	18	6.9	31.51	31.97	24.760
6	30	0	7.0	31.63	32.19	24.836
6	30	28	7.0	31.65	32.21	24.852
6	50	0	7.0	32.02	32.58	25.136
6	50	48	7.1	32.03	32.63	25.147
6	60	0	6.9	32.13	32.61	25.236
6	60	58	5.9	32.12	32.62	25.232
7	30	0	6.7	31.25	31.56	24.575
7	30	24	6.7	31.36	31.72	24.656
7	50	0	6.9	32.01	32.49	25.142
7	50	55	6.9	32.01	32.45	25.148
7	60	0	7.4	31.73	32.60	24.872
7	60	59	7.4	31.72	32.63	24.861
9	30	0	6.7	31.32	31.70	24.621
9	30	19	6.7	31.32	31.71	24.626
9	50	0	7.0	31.79	32.32	24.967
9	50	44	7.0	31.80	32.34	24.971
9	60	0	7.4	31.82	32.75	24.934
9	60	57	7.4	31.82	32.75	24.935
10	20	0	6.7	31.24	31.63	24.562
10	20	21	6.7	31.28	31.67	24.587
10	20	0	6.6	30.85	31.20	24.266
10	20	20	6.7	30.87	31.24	24.277
10	30	0	7.0	31.52	32.07	24.754
10	30	26	7.0	31.52	32.08	24.751
10	30	0	6.7	30.77	31.15	24.194
10	30	20	6.7	30.76	31.15	24.190

APPENDIX B

(continued)

October 1982 (continued)						
Transect	Contour (m)	Depth (m)	Temperature (°C)	Salinity (o/oo)	Conductivity (m(s)/cm)	Sigma-T (G/cc)
10	50	0	7.3	31.76	32.57	24.902
10	50	47	7.3	31.76	32.59	24.902
11	30	0	7.0	31.05	31.65	24.381
11	30	24	7.0	31.05	31.67	24.383
11	50	0	7.6	31.67	32.75	24.791
11	50	46	7.6	31.69	32.79	24.806

- = Values not determined

APPENDIX C

TAXONOMIC LIST OF ORGANISMS IDENTIFIED

Organisms	Infaunal Grabs	Epifaunal Trawls
CHLOROPHYTA		
PHAEOPHYTA		
Unidentified species		*
Laminariaceae		
Laminaria sp.		*
Alariaceae		
Alaria sp.		*
Fucaceae		
Fucus sp.		*
RHODOPHYTA		
Unidentified sp.		*
ANTHOPHYTA		
Zosteraceae		
Zostera marina drift		*
PORIFERA		
Grantiidae		
Grantia sp.		*
Demospongia		
Myxillidae		
Myxilla sp.		*
Myxilla incrustans		*
Demospongia halichondrina		*
Halichondridae		
Halichondria sp.		*
Halichondria panicea		*
Suberitidae		
Suberites ficus		*
Suberites concinnus		*
Isodictya quatsinoensis		*
CNIDARIA		
Hydrozoa		
Bougainvilliidae		
Pandea sp. 1	*	
Hydractinia sp. 1	*	
Tubulariidae		
Tubularia sp. 1	*	
Campanulariidae		
Campanularia sp.	*	
Obelia dichotoma	*	
Obelia dubia	*	
Lafoeidae		

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Campanulinidae		
Tima sp.	*	
Sertulariidae		
Sertularella gigantea	*	
Sertularella tricuspidata	*	
Sertularia variabilis	*	
Abietinaria sp.	*	
Abietinaria variabilis	*	
Abietinaria nr. urceolus	*	
Abietinaria turgida	*	
Abietinaria sp. 1	*	*
Thuiaria cedrina	*	
Thuiaria cylindrica	*	*
Haleciidae		
Halecium sp.	*	
Halecium wilsoni	*	
Halecium sp. 1	*	
Halecium sp. 2	*	
Anthozoa		
Zooantharia actiniaria		
Anemone sp. 14	*	
Anemone sp. 15	*	
Anemone sp. 16	*	*
Anemone sp. 17	*	
Anemone sp. 18	*	
Anemone sp. 19	*	
Anemone sp. 20	*	
Anemone sp. 21	*	
Actinostolidae		
Stomphia sp., juvenile	*	
Stomphia sp.	*	
Metridiidae		
Metridium senile	*	
PLATYHELMINTHES	*	
NEMERTINEA	*	
NEMATODA		
ANNELIDA		
Polynoidae		
Unidentified sp.		*
Arcteobia anticostiensis	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Eunoe cirrosa	*	
Harmothoe extenuata	*	
Harmothoe multisetosa	*	*
Lepidonotus squamatus	*	
Sigalionidae		
Pholoe minuta	*	*
Sigalion sp.	*	
Pisionidae	*	
Pisione sp.	*	
Phyllodocidae		
Unidentified sp.		*
Phyllodocidae, juvenile	*	
Anaitides groenlandica	*	
Anaitides mucosa	*	
Anaitides sp.	*	
Phyllodoce sp.	*	
Eteone sp.	*	
Eteone longa	*	
Eulalia sp.	*	
Mysta sp.	*	
Mysta barbata	*	
Hesionura sp.	*	
Hesionidae		
Hesionidae, juvenile	*	*
Syllidae		
Unidentified sp.		*
Autolytus sp.	*	*
Typosyllis sp.	*	*
Eusyllis blomstrandi	*	
Exogone sp.	*	
Sphaerosyllis sp.	*	
Brania sp.	*	
Nereidae		
Unidentified sp.		*
Nereis sp.	*	
Nephtyidae		
Nephtys sp.	*	
Nephtys ciliata	*	
Nephtys caeca	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Nepthys rickettsii	*	
Nephtys longosetosa	*	
Nephtys ferruginea	*	
Sphaerodoridae		
Sphaerodoropsis minuta	*	
Glyceridae		
Glycera sp.	*	
Glycera capitata	*	
Goniadidae		
Glycinde picta	*	
Glycinde armigera	*	
Onuphidae		
Onuphis iridescens	*	
Lumbrineridae		
Lumbrineris sp.	*	
Lumbrineris bicirrata	*	
Dorvilleidae		
Protodorvillea sp.	*	
Ophryotrocha sp.	*	*
Schistomeringos caeca	*	
Schistomeringos annulata	*	
Orbiniidae		
Scoloplos armiger	*	
Scoloplos armeceps	*	
Paraonidae		
Aricidea nr. suecica	*	
Aricidea lopezi lopezi	*	
Aricedea sp. a	*	
Paraonella platybranchia	*	
Apistobranchus tullbergi	*	
Spionidae		
Spionidae gen Nova	*	
Polydora sp.	*	
Polydora socialis	*	
Polydora caulleryi	*	
Gattyana cirrosa	*	
Prionospio steenstrupi	*	
Spio sp.	*	
Spio nr. filicornis	*	
Spiophanes sp.	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Spiophanes bombyx	*	
Spiophanes berkeleyorum	*	
Scolelepis squamata	*	
Minuspio cirrifera	*	*
Magelonidae		
Magelona nr. cerae	*	
Magelona sacculata	*	
Chaetopteridae		
Chaetopterus variopedatus	*	
Spiochaetopterus sp.	*	
Spiochaetopterus costarum	*	
Cirratulidae		
Cirratulus sp.	*	*
Tharyx sp.	*	
Chaetozone setosa	*	
Flabelligeridae		
Brada villosa	*	
Pherusa sp.	*	
Pherusa plumosa	*	
Opheliidae		
Armandia brevis	*	
Ophelia sp.	*	
Ophelia limacina	*	
Travisia sp.	*	
Travisia forbesii	*	
Travisia pupa	*	
Ophelina breviata	*	
Capitellidae		
Capitella capitata	*	
Notomastus lineatus	*	
Mediomastus californiensis	*	
Decamastus gracilis	*	
Barontolla sp.	*	
Maldanidae		
Praxillella sp.	*	
Rhodine birorquata	*	
Oweniidae		
Owenia fusiformis	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Myriochele sp.	*	
Myriochele oculata	*	
Pectinariidae		
Cistenides granulata	*	
Ampharetidae		
Ampharete sp.	*	
Ampharete goesi	*	
Amphare cf acutifrons	*	
Asabellides sibirica	*	
Terebellidae		
Leaena abranchiata	*	
Nicolea zostericola	*	
Pista cristata	*	
Polycirrus sp.	*	
Lanassa venusta venusta	*	
Laphania boecki	*	
Proclea graffii	*	
Sabellidae		
Chone sp.	*	
Chone gracilis	*	
Chone magna	*	
Euchone sp.	*	
Euchone analis	*	
Euchone hancocki	*	
Euchone arenae	*	
Potamilla reniformis	*	
Sabella media	*	
Serpulidae		
Polygordius sp.	*	
Oligochaeta		
Hirudinea		
MOLLUSCA		
Gastropoda		
Acmaediae		
Collisella sp. 1		*
Lepeta sp. 1	*	
Trochidae		
Margarites cf. helicinus	*	*
Margarites pupillus		*
Margarites costalis	*	*

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Mesogastropoda		
Littorina sp.	*	
Tachyrhynchus erosus	*	
Trichotropidae		
Tichotropis insignis		*
Tichotropis cancellata	*	*
Lamellariidae		
Marsenia cf. rhombica	*	
Velutina laevigata		*
Naticidae eggs		*
Natica clausa	*	*
Polinices pallida		*
Polinices sp.	*	*
Cymatiidae		
Fusitriton oregonensis		*
Neogastropoda stenoglossa		
Muricidae		
Nucella sp.		
Nucella lamellosa		*
Nucella lima		*
Boreotrophor clathratus	*	
Buccinidae		
Neptuneidae		
Beringius beringi		*
Liomesus nux		*
Neptunea lyrata		*
Volutopsius castaneus	*	
Turridae		
Turridae, juvenile	*	
Suavodrillia kennicottii	*	
Mangelia? sp. a	*	
Oenopota cf. turricula	*	
Oenopota arctica	*	
Oenopota cf. arctica	*	
Oenopota sp. a	*	
Kurtsiella plumbae	*	
Turridae sp. a	*	
Odostomia sp.	*	
Turbonilla sp.	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Cephalaspidea	*	
Cylichna sp.	*	
Cylichna alba	*	
Scaphander sp. 1	*	
Philine sp. 1	*	
Philine sp. 2	*	
Diaphana minuta	*	
Haminoea sp. 1	*	
Retusa sp. 1	*	
Retusa sp. 2	*	
Nudibranchia		
Neaeromya compressa	*	*
Polyplacophora		
Mopaliidae		
Mopalia hindsi		*
Bivalvia		
Nuculidae		
Nucula tenuis	*	
Nuculana sp.	*	
Nuculana cf. *pernula*	*	
Yoldia cf. *hyperborea*	*	
Yoldia myalis	*	
Yoldia scissurata	*	
Mytilidae	*	*
Mytilus edulis	*	
Megacrenella columbiana	*	
Musculus sp., juvenile	*	
Musculus niger	*	
Musculus cf. *discors*	*	
Modiolus sp.	*	
Pterioida pteriina	*	
Anomiidae		*
Pododesmus sp.	*	
Lima sp.	*	
Limatula sp.	*	
Limatula subauriculata	*	
Limatula cf. *attenuata*	*	
Pterioida ostreina	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Ostreidae		*
Ostrea lurida	*	
Axinopsida serricata	*	
Diplodonta cf. *impo*	*	
Cyclocardia sp.	*	*
Kelliidae		
Pseudopythina compressa		*
Mysella cf. *tumida*	*	
Carditidae		
Cyclocardia crebricostata	*	
Cyclocardia incisa		
Cyclocardia crassidens	*	*
Astartidae		
Astarte sp., juvenile	*	*
Astarte rollandi	*	*
Astarte cf. *vernicosa*	*	
Cardiidae		
Clinocardium sp., juvenile	*	
Serripes groenlandicus	*	*
Mactridae		
Spisula sp.	*	*
Mactra alaskana	*	
Mactra nasuata	*	
Solenidae		
Siliqua patula	*	*
Tellinidae		
Macoma sp.	*	*
Macoma moesta	*	
Macoma moesta alaskana	*	
Macoma crassula	*	
Macoma lama	*	
Macoma cf. *balthica*	*	
Macoma balthica	*	*
Macoma cf. *calcarea*	*	
Macoma sp. a	*	
Tellina lutea		*
Tellina nuculoides	*	
Tellina sp.	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Veneridae		
Saxidomus gigantea	*	*
Psephidia lordi	*	
Humilaria kennerlyi	*	
Patinopecten caurinus	*	
Mya sp.	*	
Hiatellidae	*	
Hiatella arctica	*	*
Lyonsia californica	*	
Thracia sp.	*	
Thracia cf. *beringi*	*	
ANTHROPODA PYCNOGONIDAE		
Pycnogonidae	*	
Crustacea		
Ostracoda		
Calanoida		
Caligus sp.	*	
Cirripedia		
Thoracica		
Balanidae		
Balanus sp.		*
Balanus balanus		*
Balanus crenatus		*
Balanus rostratus		*
Solidobalanus hesperius		*
Mysidacea		
Pacifacanthomysis nephrophtholnia	*	
Xenacanthomysis pseudomacropsis	*	
Mysidae		
Acanthomysis sp.	*	
Acanthomysis pseudomacropsis		*
Acanthomysis sculpta		*
Archaeomysis grebnitzkii		*
Neomysis kadiakensis		*
Cumacea		
Lampropidae		
Lamprops fasciata	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Lamprops carinata	*	
Lamprops? carinata	*	
Lamprops quadriplicata	*	
Lamprops pumilo	*	
Hemilamprops californica	*	
Leuconidae		
Leucon nasica	*	
Eudorellopsis deformis	*	
Diastylidae		
Diastylis alaskensis	*	
Diastylis bidentata	*	
Campylaspidae		
Campylaspis crispa	*	
Tanaidacea		
Paratanaidae		
Leptognathia gracilis	*	
Isopoda		
Anthuridae		
Idoteidae		
Synidotea nodulosa	*	
Munnidae		
Munna stephenseni	*	
Pleurogonium sp.	*	
Amphipoda		
Acanthonotozomataidae		
Odius carinatus	*	
Ampeliscidae		
Ampelisca macrocephala	*	
Byblis gaimardi	*	
Argissidae		
Argissa hamatipes	*	
Atylidae		
Atylus collingi	*	
Calliopiidae		
Apherusa sp.	*	
Corophiidae		
Corophium crassicome	*	
Ericthonius grebnitzkii	*	
Dexaminidae		
Guernea nordenskioldi	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Eusiridae		
Pontogeneia sp.	*	
Pontogeneia sp. 1	*	
Pontogeneia sp. 2	*	
Pontogeneia sp. 3	*	
Pontogeneia sp. 4	*	
Pontogeneia sp. 5	*	
Pontogeneia sp. S	*	
Gammaridae		
Anisogammarus pugettensis	*	
Maera loveni	*	
Melita dentata	*	
Melita oregonensis	*	
Haustoriidae		
Eohaustorius sawyeri	*	
Isaeidae		
Photis spasskii	*	
Protomedeia cf. penates	*	
Protomedeia cf. fasciata	*	
Protomedeia sp. 1	*	
Protomedeia sp. 2	*	
Gammaropsis sp. 1	*	
Gammaropsis sp. 2	*	
Gammaropsis sp. 3	*	
Gammaropsis sp. 4	*	
Gammaropsis sp. 5	*	
Ischyroceridae		
Ischyrocerus sp.	*	
Lysianassidae		
Anonyx nugax	*	
Anonyx liljeborgi	*	
Hipponedon propinguus	*	
Orchomene minuta	*	
Orchomene pacifica	*	
Wecomedon similis	*	
Oedicerotidae		
Bathymedon ivanovi	*	
Bathymedon sp. 1	*	
Bathymedon sp. 2	*	
Monoculodes castalskii	*	

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Mallotus villosus		*
Osmerus mordax		*
Allosmerus elongatus		*
Gadidae		
Gaddidae, juvenile		*
Gadus macrocephalus		*
Gadus macrocephalus, juvenile		*
Microgadus proximus		*
Microgadus proximus, juvenile		*
Theragra chalcogramma		*
Theragra chalcogramma, juvenile		*
Zoarcidae		
Gnathostomata II		
Scomberesocidae		
Cololabis saira		*
Gasterosteidae		
Gastertosteus aculeatus		*
Syngrathidae		
Syngnathus griseolineatus		*
Hexagrammidae		
Hexagrammos lagocephalus		*
Hexagrammos octogrammus		*
Hexagrammos stelleri		*
Ophiodon elongatus		*
Hexagrammid Type A		
Anoplopomatidae		
Anoplopoma fimbria		*
Cottidae		
Artedius fenestralis		*
Enophrys bison		*
Gymnocanthus sp.		*
Gymnocanthus sp. ?		*
Gymnocanthus pistilliger		*
Hemilepidotus himilepidotus		*
Hemilepodotus jordani		*
Leptocottus armatus		*
Myoxocephalus sp.		*
Myoxocephalus polyacanthocephalus		*
Oligocottus maculosus		*

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Monoculodes spinipes	*	
Synchelidium sp.	*	
Westwoodilla sp. 1	*	
Oedicerotid sp. 7	*	
Phoxocephalidae		
Harpiniopsis sp.	*	
Harpinopsis gurjanovac	*	
Rhepoxynius sp.	*	
Foxiphalus alenti	*	
Grandifoxus acanthinus	*	
Grandifoxus aciculata	*	
Grandifoxus lindbergi	*	
Grandifoxus longirostris	*	
Grandifoxus vulpinus	*	
Pleustidae		
Pleustes behningi	*	
Pleustes pandplus	*	
Pleusymtes sp. 1	*	
Pleusymtes sp. 2	*	
Pleusymtes sp. 3	*	
Podoceridae		
Dulichia sp.	*	
Stenothoidae		
Metopella sp.	*	
Synopiidae		
Tiron biocellata	*	
Caprellidae		
Caprella drepanochir	*	
Caprella gracilior	*	
Decapoda		
Hippolyidae		
Heptacarpus paludecola	*	
Pandalidae		
Pandalus sp.	*	
Pandalus goniurus		*
Pandalus tridens		*
Pandalus stenolepis		*
Pandalopsis aleutica		*
Crangonidae		*
Crangon sp.		*

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Crangon alaskensis		*
Crangon stylirostris		*
Crangon dalli		*
Sclerocrangon boreas		*
Argis crassa		*
Anomura		*
Paguridae	*	
Pagurus ochotensis		*
Pagurus aleuticus		*
Pagurus aleuticus?		*
Pagurus capillatus		*
Pagurus kennerlyi		*
Pagurus beringanus		*
Pagurus confragosus		*
Pagurus trigonocheirus		*
Pagurus capillatus kennerlyi		*
Pagurus sp. 2		*
Elassochirus tenuimanus		*
Elassochirus gilli		*
Lithodidae		
Paralithodes camtschatica		
Brachyura	*	
Majidae	*	
Orogonia gracilis		*
Hyas lyratus		*
Chionoecetes opilio		*
Chionoecetes bairdi		*
Pugettia gracilis		*
Atelecyclidae		
Telmessus cheiragonus		*
Cancridae		
Cancer branneri		*
Cancer magister		*
Cancer oregonensis		*
Pinnotheridae		
SIPUNCULA	*	
PHORONIDA		

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
ECTOPROCTA		
New Bryozoa genus		
Alcyonidiidae		
Alcyonidium proboscideum	*	*
Flustrellidridae		
Flustrella gigantea		*
Lichenoporidae		
Lichenopora sp.		*
Scrupariidae		
Scruparia ambigua		*
Flustridae		
Carbasea carbasea		*
Flustra serrulata		*
Flustra carbasea		*
Calloporidae		
Bidenkapia spitsbergensis alaskensis		*
Tegella sp.		
Calpensiidae		
Microporina articulata		*
Bugulidae		
Dendrobeania murrayana		*
Dendrobeania pseudolevinseni		*
Dendrobeania? orientalis		*
Dendrobeania pseuomurrayana		*
Dendrobeania levinseni		*
Scrupocellariidae		
Tricellaria sp.		*
Mucronellidae		
Cystisella saccata		*
Reteporidae		
Rhynchozoon sp.		*
Celleporidae		
Celleporina? hyalina		*
Celleporina sp.		*
Myriozoidae		
Myriozoella plana		*
Smittinid cf. tegella		*
Pentapora foliacea		*
Cryptoarachnidium sp.		*

