INVESTIGATIONS ON SHALLOW SUBTIDAL HABITATS AND ASSEMBLAGES IN LOWER COOK INLET

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

The main objectives of this study were to expand the available information base on shallow subtidal habitats in Kachemak and Kamishak Bays, to describe the large horse mussel (Modiolus) assemblage in more detail, and to examine the trophic structure of shallow subtidal assemblages. Major emphasis was given to rocky substrates.

Three important types of assemblages were observed on shallow subtidal rocky habitats. The southern Kachemak Bay assemblage, strongly resembling shallow subtidal rocky assemblages in the northeastern Pacific, was strongly dominated by kelps and is probably least vulnerable to impingement of oil contamination and least sensitive to the effects of an acute oil spill. The northern Kachemak Bay assemblage included an important kelp component but was strongly dominated by suspension feeders. Standing stocks of suspension feeders were very high. This assemblage is probably moderately vulnerable to impingement but highly sensitive to the effects of an acute oil spill. The western Cook Inlet assemblage, strongly resembling epifaunal assemblages in the Bering and Beaufort Seas, was strongly dominated by suspension feeders. Except in the intertidal and very shallow subtidal zones, kelps were absent. The area is probably highly vulnerable to impingement of oil contamination and highly sensitive to the effects of acute spills. Acute spills from drilling platforms, terminal facilities, tankers, or pipelines probably constitute the greatest threat to shallow subtidal assemblages in lower Cook Inlet. Other oil-related impacts are of lesser concern because of the remoteness of these assemblages from the activities and the high degree of turbulence in the overlying water masses.

II. 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 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 severe observable impacts of oil-related problems can occur in the littoral zone (Boesch, Hershner and Milgram 1974; Smith 1968; Nelson-Smith 1972; NAS 1975).

A. 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 (Rosenthal and Lees 1976). Soft intertidal habitats (sand and mud) were not studied until spring and summer of 1976, when the Bureau of Land Management (BLM) initiated a reconnaissance of physical, chemical, and biological systems in lower Cook Inlet through its Outer Continental Shelf Environmental Assessment Program (OCSEAP).

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

These studies were initially designed to collect the information necessary to permit BLM to write the Environmental Impact Statement for the OCS oil and gas lease sale. As part of the reconnaissance, the first phase of this study (R. U. #417) was designed to examine and describe beaches representative of the major littoral habitats in lower Cook Inlet (Lees and Houghton 1977).

Additional site-specific studies followed, but did not permit examination of the diversity of habitat types suspected in the littoral zone throughout lower Cook Inlet. Furthermore, because of the breadth of the scope of these studies, certain specific aspects could not be addressed, leaving some important data gaps.

B. OBJECTIVES

The specific objectives of this study have been to:

1. Examine more shallow subtidal locations in Kachemak and Kamishak Bays in order to improve our understanding of the range of variation of the community types existing there;

2. Study populations of the horse mussel *Modiolus modiolus* and benthic assemblages associated with it; and

3. Expand the data base on the trophic structure of shallow subtidal assemblages in Kachemak and Kamishak Bays.

III. 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 and 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 Rosenthal and Lees (1976, 1979), Lees and Houghton (1977), and Lees et al. (1979a).Additional information is included in Lees (1976, 1977, and MS), Erikson (1977), Sundberg and Clausen (1977), Cunning (1977), Driskell and Lees (1977), 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 rock intertidal habitats, the rocky subtidal areas in Kachemak Bay, and the mud flats.

Rosenthal and Lees (1976) studied several littoral habitats in Kachemak Bay from 1974 to 1976. The majority of their 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 varied considerably on a seasonal basis; greatest cover occurred in the summer. A similar pattern was reported for sessile invertebrates such as barnacles and mussels. In addition, the report provides a preliminary description of trophic structure on rocky habitats and 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 high standing stocks of the horse mussel Modiolus modiolus on the north shelf were noted.

The intertidal reconnaissance in lower Cook Inlet indicated 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 (Lees and Houghton 1977). 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 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.

Lees and Houghton (1977) 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 Lees (1976) 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 formed dense aggregations under large cobbles (Lees and Houghton 1977).

It is suspected, based on the reconnaissance study, that intertidal resources are important to several non-resident or migratory organisms. For instance, migratory shorebirds, gulls, and sea ducks feed heavily on organisms living in soft intertidal substrates, especially mud. 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 described by Lees et al. (1979a) 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.

Lees et al. (1979a), 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 seasonal 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 are rather impoverished.

Rosenthal and Lees (1979) investigated composition, abundance and trophic structure 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.

The importance of the interactions between birds and the littoral zone has been noted by Erikson (1977), Sanger, Jones and Wiswar (1979), and Lees et al. (1979a). 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 and gulls, but shorebirds are seasonally very abundant. Sanger, Jones and Wiswar (1979) examined food habits of a number of species and found that sea ducks fed largely on heavily 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*.