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
ECHINODERMATA		
Asteroidea		
Solasteridae		
Solaster endeca		*
Solaster papossus		*
Pteraster sp.		*
Echinasteridae		
Henricia leviuscula		*
Asteriidae		
Asterias amurensis	*	*
Evasterias troschelii		*
Leptasterias coei		*
Leptasterias groenlandica		*
Stylasterias sp.		*
Pycnopodia helianthoides		*
Ophiuroidea	*	
Ophiuridae		
Ophiura sarsi		*
Ophiactidae		
Ophiopholis aculeata var. *kenneryli*		*
Amphiuridae		
Amphoidia digitata		*
Amphipholis squamata		*
Echinoidea		
Echinoidea echinoida		*
Strongylocentrotidae		
Strongylocentrotus droebachiensis	*	*
Dendrasteridae		
Dendraster excentricus	*	*
Spatangidae	*	
Holothuroida		
Phyllophoridae		
Havelockia sp. 2	*	
Cucumariidae		
Cucumaria fallax		*
Eupentacta quinquesemita	*	*
Pentamera calcigera	*	
Pentamera lissoplaca	*	*

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Pentamera sp. b	*	
Thyone sp.	*	
Chiridotidae	*	
Chiridota sp.	*	
Myriotrhochidae	*	
CHORDATA	*	
Hemichordata	*	
Urochordata	*	
Ascidiacea		
Ascidiacea, solitary?		*
Ascidiacea, compond?		*
Clavelinidae		
Distaplia sp.	*	*
Archidistoma sp.		*
Polyclinidae		
Synoicum jordani		*
Aplidiopsis pannosum		*
Polyclinum sp.		*
Aplidium sp.		*
Agnesiidae		
Agnesia septentrionalis	*	*
Ascidiacea pleurogona stolidobranchiata		*
Styelidae		
Dendrodoa aggregata		*
Styela? coriacea	*	*
Pyuridae		
Boltenia ovifera		*
Halocynthia aurantium	*	*
Batoidimorpha		
Rajidae		
Raja abyssicola		*
Raja binoculata		*
Osteichthyes		
Clupeidae		
Clupea harengus pallasi		*
Protacanthopterygii salmoniformes		*
Osmeridae		

APPENDIX C

(continued)

Organisms	Infaunal Grabs	Epifaunal Trawls
Radulinus asprellus		*
Triglops pingeli		*
Agonidae		
Aspidophoroides bartoni		*
Agonus acipenserinus		*
Occella dodecaedron		*
Pallasina barbata		*
Cyclopteridae		
Liparis sp.		*
Liparis dennyi		*
Liparis pulchellus		*
Liparis sp. 1		*
Liparis sp. 2		*
Trichodontidae		
Trichodon trichodon		*
Stichaeidae		
Anoplarchus sp.		*
Lumpenus sagitta		*
Pholidae		
Pholis laeta		*
Ammodytidae		
Ammodytes hexapterus	*	*
Pleuronectidae		
Pleuronectidae, juvenile		*
Atheresthes stomias		*
Eopsetta jordani		*
Hippoglossoides elassodon		*
Isopsetta isolepis		*
Lepidopsetta bilineata		*
Lepidopsetta bilineata, juvenile		*
Limanda aspera		*
Limanda aspera, juvenile		*
Limanda proboscidea		*
Platichthys stellatus		*
Pleuronectes quadrituberculatus		*
Hippoglossus stenolepis		*

APPENDIX D

RAW DATA FROM INFAUNAL SAMPLES

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	02	02	02	02	02	02	02	02	02	02	02	02	02	02	02
DEPTH	10	10	10	10	10	30	30	30	30	30	50	50	50	50	50
REPLICATE	1	2	3	4	5	1	2	3	4	6	1	2	3	4	5
SPECIES															
1. CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. ANTHOZOA	0	0	0	0	0	2	3	1	0	3	8	9	18	11	4
5. PLATYHELMINTHES	0	0	0	0	0	1	1	7	0	0	0	0	0	0	0
6. NEMERTINEA	0	1	0	0	0	43	3	15	3	2	0	1	1	6	3
7. NEMATODA	0	3	1	1	0	45	2	4	5	2	1	1	2	0	0
8. POLYCHAETA	0	0	2	0	0	5	1	1	0	0	0	0	0	0	0
9. POLYNOIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0
17. SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18. PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0
20. ANAITIDES GROENLANDICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21. ANAITIDES MUCOSA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
22. ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	0	0	1	8	0	0	0	1	0	0	0	0	0
24. ETEONE LONGA	0	0	1	4	2	66	15	21	6	4	0	2	2	2	1
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26. MYSTA SP.	1	1	0	0	0	0	0	1	0	0	0	0	0	0	2
27. MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
29. HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30. HESIONIDAE, JUV.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
31. SYLLIDAE	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0
32. AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. TYPOSYLLIS SP.	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35. EXOGONE SP.	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
36. SPHAEROSYLLIS SP.	0	0	0	0	0	1	0	3	0	0	0	0	5	0	0
37. BRANIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38. NEREIDAE	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
39. NEREIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40. NEPHTYS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41. NEPHTYS CILIATA	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
42. NEPHTYS CAECA	1	0	0	2	2	0	0	0	0	1	0	0	2	1	0
43. NEPHTYS RICKETTSII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	4	1	1	12	3	0	0	0	0	0	0	0	0	0	0
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48. GLYCERA CAPITATA	0	0	0	0	0	2	2	4	2	0	0	1	1	1	3

APPENDIX D
(continued)

SAMPLES

SPECIES	06 02 10 1	06 02 10 2	06 02 10 3	06 02 10 4	06 02 10 5	06 02 30 1	06 02 30 2	06 02 30 3	06 02 30 4	06 02 30 6	06 02 50 1	06 02 50 2	06 02 50 3	06 02 50 4	06 02 50 5
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	02	02	02	02	02	02	02	02	02	02	02	02	02	02	02
DEPTH	10	10	10	10	10	30	30	30	30	30	50	50	50	50	50
REPLICATE	1	2	3	4	5	1	2	3	4	6	1	2	3	4	5
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52. ONUPHIS IRIDESCENS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53. LUMBRINERIS SP.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	2	7	0	12	6	0	0	2	0	0	0	0	0	2	0
61. SCOLOPLOS ARMECEPS	0	0	0	0	0	2	4	4	0	0	0	0	0	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	0	0	0	0	16	0	1	0	0	0	1	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66. PARAONELLA PLATYBRANCHIA	2	0	0	5	0	0	0	1	0	0	0	0	0	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0
72. POLYDORA CAULLERYI	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	0	0	1	0	7	0	0	0	0	0	1	0	0	0	1
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	40	0	0	163	225	1	0	0	0	1	5	2	13	10	4
79. SPIOPHANES BERKELEYORUM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	15	53	1	7	3	0	0	0	0	0	0	0	0	0	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	7	0	2	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83. MAGELONA SACCULATA	7	0	0	11	1	0	0	0	0	0	0	0	0	0	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86. SPIOCHAETOPTERUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88. CIRRATULIDAE	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
90. THARYX SP.	0	0	0	0	0	7	1	3	1	0	0	0	0	0	0
91. CHAETOZONE SETOSA	112	0	0	304	607	1	0	2	2	0	0	0	1	0	2
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D
(continued)

SAMPLES

	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	02	02	02	02	02	02	02	02	02	02	02	02	02	02	02
DEPTH	10	10	10	10	10	30	30	30	30	30	50	50	50	50	50
REPLICATE	1	2	3	4	5	1	2	3	4	6	1	2	3	4	5
SPECIES															
98. OPHELIA LIMACINA	0	0	0	0	0	0	1	3	1	1	5	3	1	7	4
99. TRAVISIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100. TRAVISIA FORBESII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101. TRAVISIA PUPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102. OPHELINA BREVIATA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	96	8	22	3	0	0	0	1	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105. MEDIOMASTUS CALIFORNIENSIS	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
106. DECAMASTUS GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109. PRAXILLELLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110. RHODINE BIRORQUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS	7	0	2	17	39	62	44	62	20	76	1	6	6	5	2
112. MYRIOCHELE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
116. AMPHARETIDAE	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	0	0	0	1	2	6	3	2	0	1	5	4	17	4	0
120. ASABELLIDES SIBIRICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE	0	0	0	0	0	0	2	0	1	0	0	0	1	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124. PISTA CRISTATA	0	0	0	0	0	0	0	0	0	0	1	2	2	3	0
125. POLYCIRRUS SP.	0	0	0	0	0	43	0	1	0	0	0	1	0	0	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	1	0	0	0	1	2	0	5	1	4
127. LAPHANIA BOECKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
129. SABELLIDAE	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
130. CHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132. CHONE MAGNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0
136. EUCHONE ARENAE	0	0	0	0	0	30	0	37	1	0	2	2	2	1	0
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139. SERPULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	0	0	0	0	0	6	27	25	3	0	2	0	0	0	1
141. OLIGOCHAETA	4	0	4	1	0	176	46	33	17	12	0	0	5	3	1
142. HIRUDINEA	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
145. LEPETA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	02	02	02	02	02	02	02	02	02	02	02	02	02	02	02
DEPTH	10	10	10	10	10	30	30	30	30	30	50	50	50	50	50
REPLICATE	1	2	3	4	5	1	2	3	4	6	1	2	3	4	5
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
149. LITTORINA SP.	0	1	39	0	1	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	0	0	0	0	0	0	0	0	0	1	0	3	0	2
154. POLINICES SP.	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
155. TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160. OENOPOTA CF. ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162. KURTSIELLA PLUMBAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163. TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167. CYLICHNA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
168. CYLICHNA ALBA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
169. CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
173. DIAPHANA MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176. RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179. BIVALVIA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
183. YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	0	0	0	0	4	0	1	2	0	5	6	1	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
189. MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	02	02	02	02	02	02	02	02	02	02	02	02	02	02	02
DEPTH	10	10	10	10	10	30	30	30	30	30	50	50	50	50	50
REPLICATE	1	2	3	4	5	1	2	3	4	6	1	2	3	4	5
SPECIES															
196. AXINOPSIDA SERRICATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
199. MYSELLA CF. TUMIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	0	0	0	0	0	26	16	1	9	1	11	50	4	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
209. MACTRA NASUATA	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
211. MACOMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212. MACOMA MOESTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	0	0	0	0	0	0	4	0	0	5	1	1	3	4	4
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229. THRACIA SP. ,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
231. CARIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
232. PAGURIDAE	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238. SIPUNCULA	0	0	0	0	0	242	70	59	9	2	2	6	16	0	2
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241. OPHIUROIDEA	0	0	0	0	0	18	1	2	0	0	0	0	0	0	0
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
243. DENDRASTER EXCENTRICUS	0	1	0	0	0	0	0	0	0	2	26	27	26	9	71
244. SPATANGIDAE	0	0	0	0	0	0	8	0	3	40	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES															
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	5.00	1.00	0.00	0.00	24.0	0.00	0.00	4.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	0.00	0.00	0.00	0.00	366.	95.0	1.00	6.00	0.00	2.00	7.00	0.00	0.00	3.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	13.0	9.00	12.0	23.0	18.0	44.0	28.0	32.0	19.0	26.0	25.0	26.0	36.0	21.0	20.0
264. H	1.44	.939	1.08	1.53	1.04	2.33	2.43	2.57	2.41	2.10	2.53	2.66	2.80	2.72	1.78
265. EVENNESS	0.56	.427	.435	.489	0.36	.617	0.73	0.74	.817	.643	.787	.818	.781	.894	.595
266. TOTAB	197.	69.0	150.	579.	925.	1218	408.	320.	84.0	197.	75.0	100.	210.	78.0	117.

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
SPECIES															
1. CNIDARIA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TIMA SP.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4. ANTHOZOA	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
5. PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. NEMERTINEA	0	1	3	6	0	0	0	0	0	3	1	3	1	12	9
7. NEMATODA	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
8. POLYCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. POLYNOIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	0	0	8	9	0	0	0	0	0	0	0	0	0	0	0
17. SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18. PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20. ANAITIDES GROENLANDICA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
21. ANAITIDES MUCOSA	0	0	21	0	1	0	0	1	0	0	0	0	0	8	8
22. ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
24. ETEONE LONGA	1	15	6	1	4	2	3	2	1	0	0	0	0	3	9
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26. MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27. MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29. HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30. HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31. SYLLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32. AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. TYPOSYLLIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35. EXOGONE SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
36. SPHAEROSYLLIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37. BRANIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38. NEREIDAE	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
39. NEREIS SP.	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
40. NEPHTYS SP.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
41. NEPHTYS CILIATA	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
42. NEPHTYS CAECA	0	0	2	2	2	0	0	0	0	0	0	1	0	2	2
43. NEPHTYS RICKETTSII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	3	1	17	7	25	9	18	12	11	0	1	2	1	0	0
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48. GLYCERA CAPITATA	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6

APPENDIX D

(continued)

SAMPLES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
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SPECIES															
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	0	0	8	13	1	1	0	0	0	0	0	0	0	0	0
52. ONUPHIS IRIDESCENS	0	0	1	22	0	0	0	0	0	0	0	0	0	0	0
53. LUMBRINERIS SP.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
60. SCOLOPLOS ARMIGER	5	9	20	14	46	16	79	72	35	1	22	21	11	10	6
61. SCOLOPLOS ARMECEPS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	10	8	0	0	0	0	1	0	2	0	0	0	0	0	0
70. POLYDORA SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1
72. POLYDORA CAULLERYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
74. PRIONOSPIO STEENSTRUPI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
75. SPIO SP.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	0	0	14	0	0	0	0	0	0	0	3	1	1	0	3
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	6	1	106	52	24	8	13	15	1	0	0	0	0	18	19
79. SPIOPHANES BERKELEYORUM	0	0	0	78	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	0	0	27	4	2	4	0	5	0	0	0	0	0	0	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0
83. MAGELONA SACCULATA	0	0	4	24	11	24	11	29	2	1	0	0	1	0	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86. SPIOCHAETOPTERUS SP.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7
91. CHAETOZONE SETOSA	4	0	6	19	0	1	0	0	0	1	0	0	0	0	0
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
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SPECIES															
98. OPHELIA LIMACINA	1	1	1	1	0	0	0	0	1	1	17	8	2	0	0
99. TRAVISIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100. TRAVISIA FORBESII	0	0	0	5	0	0	0	0	0	0	1	1	0	0	0
101. TRAVISIA PUPA	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0
102. OPHELINA BREVIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
105. MEDIOMASTUS CALIFORNIENSIS	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
106. DECAMASTUS GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109. PRAXILLELLA SP.	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0
110. RHODINE BIRORQUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5
111. OWENIA FUSIFORMIS	1	0	1	0	0	0	1	0	0	0	1	1	1	357	453
112. MYRIOCHELE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	0	0	2	35	0	0	0	0	0	0	1	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA	0	0	2	0	0	0	0	0	0	0	0	0	0	14	12
116. AMPHARETIDAE	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	0	0	1	8	0	0	0	0	0	0	0	0	0	14	9
120. ASABELLIDES SIBIRICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124. PISTA CRISTATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125. POLYCIRRUS SP.	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
127. LAPHANIA BOECKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
129. SABELLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130. CHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132. CHONE MAGNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
136. EUCHONE ARENAE	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139. SERPULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	0	0	0	0	0	0	1	0	0	0	0	0	0	9	1
141. OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
142. HIRUDINEA	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145. LEPETA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
SPECIES															
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
149. LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
154. POLINICES SP.	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
155. TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
160. OENOPOTA CF. ARCTICA	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162. KURTSIELLA PLUMBAE	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0
163. TURRIDAE SP. A	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167. CYLICHNA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
168. CYLICHNA ALBA	0	0	5	7	0	0	0	0	0	0	0	0	0	0	0
169. CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173. DIAPHANA MINUTA	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
176. RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179. BIVALVIA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
183. YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189. MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
196. AXINOPSIDA SERRICATA	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	0	26	3	0	0	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	0	0	12	0	0	0	96	0	12	18	4	0	0	0
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	0	0	2	7	4	0	1	2	0	0	2	1	0	0	0
209. MACTRA NASUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	8	6	7	0	1	1	0	2	3	0	0	0	0	0	0
211. MACOMA SP.	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
212. MACOMA MOESTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	0	0	9	0	0	0	0	2	0	0	0	0	0	0	7
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229. THRACIA SP. ,	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
231. CARIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
232. PAGURIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
238. SIPUNCULA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
241. OPHIUROIDEA	0	0	0	2	0	0	0	0	0	0	0	0	0	2	2
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
243. DENDRASTER EXCENTRICUS	0	0	55	58	0	1	0	0	0	5	5	7	8	1	1
244. SPATANGIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	03	03	03	03	04	04	04	04	04	04	04	04	04	04	04
DEPTH	10	10	30	50	10	10	10	10	10	30	30	30	30	50	50
REPLICATE	1	2	1	1	1	2	3	4	5	1	2	3	4	1	2
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	7.00
252. PENTAMERA SP. B	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.0	3.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	11.0	11.0	41.0	53.0	14.0	14.0	11.0	13.0	10.0	11.0	17.0	12.0	10.0	33.0	36.0
264. H	2.10	1.92	2.75	3.13	1.81	1.98	1.33	1.61	1.36	1.86	2.04	1.88	1.75	1.49	1.30
265. EVENNESS	.877	.802	.741	.788	.686	0.75	.554	0.63	.589	.777	.719	.758	.759	.426	.364
266. TOTAB	42.0	47.0	389.	479.	124.	72.0	130.	240.	58.0	28.0	78.0	51.0	28.0	505.	595.

APPENDIX D

(continued)

SAMPLES

SPECIES	06 04 50 3	06 04 50 4	06 04 50 5	06 06 30 1	06 06 30 2	06 06 30 4	06 06 50 1	06 06 50 2	06 06 50 3	06 06 50 4	06 06 50 5	06 07 10 1	06 07 10 2	06 07 10 3	06 07 10 4
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
1. CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. ANTHOZOA	2	2	1	0	0	0	2	0	0	0	0	0	0	0	0
5. PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. NEMERTINEA	4	6	2	2	7	7	4	6	6	2	3	0	0	0	0
7. NEMATODA	0	2	4	0	1	27	1	3	1	0	0	0	1	0	0
8. POLYCHAETA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9. POLYNOIDAE	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10. ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	2	4	3	0	1	19	2	10	7	1	6	1	0	0	0
17. SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18. PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20. ANAITIDES GROENLANDICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21. ANAITIDES MUCOSA	4	21	11	3	3	3	1	0	0	0	0	0	0	1	0
22. ANAITIDES SP.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	0	1	0	5	0	0	0	0	0	0	0	0	0
24. ETEONE LONGA	1	8	0	1	2	163	0	0	0	0	0	1	0	1	0
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26. MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27. MYSTA BARBATA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29. HESIONIDAE	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
30. HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31. SYLLIDAE	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
32. AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. TYPOSYLLIS SP.	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35. EXOGONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36. SPHAEROSYLLIS SP.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
37. BRANIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38. NEREIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39. NEREIS SP.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
40. NEPHTYS SP.	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1
41. NEPHTYS CILIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
42. NEPHTYS CAECA	3	6	3	0	0	0	0	2	0	0	0	1	0	1	0
43. NEPHTYS RICKETTSII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	0	0	0	0	0	0	2	0	2	0	5	15	15	13	13
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
48. GLYCERA CAPITATA	4	3	8	3	1	3	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
52. ONUPHIS IRIDESCENS	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0
53. LUMBRINERIS SP.	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	3	5	6	4	1	10	14	15	20	5	17	5	29	9	1
61. SCOLOPLOS ARMECEPS	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	0	0	0	0	12	2	6	1	0	0	0	0	0
72. POLYDORA CAULLERYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	3	27	7	0	0	4	2	0	0	0	0	6	13	0	5
79. SPIOPHANES BERKELEYORUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	0	0	0	0	0	0	0	0	0	5	0	1	0	0	1
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	0	0	0	0	0	6	4	4	2	2	0	0	0	0
83. MAGELONA SACCULATA	0	0	0	0	0	0	14	8	5	3	2	9	6	6	11
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86. SPIOCHAETOPTERUS SP.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	1	4	0	0	0	4	0	0	0	0	0	0	0	0	1
91. CHAETOZONE SETOSA	0	0	0	1	0	1	1	1	8	2	2	2	1	1	0
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
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SPECIES															
98. OPHELIA LIMACINA	1	11	1	0	2	1	8	12	5	3	9	0	0	0	0
99. TRAVISIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100. TRAVISIA FORBESII	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
101. TRAVISIA PUPA	0	0	0	0	0	0	0	0	0	0	0	5	5	16	7
102. OPHELINA BREVIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105. MEDIOMASTUS CALIFORNIENSIS	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
106. DECAMASTUS GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109. PRAXILLELLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110. RHODINE BIRORQUATA	3	5	2	0	0	0	0	0	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS	125	83	287	43	9	67	1	0	0	0	0	0	1	0	0
112. MYRIOCHELE SP.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	0	0	0	0	0	0	7	12	4	2	15	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA	8	28	10	0	0	2	0	0	0	0	0	0	0	0	0
116. AMPHARETIDAE	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	2	9	6	0	0	2	10	13	25	7	2	0	0	0	0
120. ASABELLIDES SIBIRICA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124. PISTA CRISTATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125. POLYCIRRUS SP.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127. LAPHANIA BOECKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0
129. SABELLIDAE	0	2	0	0	0	5	0	0	0	0	0	0	0	0	0
130. CHONE SP.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132. CHONE MAGNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136. EUCHONE ARENAE	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139. SERPULIDAE	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
141. OLIGOCHAETA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
142. HIRUDINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
145. LEPETA SP. A	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

APPENDIX D
(continued)

SAMPLES

	MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
	TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
	DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
	REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES																
147.	MARGARITES CF. HELICINUS	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
148.	MARGARITES COSTALIS	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
149.	LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150.	TACHYRHYNCHUS EROSUS	0	0	0	0	0	0	1	3	0	1	7	0	0	0	0
151.	TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152.	MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153.	NATICA CLAUSA	1	2	3	0	0	1	0	0	0	0	1	0	0	0	0
154.	POLINICES SP.	0	0	0	0	0	0	3	2	1	2	1	0	0	0	0
155.	TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156.	SUAVODRILLIA KENNICOTTII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157.	MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
158.	OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159.	OENOPOTA CF. TURRICULA	0	0	0	0	0	0	2	3	1	0	1	0	0	0	0
160.	OENOPOTA CF. ARCTICA	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
161.	OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162.	KURTSIELLA PLUMBAE	0	0	0	0	0	0	8	2	5	3	7	0	0	0	0
163.	TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164.	ODOSTOMIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165.	TURBONILLA SP.	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
166.	CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167.	CYLICHNA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
168.	CYLICHNA ALBA	0	0	0	0	0	0	3	2	3	0	0	0	0	0	0
169.	CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170.	SCAPHANDER SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171.	PHILINE SP. A	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
172.	PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173.	DIAPHANA MINUTA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
174.	HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175.	RETUSA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176.	RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177.	NUDIBRANCHIA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
178.	NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179.	BIVALVIA	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
180.	NUCULA TENUIS	0	0	0	0	0	0	1	1	2	3	1	0	0	0	0
181.	NUCULANA SP.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
182.	NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
183.	YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184.	YOLDIA MYALIS	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
185.	YOLDIA SCISSURATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186.	MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187.	MEGACRENELLA COLUMBIANA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
188.	MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189.	MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190.	MUSCULUS CF. DISCORS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
191.	MODIOLUS SP.	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
192.	LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193.	LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194.	LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195.	LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
SPECIES															
196. AXINOPSIDA SERRICATA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	0	0	0	0	0.0	0	3	2	0	3	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	0	0	0	1	0.0	6	4	13	14	20	0	0	0	0
201. CYCLOCARDIA INCISA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0
203. ASTARTE ROLLANDI	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	2	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0.0	0	0	0	1	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0.0	0	0	0	2	0	0	0	0	0
208. MACTRA ALASKANA	0	0	0	0	0	0.0	11	24	16	11	28	0	0	0	0
209. MACTRA NASUATA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
211. MACOMA SP.	0	0	0	0	0	0.0	3	2	2	0	3	0	1	0	0
212. MACOMA MOESTA	0	0	0	0	0	0.0	0	0	0	0	3	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	0	0	0.0	0	2	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	1	0	0	0	0.0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	1
216. MACOMA BALTHICA	1	3	1	1	0	0.0	1	0	0	3	0	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	0	0	0	0	0	0.0	6	9	6	3	6	0	0	0	0
222. SAXIDOMUS GIGANTEA	0	0	0	1	0	0.0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0.0	0	0	0	0	1	0	0	0	0
226. MYA SP.	1	2	0	0	0	0.0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0.0	1	1	0	2	0	0	0	0	0
229. THRACIA SP. ,	0	0	0	0	0	0.0	4	1	1	0	3	0	0	0	0
230. DECAPODA	0	0	0	0	0	0.0	0	0	0	0	0	0	2	0	0
231. CARIDEA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
232. PAGURIDAE	0	0	0	0	0	0.0	1	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	3	4	0	0	0	1.0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	0	0	0.0	1	0	3	1	1	0	0	0	0
238. SIPUNCULA	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	-0.5	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
241. OPHIUROIDEA	3	12	9	0	1	1.0	0	1	2	0	3	0	0	0	0
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	1	0	0	0.0	0	0	0	0	0	0	0	0	0
243. DENDRASTER EXCENTRICUS	0	0	0	0	0	0.0	15	55	28	20	21	0	0	0	0
244. SPATANGIDAE	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	04	04	04	06	06	06	06	06	06	06	06	07	07	07	07
DEPTH	50	50	50	30	30	30	50	50	50	50	50	10	10	10	10
REPLICATE	3	4	5	1	2	4	1	2	3	4	5	1	2	3	4
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	1.00	1.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	1.00	1.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	1.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	2.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
263. NSPECIES	33.0	50.0	32.0	13.0	14.0	28.0	38.0	38.0	29.0	28.0	35.0	10.0	13.0	11.0	9.00
264. H	1.80	2.89	1.37	1.43	2.23	1.86	3.20	2.88	2.86	2.86	2.97	1.90	1.85	1.81	1.73
265. EVENNESS	.514	.739	.394	.557	.846	0.56	.878	.792	0.85	.859	.834	.826	.722	.755	.787
266. TOTAB	193.	284.	387.	65.0	32.0	337.	160.	216.	181.	103.	183.	46.0	77.0	51.0	41.0

APPENDIX D

(continued)

SAMPLES

	MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
	TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
	DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
	REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
SPECIES																
1.	CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.	PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.	TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.	ANTHOZOA	0	3	0	2	7	0	2	0	0	1	0	0	0	0	0
5.	PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.	NEMERTINEA	0	6	1	15	20	8	9	1	9	0	26	2	3	31	1
7.	NEMATODA	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
8.	POLYCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.	POLYNOIDAE	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
10.	ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.	EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.	HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.	HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.	LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.	SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.	PHOLOE MINUTA	0	8	0	0	6	0	0	0	1	0	0	0	0	1	0
17.	SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.	PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.	PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.	ANAITIDES GROENLANDICA	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
21.	ANAITIDES MUCOSA	0	4	1	1	2	3	5	6	1	0	1	0	1	10	0
22.	ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.	ETEONE SP.	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
24.	ETEONE LONGA	0	8	1	1	1	4	4	8	5	0	20	1	9	4	1
25.	EULALIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.	MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
27.	MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.	HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.	HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.	HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.	SYLLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.	AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.	TYPOSYLLIS SP.	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
34.	EUSYLLIS BLOMSTRANDI	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
35.	EXOGONE SP.	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
36.	SPHAEROSYLLIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.	BRANIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38.	NEREIDAE	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
39.	NEREIS SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
40.	NEPHTYS SP.	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0
41.	NEPHTYS CILIATA	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0
42.	NEPHTYS CAECA	0	1	0	0	0	1	0	0	1	0	1	1	0	1	0
43.	NEPHTYS RICKETTSII	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
44.	NEPHTYS LONGOSETOSA	13	0	0	0	0	0	0	0	0	1	0	0	0	0	0
45.	NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46.	SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
47.	GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48.	GLYCERA CAPITATA	0	2	0	1	1	2	7	8	6	8	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
52. ONUPHIS IRIDESCENS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53. LUMBRINERIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	3	0	5	14	2	4	5	1	2	3	10	0	29	16	0
61. SCOLOPLOS ARMECEPS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	0	0	0	0	0	0	0	0	2	0	0	6	0
72. POLYDORA CAULLERYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	0	0	1	0	2	2	1	2	1	0	7	0	3	5	0
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	4	5	24	12	20	76	117	60	92	1	52	3	12	252	0
79. SPIOPHANES BERKELEYORUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	0	0	0	0	0	0	0	0	0	0	12	0	0	1	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	3	1	0	0	0	0	0	0	0	14	0	0	12	0
83. MAGELONA SACCULATA	3	0	0	0	0	0	0	0	0	0	27	0	11	2	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
86. SPIOCHAETOPTERUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
91. CHAETOZONE SETOSA	0	1	1	1	3	0	0	0	0	0	1	0	0	1	0
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SPECIES	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
98. OPHELIA LIMACINA	0	0	0	0	1	5	7	6	1	2	32	2	8	7	0
99. TRAVISIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100. TRAVISIA FORBESII	0	0	0	1	0	0	0	0	1	0	0	0	0	5	0
101. TRAVISIA PUPA	7	0	0	0	0	0	0	0	0	0	0	0	0	2	1
102. OPHELINA BREVIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
105. MEDIOMASTUS CALIFORNIENSIS	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0
106. DECAMASTUS GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
109. PRAXILLELLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110. RHODINE BIRORQUATA	0	16	0	1	8	0	0	0	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS	0	3	36	44	25	0	10	5	7	7	0	69	33	1	0
112. MYRIOCHELE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
115. CISTENIDES GRANULATA	0	35	0	2	8	0	1	1	1	0	0	0	0	0	0
116. AMPHARETIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	0	6	0	3	2	0	2	0	3	0	8	0	4	5	0
120. ASABELLIDES SIBIRICA	0	2	0	0	5	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0
124. PISTA CRISTATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125. POLYCIRRUS SP.	0	2	0	0	0	1	2	1	1	1	0	0	0	0	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127. LAPHANIA BOECKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129. SABELLIDAE	0	42	0	0	14	0	0	0	0	0	0	0	0	0	0
130. CHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	142	0	0	35	0	0	0	1	0	0	0	0	0	0
132. CHONE MAGNA	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
133. EUCHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	133	0	2	262	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
136. EUCHONE ARENAE	0	0	0	0	0	5	1	0	5	0	0	0	0	0	0
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
139. SERPULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141. OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
142. HIRUDINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145. LEPETA SP. A	0	15	0	0	3	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D
(continued)

SAMPLES

SPECIES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
149. LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
154. POLINICES SP.	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
155. TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
160. OENOPOTA CF. ARCTICA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162. KURTSIELLA PLUMBAE	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
163. TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167. CYLICHNA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
168. CYLICHNA ALBA	0	0	0	0	1	0	0	0	2	1	1	0	0	0	0
169. CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173. DIAPHANA MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176. RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179. BIVALVIA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
183. YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189. MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
196. AXINOPSIDA SERRICATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	0	0	0	0	0	4	3	2	2	0	1	0	0	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
209. MACTRA NASUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
211. MACOMA SP.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212. MACOMA MOESTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	0	8	0	1	9	0	0	1	0	0	0	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229. THRACIA SP. ,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
231. CARIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
232. PAGURIDAE	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238. SIPUNCULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241. OPHIUROIDEA	0	30	0	0	7	0	0	0	0	0	0	0	0	0	0
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
243. DENDRASTER EXCENTRICUS	0	0	0	0	0	2	4	2	1	3	5	0	14	12	2
244. SPATANGIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES															
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	07	07	07	07	07	07	07	07	07	07	08	09	09	09	10
DEPTH	10	30	30	30	30	50	50	50	50	50	50	30	30	50	10
REPLICATE	5	2	3	4	5	1	2	3	4	5	1	1	2	1	1
SPECIES															
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
254. CHIRIDOTA SP.	0.00	4.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	15.0	0.00	64.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	6.00	38.0	11.0	21.0	48.0	14.0	17.0	16.0	22.0	13.0	27.0	7.00	14.0	25.0	8.00
264. H	1.53	2.44	1.50	1.92	2.21	1.50	1.57	1.76	1.66	2.23	2.59	.594	2.16	1.52	1.89
265. EVENNESS	.852	.671	.626	.629	0.57	.568	.555	.634	.537	.868	.787	.306	.817	.472	.909
266. TOTAB	31.0	523.	78.0	170.	496.	118.	183.	108.	146.	32.0	242.	79.0	131.	381.	16.0

APPENDIX D

(continued)

SAMPLES

	06	06	06	06	06	06	06	06	06	06	06	06	06	08	08
TRANSECT	10	10	10	11	11	11	11	11	11	11	11	11	11	A4	01
DEPTH	16	30	50	15	15	30	30	30	50	50	50	50	50	30	60
REPLICATE	1	1	1	1	2	1	2	3	1	2	3	4	5	1	1
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1. CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
3. TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
4. ANTHOZOA	0	0	1	0	0	1	0	0	1	0	0	1	1	2	0
5. PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. NEMERTINEA	6	18	3	0	0	39	9	38	1	8	14	24	27	4	4
7. NEMATODA	0	0	0	0	3	3	3	50	1	0	1	1	2	0	0
8. POLYCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. POLYNOIDAE	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10. ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	0	0	2	0	0	0	0	0	0	0	0	1	4	0	1
17. SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18. PISIONE SP.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20. ANAITIDES GROENLANDICA	0	9	0	0	0	0	0	0	0	0	1	0	0	0	0
21. ANAITIDES MUCOSA	0	3	6	0	1	2	2	5	1	3	3	3	9	0	0
22. ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	0	0	0	0	0	1	0	0	0	7	1	0	2
24. ETEONE LONGA	2	14	1	0	0	0	0	6	4	0	8	0	15	1	1
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
26. MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27. MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29. HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1
30. HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31. SYLLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32. AUTOLYTUS SP.	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
33. TYPOSYLLIS SP.	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
35. EXOGONE SP.	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
36. SPHAEROSYLLIS SP.	0	0	0	0	0	0	0	7	0	0	0	8	3	0	0
37. BRANIA SP.	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0
38. NEREIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39. NEREIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40. NEPHTYS SP.	0	0	0	3	0	0	0	0	0	0	5	1	0	0	1
41. NEPHTYS CILIATA	0	0	0	0	0	2	0	2	3	0	3	1	0	0	0
42. NEPHTYS CAECA	0	0	1	0	0	2	6	1	1	2	0	1	1	0	0
43. NEPHTYS RICKETTSII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	0	0	0	0	3	0	0	0	1	0	0	0	1	0	4
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48. GLYCERA CAPITATA	0	5	1	0	0	0	0	0	5	3	5	3	4	4	2

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	08	08
TRANSECT	10	10	10	11	11	11	11	11	11	11	11	11	11	A4	01
DEPTH	16	30	50	15	15	30	30	30	50	50	50	50	50	30	60
REPLICATE	1	1	1	1	2	1	2	3	1	2	3	4	5	1	1
SPECIES															
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
51. GLYCINDE ARMIGERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52. ONUPHIS IRIDESCENS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
53. LUMBRINERIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	20	0	0	0	0	0	1	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	12	36	27	2	6	1	1	0	4	9	3	2	11	13	2
61. SCOLOPLOS ARMECEPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	0	6	0	12	0	0	0	1	1	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
72. POLYDORA CAULLERYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	1	3	2	0	0	0	0	0	4	1	1	11	6	0	0
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	26	101	40	0	1	59	173	158	201	160	317	916	788	69	164
79. SPIOPHANES BERKELEYORUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	0	3	0	0	0	0	0	0	0	1	0	3	0	10
83. MAGELONA SACCULATA	42	0	5	0	0	0	0	0	0	0	0	0	0	0	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86. SPIOCHAETOPTERUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5
91. CHAETOZONE SETOSA	8	7	2	0	0	0	0	0	0	0	0	2	3	0	2
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES	MONTH TRANSECT DEPTH REPLICATE	06 10 16 1	06 10 30 1	06 10 50 1	06 11 15 1	06 11 15 2	06 11 30 1	06 11 30 2	06 11 30 3	06 11 50 1	06 11 50 2	06 11 50 3	06 11 50 4	06 11 50 5	08 A4 30 1	08 01 60 1
98. OPHELIA LIMACINA		0	17	7	22	0	15	6	10	3	0	0	11	10	0	2
99. TRAVISIA SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100. TRAVISIA FORBESII		0	1	3	0	0	0	1	0	2	2	2	1	2	0	0
101. TRAVISIA PUPA		11	2	0	0	0	0	0	0	0	0	0	0	0	0	2
102. OPHELINA BREVIATA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS		5	0	1	0	0	0	0	0	1	1	2	2	2	1	0
105. MEDIOMASTUS CALIFORNIENSIS		0	9	0	0	0	0	0	0	0	0	0	0	0	0	1
106. DECAMASTUS GRACILIS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
107. BARONTOLLA SP.		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
108. MALDANIDAE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109. PRAXILLELLA SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
110. RHODINE BIRORQUATA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS		0	2	2	0	3	195	141	154	17	26	39	14	20	1	0
112. MYRIOCHELE SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114. PECTINARIIDAE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA		0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
116. AMPHARETIDAE		0	0	0	0	1	0	0	0	0	0	0	6	17	0	14
117. AMPHARETE SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS		8	12	2	0	0	0	0	0	3	0	1	1	0	1	3
120. ASABELLIDES SIBIRICA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122. LEAENA ABRANCHIATA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123. NICOLEA ZOSTERICOLA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124. PISTA CRISTATA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125. POLYCIRRUS SP.		0	0	0	0	0	0	0	0	1	0	0	0	1	1	7
126. LANASSA VENUSTA VENUSTA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127. LAPHANIA BOECKI		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII		0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
129. SABELLIDAE		0	0	0	0	0	0	0	0	0	1	4	0	0	0	0
130. CHONE SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
132. CHONE MAGNA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
134. EUCHONE ANALIS		0	0	0	0	0	0	0	3	0	0	1	0	0	0	0
135. EUCHONE HANCOCKI		0	0	0	0	0	0	0	0	0	0	0	0	0	0	144
136. EUCHONE ARENAE		0	0	0	0	0	9	0	0	11	3	21	17	8	0	1
137. POTAMILLA RENIFORMIS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA		0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
139. SERPULIDAE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.		0	0	0	0	1	77	10	127	1	1	0	39	3	0	0
141. OLIGOCHAETA		0	0	0	0	1	0	0	4	1	0	10	0	3	0	1
142. HIRUDINEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
143. MOLLUSCA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145. LEPETA SP. A		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	08	08
TRANSECT	10	10	10	11	11	11	11	11	11	11	11	11	11	A4	01
DEPTH	16	30	50	15	15	30	30	30	50	50	50	50	50	30	60
REPLICATE	1	1	1	1	2	1	2	3	1	2	3	4	5	1	1
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0
149. LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0
154. POLINICES SP.	0	3	0	0	0	0	0	2	0	0	0	0	0	0	2
155. TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160. OENOPOTA CF. ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162. KURTSIELLA PLUMBAE	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
163. TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
167. CYLICHNA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
168. CYLICHNA ALBA	0	5	1	0	0	0	0	0	4	0	0	3	0	0	1
169. CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173. DIAPHANA MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
176. RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
179. BIVALVIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
183. YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189. MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES	MONTH 06 TRANSECT 10 DEPTH 16 REPLICATE 1	06 10 30 1	06 10 50 1	06 11 15 1	06 11 15 2	06 11 30 1	06 11 30 2	06 11 30 3	06 11 50 1	06 11 50 2	06 11 50 3	06 11 50 4	06 11 50 5	08 A4 30 1	08 01 60 1
196. AXINOPSIDA SERRICATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	21	4	0	0	0	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	54	2	0	0	0	0	0	55	14	15	15	17	0	2
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	1	0	0	0	28	27	11	1	1	0	0	1	0	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
205. CLINOCARDIUM SP., JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	0	6	0	0	0	0	0	0	0	1	0	0	0	0	2
209. MACTRA NASUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
211. MACOMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
212. MACOMA MOESTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	0	7	1	0	0	0	0	0	0	0	0	1	0	0	0
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
229. THRACIA SP. ,	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
231. CARIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
232. PAGURIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238. SIPUNCULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
241. OPHIUROIDEA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
243. DENDRASTER EXCENTRICUS	0	37	6	4	0	5	5	4	6	2	0	12	5	0	20
244. SPATANGIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SPECIES	SAMPLES														
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06	08	08
TRANSECT	10	10	10	11	11	11	11	11	11	11	11	11	11	A4	01
DEPTH	16	30	50	15	15	30	30	30	50	50	50	50	50	30	60
REPLICATE	1	1	1	1	2	1	2	3	1	2	3	4	5	1	1
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	6.00	0.00	14.0	0.00	0.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	11.0	31.0	28.0	4.00	10.0	19.0	14.0	24.0	29.0	24.0	27.0	33.0	38.0	17.0	48.0
264. H	1.92	2.64	2.50	0.91	2.06	1.81	1.43	2.07	1.68	1.48	1.48	.949	1.24	1.50	2.38
265. EVENNESS	.802	.768	.749	.657	.895	.616	.542	.652	.497	.467	.448	.272	.342	.531	.614
266. TOTAB	122.	391.	129.	31.0	21.0	449.	388.	623.	342.	245.	470.	1110	1018	109.	505.