IV. PHYSICAL SETTING AND STUDY AREAS

Cook Inlet is a large tidal estuary located on the northwest edge of the Gulf of Alaska in south-central Alaska. The axis of the inlet trends north-northeast to south-southwest and is approximately 330 km long, increasing in width from 36 km in the north to 83 km in the south. The inlet, 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 Shelikov Strait (BLM, 1976). It has been suggested, however, that a considerable proportion of the oceanic water entering Cook Inlet on an incoming tide is pumped back out on the subsequent outgoing tide (BLM, 1976). During the winter and spring, ice conditions are much more harsh on the west side of the inlet. Thus, the oceanographic conditions on each side of the inlet are significantly different, resulting in notable differences in the nature of intertidal and shallow water biological communities.

A. EAST SIDE OF INLET - ROCK

All surveys on the east side of Cook Inlet were conducted in Kachemak Bay. The sites included Jakolof Bay, a station west of Barabara Point, Archimanditof Shoals, Bluff Point and Troublesome Creek. These areas comprise a broad variety of habitat types. Other sites that have been examined since 1974 included Seldovia Point, Cohen Island, and Gull Island.

1. 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 1). The bay is generally shallow and has a narrow entrance less than 12 meters deep. The head of the bay is shallow and fed by a freshwater stream. The shoreline is rocky and wooded.

Most observations and underwater sampling were confined to the shallow reef that projects off the rocky headland on the northwest side of the bay. This area has been studied since 1974 (Rosenthal and Lees 1976). The 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 visable on a slack tide. The substrate underlying the vegetative canopy is composed of bedrock, cobbles, and small to medium sized boulders (Rosenthal and Lees 1976). Between this terrace and the floor of the channel is a moderate slope of talus or bedrock. 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 (Rosenthal and Lees 1976). In the shallow areas, the kelp *Alaria fistulosa* form 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 (Rosenthal and Lees 1976).

2. Barabara Point

The kelp bed at Barabara Point is continuous with that at Seldovia Point (Figure 1), but is strongly dominated by bull kelp. However, 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. The depth of the area surveyed was about 10 m. The boulder-bedrock substrate has numerous crevices and ledges and offers considerable bottom relief. Many of the outcrops appear to be low-grade coal well overgrown with encrusting coralline algae and epifaunal invertebrates.

3. The Northern Shelf

On the north side of Kachemak Bay, west of Homer Spit, is a broad, rocky shelf (Figure 1). Called herein the northern shelf, this relatively flat bench extends from Archimandritof Shoals, off the west side of the Spit, northwest to its widest point off Troublesome Creek and Anchor Point. The substrate of the shelf is flat and characterized by rock, which predominated at every site. Cobble and boulder fields were the principal type of structure observed, and patches of shell debris were also common. In several areas, the boulders and associated outcrops were composed of coal. During winter storms, large quantities of coal are broken up and moved across the shelf to the beach. Evidence of silt deposition varied locally. Generally algal cover was substantially less on the shelf than in the study areas on the south side of the bay. The physical and chemical charactertistics of the seawater bathing the shelf become more oceanic toward its western end.

B. WEST SIDE OF INLET - ROCK

All of the systematic work on rock habitat on the west side of Cook Inlet was conducted in Kamishak Bay at three key locations, namely, Scott 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 (Lees and Houghton 1977), 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.

Turbidity and weather conditions in Kamishak Bay and on the west side of the inlet were generally poor for conducting diving surveys. Generally, they act to preclude satisfactory work for much of the year. In April, we spent six days at Scott Island and cancelled all dive activities. We returned in June, dove for three days under marginal conditions before cancelling the remaining scheduled activities because of turbidity. In August, we were able to conduct quantitative surveys at several locations, but the areas were barely workable because of turbidity.

1. Scott Island

Scott Island is a low, relatively flat island of moderate size (30 hectares) in the entrance to Iniskin Bay (Figure 1). Large reefs marked by a number of small islets and emergent rocks provide the shorelines of the island considerable protection from the oceanic swells crossing lower Cook Inlet from the ocean entrances, especially during tow tides. 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 (NE, N, and W) sides of the island provide a boat landing and access to the wooded top of the island.

From the base of a cliff at the southwestern corner of the island, a rock bench slopes generally seaward. The upper level of the bench supports Fucus. The middle level supports Rhodymenia. The lowest portion of the bench extends to about -0.5 m MLLW. Several large shallow tide pools scattered about this bench support Laminaria groenlandica. 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.

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 (Figure 1). The complex shoreline west from the mouth of Iniskin comprises vertical rock cliffs, angular sea stacks, rocky islets and reefs; and 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. From the base of a 5- to 6-m cliff, an undulating bedrock beach extends seaward as a descending series of rock benches separated by lower-lying channels. The upper level supported dense *Fucus*. 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 bouldery tide pools break up the beach pattern.

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

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

3. White Gull Island

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

The study transect was on the exposed 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. Black Reef

Black Reef, a rock outcrop northeast of the entrance to Iliamna Bay, (Figure 1), extends above the water surface in several places. It is a series of bedrock pinnacles surrounded by talus slopes of medium-to large-sized boulders. The pinnacles have vertical or overhanging sides to a depth of about 7 m. The seafloor surrounding the reef structure is about 10 to 15 m deep and composed of silty sand with ripple marks.