APPENDIX D

(continued)

SPECIES	SAMPLES														
MONTH	08	08	08	08	08	08	08	08	10	10	10	10	10	10	10
TRANSECT	01	02	03	04	06	07	08	09	02	02	02	02	03	03	03
DEPTH	60	60	60	60	60	60	60	60	30	30	60	60	30	30	60
REPLICATE	2	1	1	1	1	1	1	1	1	2	1	2	1	2	1
1. CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. ANTHOZOA	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
5. PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
6. NEMERTINEA	9	1	11	14	5	33	25	6	0	0	1	1	0	1	6
7. NEMATODA	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0
8. POLYCHAETA	0	0	0	0	0	0	0	32	0	0	0	13	0	0	0
9. POLYNOIDAE	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
10. ARCTEOBIA ANTICOSTIENSIS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	1	0	1	27	1	3	1	1	0	0	0	0	0	0	0
17. SIGALION SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18. PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20. ANAITIDES GROENLANDICA	0	0	0	0	1	0	0	0	1	3	0	0	0	0	0
21. ANAITIDES MUCOSA	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
22. ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	0	0	0	0	0	0	0	9	1	0	0	0	0
24. ETEONE LONGA	0	0	1	1	0	1	7	10	0	7	0	3	3	2	4
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26. MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27. MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29. HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2
30. HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
31. SYLLIDAE	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
32. AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
33. TYPOSYLLIS SP.	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35. EXOGONE SP.	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
36. SPHAEROSYLLIS SP.	0	0	0	0	0	0	0	0	0	11	0	4	0	0	0
37. BRANIA SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
38. NEREIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39. NEREIS SP.	0	0	0	0	0	0	0	1	0	0	0	0	2	3	0
40. NEPHTYS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41. NEPHTYS CILIATA	0	0	1	0	0	0	0	0	0	0	0	0	0	7	0
42. NEPHTYS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	4	1	1
43. NEPHTYS RICKETTSII	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	4	0	9	13	1	0	0	0	0	0	3	0	0	1	0
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48. GLYCERA CAPITATA	1	0	0	0	4	0	3	2	0	10	1	5	0	3	7

APPENDIX D

(continued)

SPECIES	08 01 60 2	08 02 60 1	08 03 60 1	08 04 60 1	08 06 60 1	08 07 60 1	08 08 60 1	08 09 60 1	10 02 30 1	10 02 30 2	10 02 60 1	10 02 60 2	10 03 30 1	10 03 30 2	10 03 60 1
49. GONIADIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50. GLYCINDE PICTA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	3	0	0	7	0	3	0	4	0	0	0	1	0	0	0
52. ONUPHIS IRIDESCENS	1	0	10	2	0	3	0	0	0	0	0	2	0	0	0
53. LUMBRINERIS SP.	1	0	1	21	0	0	0	0	0	0	0	1	0	0	0
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	2	1	16	3	8	19	10	31	0	0	0	0	6	8	4
61. SCOLOPLOS ARMECEPS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
72. POLYDORA CAULLERYI	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	1	0	2	1	0	0	0	1	0	0	3	0	0	0	1
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
76. SPIO NR FILICORNIS	1	0	9	0	0	0	2	10	0	0	4	27	1	0	2
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
78. SPIOPHANES BOMBYX	39	0	65	50	27	115	351	321	0	3	1	3	18	10	15
79. SPIOPHANES BERKELEYORUM	0	0	1	85	0	0	0	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	7	0	9	9	0	10	0	9	0	0	0	0	1	0	0
83. MAGELONA SACCULATA	0	0	2	0	0	0	0	1	0	0	0	0	3	0	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
86. SPIOCHAETOPTERUS SP.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	2	0	2	2	0	0	0	2	0	0	0	0	0	0	0
91. CHAETOZONE SETOSA	7	0	3	2	0	1	0	1	0	0	0	0	0	0	0
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
93. BRADA VILLOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES	MONTH 08 TRANSECT 01 DEPTH 60 REPLICATE 2	08 02 60 1	08 03 60 1	08 04 60 1	08 06 60 1	08 07 60 1	08 08 60 1	08 09 60 1	10 02 30 1	10 02 30 2	10 02 60 1	10 02 60 2	10 03 30 1	10 03 30 2	10 03 60 1
98. OPHELIA LIMACINA	0	0	16	0	2	20	9	11	0	3	0	2	2	12	10
99. TRAVISIA SP.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
100. TRAVISIA FORBESII	0	0	0	0	3	1	25	0	0	0	0	0	0	3	0
101. TRAVISIA PUPA	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
102. OPHELINA BREVIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
105. MEDIOMASTUS CALIFORNIENSIS	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0
106. DECAMASTUS GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
109. PRAXILLELLA SP.	3	0	2	21	0	0	0	0	0	0	0	0	0	0	2
110. RHODINE BIRORQUATA	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS	0	0	0	1	2	1	0	0	23	58	2	13	0	0	1
112. MYRIOCHELE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	0	0	10	13	3	12	0	0	0	0	5	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA	1	0	0	0	28	1	0	1	0	0	1	0	0	1	1
116. AMPHARETIDAE	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	0	0	14	5	10	13	13	23	0	1	2	0	4	0	4
120. ASABELLIDES SIBIRICA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
121. TEREBELLIDAE	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124. PISTA CRISTATA	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
125. POLYCIRRUS SP.	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127. LAPHANIA BOECKI	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129. SABELLIDAE	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
130. CHONE SP.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
132. CHONE MAGNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	23	0	21	0	0	0	0	0	0	0	0	0	0	0	0
136. EUCHONE ARENAE	0	0	0	0	0	0	12	0	0	0	1	87	0	0	1
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
138. SABELLA MEDIA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
139. SERPULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	0	0	0	0	0	0	7	1	0	6	0	11	0	1	1
141. OLIGOCHAETA	1	0	0	0	0	0	0	0	0	24	0	0	0	0	0
142. HIRUDINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
145. LEPETA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES															
MONTH	08	08	08	08	08	08	08	08	10	10	10	10	10	10	10
TRANSECT	01	02	03	04	06	07	08	09	02	02	02	02	03	03	03
DEPTH	60	60	60	60	60	60	60	60	30	30	60	60	30	30	60
REPLICATE	2	1	1	1	1	1	1	1	1	2	1	2	1	2	1
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	0	0	2	0	0	0	0	1	0	0	0	0	0	1	1
149. LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
154. POLINICES SP.	0	1	0	0	0	0	2	0	0	0	0	0	0	3	0
155. TURRIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	0	0	0	0	1	2	3	0	0	0	1	0	0	0
160. OENOPOTA CF. ARCTICA	3	1	0	0	0	0	0	1	0	0	1	0	0	0	0
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162. KURTSIELLA PLUMBAE	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
163. TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
167. CYLICHNA SP.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
168. CYLICHNA ALBA	0	0	1	0	0	0	0	3	0	0	0	0	2	0	0
169. CYLICHNA? SP. A	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
173. DIAPHANA MINUTA	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0
176. RETUSA SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
179. BIVALVIA	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	2	0	0	16	0	0	0	0	0	0	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
183. YOLDIA CF. HYPERBOREA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189. MUSCULUS NIGER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	08	08	08	08	08	08	08	08	10	10	10	10	10	10	10
TRANSECT	01	02	03	04	06	07	08	09	02	02	02	02	03	03	03
DEPTH	60	60	60	60	60	60	60	60	30	30	60	60	30	30	60
REPLICATE	2	1	1	1	1	1	1	1	1	2	1	2	1	2	1
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
196. AXINOPSIDA SERRICATA	12	0	6	14	0	1	0	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	0	19	5	0	10	1	2	6	0	0	7	11	57	18	1
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	2	0	0	6	0	0	0	3	2	0	0	7	4	2
204. ASTARTE CF. VERNICOSA	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	2	0	3	2	0	1	0	2	0	0	0	0	0	0	0
209. MACTRA NASUATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211. MACOMA SP.	0	0	3	5	0	0	0	0	0	1	0	0	0	0	0
212. MACOMA MOESTA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
213. MACOMA MOESTA ALASKANA	5	0	4	7	0	0	0	0	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221. TELLINA NUCULOIDES	1	0	0	0	0	1	19	0	0	0	0	0	0	1	0
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	7	0	5	0	0	0	0	0	0	0	0	2	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229. THRACIA SP. ,	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
231. CARIDEA	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
232. PAGURIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
238. SIPUNCULA	0	0	2	2	0	0	0	0	0	0	1	2	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241. OPHIUROIDEA	0	0	10	19	1	4	1	1	0	0	0	8	0	0	0
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
243. DENDRASTER EXCENTRICUS	7	0	88	0	4	16	0	5	0	0	0	36	19	35	4
244. SPATANGIDAE	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES														
MONTH	08	08	08	08	08	08	08	08	10	10	10	10	10	10	10
TRANSECT	01	02	03	04	06	07	08	09	02	02	02	02	03	03	03
DEPTH	60	60	60	60	60	60	60	60	30	30	60	60	30	30	60
REPLICATE	2	1	1	1	1	1	1	1	1	2	1	2	1	2	1
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES															
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	37.0	8.00	49.0	42.0	22.0	33.0	24.0	33.0	3.00	24.0	24.0	39.0	21.0	22.0	25.0
264. H	2.84	1.40	2.88	2.89	2.45	2.21	1.43	1.66	.503	2.34	2.94	2.60	2.12	2.40	2.80
265. EVENNESS	.786	.672	.739	.772	.792	.633	0.45	.474	.458	.736	.926	.711	.696	.777	.871
266. TOTAB	157.	32.0	356.	372.	121.	272.	508.	502.	27.0	159.	47.0	269.	138.	118.	77.0

APPENDIX D

(continued)

	SAMPLES												
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
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SPECIES													
1. CNIDARIA	0	0	0	0	0	0	0	0	0	0	0	0	0
2. PANDEA SP. 1	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
4. ANTHOZOA	0	0	0	3	1	0	0	0	0	1	0	0	0
5. PLATYHELMINTHES	0	0	0	0	0	0	0	0	0	0	0	0	0
6. NEMERTINEA	1	12	8	32	24	0	1	31	45	6	1	2	13
7. NEMATODA	0	1	0	1	0	0	0	3	1	0	0	0	4
8. POLYCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0
9. POLYNOIDAE	0	0	0	0	0	0	0	0	0	0	0	0	3
10. ARCTEOBIA ANTICOSTIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0
11. EUNOE CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0
12. HARMOTHOE EXTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0
13. HARMOTHOE MULTISETOSA	0	0	0	0	0	0	0	0	0	0	0	0	0
14. LEPIDONOTUS SQUAMATUS	0	0	0	0	0	0	0	0	0	0	0	0	0
15. SIGALIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
16. PHOLOE MINUTA	0	3	6	16	8	0	0	3	2	0	0	0	5
17. SIGALION SP.	0	0	0	1	0	0	0	1	0	0	0	0	0
18. PISIONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
19. PHYLLODOCIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
20. ANAITIDES GROENLANDICA	0	0	1	0	0	0	0	0	0	0	0	0	0
21. ANAITIDES MUCOSA	0	1	1	0	0	0	0	0	3	0	0	0	5
22. ANAITIDES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
23. ETEONE SP.	0	0	2	2	0	0	0	0	0	0	0	0	0
24. ETEONE LONGA	3	1	0	4	4	0	0	1	1	1	1	1	7
25. EULALIA SP.	0	0	0	0	0	0	0	0	0	1	0	0	0
26. MYSTA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
27. MYSTA BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0
28. HESIONURA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
29. HESIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
30. HESIONIDAE, JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0
31. SYLLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
32. AUTOLYTUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
33. TYPOSYLLIS SP.	0	0	0	0	0	0	0	0	0	0	1	0	0
34. EUSYLLIS BLOMSTRANDI	0	0	0	0	0	0	0	0	0	0	0	1	3
35. EXOGONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	2
36. SPHAEROSYLLIS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
37. BRANIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
38. NEREIDAE	0	0	0	0	0	0	0	0	0	0	0	0	1
39. NEREIS SP.	0	0	1	3	1	0	0	0	0	0	0	0	0
40. NEPHTYS SP.	0	4	0	0	2	0	0	0	0	0	0	0	0
41. NEPHTYS CILIATA	0	0	0	0	0	0	0	0	0	0	0	0	0
42. NEPHTYS CAECA	1	3	1	1	0	0	0	0	0	0	0	1	0
43. NEPHTYS RICKETTSII	0	0	0	0	0	0	0	0	0	0	0	0	0
44. NEPHTYS LONGOSETOSA	14	3	1	3	0	0	0	0	3	0	0	0	0
45. NEPHTYS FERRUGINEA	0	0	0	0	0	0	0	0	0	0	0	0	0
46. SPHAERODOROPSIS MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0
47. GLYCERA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
48. GLYCERA CAPITATA	3	0	0	3	0	2	4	1	1	2	6	3	4

APPENDIX D

(continued)

	SAMPLES												
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
SPECIES													
49. GONIADIDAE	0	0	0	0	0	0	0	1	0	0	0	0	0
50. GLYCINDE PICTA	0	0	0	0	1	0	0	0	0	0	0	0	0
51. GLYCINDE ARMIGERA	0	0	0	12	7	0	0	4	1	0	0	2	0
52. ONUPHIS IRIDESCENS	1	0	0	3	1	0	0	0	0	0	0	0	0
53. LUMBRINERIS SP.	0	0	0	12	9	0	0	1	0	0	0	0	0
54. LUMBRINERIS BICIRRATA	0	0	0	0	0	0	0	0	1	0	0	0	0
55. DORVILLEIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
56. PROTODORVILLEA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
57. OPHRYOTROCHA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
58. SCHISTOMERINGOS CAECA	0	0	0	0	0	0	0	0	0	0	0	0	0
59. SCHISTOMERINGOS ANNULATA	0	0	0	0	0	0	0	0	0	0	0	0	0
60. SCOLOPLOS ARMIGER	5	41	26	13	7	7	10	2	8	2	5	4	1
61. SCOLOPLOS ARMECEPS	0	0	0	0	0	26	0	0	0	0	4	0	0
62. PARAONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
63. ARICIDEA NR. SUECICA	0	0	0	6	0	0	0	0	0	0	0	0	0
64. ARICIDEA LOPEZI LOPEZI	0	1	0	0	0	0	0	0	2	0	0	0	0
65. ARICEDEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	2
66. PARAONELLA PLATYBRANCHIA	0	0	0	0	0	0	0	1	0	0	0	0	0
67. APISTOBRANCHUS TULLBERGI	0	0	0	0	0	0	0	0	0	0	0	0	0
68. SPIONIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
69. SPIONIDAE GEN NOV	0	0	0	0	0	0	0	0	0	0	0	0	0
70. POLYDORA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
71. POLYDORA SOCIALIS	0	0	0	0	0	0	0	0	0	0	0	0	0
72. POLYDORA CAULLERYI	0	0	0	0	0	0	0	0	0	0	0	0	0
73. GATTYANA CIRROSA	0	0	0	0	0	0	0	0	0	0	0	0	0
74. PRIONOSPIO STEENSTRUPI	2	0	0	4	8	3	3	1	0	0	0	0	1
75. SPIO SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
76. SPIO NR FILICORNIS	0	2	1	0	0	0	0	8	7	0	0	3	9
77. SPIOPHANES? SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
78. SPIOPHANES BOMBYX	29	0	0	141	138	0	0	2199	1482	1	1	78	313
79. SPIOPHANES BERKELEYORUM	0	0	0	32	5	0	0	0	0	0	0	0	0
80. SCOLELEPIS SQUAMATA	0	58	19	0	0	0	0	1	0	0	0	0	0
81. MINUSPIO CIRRIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0
82. MAGELONA NR CERAE	0	0	1	22	4	0	0	0	1	0	0	0	3
83. MAGELONA SACCULATA	0	140	79	1	0	0	0	4	9	0	0	0	0
84. CHAETOPTERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	2
85. CHAETOPTERUS VARIOPEDATUS	0	0	0	0	1	0	0	0	0	0	0	2	0
86. SPIOCHAETOPTERUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
87. SPIOCHAETOPTERUS COSTARUM	0	0	0	0	0	0	0	0	0	0	0	0	0
88. CIRRATULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
89. CIRRATULUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
90. THARYX SP.	1	0	0	3	5	0	0	0	0	0	0	0	1
91. CHAETOZONE SETOSA	0	287	190	3	2	0	0	3	7	0	0	2	0
92. FLABELLIGERIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
93. BRADA VILLOSA	0	0	0	0	0	0	0	0	0	0	1	0	0
94. PHERUSA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
95. PHERUSA PLUMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0
96. ARMANDIA BREVIS	0	0	0	0	0	0	0	0	0	0	0	0	0
97. OPHELIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES	10 03 60 2	10 04 30 1	10 04 30 2	10 04 60 1	10 04 60 2	10 06 30 1	10 06 30 2	10 06 60 1	10 06 60 2	10 07 30 1	10 07 30 2	10 11 60 1	10 11 60 2
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
98. OPHELIA LIMACINA	1	0	0	0	0	0	3	12	29	0	2	5	12
99. TRAVISIA SP.	0	0	0	0	0	0	0	1	0	0	0	0	0
100. TRAVISIA FORBESII	0	0	0	1	0	0	0	1	0	0	1	1	1
101. TRAVISIA PUPA	0	0	1	0	0	0	0	0	0	1	0	0	0
102. OPHELINA BREVIATA	0	0	0	0	0	0	0	0	0	0	0	0	0
103. CAPITELLA CAPITATA	0	0	0	0	0	0	0	0	0	0	0	0	0
104. NOTOMASTUS LINEATUS	0	0	0	0	0	0	0	0	0	0	0	0	1
105. MEDIOMASTUS CALIFORNIENSIS	0	1	2	34	25	0	0	0	1	0	0	0	0
106. DECAMASTUS GRACILIS	0	0	0	18	9	0	0	0	1	0	0	0	0
107. BARONTOLLA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
108. MALDANIDAE	0	1	0	0	0	0	0	2	2	0	0	0	2
109. PRAXILLELLA SP.	2	0	1	31	28	0	0	0	0	0	0	0	13
110. RHODINE BIRORQUATA	0	0	0	0	0	0	0	0	0	0	0	0	0
111. OWENIA FUSIFORMIS	1	0	0	0	0	5	5	0	0	120	15	3	1
112. MYRIOCHELE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
113. MYRIOCHELE OCULATA	1	2	0	35	40	0	0	7	3	0	0	0	0
114. PECTINARIIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
115. CISTENIDES GRANULATA	0	0	0	0	0	2	1	0	0	0	0	3	1
116. AMPHARETIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
117. AMPHARETE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
118. AMPHARETE GOESI	0	0	0	0	0	0	0	0	0	0	0	0	0
119. AMPHARE CF ACUTIFRONS	1	12	14	13	14	0	0	3	4	0	5	0	3
120. ASABELLIDES SIBIRICA	0	0	0	0	0	0	0	0	0	0	0	0	0
121. TEREBELLIDAE	0	0	2	0	0	0	0	0	0	0	0	0	0
122. LEAENA ABRANCHIATA	0	0	0	0	0	0	0	0	0	0	0	0	0
123. NICOLEA ZOSTERICOLA	0	0	0	0	0	0	0	0	1	0	0	0	5
124. PISTA CRISTATA	0	0	0	0	0	0	0	0	0	0	0	0	0
125. POLYCIRRUS SP.	0	0	1	0	0	0	0	0	0	0	0	0	0
126. LANASSA VENUSTA VENUSTA	0	0	0	0	0	0	0	0	0	0	0	0	0
127. LAPHANIA BOECKI	1	0	0	1	4	0	0	0	0	0	0	0	0
128. PROCLEA GRAFFII	1	0	0	0	0	0	0	1	0	2	0	0	0
129. SABELLIDAE	0	1	0	0	0	0	0	0	0	0	0	1	4
130. CHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
131. CHONE GRACILIS	0	0	0	0	0	0	0	0	2	0	0	0	0
132. CHONE MAGNA	0	0	0	0	0	0	0	0	0	0	0	0	0
133. EUCHONE SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
134. EUCHONE ANALIS	0	0	0	0	0	0	0	0	0	0	0	0	0
135. EUCHONE HANCOCKI	0	0	0	0	0	0	0	1	0	0	0	0	0
136. EUCHONE ARENAE	0	0	0	0	0	0	0	2	0	0	0	0	1
137. POTAMILLA RENIFORMIS	0	0	0	0	0	0	0	0	0	0	0	0	0
138. SABELLA MEDIA	0	0	0	0	0	0	0	0	0	0	0	0	2
139. SERPULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
140. POLYGORDIUS SP.	0	0	0	0	0	0	2	0	0	0	0	0	17
141. OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0
142. HIRUDINEA	0	0	0	0	0	0	0	0	0	0	0	0	0
143. MOLLUSCA	0	0	0	0	0	0	0	0	0	0	0	0	0
144. GASTROPODA	0	0	0	0	0	0	0	0	0	0	0	0	1
145. LEPETA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0
146. MARGARITES SP.	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

SPECIES													
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
147. MARGARITES CF. HELICINUS	0	0	0	0	0	0	0	0	0	0	0	0	0
148. MARGARITES COSTALIS	1	14	7	0	0	0	0	0	0	0	0	2	0
149. LITTORINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
150. TACHYRHYNCHUS EROSUS	0	0	0	1	0	0	0	0	0	0	0	0	0
151. TRICHOTROPIS CANCELLATA	0	0	1	0	0	0	0	0	0	0	0	0	0
152. MARSENIA CF. RHOMBICA	0	0	0	0	0	0	0	0	0	0	0	0	0
153. NATICA CLAUSA	0	2	1	0	0	0	0	0	0	0	0	0	1
154. POLINICES SP.	0	0	0	0	0	0	0	0	0	0	1	1	0
155. TURRIDAE, JUV.	0	6	3	1	0	0	0	0	0	0	0	0	0
156. SUAVODRILLIA KENNICOTTII	0	0	0	1	0	0	0	0	0	0	0	0	0
157. MANGELIA? SP. A	0	0	0	1	0	0	0	0	0	0	0	0	0
158. OENOPOTA SP.	0	0	0	0	0	0	0	0	5	0	0	0	0
159. OENOPOTA CF. TURRICULA	0	2	3	0	0	0	0	0	0	0	0	3	2
160. OENOPOTA CF. ARCTICA	0	4	1	1	0	0	0	0	0	0	0	0	0
161. OENOPOTA SP. A	0	0	0	0	0	0	0	0	1	0	0	0	0
162. KURTSIELLA PLUMBAE	0	7	10	7	3	0	0	5	0	0	0	0	0
163. TURRIDAE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0
164. ODOSTOMIA SP.	0	0	0	2	0	0	0	0	0	0	0	0	0
165. TURBONILLA SP.	0	0	0	2	0	0	0	0	0	0	0	0	0
166. CEPHALASPIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0
167. CYLICHNA SP.	0	0	0	6	0	0	0	0	0	0	0	0	0
168. CYLICHNA ALBA	0	5	0	0	3	0	0	1	0	0	0	0	0
169. CYLICHNA? SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0
170. SCAPHANDER SP. A	0	0	0	0	0	0	0	1	1	0	0	0	0
171. PHILINE SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0
172. PHILINE SP. B	0	0	0	0	0	0	0	0	0	0	0	0	0
173. DIAPHANA MINUTA	0	0	0	0	0	0	0	0	0	0	0	0	0
174. HAMINOEA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	0
175. RETUSA SP. A	0	0	0	0	0	0	0	0	0	0	0	0	1
176. RETUSA SP. B	0	0	0	5	2	0	0	0	0	0	0	0	0
177. NUDIBRANCHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
178. NEAEROMYA COMPRESSA	0	0	0	0	0	0	0	0	0	0	0	0	0
179. BIVALVIA	0	0	0	0	0	0	0	0	0	0	0	0	0
180. NUCULA TENUIS	0	0	0	34	13	0	0	2	0	0	0	0	0
181. NUCULANA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
182. NUCULANA CF. PERNULA	0	0	0	0	0	0	0	0	0	0	0	0	0
183. YOLDIA CF. HYPERBOREA	0	0	0	2	0	0	0	0	0	0	0	0	0
184. YOLDIA MYALIS	0	0	0	0	0	0	0	0	0	0	0	0	0
185. YOLDIA SCISSURATA	0	0	0	26	4	0	0	0	0	0	0	0	0
186. MYTILIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
187. MEGACRENELLA COLUMBIANA	0	0	0	0	0	0	0	0	0	0	0	0	0
188. MUSCULUS SP. JUV.	0	0	0	0	0	0	0	0	0	0	0	0	0
189. MUSCULUS NIGER	0	1	0	0	0	0	0	0	0	0	0	0	0
190. MUSCULUS CF. DISCORS	0	0	0	0	0	0	0	0	0	0	0	0	0
191. MODIOLUS SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
192. LIMA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
193. LIMATULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
194. LIMATULA SUBAURICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0
195. LIMATULA CF. ATTENUATA	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

SAMPLES

MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
SPECIES													
196. AXINOPSIDA SERRICATA	0	0	0	44	28	0	0	0	0	0	0	0	0
197. DIPLODONTA CF. IMPO	0	0	0	0	0	0	0	0	0	0	0	0	0
198. CYCLOCARDIA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
199. MYSELLA CF. TUMIDA	0	0	0	0	0	0	0	0	0	0	0	0	0
200. CYCLOCARDIA CREBRICOSTATA	3	3	10	5	0	0	0	0	0	0	0	0	1
201. CYCLOCARDIA INCISA	0	0	0	0	0	0	0	0	0	0	0	0	0
202. ASTARTE SP., JUV.	0	0	0	0	1	0	0	0	0	0	0	0	0
203. ASTARTE ROLLANDI	0	0	0	0	0	0	0	0	0	0	0	0	0
204. ASTARTE CF. VERNICOSA	0	0	0	0	0	0	0	0	0	0	0	0	0
205. CLINOCARDIUM SP., JUV.	0	1	0	2	0	0	0	0	0	0	0	0	0
206. SERRIPES GROENLANDICUS	0	0	0	0	0	0	0	0	0	0	0	0	0
207. SPISULA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
208. MACTRA ALASKANA	0	0	0	0	0	0	0	1	1	0	0	1	0
209. MACTRA NASUATA	0	0	0	0	0	0	0	0	0	0	0	0	0
210. SILIQUA PATULA	0	0	2	0	0	0	0	0	0	0	0	0	0
211. MACOMA SP.	0	0	0	11	4	0	0	0	0	0	0	0	0
212. MACOMA MOESTA	0	0	0	6	8	0	0	1	0	0	0	0	0
213. MACOMA MOESTA ALASKANA	0	0	0	0	0	0	0	0	0	0	0	0	0
214. MACOMA CRASSULA	0	0	0	0	0	0	0	0	0	0	0	0	0
215. MACOMA LAMA	0	0	0	0	0	0	0	0	0	0	0	0	0
216. MACOMA BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0
217. MACOMA CF. BALTHICA	0	0	0	0	0	0	0	0	0	0	0	0	0
218. MACOMA CF. CALCAREA	0	0	0	0	0	0	0	0	0	0	0	0	0
219. MACOMA SP. A	0	0	0	3	0	0	0	0	0	0	0	0	0
220. TELLINA SP.	0	0	0	0	0	0	0	0	0	0	0	0	1
221. TELLINA NUCULOIDES	0	11	11	0	0	0	0	0	0	0	0	0	0
222. SAXIDOMUS GIGANTEA	0	0	0	0	0	0	0	0	0	0	0	0	0
223. PSEPHIDIA LORDI	0	0	0	0	0	0	0	0	0	0	0	0	0
224. HUMILARIA KENNERLYI	0	0	0	0	0	0	0	0	0	0	0	0	0
225. PATINOPECTEN CAUIRUS	0	0	0	0	0	0	0	0	0	0	0	0	0
226. MYA SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
227. HIATELLA ARCTICA	0	0	0	0	0	0	0	0	0	0	0	0	0
228. LYONSIA CALIFORNICA	0	0	0	0	0	0	0	0	0	0	0	0	0
229. THRACIA SP. ,	0	0	0	0	0	0	0	0	0	0	0	0	0
230. DECAPODA	0	0	0	0	0	0	0	0	0	0	0	0	2
231. CARIDEA	0	0	0	1	0	0	0	0	0	0	0	0	3
232. PAGURIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
233. MAJIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
234. OROGONIA GRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0
235. CHIONIECETES SP.	0	0	1	0	0	0	0	0	0	0	0	0	0
236. CANCRIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0
237. PINNOTHERIDAE	0	0	0	0	0	0	0	0	0	0	0	2	2
238. SIPUNCULA	0	0	0	0	1	0	0	0	0	0	0	0	0
239. ALCYONIDIUM SP.	0	0	0	0	0	0	0	0	0	0	0	0	0
240. ASTERIAS AMURENSIS	0	0	0	0	0	0	0	0	0	0	0	0	1
241. OPHIUROIDEA	0	3	1	24	0	0	1	2	4	0	13	1	2
242. STRONGYLOCENTROTUS DROEBACHIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0
243. DENDRASTER EXCENTRICUS	1	29	30	0	6	0	0	23	16	1	0	4	16
244. SPATANGIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

(continued)

	SAMPLES												
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	03	04	04	04	04	06	06	06	06	07	07	11	11
DEPTH	60	30	30	60	60	30	30	60	60	30	30	60	60
REPLICATE	2	1	2	1	2	1	2	1	2	1	2	1	2
	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES													
245. DENDROCHIROTIDA	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
246. HOLOTHUROIDEA DENDROCHIROTACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
247. HAVELOCKIA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
248. THYONINAE A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
249. EUPENTACTA QUINQUESEMITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250. PENTAMERA SP.	0.00	0.00	0.00	1.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
251. PENTAMERA LISSOPLACA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
252. PENTAMERA SP. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
253. CHIRIDOTIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
254. CHIRIDOTA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
255. MYRIOTRHOCHIDAE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
256. HEMICHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
257. UROCHORDATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
258. DISTAPLIA SP.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
259. AGNESIA SEPTENTRIONALIS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260. STYELA ?CORIACEA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
261. HALOCYNTHIA AURANTIUM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262. AMMODYTES HEXAPTERUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
263. NSPECIES	20.0	32.0	33.0	52.0	37.0	6.00	9.00	34.0	30.0	11.0	14.0	23.0	43.0
264. H	2.16	1.98	2.10	3.12	2.69	1.31	1.91	.375	.578	.656	2.15	1.79	1.76
265. EVENNESS	.722	.571	.602	.789	.745	0.73	.871	.106	0.17	.274	.816	.571	.468
266. TOTAB	73.0	662.	439.	640.	424.	45.0	30.0	2331	1645	138.	57.0	126.	475.

APPENDIX E

RAW DATA FROM EPIFAUNAL SAMPLES

SAMPLES

MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	01	01	01	02	02	03	03	03	04	04	06	06	06
DEPTH	15	30	50	30	50	20	30	50	20	50	10	15	30
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	03
SPECIES													
1. CHLOROPHYTA	0.000	0.000	0.000	0.000	0	0.007	0.008	0	0	0.000	0	0	0.000
2. PHAEOPHYTA	.0492	.0513	.3983	.0074	0	2.723	0.313	0	0	0.000	0	0	0.000
3. RHODOPHYTA	0.000	0.000	0.000	.0052	0	0.133	0.046	0	0	0.000	0	0	0.000
4. ZOSTERA MARINA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
5. PORIFERA	0.000	0.000	0.000	0.394	0	0.000	0.000	0	0	0.270	0	0	0.000
6. HYDROIDA	0.000	0.000	0.000	.0025	0	0.000	0.000	0	0	0.000	0	0	0.000
7. ZOOANTHARIA ACTINIARIA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	3.631	0	0	0.000
8. ANEMONE SP. 16	0.000	0.000	0.000	.0961	0	0.000	0.000	0	0	.0194	0	0	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
10. METRIDIUM SENILE	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
11. POLYCHAETA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
12. POTAMILLA RENIFORMIS	0.000	0.000	0.000	0.654	0	0.000	0.000	0	0	0.000	0	0	0.000
13. GASTROPODA	0.000	0.000	0.000	.0019	0	0.000	0.000	0	0	0.000	0	0	0.000
14. MARGARITES PUPILLUS	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
15. TRICHOTROPIS INSIGNIS	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
16. TRICHOTROPIS CANCELLATA	0.000	0.000	0.000	.0028	0	0.000	0.000	0	0	0.000	0	0	0.000
17. VELUTINA LAEVIGATA	0.000	0.000	0.000	.0004	0	0.000	0.000	0	0	0.000	0	0	0.000
18. NATICA CLAUSA	0.000	0.013	.0104	.0004	0	0.000	0.000	0	0	0.000	0	0	0.000
19. POLINICES PALLIDA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
20. FUSITRITON OREGONENSIS	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
21. NUCELLA SP.	0.000	0.000	0.000	0.038	0	0.000	0.000	0	0	0.000	0	0	0.000
22. BERINGIUS BERINGI	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
23. LIOMESUS NUX	0.000	0.000	0.000	.0039	0	0.000	0.000	0	0	0.000	0	0	0.000
24. NEPTUNEA LYRATA	0.000	0.000	.0459	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
25. NUDIBRANCHIA	0.000	0.000	0.000	.0037	0	0.000	0.000	0	0	0.000	0	0	0.000
26. MOPALIA HINDSI	0.000	0.000	0.000	.0086	0	0.000	0.000	0	0	0.000	0	0	0.000
27. BIVALVIA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
28. MYTILUS EDULIS	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
29. PODODESMUS SP.	0.000	0.000	0.000	.0192	0	0.000	0.000	0	0	0.000	0	0	0.000
30. CYCLOCARDIA SP.	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
31. ASTARTE SP. JUV.	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
32. SERRIPES GROENLANDICUS	0.000	0.000	0.000	.0148	0	0.000	0.000	0	0	0.000	0	0	0.000
33. SPISULA SP.	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
34. SILIQUA PATULA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
35. MACOMA SP.	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
36. TELLINA LUTEA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
37. TELLINA NUCULOIDES	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
38. HIATELLA ARCTICA	0.000	0.000	0.000	.0018	0	0.000	0.000	0	0	0.000	0	0	0.000
39. CIRRIPEDIA	0.000	0.000	0.000	15.03	0	0.000	0.000	0	0	0.220	0	0	2.383
40. DECAPODA	0.000	0.000	0.000	.0002	0	0.000	0.000	0	0	0.000	0	0	0.000
41. HIPPOLYTIDAE	0.022	0.070	.0657	.0107	0	0.004	0.000	0	0	.0124	0	0	0.000
42. PAGURIDAE	0.008	0.003	0.000	0.724	0	0.000	0.000	0	0	0.006	0	0	0.000
43. PARALITHODES CAMTSCHATICA	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
44. MAJIDAE	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
45. OROGONIA GRACILIS	0.000	0.000	0.000	.0396	0	0.000	0.000	0	0	0.000	0	0	0.000
46. HYAS LYRATUS	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
47. CHIONIECETES SP.	0.000	0.000	0.000	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000
48. CHIONOECETES OPILIO	0.000	0.000	2.678	0.000	0	0.000	0.000	0	0	0.000	0	0	0.000

APPENDIX E

(continued)

SAMPLES

SPECIES	MONTH 06 TRANSECT 01 DEPTH 15 REPLICATE 01	06 01 30 01	06 01 50 01	06 02 30 01	06 02 50 01	06 03 20 01	06 03 30 01	06 03 50 01	06 04 20 01	06 04 50 01	06 06 10 01	06 06 15 01	06 06 30 03
49. CHIONOECETES BAIRDI	0.000	2.632	0.000	.0064	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
50. PUGETTIA GRACILIS	0.000	0.000	0.000	.0062	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
51. TELMESSUS CHEIRAGONUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
52. CANCER MAGISTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
53. CANCER OREGONENSIS	0.000	0.000	.0041	.2481	0.000	0.000	0.000	0.000	0	.0603	0.000	0.000	0
54. ECTOPROCTA	0.000	0.000	0.000	.0252	0.000	0.000	0.001	0.000	0	0.000	0.000	0.000	0
55. ASTEROIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
56. SOLASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
57. PTERASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
58. HENRICIA LEVIUSCULA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
59. ASTERIAS AMURENSIS	0.000	0.000	0.000	.4539	0.000	0.000	16.57	0.817	0	.0239	0.000	0.000	0
60. STYLASTERIAS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
61. OPHIUROIDEA	0.000	0.000	0.000	.0012	0.000	0.000	0.000	0.000	0	2.723	0.000	0.000	0
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	.0206	0.000	0.000	0
63. DENDRASTER EXCENTRICUS	1.271	.1209	.0266	0.001	1.816	0.000	0.000	0.000	0	0.000	0.000	0.000	0
64. HOLOTHUROIDA	0.000	0.000	0.000	.0665	0.000	0.000	0.000	0.000	0	.1338	0.000	0.000	0
65. ASCIDIACEA, COMPOUND	0.000	0.000	0.000	3.190	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
66. ASCIDIACEA, SOLITARY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
67. DENDRODOA AGGREGATA	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
68. BOLTENIA OVIFERA	0.000	0.000	0.000	.1101	0.000	0.085	0.000	0.000	0	.0491	0.000	0.000	0
69. HALOCYNTHIA AURANTIUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
70. RAJA ABYSSICOLA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
71. RAJA BINOCULATA	0.000	0.000	0.000	2.633	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
72. OSTEICHTHYES	0.000	0.000	0.000	0.000	6.808	0.000	0.000	0.000	0	0.000	0.000	0.000	0
73. CLUPEIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	.9078	0
74. CLUPEA HARENGUS PALLASI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
75. OSMERUS MORDAX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
76. ALLOSMERUS ELONGATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
77. GADIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
78. GADIDAE, JUV.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
79. GADUS MACROCEPHALUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.269	0	0.000	0.000	0.000	0
80. MICROGADUS PROXIMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
81. THERAGRA CHALCOGRAMMA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	.2723	0.000	0.000	0
82. ZOARCIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	.0908	0.000	0.000	0
83. COLOLABIS SAIRA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
84. GASTEROSTEUS ACULEATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
85. HEXAGRAMMIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
86. HEXAGRAMMOS LAGOCEPHALUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
87. HEXAGRAMMOS OCTOGRAMMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
88. HEXAGRAMMOS STELLERI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
89. ANOPLOPOMA FIMBRIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
90. COTTIDAE	0.000	0.000	.0012	4.811	0.000	0.000	.5674	0.000	0	0.056	.9078	0.000	0
91. AGONIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
92. LIPARIS SP.	0.000	0.000	.0056	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
93. TRICHODON TRICHODON	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
94. ANOPLARCHUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
95. LUMPENUS SAGITTA	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
96. PHOLIS LAETA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0
97. AMMODYTES HEXAPTERUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.270	0.000	0.000	0