5. Turtle Reef

Turtle Reef is a series of rock reefs and outcroppings fringing the shore of South Head, the southern headland guarding the entrance to Iliamna Bay (Figure 1). The reef extends to about 1 km offshore and most of the rocks are emersed at low tide. The intertidal zone on the SW side of the reef was examined qualitatively by scuba techniques during high tide in a futile attempt to assess subtidal conditions.

V. METHODS

A. FIELD COLLECTION PROCEDURES

Both quantitative and qualitative data collection techniques were utilized at various study sites. The most commonly used quantitative technique was enumeration of organisms within 1/4 m^2 quadrats placed randomly along a transect. Within each quadrat, the number and/or relative cover of each observable taxon were recorded and all plants attached within the frame were removed and bagged for subsequent weighing. Additional quadrats from 1/16 m^2 to 30 m^2 were sometimes utilized to obtain better estimates of density and cover for the less common plants and animals in the study area.

Samples of Modiolus were collected to establish biomass, size distributions and density estimates. Both 1/4 m^2 and mass removal techniques were used. Qualitative extralimital species and feeding observations were recorded.

The diet of sea stars was examined by 1) turning an animal over to examine for food items contained under or within the folds of the everted stomach, or 2) gently palpating the aboral surface to cause extrusion of the stomach contents.

B. LABORATORY PROCEDURES

Plant samples from each quadrat were handled and recorded individually. Drained wet weight and length were measured for each laminarian; aggregate drained wet weights were measured for all other algae.

Length of various invertebrate species was measured to establish size distribution. Preserved (10 percent formalin) whole weights, wet tissue and dry tissue weights were measured for Modiolus.

C. DATA ANALYSIS

Mean and standard deviation were used to summarize such parameters as abundance, relative cover and biomass. Relationships between parameters such as wet tissue weight vs. individual size were derived using linear regression techniques, usually with a $\log_{10}$ transformation to both variables ($\log Y = b \log X + a$).

Size frequency analysis of population distribution was usually accomplished graphically while similarities between populations were tested using a nonparametric Kolmogorov-Smirnov two-way test of significance.

Feeding observations from field notes and lab dissections were entered into a computer data base and then extracted via various cross indices to establish predator-prey relationships.

In data tables in this report, absence of a species is indicated by 0 and observations for a species is indicated by dash (-).

VI. RESULTS

A. KACHEMAK BAY - ROCK SUBSTRATE

1. The Biological Assemblage at Archimandritof Shoals

Since 1975, numerous sites have been examined on Archimandritof Shoals. Three additional sites were examined in 1978 (Table 1, Appendices A-1 to A-3). Algal cover was generally light and patchy at the shallow sites and very sparse at the deeper sites. The major alga at shallower depths was *Agarum*; its density and cover averaged $2.0/m^2$ and 8.8 percent at a depth of 4.6 m. Cover by encrusting coralline algae averaged 42.5 percent. At 6.7 m, density of *Agarum* decreased to $0.5/m^2$. An ephemeral bed of *Laminaria* and *Nereocystis* was also present at this depth, but densities only averaged 0.6 and $0.4/m^2$ respectively. At 15.5 m, the only algal taxa noted (encrusting coralline and *Rhodymenia palmata*) were sparse. A total of 10 herbivore species was reported from these sites.

The primary grazer was the sea urchin *Strongylocentrotus*, averaging $47.0/m^2$ at 4.6 m and $137/m^2$ at 6.7 m. None was observed at 15.5 m. From 1977 data, the populations were composed mainly of adult animals with a mean diameter of 40.0 mm. Size distribution was unimodal, suggesting that recruitment to the population was slow (Lees and Houghton 1977). Less important grazers were *Tonicella* and *Schizoplax* with 21.0 and $3.0/m^2$ at 4.6 m.

Among the more than forty species of suspension feeders reported from this site, the most important were the clams *Modiolus* and *Saxidomus*, and the sabellid polychaete *Potamilla*. Non-destructive quadrat counts of *Modiolus* taken at 4.6, 6.7 and 15.5 m depths produce density estimates of 18.0, 63.2 and 134.4 individuals/m^2, respectively. These are probably quite conservative since a comparison of pre- and post-removal counts showed that the actual density is two to three times that indicated by visual estimates. *Potamilla* coverage averaged 52.5 percent at the 6.7 m site and was frequently found growing densely around *Modiolus*. Also in association

TABLE 1 SPECIES COMPOSITION FOR ARCHIMANDRITOF SHOALS; 28 JUNE 1978

TAXA		Depth below MLLW (m) 4.6	6.7	6.7	6.7	6.7
ALGAE - Phaeophyta						
Agarum cribrosum, adult	($\bar{x} \pm s$,%)	8.8 ± 6.3%	-	-	-	-
	($\bar{x} \pm s$)	0.5 ± 0.6	0.3 ± 0.5	-	-	-
	(no./m^2)	2.0	0.1	-	-	-
A. cribrosum, juvenile	($\bar{x} \pm s$)	-	2.2 ± 0.8	-	-	-
	(no./m^2)	-	0.4	-	-	-
Laminaria groenlandica, juvenile	($\bar{x} \pm s$)	0	3.2 ± 2.5	-	-	-
	(no./m^2)	0	0.6	-	-	-
Nereocystis luetkeana, juvenile	($\bar{x} \pm s$)	0	2.0 ± 1.8	-	-	-
	(no./m^2)	0	0.4	-	-	-
ALGAE Rhodophyta						
Coralline alga, encrust.	($\bar{x} \pm s$,%)	42.5 ± 12.6%	-	-	-	-
CNIDARIA - Hydrozoa						
Abietinaria spp	($\bar{x} \pm s$,%)	2.1 ± 2.3%	-	-	-	-
ANNELIDA - Polychaeta						
Potamilla ?reniformis	($\bar{x} \pm s$,%)	52.5 ± 13.2%	-	-	-	-
MOLLUSCA - Gastropoda						
Fusitriton oregonensis	($\bar{x} \pm s$)	0	2.0 ± 2.9	-	-	-
	(no./m^2)	0	0.4	-	-	-
Neptunea lyrata	($\bar{x} \pm s$)	0	1.0 ± 1.5	-	-	-
	(no./m^2)	0	0.2	-	-	-
Trichotropis cancellata	($\bar{x} \pm s$)	0.3 ± 0.5	-	-	-	-
	(no./m^2)	1.0	-	-	-	-
MOLLUSCA - Pelecypoda						
Modiolus modiolus	($\bar{x} \pm s$)	4.2 ± 2.5	-	-	-	15.8 ± 6.2
	(no./m^2)	18.0	-	-	-	63.2

TABLE 1 (Continued)

TAXA		Depth below MLLW (m) 4.6	6.7	6.7	6.7	6.7
Saxidomus giganteus	($\bar{x} \pm s$)	5.8 ± 3.3	-	-	-	-
	(no./m^2)	23.0	-	-	-	-
MOLLUSCA - Polyplacophora						
Schizoplax brandtii	($\bar{x} \pm s$)	0.8 ± 1.0	-	-	-	-
	(no./m^2)	3.0	-	-	-	-
Tonicella lineata	($\bar{x} \pm s$)	5.3 ± 4.8	-	-	-	-
	(no./m^2)	21.0	-	-	-	-
ECHINODERMATA - Asteroidea						
Crossaster papposus	($\bar{x} \pm s$)	0	0.3 ± 0.5	-	-	-
	(no./m^2)	0	0.1	-	-	-
Leptasterias ?hylodes	($\bar{x} \pm s$)	0	0.2 ± 0.4	-	-	-
	(no./m^2)	0	0.03	-	-	-
L. polaris acervata	($\bar{x} \pm s$)	0.3 ± 0.5	0.2 ± 0.4	-	-	-
	(no./m^2)	1.0	0.03	-	-	-
Solaster stimpsoni	($\bar{x} \pm s$)	0	0.2 ± 0.4	-	-	-
	(no./m^2)	0	0.03	-	-	-
ECHINODERMATA - Echinoidea						
Strongylocentrotus drobachiensis	($\bar{x} \pm s$)	11.8 ± 1.3	-	-	34.2 ± 6.2	-
	(no./m^2)	47.0	-	-	13.7	-
CHORDATA						
Cottidae, unid.	(no./m^2)	0	-	0.03	-	-
Lepidopsetta bilineata	(no./m^2)	0	-	0.03	-	-
Quadrat Size (m):		½ x ½	1 x 5	1 x 30	0.5 x 5	½ x ½
No. of Quadrats:		4	6	1	6	10

with *Modiolus* were the clams *Saxidomus giganteus* and *Macoma inquinata*. These species were found below the surface mat of *Modiolus*. Adult *Saxidomus* densities in excess of 20/m^2 were observed at a depth of 4.6 m.

Average shell length for *Modiolus* removed from the 6.7 m site was 8.14 cm whereas from the 15.5 m site, it was 9.03 cm. At the deeper site, the size distribution of *Modiolus* was unimodal with a peak near 100 mm. Very few juveniles were obtained. Using the length vs. wet tissue weight relationship obtained from the deeper site, biomass at that location averaged 3238.0 g wet tissue/m^2.

Several additional species of suspension feeders extend above the substrate surface into the water column. Important among this group are hydroids, particularly of the family Sertulariidae, bryozoans such as *Flustrella gigantea* and the tunicate *Halocynthia aurantium*.

Thirty-five species of scavengers and predators were observed, including crustaceans, gastropods, starfish and fish. Overall densities were low; the snails *Fusitrition oregonensis* and *Neptunea pribiloffensis* were most numerous. At the 6.7 m depth, their densitites averaged 0.4 and 0.2/m^2 respectively. The several starfish species recorded were sparse (< 0.1 individuals/m^2).

2. The Biological Assemblage at Bishop's Beach

Three sites were surveyed off Bishop's Beach; all were deeper than 14 m. The area was quite silty with patches of cobble, small boulders and mud. No brown algae were observed; however, the foliose rhodophytes *Opuntiella* and *Rhodymenia pertusae* were noted.