APPENDIX E

(continued)

	SAMPLES												
MONTH	06	06	06	06	06	06	06	06	06	06	06	06	06
TRANSECT	01	01	01	02	02	03	03	03	04	04	06	06	06
DEPTH	15	30	50	30	50	20	30	50	20	50	10	15	30
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	03
SPECIES													
98. PLEURONECTIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2723	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.000	.0048	0.000	0.000	0.000	0.000	0.000	0.000	.0908	0.000	2.269	2.269	0.000
100. ATHERESTHES STOMIAS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
101. EOPSETTA JORDANI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.000	0.000	0.000	0.000	.4539	0.000	3.177	1.725	0.000	0.000	0.000	0.000	0.000
103. ISOPSETTA ISOLEPIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
104. LEPIDOPSETTA BILINEATA	4.857	11.80	2.950	4.766	13.39	.1816	17.48	3.177	4.539	9.305	0.000	0.000	7.262
105. LIMANDA ASPERA	3.631	1.135	3.586	0.336	3.177	22.01	28.14	43.03	10.21	14.98	0.000	0.000	1.929
106. LIMANDA PROBOSCIDEA	0.000	0.000	0.000	0.000	0.000	0.000	.1135	.3631	.4539	0.000	0.000	0.000	0.000
107. PLATICHTHYS STELLATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.5901	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	.4539	0.000	0.000	0.000	0.000	0.000	.7262	0.000	.5674	0.000	0.000	0.000	.1362
109. HIPPOGLOSSUS STENOLEPIS	0.000	0.000	.1816	0.000	0.000	0.000	.1816	0.000	0.000	0.000	0.000	0.000	0.000
110. TOTAL ALGAE	.0492	.0513	.3983	.0126	0.000	2.856	0.359	0.000	0.000	0.000	0.000	0.000	0.000
111. TOTAL INVERTEBRATES	1.301	2.839	2.831	17.97	1.816	0.089	16.57	0.817	0.000	7.170	0.000	0.000	2.383
112. TOTAL FISH	8.942	12.94	6.730	12.55	23.83	22.20	50.38	50.56	16.45	25.25	3.177	3.177	9.328
113. TOTAL FLATFISH	8.942	12.94	6.718	5.102	17.02	22.20	49.82	48.29	16.45	24.28	2.269	2.269	9.328
114. TOTAL BIOMASS	10.29	15.83	9.959	33.71	25.65	25.15	67.32	51.38	16.45	32.42	3.177	3.177	11.71
115. NO. SPECIES	7.000	9.000	13.00	37.00	5.000	7.000	12.00	6.000	6.000	19.00	2.000	2.000	4.000
116. DIVERSITY (H)	1.162	.7959	1.376	1.782	1.209	.4435	1.351	.6732	1.014	1.453	.5983	.5983	.9692
117. EVENNESS	.5972	.3622	.5366	.4934	.7512	.2279	.5436	.3757	.5662	.4935	.8631	.8631	.6991
118. TOTAL ABUNDANCE	10.29	15.83	9.959	33.71	25.65	25.15	67.32	51.38	16.45	32.42	3.177	3.177	11.71

APPENDIX E

(continued)

SAMPLES

	06	06	06	06	08	08	08	08	08	08	08	08	08
MONTH	06	06	06	06	08	08	08	08	08	08	08	08	08
TRANSECT	07	08	09	09	A4	A4	A4	A4	01	01	01	01	02
DEPTH	10	50	30	65	20	30	50	60	20	30	50	60	20
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
1. CHLOROPHYTA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2. PHAEOPHYTA	0	0.000	0.000	0.000	0.022	0.000	0.000	0.072	0.275	0.000	0.000	0.000	0.000
3. RHODOPHYTA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4. ZOSTERA MARINA	0	0.000	0.000	0.000	.1745	.4754	0.000	0.138	0.000	0.000	0.000	0.000	0.000
5. PORIFERA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.400
6. HYDROIDA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000
7. ZOOANTHARIA ACTINIARIA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.71
8. ANEMONE SP. 16	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10. METRIDIUM SENILE	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11. POLYCHAETA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12. POTAMILLA RENIFORMIS	0	0.000	0.000	0.000	0.001	.0185	0.000	0.000	0.000	0.000	0.000	0.000	158.6
13. GASTROPODA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
14. MARGARITES PUPILLUS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15. TRICHOTROPIS INSIGNIS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16. TRICHOTROPIS CANCELLATA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17. VELUTINA LAEVIGATA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18. NATICA CLAUSA	0	0.000	0.000	0.000	0.000	.0078	0.017	0.003	0.010	0.010	0.006	0.002	0.000
19. POLINICES PALLIDA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20. FUSITRITON OREGONENSIS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21. NUCELLA SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22. BERINGIUS BERINGI	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23. LIOMESUS NUX	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24. NEPTUNEA LYRATA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.187	0.000
25. NUDIBRANCHIA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26. MOPALIA HINDSI	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27. BIVALVIA	0	0.000	0.000	0.081	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
28. MYTILUS EDULIS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29. PODODESMUS SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30. CYCLOCARDIA SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31. ASTARTE SP. JUV.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
32. SERRIPES GROENLANDICUS	0	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
33. SPISULA SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34. SILIQUA PATULA	0	0.000	0.028	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35. MACOMA SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012
36. TELLINA LUTEA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
37. TELLINA NUCULOIDES	0	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38. HIATELLA ARCTICA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39. CIRRIPEDIA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40. DECAPODA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.180
41. HIPPOLYTIDAE	0	0.000	0.032	0.032	0.059	.0925	0.041	0.028	0.084	0.000	0.063	0.087	0.028
42. PAGURIDAE	0	.1784	0.028	0.028	0.000	.0353	0.007	0.118	0.000	0.000	0.000	0.008	1.600
43. PARALITHODES CAMTSCHATICA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44. MAJIDAE	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.180
45. OROGONIA GRACILIS	0	.0384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46. HYAS LYRATUS	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
47. CHIONIECETES SP.	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
48. CHIONOECETES OPILIO	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000

APPENDIX E

(continued)

SAMPLES													
MONTH	06	06	06	06	08	08	08	08	08	08	08	08	08
TRANSECT	07	08	09	09	A4	A4	A4	A4	01	01	01	01	02
DEPTH	10	50	30	65	20	30	50	60	20	30	50	60	20
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--
49. CHIONOECETES BAIRDI	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.090	0.005	0.000
50. PUGETTIA GRACILIS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51. TELMESSUS CHEIRAGONUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52. CANCER MAGISTER	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
53. CANCER OREGONENSIS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
54. ECTOPROCTA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.940
55. ASTEROIDEA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
56. SOLASTER SP.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57. PTERASTER SP.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58. HENRICIA LEVIUSCULA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59. ASTERIAS AMURENSIS	23.15	52.57	55.60	56.96	3.631	3.631	.5674	0.070	0.000	0.000	0.000	0.000	0.000
60. STYLASTERIAS SP.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000
61. OPHIUROIDEA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
63. DENDRASTER EXCENTRICUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64. HOLOTHUROIDA	0.00	0.000	0.000	0.000	.1705	0.000	0.000	0.000	0.000	0.000	0.014	0.008	0.000
65. ASCIDIACEA, COMPOUND	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500
66. ASCIDIACEA, SOLITARY	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.376
67. DENDRODOA AGGREGATA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68. BOLTENIA OVIFERA	0.00	0.000	0.026	1.387	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000
69. HALOCYNTHIA AURANTIUM	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	70.81
70. RAJA ABYSSICOLA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71. RAJA BINOCULATA	0.00	3.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72. OSTEICHTHYES	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73. CLUPEIDAE	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74. CLUPEA HARENGUS PALLASI	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75. OSMERUS MORDAX	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76. ALLOSMERUS ELONGATUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
77. GADIDAE	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78. GADIDAE, JUV.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
79. GADUS MACROCEPHALUS	0.00	0.000	0.000	1.475	1.006	1.222	0.191	0.008	0.045	0.023	0.006	0.005	0.000
80. MICROGADUS PROXIMUS	0.00	.4539	8.057	10.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.631
81. THERAGRA CHALCOGRAMMA	0.00	0.000	0.000	0.054	0.000	3.631	0.000	0.000	0.000	0.000	0.000	0.000	0.000
82. ZOARCIDAE	0.00	1.135	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83. COLOLABIS SAIRA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84. GASTEROSTEUS ACULEATUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
85. HEXAGRAMMIDAE	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
86. HEXAGRAMMOS LAGOCEPHALUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87. HEXAGRAMMOS OCTOGRAMMUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88. HEXAGRAMMOS STELLERI	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
89. ANOPLOPOMA FIMBRIA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.450	0.000	0.000
90. COTTIDAE	0.00	0.000	2.837	2.837	.0154	2.793	1.362	0.025	0.000	0.000	0.008	.9088	0.000
91. AGONIDAE	0.00	0.105	0.124	0.124	0.000	.0077	0.000	0.000	0.000	0.000	0.000	0.001	0.000
92. LIPARIS SP.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
93. TRICHODON TRICHODON	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.006	0.000	0.000	0.000
94. ANOPLARCHUS SP.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95. LUMPENUS SAGITTA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
96. PHOLIS LAETA	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97. AMMODYTES HEXAPTERUS	0.00	0.000	0.000	0.000	.1511	0.051	0.000	0.000	0.009	0.000	0.002	0.000	0.000

APPENDIX E

(continued)

	SAMPLES												
MONTH	06	06	06	06	08	08	08	08	08	08	08	08	08
TRANSECT	07	08	09	09	A4	A4	A4	A4	01	01	01	01	02
DEPTH	10	50	30	65	20	30	50	60	20	30	50	60	20
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
98. PLEURONECTIDAE	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.020	0.006	0.000	0.000
100. ATHERESTHES STOMIAS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.000
101. EOPSETTA JORDANI	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.00	0.000	1.475	1.475	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.275	0.000
103. ISOPSETTA ISOLEPIS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.9078	0.100	0.000	0.000
104. LEPIDOPSETTA BILINEATA	0.00	13.62	31.77	31.77	4.993	8.624	2.723	2.496	4.539	6.808	3.177	3.177	12.71
105. LIMANDA ASPERA	0.00	27.01	29.12	29.50	13.62	11.80	6.808	7.716	.3404	3.177	6.808	2.723	0.000
106. LIMANDA PROBOSCIDEA	0.00	.2269	1.135	1.135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
107. PLATICHTHYS STELLATUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
109. HIPPOGLOSSUS STENOLEPIS	0.00	.9078	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.000	0.000
110. TOTAL ALGAE	0.00	0.000	0.000	0.000	0.022	0.000	0.000	0.072	0.275	0.000	0.000	0.000	0.000
111. TOTAL INVERTEBRATES	23.15	52.79	55.79	58.51	4.036	4.317	.6324	0.359	0.094	0.016	0.173	0.305	247.0
112. TOTAL FISH	0.00	46.49	74.57	78.48	19.78	28.13	11.08	10.42	4.986	10.94	10.93	7.117	16.34
113. TOTAL FLATFISH	0.00	41.76	63.50	63.89	18.61	20.43	9.532	10.38	4.890	10.91	10.47	6.203	12.71
114. TOTAL BIOMASS	23.15	99.28	130.4	137.0	23.84	32.45	11.72	10.85	5.355	10.96	11.11	7.422	268.7
115. NO. SPECIES	1.00	11.00	15.00	15.00	11.00	14.00	8.000	12.00	9.000	8.000	14.00	15.00	18.00
116. DIVERSITY (H)	0.00	1.224	1.412	1.510	1.197	1.660	1.152	.8546	.6463	.9001	1.041	1.311	1.190
117. EVENNESS	0.00	.5106	.5214	.5576	.4993	.6291	.5541	.3439	.2942	.4328	.3946	.4842	.4117
118. TOTAL ABUNDANCE	23.15	99.28	130.4	137.0	23.84	32.45	11.72	10.85	5.355	10.96	11.11	7.422	268.7

APPENDIX E

(continued)

SAMPLES													
MONTH	08	08	08	08	08	08	08	08	08	08	08	08	08
TRANSECT	02	02	03	03	04	04	04	06	06	06	06	07	07
DEPTH	60	60	30	60	60	60	60	20	30	50	60	10	30
REPLICATE	01	02	01	01	01	02	03	01	01	01	01	01	01
SPECIES													
1. CHLOROPHYTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2. PHAEOPHYTA	0.000	0.000	0.023	0.000	0.050	0.035	0.245	.0069	0.000	0.000	0.000	0.000	0.000
3. RHODOPHYTA	0.000	0.000	0.000	0.270	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4. ZOSTERA MARINA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0503	0.000	0.000	0.000	0.000	0.000
5. PORIFERA	0.000	0.000	0.000	0.195	0.000	0.170	0.200	0.000	3.631	0.000	0.000	0.000	.3163
6. HYDROIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7. ZOOANTHARIA ACTINIARIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8. ANEMONE SP. 16	0.038	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10. METRIDIUM SENILE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11. POLYCHAETA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12. POTAMILLA RENIFORMIS	0.002	0.079	0.110	0.000	0.000	0.000	0.000	0.000	4.085	0.000	0.000	0.000	0.000
13. GASTROPODA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14. MARGARITES PUPILLUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000
15. TRICHOTROPIS INSIGNIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0086
16. TRICHOTROPIS CANCELLATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.1362	0.000	0.000	0.000	0.000
17. VELUTINA LAEVIGATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	.0196
18. NATICA CLAUSA	0.000	0.010	0.000	0.000	0.000	0.003	0.000	0.000	.0109	0.000	.0287	0.000	.0169
19. POLINICES PALLIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20. FUSITRITON OREGONENSIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21. NUCELLA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22. BERINGIUS BERINGI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23. LIOMESUS NUX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24. NEPTUNEA LYRATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25. NUDIBRANCHIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0064
26. MOPALIA HINDSI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0074	0.000	0.000	0.000	0.000
27. BIVALVIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28. MYTILUS EDULIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.408	0.000	0.000	0.000	0.000
29. PODODESMUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.808	0.000	0.000	0.000	.2269
30. CYCLOCARDIA SP.	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31. ASTARTE SP. JUV.	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32. SERRIPES GROENLANDICUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
33. SPISULA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34. SILIQUA PATULA	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35. MACOMA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
36. TELLINA LUTEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000
37. TELLINA NUCULOIDES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38. HIATELLA ARCTICA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39. CIRRIPEDIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.631
40. DECAPODA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	.9078	0.000	0.000	0.000
41. HIPPOLYTIDAE	0.006	0.000	0.055	0.008	0.042	0.120	0.004	0.263	.0087	.0505	.0507	.4919	.0069
42. PAGURIDAE	0.006	0.008	0.010	0.205	0.460	0.120	0.425	0.000	0.804	.1484	0.030	.2269	.0643
43. PARALITHODES CAMTSCHATICA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44. MAJIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
45. OROGONIA GRACILIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46. HYAS LYRATUS	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	.0084	0.000	0.000	.	0.000
47. CHIONIECETES SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
48. CHIONOECETES OPILIO	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX E

(continued)

SAMPLES

SPECIES													
MONTH	08	08	08	08	08	08	08	08	08	08	08	08	08
TRANSECT	02	02	03	03	04	04	04	06	06	06	06	07	07
DEPTH	60	60	30	60	60	60	60	20	30	50	60	10	30
REPLICATE	01	02	01	01	01	02	03	01	01	01	01	01	01
49. CHIONOECETES BAIRDI	0.001	0.000	0.000	0.000	0.005	0.004	0.040	0.000	0.000	0.005	0.000	0.000	0.000
50. PUGETTIA GRACILIS	0.000	0.000	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51. TELMESSUS CHEIRAGONUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52. CANCER MAGISTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
53. CANCER OREGONENSIS	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	.0787	.0095	0.000	0.000	.0126
54. ECTOPROCTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.448	0.000	0.000	0.000	0.000	0.000
55. ASTEROIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.4539
56. SOLASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.1064	0.000	0.000	0.000	0.000
57. PTERASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58. HENRICIA LEVIUSCULA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59. ASTERIAS AMURENSIS	0.005	0.003	7.716	0.003	0.000	0.000	0.030	.1378	8.624	0.014	3.177	0.000	7.262
60. STYLASTERIAS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
61. OPHIUROIDEA	0.000	0.008	0.000	0.001	0.000	0.000	0.000	0.000	.0272	0.000	0.000	0.000	.0119
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.000	0.041	0.000	0.025	0.000	0.000	0.000	0.000	0.060	0.000	0.000	0.000	.0074
63. DENDRASTER EXCENTRICUS	3.177	1.816	0.000	0.015	0.000	0.000	0.000	0.000	0.000	.0169	.6467	0.000	0.000
64. HOLOTHUROIDA	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	.0079	0.000	0.000	0.000	0.000
65. ASCIDIACEA, COMPOUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
66. ASCIDIACEA, SOLITARY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67. DENDRODOA AGGREGATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68. BOLTENIA OVIFERA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	49.93	0.000	3.177	0.000	1.362
69. HALOCYNTHIA AURANTIUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0175
70. RAJA ABYSSICOLA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71. RAJA BINOCULATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72. OSTEICHTHYES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73. CLUPEIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74. CLUPEA HARENGUS PALLASI	0.000	0.000	0.000	0.000	.9078	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75. OSMERUS MORDAX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76. ALLOSMERUS ELONGATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.326	0.000
77. GADIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.723	0.000	0.000	0.000	0.000
78. GADIDAE, JUV.	0.005	0.004	0.095	0.000	0.050	0.000	0.004	.0589	.0429	.0971	.0086	0.000	0.000
79. GADUS MACROCEPHALUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80. MICROGADUS PROXIMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2438	0.051
81. THERAGRA CHALCOGRAMMA	0.000	0.000	0.000	0.020	0.000	0.000	0.000	.4539	0.000	0.000	0.000	0.000	0.000
82. ZOARCIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83. COLOLABIS SAIRA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84. GASTEROSTEUS ACULEATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
85. HEXAGRAMMIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.631
86. HEXAGRAMMOS LAGOCEPHALUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87. HEXAGRAMMOS OCTOGRAMMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88. HEXAGRAMMOS STELLERI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
89. ANOPLOPOMA FIMBRIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90. COTTIDAE	.4539	0.000	0.000	0.000	0.000	0.000	0.000	.4539	.4191	0.000	0.000	0.000	0.000
91. AGONIDAE	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.098	0.000	0.000	0.082	1.589
92. LIPARIS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
93. TRICHODON TRICHODON	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0311	.0272
94. ANOPLARCHUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95. LUMPENUS SAGITTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96. PHOLIS LAETA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97. AMMODYTES HEXAPTERUS	0.100	0.080	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.0188	0.000

APPENDIX E

(continued)