At the three depths surveyed (14.6, 15.2 and 18.3 m) suspension feeders dominated the assemblage (Table 2). Species composition was very similar to that reported for Archimandritof Shoals. Sertulariid hydroids, sponges, the mussel *Modiolus* and *Balanus* were the most important species.

TABLE 2

SPECIES COMPOSITION FOR BISHOP'S BEACH SUBTIDAL ZONE; 1/4 m^2 SQUARE QUADRATS

Taxa	Date Depth (m)	9/26/78 18.3	10/6/78 15.2	10/6/78 16.0	11/25/78 15.2
PORIFERA					
?*Halichondria* sp.	$\bar{x} \pm s$ %	0.9 ± 1.8 %	4.1 ± .6.5 %	0.8 ± 1.6 %	
CNIDARIA - Hydrozoa					
Abietinaria sp.	$\bar{x} \pm s$ %	0.2 ± 0.6 %	0.4 ± 1.3 %		0.6 ± 1.4 %
Campanularia verticillata	$x \pm s$ %	1.1 ± 2.1 %	0.2 ± 0.6 %		
Sertulariidae,unid	$x \pm s$ %	0.6 ± 1.4 %	1.6 ± 2.6 %	2.2 ± 2.5 %	2.0 ± 2.1 %
ARTHROPODA - Crustacea					
Balanus spp.	$\bar{x} \pm s$ %	8.8 ± 4.9 %	0.6 ± 0.9 %	10.0 ± 4.1 %	0.1 ± 0.5 %
Caridea, unid	no/m^2	P	P	P	P
Elassochirus gilli	no/m^2		0.3	1.6	
Oregonia gracilis	no/m^2	0.9	0.6	2.8	0.9
Pagurus sp.	no/m^2	4.0	1.7	10.8	P
MOLLUSCA - Gastropoda					
Acmaea mitra	no/m^2		6.3	0.4	4.3
Fusitriton oregonensis	no/m^2	1.4	0.6	3.6	1.1
Neptunea spp.	no/m^2	2.0	0.9	1.2	0.9
Nucella lamellosa	no/m^2			28.4	
Trophon sp.	no/m^2	1.1		0.8	0.6
MOLLUSCA - Pelecypoda					
Chlamys spp.	no/m^2	2.0		1.6	
Modiolus modiolus	no/m^2	39.4	9.1	26.4	18.0
Pododesmus macroschisma	no/m^2	2.9	1.4		
MOLLUSCA - Polyplacophora					
Tonicella sp.	no/m^2	1.1	10.3	2.8	
ECTOPROCTA					
Flustrella gigantea	$\bar{x} \pm s$ %	0.3 ± 0.7 %	1.0 ± 2.7 %	1.4 ± 2.1 %	0.8 ± 1.5 %
Microporina borealis	$x \pm s$ %				1.4 ± 1.6 %
BRACHIOPODA					
Terebratalia transversa	no/m^2	2.0	0.6		
ECHINODERMATA - Echinoidea					
Strongylocentrotus drobachiensis	no/m^2		4.3		2.9
Number of Quadrats:					
Uncorrected depth (ft.)		60	50	60	50
(m)		18.3	15.2	18.3	15.2
Substrate:		Cobbles, rocks, shell debris, and small boulders	Cobble, shell debris, (*Modiolus* bed) and small rocks	Cobble, small rocks, shell debris, (*Modiolus* bed)	Cobble, shell debris, (*Modiolus* bed and, small rocks)

In August 1976, density of Modiolus at 14.6 m was estimated to be 15/m^2 with wet tissue biomass of approximately 710 g/m^2 (Rosenthal and Lees 1976). Non-destructive quadrat counts of Modiolus at the deeper stations in 1978 produced mean density estimates of 9.1 and 18.0/m^2 at 15.2 m and 39.4 and 26.4/m^2 at 18.3 m. As noted above, however, surface counts tend to yield conservative estimates. The major herbivorous species were the urchin Strongylocentrotus, the chiton Tonicella, and the limpet Acmaea mitra; density estimates for Strongylocentrotus were 2.9 and 4.3/m^2 at 15.2 m. Size data from 1976 showed a unimodal distribution with an average test diameter of 51.4 mm (Rosenthal and Lees 1976); the paucity of specimens below 40 mm was considered peculiar. Both Tonicella and Acmaea were more abundant in the shallower depths.

The snails Neptunea and Fusitriton, hermit crabs, and the crab Oregonia gracilis were numerically the dominant predator/scavengers; their densities were slightly higher at the deepest station. Several other predators observed were Placiphorella, Pteraster, Nucella, Elassochirus and a few fish species.

3. The Biological Assemblage at Bluff Point

The Bluff Point subtidal region is generally a fairly flat area dominated by patches of cobble, larger boulders, and shell debris. Reef structures and pavement bedrock are less common. The area is swept by moderate currents and the water is usually somewhat less turbid than at Archimandritof Shoals and Bishop's Beach (Figure 1).

A number of sites have been examined in this area (Rosenthal and Lees 1976, Lees and Houghton 1977). Two additional dives were made in 1978 (Table 3; Appendices B-1 and B-2). The description of the assemblage is based on combined data.