SAMPLES

SPECIES													
MONTH	08	08	08	08	08	08	08	08	08	08	08	08	08
TRANSECT	02	02	03	03	04	04	04	06	06	06	06	07	07
DEPTH	60	60	30	60	60	60	60	20	30	50	60	10	30
REPLICATE	01	02	01	01	01	02	03	01	01	01	01	01	01
	--	--	--	--	--	--	--	--	--	--	--	--	--
98. PLEURONECTIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100. ATHERESTHES STOMIAS	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	.0397	0.230	0.000	0.000
101. EOPSETTA JORDANI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.000	0.000	0.026	0.005	0.318	0.143	0.275	0.000	0.000	0.000	0.000	0.000	0.000
103. ISOPSETTA ISOLEPIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
104. LEPIDOPSETTA BILINEATA	0.275	3.177	6.808	3.631	3.136	3.136	3.631	2.269	0.000	6.808	12.26	0.613	3.631
105. LIMANDA ASPERA	3.631	.4539	12.71	12.71	11.35	9.986	16.79	15.89	0.000	19.97	24.51	7.716	0.000
106. LIMANDA PROBOSCIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
107. PLATICHTHYS STELLATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.9078	0.000	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.000	0.000	0.000	0.000	.4539	0.000	0.000	2.723	0.000	3.177	0.000	.5016	0.000
109. HIPPOGLOSSUS STENOLEPIS	0.000	0.000	.4539	0.275	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110. TOTAL ALGAE	0.000	0.000	0.023	0.270	0.050	0.035	0.245	.0069	0.000	0.000	0.000	0.000	0.000
111. TOTAL INVERTEBRATES	3.235	2.375	7.894	0.488	0.508	0.417	0.699	.8991	74.94	1.219	7.111	.7189	13.42
112. TOTAL FISH	4.465	3.715	20.13	16.64	16.21	13.26	20.80	22.75	3.283	30.09	37.00	9.533	8.929
113. TOTAL FLATFISH	3.906	3.631	20.00	16.62	15.26	13.26	20.80	21.79	0.000	30.00	37.00	8.831	3.631
114. TOTAL BIOMASS	7.700	6.090	28.05	17.40	16.77	13.72	21.75	23.66	78.23	31.31	44.12	10.25	22.35
115. NO. SPECIES	12.00	15.00	15.00	15.00	11.00	9.000	11.00	12.00	24.00	13.00	10.00	10.00	21.00
116. DIVERSITY (H)	1.112	1.268	1.204	.8335	1.060	.7728	.7729	1.203	1.328	1.040	1.170	1.026	1.870
117. EVENNESS	.4476	.4684	.4446	.3078	0.442	.3517	.3223	.4843	.4178	.4055	0.508	.4457	.6143
118. TOTAL ABUNDANCE	7.700	6.090	28.05	17.40	16.77	13.72	21.75	23.66	78.23	31.31	44.12	10.25	22.35

APPENDIX E

(continued)

	SAMPLES												
MONTH	08	08	08	08	08	08	08	08	08	08	08	08	10
TRANSECT	07	08	08	08	08	09	09	09	09	10	10	10	02
DEPTH	50	10	30	50	60	20	30	50	60	20	30	60	30
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES													
1. CHLOROPHYTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
2. PHAEOPHYTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
3. RHODOPHYTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
4. ZOSTERA MARINA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
5. PORIFERA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	.2269	0.055
6. HYDROIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
7. ZOOANTHARIA ACTINIARIA	0.000	0.000	4.539	0.000	0.000	0.000	0.000	0.000	0.000	0	.2269	0.000	0.095
8. ANEMONE SP. 16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	.9078	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
10. METRIDIUM SENILE	0.000	0.000	0.000	.0258	0.000	0.000	0.000	0.000	.2269	0	0.000	0.000	0.000
11. POLYCHAETA	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0	0.000	0.000	0.000
12. POTAMILLA RENIFORMIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.040
13. GASTROPODA	0.000	0.000	2.814	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
14. MARGARITES PUPILLUS	0.000	0.000	.0297	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.010
15. TRICHOTROPIS INSIGNIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
16. TRICHOTROPIS CANCELLATA	0.000	0.000	.3039	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.017
17. VELUTINA LAEVIGATA	0.000	0.000	.0481	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
18. NATICA CLAUSA	0.000	0.000	.0138	0.000	0.000	0.000	0.000	.2269	.2269	0	0.000	.2269	0.000
19. POLINICES PALLIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
20. FUSITRITON OREGONENSIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
21. NUCELLA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.158
22. BERINGIUS BERINGI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
23. LIOMESUS NUX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
24. NEPTUNEA LYRATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
25. NUDIBRANCHIA	.0067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
26. MOPALIA HINDSI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
27. BIVALVIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.002
28. MYTILUS EDULIS	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.002
29. PODODESMUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
30. CYCLOCARDIA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
31. ASTARTE SP. JUV.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0	0.000	0.000	0.000
32. SERRIPES GROENLANDICUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
33. SPISULA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
34. SILIQUA PATULA	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0	0.000	0.000	0.000
35. MACOMA SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.001
36. TELLINA LUTEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
37. TELLINA NUCULOIDES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
38. HIATELLA ARCTICA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
39. CIRRIPEDIA	0.000	0.000	0.000	.4515	0.000	0.000	0.000	0.000	0.000	0	.2269	0.000	4.130
40. DECAPODA	.5254	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
41. HIPPOLYTIDAE	.0054	2.496	.3898	.0202	.0325	.4549	.2269	.2269	0.000	0	.2269	.2269	0.053
42. PAGURIDAE	.0288	0.000	.2824	0.000	.1389	0.000	.2269	0.000	.2269	0	0.000	.2269	1.055
43. PARALITHODES CAMTSCHATICA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0	0.000	0.000	0.000
44. MAJIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
45. OROGONIA GRACILIS	0.000	0.000	1.362	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
46. HYAS LYRATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
47. CHIONIECETES SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000
48. CHIONOECETES OPILIO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000

APPENDIX E

(continued)

SAMPLES

	1	2	3	4	5	6	7	8	9	10	11	12	13
MONTH	08	08	08	08	08	08	08	08	08	08	08	08	10
TRANSECT	07	08	08	08	08	09	09	09	09	10	10	10	02
DEPTH	50	10	30	50	60	20	30	50	60	20	30	60	30
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
49. CHIONOECETES BAIRDI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000
50. PUGETTIA GRACILIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
51. TELMESSUS CHEIRAGONUS	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000
52. CANCER MAGISTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
53. CANCER OREGONENSIS	0.000	0.000	.0417	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	.2269	0.040
54. ECTOPROCTA	0.000	0.000	0.049	0.000	0.000	0.000	.0021	0.000	0.000	0.000	0.000	0.000	0.142
55. ASTEROIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
56. SOLASTER SP.	0.000	0.000	.0954	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045
57. PTERASTER SP.	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58. HENRICIA LEVIUSCULA	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020
59. ASTERIAS AMURENSIS	4.539	1.589	15.89	10.89	0.012	4.539	7.035	8.170	22.69	4.312	6.355	0.000	3.631
60. STYLASTERIAS SP.	0.000	0.000	.4988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
61. OPHIUROIDEA	0.000	0.000	.0242	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63. DENDRASTER EXCENTRICUS	.0066	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000
64. HOLOTHUROIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
65. ASCIDIACEA, COMPOUND	.0184	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095
66. ASCIDIACEA, SOLITARY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010
67. DENDRODOA AGGREGATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68. BOLTENIA OVIFERA	3.631	0.000	56.28	.9078	3.631	0.000	.2269	0.000	.2269	0.000	.2269	7.716	0.000
69. HALOCYNTHIA AURANTIUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70. RAJA ABYSSICOLA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71. RAJA BINOCULATA	0.000	0.000	0.000	0.000	0.000	30.41	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72. OSTEICHTHYES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73. CLUPEIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74. CLUPEA HARENGUS PALLASI	0.000	.3404	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75. OSMERUS MORDAX	0.000	.4539	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76. ALLOSMERUS ELONGATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
77. GADIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78. GADIDAE, JUV.	.1085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.140
79. GADUS MACROCEPHALUS	0.000	.5674	0.000	0.000	0.000	6.355	.2269	19.52	1.135	0.000	0.000	0.000	0.000
80. MICROGADUS PROXIMUS	0.000	.1816	0.000	0.000	0.000	.2269	.2269	0.000	0.000	.4539	.4539	.2269	0.000
81. THERAGRA CHALCOGRAMMA	0.000	.5674	0.000	.0714	0.000	0.000	0.000	.2269	0.000	0.000	.2269	0.000	0.005
82. ZOARCIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83. COLOLABIS SAIRA	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84. GASTEROSTEUS ACULEATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
85. HEXAGRAMMIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
86. HEXAGRAMMOS LAGOCEPHALUS	0.000	1.248	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87. HEXAGRAMMOS OCTOGRAMMUS	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88. HEXAGRAMMOS STELLERI	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000
89. ANOPLOPOMA FIMBRIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90. COTTIDAE	0.007	2.456	1.792	0.000	0.000	.2269	3.177	7.035	1.589	0.000	.2269	0.000	0.116
91. AGONIDAE	.0825	.2269	.4539	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000
92. LIPARIS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000
93. TRICHODON TRICHODON	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	0.000
94. ANOPLARCHUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95. LUMPENUS SAGITTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96. PHOLIS LAETA	0.000	.2269	.4539	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97. AMMODYTES HEXAPTERUS	0.000	.6808	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000

APPENDIX E

(continued)

SAMPLES

MONTH	08	08	08	08	08	08	08	08	08	08	08	08	10
TRANSECT	07	08	08	08	08	09	09	09	09	10	10	10	02
DEPTH	50	10	30	50	60	20	30	50	60	20	30	60	30
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--
98. PLEURONECTIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.002
100. ATHERESTHES STOMIAS	.0668	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
101. EOPSETTA JORDANI	0.000	0.000	0.000	0.000	.6808	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.4539	0.000	0.000	0.000
103. ISOPSETTA ISOLEPIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080
104. LEPIDOPSETTA BILINEATA	12.71	.9078	7.716	7.716	25.87	4.539	7.262	7.262	19.06	0.000	.4539	8.624	0.000
105. LIMANDA ASPERA	16.34	1.135	0.000	12.94	0.039	18.61	7.035	10.89	7.716	49.48	30.41	31.32	0.385
106. LIMANDA PROBOSCIDEA	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	0.000	0.000	.4539	0.000
107. PLATICHTHYS STELLATUS	0.000	6.582	0.000	0.000	0.000	0.000	1.816	0.000	0.000	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.000	0.000	0.000	0.000	0.000	.2269	0.000	0.000	0.000	.9078	3.177	0.000	0.000
109. HIPPOGLOSSUS STENOLEPIS	0.000	.9078	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110. TOTAL ALGAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
111. TOTAL INVERTEBRATES	9.651	4.085	83.14	12.31	3.815	4.994	8.626	8.851	23.84	4.312	7.262	9.078	9.503
112. TOTAL FISH	29.31	16.71	10.42	20.72	26.59	61.05	20.20	44.94	29.96	51.29	35.63	40.62	0.728
113. TOTAL FLATFISH	29.12	9.532	7.716	20.65	26.59	23.60	16.11	18.16	27.01	50.84	34.27	40.40	0.467
114. TOTAL BIOMASS	38.98	20.79	93.56	33.03	30.41	66.04	28.82	53.79	53.80	55.60	42.89	49.70	10.34
115. NO. SPECIES	15.00	17.00	24.00	9.000	7.000	11.00	17.00	9.000	13.00	5.000	14.00	11.00	27.00
116. DIVERSITY (H)	1.402	2.317	1.397	1.256	.5198	1.439	1.873	1.606	1.359	.4479	1.065	1.099	1.617
117. EVENNESS	.5177	.8178	.4394	.5714	.2671	.6001	.6612	0.731	.5297	.2783	.4037	.4584	.4905
118. TOTAL ABUNDANCE	38.98	20.79	93.56	33.03	30.41	66.04	28.82	53.79	53.80	55.60	42.89	49.70	10.34

APPENDIX E

(continued)

SAMPLES

MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	02	02	03	03	03	03	04	04	04	04	06	06	06
DEPTH	50	60	20	30	50	60	20	30	50	60	20	50	60
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
1. CHLOROPHYTA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2. PHAEOPHYTA	0	0.000	0.00	0.000	2.000	0.000	0.000	0.500	0.000	0.000	0.075	0.000	0.000
3. RHODOPHYTA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4. ZOSTERA MARINA	0	0.000	0.00	0.000	0.000	0.000	0.500	0.000	0.000	0.000	20.77	0.000	0.050
5. PORIFERA	0	0.000	0.00	0.000	1.300	0.300	0.000	0.000	0.000	0.100	0.000	0.000	0.000
6. HYDROIDA	0	0.000	0.00	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.001	0.000
7. ZOOANTHARIA ACTINIARIA	0	0.000	5.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8. ANEMONE SP. 16	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10. METRIDIUM SENILE	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11. POLYCHAETA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12. POTAMILLA RENIFORMIS	0	0.000	0.21	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13. GASTROPODA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14. MARGARITES PUPILLUS	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15. TRICHOTROPIS INSIGNIS	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16. TRICHOTROPIS CANCELLATA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17. VELUTINA LAEVIGATA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18. NATICA CLAUSA	0	0.000	0.00	0.000	0.005	0.060	0.000	0.000	0.000	0.005	0.000	0.000	0.000
19. POLINICES PALLIDA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
20. FUSITRITON OREGONENSIS	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21. NUCELLA SP.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22. BERINGIUS BERINGI	0	0.000	0.00	0.000	0.000	0.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23. LIOMESUS NUX	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24. NEPTUNEA LYRATA	0	0.000	0.00	0.000	0.000	0.220	0.000	0.000	0.000	0.015	0.000	0.000	0.000
25. NUDIBRANCHIA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26. MOPALIA HINDSI	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27. BIVALVIA	0	0.001	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28. MYTILUS EDULIS	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29. PODODESMUS SP.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30. CYCLOCARDIA SP.	0	0.000	0.00	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31. ASTARTE SP. JUV.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32. SERRIPES GROENLANDICUS	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
33. SPISULA SP.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34. SILIQUA PATULA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35. MACOMA SP.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
36. TELLINA LUTEA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
37. TELLINA NUCULOIDES	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
38. HIATELLA ARCTICA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
39. CIRRIPEDIA	0	0.000	0.55	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40. DECAPODA	0	0.000	0.00	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41. HIPPOLYTIDAE	0	0.110	0.00	0.820	0.390	0.104	0.421	1.220	0.141	0.000	0.460	0.025	0.195
42. PAGURIDAE	0	0.000	0.00	0.001	0.320	0.045	0.325	0.000	0.000	0.010	0.000	0.000	0.000
43. PARALITHODES CAMTSCHATICA	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44. MAJIDAE	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
45. OROGONIA GRACILIS	0	0.000	0.00	0.000	0.000	0.000	0.010	0.005	0.000	0.000	0.000	0.000	0.000
46. HYAS LYRATUS	0	0.000	0.00	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
47. CHIONIECETES SP.	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000
48. CHIONOECETES OPILIO	0	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX E

(continued)

SAMPLES

SPECIES													
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	02	02	03	03	03	03	04	04	04	04	06	06	06
DEPTH	50	60	20	30	50	60	20	30	50	60	20	50	60
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
49. CHIONOECETES BAIRDI	0.000	0.000	0.000	0.001	0.02	0.000	0.000	0.000	0.043	0.000	0.000	0.000	0.025
50. PUGETTIA GRACILIS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51. TELMESSUS CHEIRAGONUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52. CANCER MAGISTER	0.000	0.000	0.610	0.270	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
53. CANCER OREGONENSIS	0.000	0.001	0.002	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
54. ECTOPROCTA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55. ASTEROIDEA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
56. SOLASTER SP.	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57. PTERASTER SP.	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58. HENRICIA LEVIUSCULA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59. ASTERIAS AMURENSIS	0.000	0.050	4.000	9.000	1.40	1.405	0.000	0.000	0.090	0.002	0.000	0.450	0.065
60. STYLASTERIAS SP.	0.000	0.000	0.000	0.000	0.75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
61. OPHIUROIDEA	0.001	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.000	0.000	0.000	0.000	0.00	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63. DENDRASTER EXCENTRICUS	0.000	0.002	0.000	0.000	0.00	0.750	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64. HOLOTHUROIDA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65. ASCIDIACEA, COMPOUND	0.000	0.000	0.000	0.000	0.01	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000
66. ASCIDIACEA, SOLITARY	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67. DENDRODOA AGGREGATA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68. BOLTENIA OVIFERA	0.000	0.000	0.160	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.065	0.000	0.000
69. HALOCYNTHIA AURANTIUM	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70. RAJA ABYSSICOLA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71. RAJA BINOCULATA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72. OSTEICHTHYES	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73. CLUPEIDAE	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74. CLUPEA HARENGUS PALLASI	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75. OSMERUS MORDAX	0.000	0.000	0.000	0.000	0.00	0.000	0.165	0.000	0.000	0.000	0.000	0.000	0.000
76. ALLOSMERUS ELONGATUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
77. GADIDAE	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
78. GADIDAE, JUV.	0.042	0.070	1.490	1.770	0.48	4.000	0.315	0.000	0.910	0.300	0.075	0.000	0.000
79. GADUS MACROCEPHALUS	0.000	0.000	0.000	0.000	0.30	0.000	0.000	0.000	0.000	3.000	0.000	0.002	0.330
80. MICROGADUS PROXIMUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
81. THERAGRA CHALCOGRAMMA	0.002	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.140	0.000	0.000	0.045	0.025
82. ZOARCIDAE	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83. COLOLABIS SAIRA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84. GASTEROSTEUS ACULEATUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
85. HEXAGRAMMIDAE	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
86. HEXAGRAMMOS LAGOCEPHALUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87. HEXAGRAMMOS OCTOGRAMMUS	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88. HEXAGRAMMOS STELLERI	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
89. ANOPLOPOMA FIMBRIA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90. COTTIDAE	0.000	0.000	2.000	0.000	0.00	0.162	0.260	1.000	0.000	0.000	0.000	0.000	0.000
91. AGONIDAE	0.000	0.000	0.180	0.012	0.00	0.000	0.220	0.085	0.000	0.001	0.020	0.000	0.000
92. LIPARIS SP.	0.000	0.000	0.040	0.005	0.00	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000
93. TRICHODON TRICHODON	0.000	0.000	0.000	0.020	0.00	0.000	0.000	0.015	0.010	0.000	0.000	0.000	0.000
94. ANOPLARCHUS SP.	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95. LUMPENUS SAGITTA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96. PHOLIS LAETA	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97. AMMODYTES HEXAPTERUS	0.000	0.000	0.150	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX E

(continued)

	SAMPLES												
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	02	02	03	03	03	03	04	04	04	04	06	06	06
DEPTH	50	60	20	30	50	60	20	30	50	60	20	50	60
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES	--	--	--	--	--	--	--	--	--	--	--	--	--
98. PLEURONECTIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.001	0.002	0.890	0.040	0.125	0.004	0.000	0.000	0.000	0.000	0.200	0.015	0.000
100. ATHERESTHES STOMIAS	0.000	0.000	0.000	0.230	0.750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.835
101. EOPSETTA JORDANI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.285	0.000	0.000	1.000	1.500	0.350	0.000	0.060	1.000	0.000	0.000	0.000	0.200
103. ISOPSETTA ISOLEPIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150
104. LEPIDOPSETTA BILINEATA	1.040	1.500	1.500	0.740	0.000	0.000	0.000	0.185	0.150	1.000	0.000	0.075	3.000
105. LIMANDA ASPERA	0.530	7.500	32.50	19.00	10.00	0.000	2.000	14.00	.0425	10.00	0.000	10.00	11.50
106. LIMANDA PROBOSCIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
107. PLATICHTHYS STELLATUS	0.000	0.000	1.250	2.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.000	0.000	5.000	1.500	1.750	0.000	0.075	0.000	0.750	0.825	0.400	0.000	0.000
109. HIPPOGLOSSUS STENOLEPIS	0.000	0.000	.0044	1.000	0.000	0.000	0.000	0.000	0.000	0.500	0.040	0.000	0.000
110. TOTAL ALGAE	0.000	0.000	0.000	0.000	2.000	0.000	0.000	0.500	0.000	0.000	0.075	0.000	0.000
111. TOTAL INVERTEBRATES	0.001	0.164	11.03	10.10	4.225	3.091	1.256	1.230	0.274	0.142	21.30	0.476	0.335
112. TOTAL FISH	1.900	9.072	45.00	27.82	14.90	4.516	3.035	15.35	3.002	15.63	0.765	10.14	16.04
113. TOTAL FLATFISH	1.856	9.002	41.14	26.01	14.13	0.354	2.075	14.24	1.942	12.32	0.640	10.09	15.68
114. TOTAL BIOMASS	1.901	9.236	56.04	37.92	21.13	7.607	4.291	17.08	3.276	15.77	22.14	10.61	16.37
115. NO. SPECIES	7.000	9.000	18.00	18.00	18.00	16.00	10.00	11.00	10.00	13.00	11.00	8.000	11.00
116. DIVERSITY (H)	1.070	.5879	1.584	1.573	1.896	1.580	1.754	.7296	1.696	1.171	.3415	.2742	.9985
117. EVENNESS	.5499	.2676	.5479	.5442	0.656	.5699	.7616	.3043	.7368	.4565	.1424	.1319	.4164
118. TOTAL ABUNDANCE	1.901	9.236	56.04	37.92	21.13	7.607	4.291	17.08	3.276	15.77	22.14	10.61	16.37

APPENDIX E

(continued)

	SAMPLES												
MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	07	07	09	09	09	09	10	10	10	10	11	11	11
DEPTH	50	60	20	30	50	60	20	30	50	60	20	30	50
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
	--	--	--	--	--	--	--	--	--	--	--	--	--
SPECIES													
1. CHLOROPHYTA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
2. PHAEOPHYTA	0.000	0.000	0.050	0.01	0.00	0.000	0.00	0.00	0.000	0.000	0.042	0.035	0.000
3. RHODOPHYTA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
4. ZOSTERA MARINA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
5. PORIFERA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.090	0.000	0.000	0.000
6. HYDROIDA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
7. ZOOANTHARIA ACTINIARIA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
8. ANEMONE SP. 16	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
10. METRIDIUM SENILE	0.000	0.000	0.150	0.00	0.00	0.000	0.00	0.00	0.970	0.000	0.000	0.000	0.000
11. POLYCHAETA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
12. POTAMILLA RENIFORMIS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.850	0.000	0.000
13. GASTROPODA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
14. MARGARITES PUPILLUS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
15. TRICHOTROPIS INSIGNIS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
16. TRICHOTROPIS CANCELLATA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
17. VELUTINA LAEVIGATA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
18. NATICA CLAUSA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.005	0.001	0.005	0.000
19. POLINICES PALLIDA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
20. FUSITRITON OREGONENSIS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.170	0.000	0.000	0.000
21. NUCELLA SP.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
22. BERINGIUS BERINGI	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
23. LIOMESUS NUX	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
24. NEPTUNEA LYRATA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
25. NUDIBRANCHIA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
26. MOPALIA HINDSI	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
27. BIVALVIA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
28. MYTILUS EDULIS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
29. PODODESMUS SP.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
30. CYCLOCARDIA SP.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
31. ASTARTE SP. JUV.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
32. SERRIPES GROENLANDICUS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
33. SPISULA SP.	0.000	0.005	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
34. SILIQUA PATULA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
35. MACOMA SP.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
36. TELLINA LUTEA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
37. TELLINA NUCULOIDES	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
38. HIATELLA ARCTICA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
39. CIRRIPEDIA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
40. DECAPODA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
41. HIPPOLYTIDAE	0.335	0.140	0.357	0.00	0.29	0.265	0.69	0.04	0.130	0.060	0.002	0.010	0.020
42. PAGURIDAE	0.180	0.050	0.000	0.00	0.04	0.001	0.00	0.00	0.000	0.090	0.003	0.080	0.005
43. PARALITHODES CAMTSCHATICA	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
44. MAJIDAE	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
45. OROGONIA GRACILIS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.015	0.000	0.000	0.000	0.030
46. HYAS LYRATUS	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
47. CHIONIECETES SP.	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000
48. CHIONOECETES OPILIO	0.000	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.000	0.000	0.000	0.000	0.000

APPENDIX E

(continued)

SAMPLES

MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	07	07	09	09	09	09	10	10	10	10	11	11	11
DEPTH	50	60	20	30	50	60	20	30	50	60	20	30	50
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
49. CHIONOECETES BAIRDI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50. PUGETTIA GRACILIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
51. TELMESSUS CHEIRAGONUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52. CANCER MAGISTER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
53. CANCER OREGONENSIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
54. ECTOPROCTA	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.010
55. ASTEROIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
56. SOLASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
57. PTERASTER SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
58. HENRICIA LEVIUSCULA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
59. ASTERIAS AMURENSIS	0.815	9.645	0.050	0.018	5.500	2.500	1.000	0.480	2.475	0.000	0.000	1.260	0.500
60. STYLASTERIAS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
61. OPHIUROIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
62. STRONGYLOCENTROTUS DROEBACHIENSIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63. DENDRASTER EXCENTRICUS	0.185	0.000	0.000	0.000	0.002	0.200	0.000	0.000	0.000	0.175	0.000	0.030	0.000
64. HOLOTHUROIDA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65. ASCIDIACEA, COMPOUND	0.000	0.000	0.170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.300	0.000
66. ASCIDIACEA, SOLITARY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67. DENDRODOA AGGREGATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68. BOLTENIA OVIFERA	0.035	0.000	0.030	0.050	0.010	0.000	0.000	0.000	0.160	1.589	0.060	0.120	0.570
69. HALOCYNTHIA AURANTIUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70. RAJA ABYSSICOLA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71. RAJA BINOCULATA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72. OSTEICHTHYES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
73. CLUPEIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74. CLUPEA HARENGUS PALLASI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75. OSMERUS MORDAX	0.000	0.000	0.030	0.090	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.055	0.000
76. ALLOSMERUS ELONGATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
77. GADIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.210	0.000	0.000	0.000	0.000	0.000
78. GADIDAE, JUV.	4.250	0.160	2.810	0.240	0.830	0.590	0.200	0.000	0.410	2.525	0.190	0.630	0.815
79. GADUS MACROCEPHALUS	0.000	6.173	8.057	0.000	2.837	0.750	2.950	0.000	0.000	0.000	0.000	0.000	0.000
80. MICROGADUS PROXIMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
81. THERAGRA CHALCOGRAMMA	0.000	0.120	0.275	0.000	0.000	0.000	0.055	0.000	0.000	0.000	0.000	0.000	0.000
82. ZOARCIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83. COLOLABIS SAIRA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84. GASTEROSTEUS ACULEATUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
85. HEXAGRAMMIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.012
86. HEXAGRAMMOS LAGOCEPHALUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
87. HEXAGRAMMOS OCTOGRAMMUS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88. HEXAGRAMMOS STELLERI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012
89. ANOPLOPOMA FIMBRIA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90. COTTIDAE	0.090	0.000	0.004	0.000	0.020	0.750	0.000	2.533	0.000	0.000	.5674	0.002	0.002
91. AGONIDAE	0.000	0.000	0.020	0.000	0.001	0.000	0.005	0.072	0.005	0.000	0.006	0.010	0.002
92. LIPARIS SP.	0.010	0.000	0.030	0.000	0.003	0.005	0.015	0.000	0.000	0.000	0.000	0.000	0.000
93. TRICHODON TRICHODON	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000
94. ANOPLARCHUS SP.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95. LUMPENUS SAGITTA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
96. PHOLIS LAETA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
97. AMMODYTES HEXAPTERUS	0.000	0.000	0.000	0.020	0.012	0.000	0.000	0.000	0.000	0.015	0.000	0.040	0.000

APPENDIX E

(continued)

SAMPLES

MONTH	10	10	10	10	10	10	10	10	10	10	10	10	10
TRANSECT	07	07	09	09	09	09	10	10	10	10	11	11	11
DEPTH	50	60	20	30	50	60	20	30	50	60	20	30	50
REPLICATE	01	01	01	01	01	01	01	01	01	01	01	01	01
SPECIES													
98. PLEURONECTIDAE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99. PLEURONECTIDAE JUV.	0.325	0.000	0.290	0.050	0.175	0.190	0.003	1.360	0.000	0.020	0.000	0.000	0.015
100. ATHERESTHES STOMIAS	0.110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
101. EOPSETTA JORDANI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
102. HIPPOGLOSSOIDES ELASSODON	0.380	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.085	0.000	0.000	0.000
103. ISOPSETTA ISOLEPIS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
104. LEPIDOPSETTA BILINEATA	12.50	3.064	0.000	0.150	4.500	4.000	0.000	.4539	3.041	10.00	1.135	.4539	1.475
105. LIMANDA ASPERA	5.500	3.404	2.500	8.738	1.000	2.500	1.500	41.65	.5901	1.929	8.034	0.250	0.170
106. LIMANDA PROBOSCIDEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
107. PLATICHTHYS STELLATUS	0.000	0.000	9.418	0.000	0.000	0.000	0.000	0.310	0.000	0.000	0.000	0.000	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.000	0.000	0.000	0.140	0.000	0.000	5.000	1.475	0.000	1.000	0.000	0.000	0.000
109. HIPPOGLOSSUS STENOLEPIS	1.081	0.230	0.000	0.000	0.090	0.000	0.000	0.000	0.000	0.000	1.362	0.000	0.000
110. TOTAL ALGAE	0.000	0.000	0.050	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.035	0.000
111. TOTAL INVERTEBRATES	1.550	9.840	0.587	0.078	5.842	2.966	1.690	0.520	3.750	2.179	0.916	1.530	1.135
112. TOTAL FISH	24.25	13.15	23.43	9.428	9.468	8.785	9.738	48.06	4.066	15.58	11.39	1.441	2.503
113. TOTAL FLATFISH	19.90	6.698	12.21	9.078	5.765	6.690	6.513	45.24	3.631	13.03	10.53	.7039	1.660
114. TOTAL BIOMASS	25.80	22.99	24.24	9.516	15.31	11.75	11.43	48.58	7.816	17.75	12.35	3.306	3.638
115. NO. SPECIES	14.00	10.00	16.00	11.00	15.00	11.00	11.00	11.00	10.00	15.00	13.00	16.00	14.00
116. DIVERSITY (H)	1.518	1.423	1.507	.4371	1.571	1.752	1.477	.6531	1.520	1.425	1.224	1.878	1.569
117. EVENNESS	.5754	.6181	.5436	.1823	0.580	.7308	.6161	.2723	0.660	.5261	.4773	.6775	.5947
118. TOTAL ABUNDANCE	25.80	22.99	24.24	9.516	15.31	11.75	11.43	48.58	7.816	17.75	12.35	3.306	3.638

APPENDIX E
(continued)

SAMPLES

MONTH	10
TRANSECT	11
DEPTH	60
REPLICATE	01

SPECIES	
1. CHLOROPHYTA	0.000
2. PHAEOPHYTA	0.000
3. RHODOPHYTA	0.000
4. ZOSTERA MARINA	0.020
5. PORIFERA	0.000
6. HYDROIDA	0.000
7. ZOOANTHARIA ACTINIARIA	0.000
8. ANEMONE SP. 16	0.000
9. ZOANTHARIA ACTINIARIA NYNANTHEAE	0.000
10. METRIDIUM SENILE	0.000
11. POLYCHAETA	0.000
12. POTAMILLA RENIFORMIS	0.000
13. GASTROPODA	0.000
14. MARGARITES PUPILLUS	0.000
15. TRICHOTROPIS INSIGNIS	0.000
16. TRICHOTROPIS CANCELLATA	0.000
17. VELUTINA LAEVIGATA	0.000
18. NATICA CLAUSA	0.000
19. POLINICES PALLIDA	0.000
20. FUSITRITON OREGONENSIS	0.000
21. NUCELLA SP.	0.000
22. BERINGIUS BERINGI	0.000
23. LIOMESUS NUX	0.000
24. NEPTUNEA LYRATA	0.000
25. NUDIBRANCHIA	0.000
26. MOPALIA HINDSI	0.000
27. BIVALVIA	0.000
28. MYTILUS EDULIS	0.000
29. PODODESMUS SP.	0.000
30. CYCLOCARDIA SP.	0.000
31. ASTARTE SP. JUV.	0.000
32. SERRIPES GROENLANDICUS	0.000
33. SPISULA SP.	0.000
34. SILIQUA PATULA	0.000
35. MACOMA SP.	0.000
36. TELLINA LUTEA	0.000
37. TELLINA NUCULOIDES	0.000
38. HIATELLA ARCTICA	0.000
39. CIRRIPEDIA	0.000
40. DECAPODA	0.000
41. HIPPOLYTIDAE	0.135
42. PAGURIDAE	0.210
43. PARALITHODES CAMTSCHATICA	0.000
44. MAJIDAE	0.000
45. OROGONIA GRACILIS	0.075
46. HYAS LYRATUS	0.000
47. CHIONIECETES SP.	0.005
48. CHIONOECETES OPILIO	0.000

APPENDIX E

(continued)

SAMPLES

SPECIES	10 11 60 01 --
98. PLEURONECTIDAE	0.000
99. PLEURONECTIDAE JUV.	0.050
100. ATHERESTHES STOMIAS	0.000
101. EOPSETTA JORDANI	0.000
102. HIPPOGLOSSOIDES ELASSODON	1.000
103. ISOPSETTA ISOLEPIS	0.000
104. LEPIDOPSETTA BILINEATA	8.000
105. LIMANDA ASPERA	1.250
106. LIMANDA PROBOSCIDEA	0.000
107. PLATICHTHYS STELLATUS	0.000
108. PLEURONECTES QUADRITUBERCULATUS	0.000
109. HIPPOGLOSSUS STENOLEPIS	0.000
110. TOTAL ALGAE	0.000
111. TOTAL INVERTEBRATES	7.111
112. TOTAL FISH	17.67
113. TOTAL FLATFISH	10.30
114. TOTAL BIOMASS	24.90
115. NO. SPECIES	20.00
116. DIVERSITY (H)	2.087
117. EVENNESS	.6967
118. TOTAL ABUNDANCE	24.90

APPENDIX F

RAW DATA FROM SEA OTTER SURVEYS

JUNE 1982

DISTANCE OFFSHORE (MILES)	2 A	2 B	3 A	3 B	4 A	4 B	5 A	5 B	6 A	6 B	7 A	7 B	8 A	8 B	9 A	9 B	10 A	10 B	11 A	11 B	12 A	12 B
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	2	0	0	0
2- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

JUNE 1982

DISTANCE OFFSHORE (MILES)	13 A	13 B	14 A	14 B	15 A	15 B	16 A	16 B	17 A	17 B	18 A	18 B	19 A	19 B	20 A	20 B	21 A	21 B	22 A	22 B	23 A	23 B
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
2- 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
6- 8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

(continued)

DISTANCE OFFSHORE (MILES)	JUNE 1982																					
	24		25		26		27		28		29		30		31		32		33		34	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0- 2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
6- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	JUNE 1982																					
	35		39		40		41		42		43											
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0- 2	6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

(continued)

DISTANCE OFFSHORE (MILES)	AUGUST 1982 2 A	2 B	3 A	3 B	4 A	4 B	5 A	5 B	6 A	6 B	7 A	7 B	8 A	8 B	9 A	9 B	10 A	10 B	11 A	11 B	12 A	12 B
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	2	0	0	1
2- 4	1	0	0	0	0	0	1	2	0	0	0	0	0	0	0	1	0	1	0	1	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
6- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10-12	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	AUGUST 1982 13 A	13 B	14 A	14 B	15 A	15 B	16 A	16 B	17 A	17 B	18 A	18 B	19 A	19 B	20 A	20 B	21 A	21 B	22 A	22 B	23 A	23 B
0- 2	0	0	0	0	0	0	0	3	4	1	2	10	0	0	0	0	4	4	1	16	0	52
2- 4	0	0	0	0	7	8	0	1	4	0	0	0	0	1	0	9	2	0	0	0	0	0
4- 6	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	1	0
6- 8	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
12-14	0	0	0	0	3	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	2	0
14-16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

(continued)

DISTANCE OFFSHORE (MILES)	AUGUST 1982 24		25		26		27		28		29		30		31		32		33		34	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0- 2	0	0	1	2	0	4	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 4	20	100	4	4	3	0	1	1	0	0	12	0	0	0	0	0	0	0	2	0	0	0
4- 6	15	66	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0
6- 8	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	AUGUST 1982 35		39		40		41		42		43											
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
0- 2	0	0	8	0	3	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0
2- 4	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F
(continued)

DISTANCE OFFSHORE (MILES)	OCTOBER 1982 2 A	2 B	3 A	3 B	4 A	4 B	5 A	5 B	6 A	6 B	7 A	7 B	8 A	8 B	9 A	9 B	10 A	10 B	11 A	11 B	12 A	12 B
0- 2	0	0	0	0	0	26	1	1	0	0	1	0	6	1	0	1	0	1	0	0	0	0
2- 4	0	0	0	0	0	0	1	0	1	0	0	0	2	1	2	1	0	1	0	0	3	3
4- 6	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	2
6- 8	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
8-10	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	OCTOBER 1982 13 A	13 B	14 A	14 B	15 A	15 B	16 A	16 B	17 A	17 B	18 A	18 B	19 A	19 B	20 A	20 B	21 A	21 B	22 A	22 B	23 A	23 B
0- 2	0	0	0	0	0	0	0	0	0	2	0	0	1	4	0	0	0	0	2	4	0	0
2- 4	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	2	0	0
4- 6	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	1
6- 8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
8-10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	1	0	0	3
10-12	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2	0	0	0	2
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
20-22	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

(continued)

DISTANCE OFFSHORE (MILES)	OCTOBER 1982 24 A	24 B	25 A	25 B	26 A	26 B	27 A	27 B	28 A	28 B	29 A	29 B	30 A	30 B	31 A	31 B	32 A	32 B	33 A	33 B	34 A	34 B
0- 2	0	0	1	1	0	1	0	0	0	2	0	0	4	0	1	0	0	1	0	0	0	0
2- 4	3	4	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	1	5	1	2	0	0	0	0	3	1	1	20	0	0	0	0	1	0	0	0	0	0
6- 8	1	1	5	3	0	1	0	0	1	0	5	4	1	0	1	1	0	3	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12-14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	OCTOBER 1982 35 A	35 B	39 A	39 B	40 A	40 B	41 A	41 B	42 A	42 B	43 A	43 B	A	B	A	B	A	B	A	B	A	B
0- 2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 4	0	2	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F
(continued)

DISTANCE OFFSHORE (MILES)	MARCH 1983 13 A	13 B	14 A	14 B	15 A	15 B	16 A	16 B	17 A	17 B	18 A	18 B	19 A	19 B	20 A	20 B	21 A	21 B	22 A	22 B	23 A	23 B
0- 2	0	0	3	5	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
2- 4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
8-10	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	1	1	0	0	0	1	0	1	2	0	0	1	0	0	0	0	0
12-14	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTANCE OFFSHORE (MILES)	MARCH 1983 2 A	2 B	3 A	3 B	4 A	4 B	5 A	5 B	6 A	6 B	7 A	7 B	8 A	8 B	9 A	9 B	10 A	10 B	11 A	11 B	12 A	12 B
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
2- 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
6- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

(continued)

MARCH 1983

DISTANCE OFFSHORE (MILES)	24 A	24 B	25 A	25 B	26 A	26 B	27 A	27 B	28 A	28 B	29 A	29 B	30 A	30 B	31 A	31 B	32 A	32 B	33 A	33 B	34 A	34 B
0- 2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
2- 4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	1	0	0	0	0	0
6- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MARCH 1983

DISTANCE OFFSHORE (MILES)	35 A	35 B	39 A	39 B	40 A	40 B	41 A	41 B	42 A	42 B	43 A	43 B	A	B	A	B	A	B	A	B	A	B
0- 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2- 4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6- 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-12	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-16	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-26	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
26-28	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0