Significant plant production appears to be restricted to rocky substrate shallower than 15 m below MLLW. In previous years, several large beds of Alaria were visible along the coastline. They have been reduced and patchy since 1975. At 15 m the dominant algae were Agarum, with up to 27

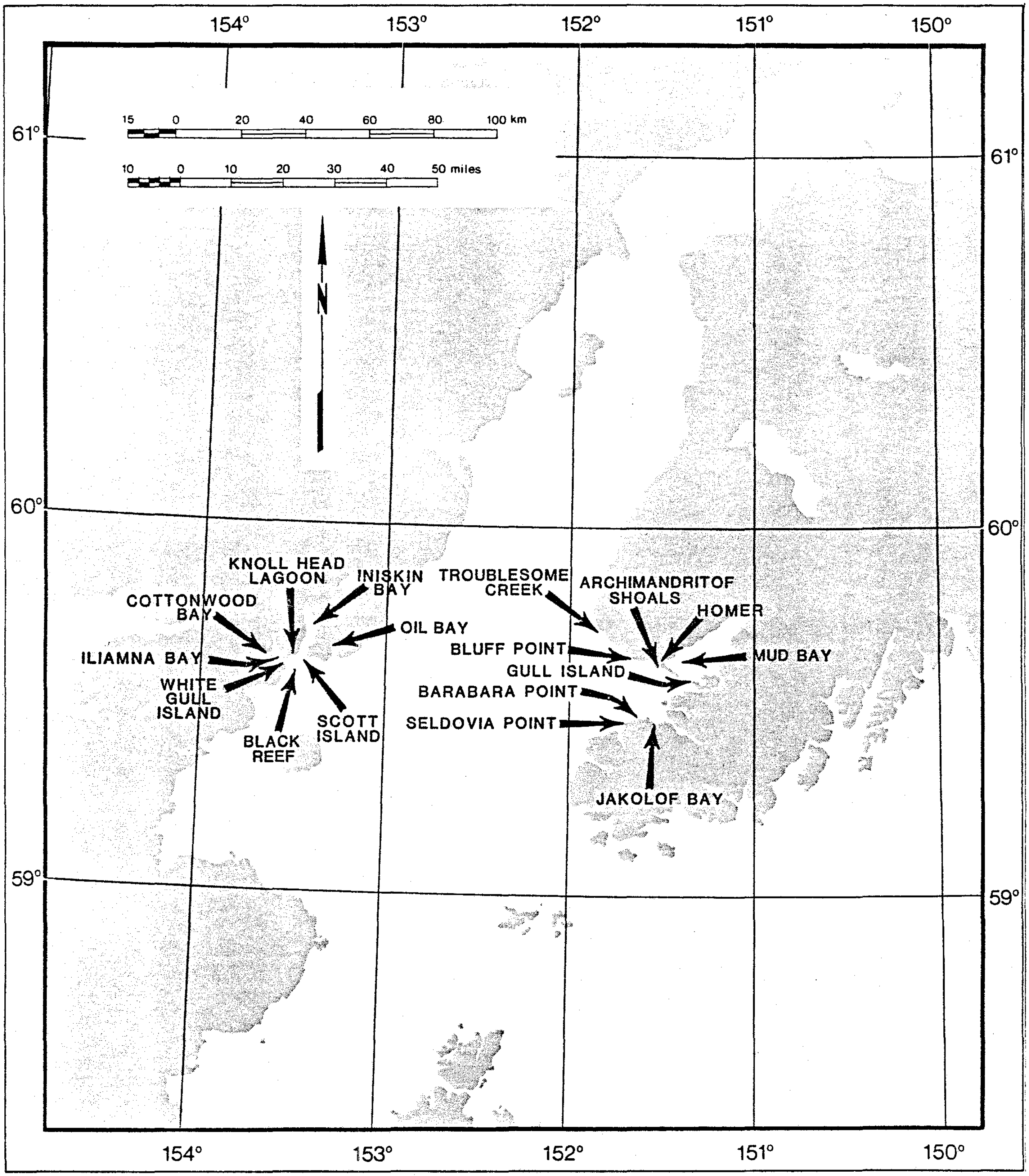


FIGURE 1

STUDY AREAS FOR LITTORAL STUDIES IN LOWER COOK INLET

TABLE 3 RECONNAISSANCE SURVEY FROM BLUFF POINT SUBTIDAL AREA; 31 JULY 1978

TAXA	Depth (m)* 15.6	Depth (m)* 10.1-11.8
ALGAE - Phaeophyta		
Agarum cribrosum		X
ALGAE - Rhodophyta		
Kallymenia sp		X
PORIFERA		
Halichondria panicea		X
CNIDARIA - Hydrozoa		
Hydrozoa, unid.		X
ANNELIDA - Polychaeta		
Owenia fusiformis		X
ARTHROPODA - Crustacea		
Balanus sp	X	
Cancer oregonensis		X
Elassochirus gilli	X	X
Pagurus sp		X
MOLLUSCA - Gastropoda		
Archidoris odneri		X
Cadlina sp	X	
Coryphella sp		X
Dendronotus dalli	X	X
Fusitriton oregonensis	X	X
Neptunea lyrata		X
Nudibranch, Dorid, unid.	X	
MOLLUSCA - Pelecypoda		
Chlamys sp	X	
Entodesmus saxicola		X
Modiolus modiolus		X
Pododesmus macroschisma	X	X
Serripes shell		X
MOLLUSCA - Polyplacophora		
Cryptochiton stelleri	X	X
Placiphorella sp	X	X
ECTOPROCTA		
Alcyonidium pedunculatum		X
Flustrella gigantea	X	X
Microporina borealis		X
BRACHIOPODA		
Hemithiris psittacea	X	
Terebratalia transversa	X	
ECHINODERMATA - Asteroidea		
Crossaster papposus	X	X
Evasterias troschelii		X
Henricia sanguinolenta	X	X
Leptasterias pularis		X
Pteraster tesselatus	X	X
Solaster dawsoni		X
Tosiaster arcticus		X
ECHINODERMATA - Echinoidea		
Strongylocentrotus drobachiensis	X	X
ECHINODERMATA - Holothuroidea		
Cucumaria fallax		X
Eupentacta quinquesemita		X
Psolus chitonoides	X	
CHORDATA - Tunicata		
Distaplia occidentalis		X
Halocynthia aurantium	X	X
Ritterella ?pulchra		X
Styela montereyensis		X
CHORDATA - Pisces		
Bathymasteridae, unid.		X
Hemilepidotus jordani		X
Myoxocephalus polyacanthocephalus		X
Sebastes sp		X

Substrate: Large boulders with cobble, rock and bedrock

*Below MLLW

plants/m^2 and 45 percent cover, Laminaria, with at least 13/m^2, and encrusting coralline algae with up to 75 percent cover. Other significant algae included Desmarestia, Callophyllis, Hildenbrandia, and Ptilota (Appendix B; Rosenthal and Lees 1976).

Among the herbivores, Strongylocentrotus, Acmaea mitra, Tonicella, and Cryptochiton were most numerous. Estimates of Strongylocentrotus densities averaged 5/m^2 in 1976. Density estimates from recent surveys were 7.4/m^2 and 0.2/m^2 at 10.1 and 20 m depths, respectively. Size structure of the urchin population were basically unimodal in earlier studies; the average test diameter of 44.5 mm indicated an adult population. Again, juveniles were absent.

The urchins displayed foraging behavior similar to those at Archimandritof Shoals. Rather than being cryptic and sedentary, individuals were exposed and probably mobile, suggesting a relative undersupply of drift algae. Such behavior is predictable at both locations in view of the scarcity of algae and effective sea urchin predators such as the sun star Pycnopodia and sea otters (Lees and Houghton 1977).

Subdominant grazers included the limpets Acmaea mitra and Diodora aspera, the snails Calliostoma and Lacuna, and chitons Tonicella and Cryptochiton. These species probably have a significant impact on the abundance of macrophytes at shallower depths. At the 10.1 m site, densities for Tonicella and Acmaea averaged 8.0 and 1.1/m^2, respectively.

Over 60 species of suspension feeders were observed in the area. The mussel Modiolus and the large fleshy, shrubby bryozoan Flustrella gigantea were visibly the most important. From earlier surveys, Modiolus densities of up to 57/m^2 were reported, but the average was estimated to be closer to 15/m^2. From the 1978 survey 3 divers at 20 m at the same general locale reported Modiolus densities ranging from 0 to 96/m^2 while estimates of fresh tissue weight ranged up to 6752.8 g/m^2The density estimate at 10.1 m was 8 indiv/m^2 (based on visual counts). Size structure for Modiolus at

Bluff Point consistently has been strongly unimodal. In earlier studies, average shell length was 12.6 cm (Rosenthal and Lees 1976) and in the recent studies, 12.2 cm; juveniles were absent.

The bryozoan Flustrella was previously recorded occurring in densities of up to 28 colonies/m^2 and 30 percent cover (Rosenthal and Lees 1976). In the recent survey at 10.1 m depth, cover average 7.9 percent. Colony heights of 15 cm were recorded. Other important suspension feeders included the bryozoan Microporina borealis with 2.7 percent average cover, the hydroids Abietinaria and Campanularia, with 2.9 and 1.3 percent cover, sabellid worms with 2.4 percent cover, and the rock jingle Pododesmus macroschisma.

About 50 predator/scavenger species were observed in the area. Numerically, the most important species were Fusitriton, averaging 1.1 and 1.4/m^2 at the 10.1 and 19.5 m sites, respectively, and Neptunea. Starfish and crustaceans were particularly diverse and important groups of predators. Of the ten species of starfish observed, five, including Crossaster papposus, Evasterias, Lethasterias nanimensis, Pteraster tesselatus and Solaster dawsoni, were common. Of the thirteen species of crustaceans observed, eight were common. Particularly notable were the crabs Hyas lyratus and Oregonia gracilis and the hermit crabs Elassochirus gilli, E. tenuimanus, Pagurus trigonocheirus and P. ochotensis. Also, one-year old king crab (carapace width <1 cm) were common at the deeper sites.

In some areas, densities and diversities of predators/scavengers were exceptionally high. At 19.5 m, a large proportion of the species observed were predators or scavengers, and most were large and common. For example, the slender star, Evasterias averaged 1.4 individuals/m^2 with a mean radius of 289 mm. Most of the predators activity in this area revolved around the predatory activities of that star on Modiolus; several large snails, crabs and hermit crabs were observed crowding around feeding Evasterias to pick off tidbits (Rosenthal and Lees 1976).

4. The Biological Assemblage at Anchor Point - Troublesome Creek

The Troublesome Creek area is very similar in physical relief to the previously described Bluff Point region. Large boulders, cobble and shell debris dominate the region, presenting a complex variety of niches. The water is sometimes less turbid than that found at Bluff Point due to dilution of turbid bay water with clean oceanic water(Figure 1).

This region had high species diversity. The dominant species at each station varied widely (Appendices C-1 through C-8). Macrophyte abundance and cover was low (Table 4), suggesting primary productivity was not high. In 1976, only four species of algae were reported; *Agarum* was the only important laminarian. In 1978, *Agarum* averaged only 0.4 individuals/m^2. Also present were *Laminaria*, *Desmarestia aculeata* and *D. ligulata* at densities of 0.2, 0.2 and 0.1 plants/m^2 respectively. Encrusting coralline algae provided 58.3 percent relative cover. The area supports a broad suite of consumers, implying high secondary productivity. Most of the consumers were long-lived species with populations of mature individuals. We postulate that plant production was reduced due to the intense competition for available substrate between plants and encrusting animals.

Suspension feeders dominated the assemblage. The most abundant species was the sea cucumber, *Cucumaria miniata*, averaging 16.7 individuals/m^2. Relative cover of the bottom by its tentacles averaged 34 percent. Various hydroid and bryozoan species were also common, including several hydroids of the family Sertulariidae, and the bryozoan *Flustrella gigantea*; the latter averaged 6 percent relative cover. The tunicates *Distaplia* sp. and *Ritterella pulchra* and the sponge *Halichondria panicea* also covered significant portions of bottom. Other important suspension feeders were the butter-clam *Saxidomus gigantea* and the large barnacle *Balanus nubilus* at a depth of 8 m.

Modiolus was found in 1976 at 14.6 m and 20 m depths. At 14.6 m, the shell-length distribution was bimodal with a mean of 97 mm. Based on an estimated average density of 10 individuals/m^2 and the length-weight

TABLE 4 SPECIES COMPOSITION FOR TROUBLESOME CREEK SUBTIDAL AREA, 8.0 M BELOW MLLW; 1 AUGUST 1978

TAXA										Cumulative Data (no./m^2)	(%/m^2)
ALGAE - Chlorophyta											
Codium ritteri	($\bar{x}$ ± s,%)	0	0	0	0	0	0	0.8 ± 1.7%	0		0.5%
ALGAE - Phaeophyta											
Agarum cribrosum	($\bar{x}$ ± s,%)	-	-	-	-	-	-	1.7 ± 5.0%	2.0 ± 2.4%		1.8%
	($\bar{x}$ ± s)	0	1.2 ± 1.2	0.4 ± 0.5	1.0 ± 1.2	-	-	0.2 ± 0.7	1.0 ± 1.3		
	(no./m^2)	0	0.5	0.2	0.4	-	-	0.9	4.0	0.4	
Desmarestia aculeata	($\bar{x}$ ± s)	0	0	1.2 ± 2.2	0.8 ± 1.8	-	-	0	0		
	(no./m^2)	0	0	0.5	0.3	-	-	0	0	0.2	
D. ligulata	($\bar{x}$ ± s)	0	0	0.4 ± 0.9	0.2 ± 0.4	-	-	0	0		
	(no./m^2)	0	0	0.2	0.1	-	-	0	0	0.1	
Laminaria groenlandica	($\bar{x}$ ± s)	1.2 ± 2.9	0	0.4 ± 0.9	0	-	-	0	0		
	(no./m^2)	0.5	0	0.2	0	-	-	0	0	0.2	
ALGAE - Rhodophyta											
Coralline alga, encrust.	($\bar{x}$ ± s,%)	-	-	-	-	-	-	61.1 ± 25.6%	54.0 ± 15.2%		58.3%
PORIFERA											
Halichondria panicea	($\bar{x}$ ± s,%)	0	0	0	0	0	7.0 ± 22.1%	0	0		2.1%
Mycale ?lingua	($\bar{x}$ ± s,%)	-	-	-	-	2.2 ± 6.7%	0	0	0		0.6%
Porifera, unid.	($\bar{x}$ ± s,%)	-	-	-	-	1.1 ± 3.3%	0	0	0		0.3%
CNIDARIA - Hydrozoa											
Abietinaria sp.	($\bar{x}$ ± s,%)	-	-	-	-	-	0	1.1 ± 3.3%	0		0.4%
Hydrozoa, unid.	($\bar{x}$ ± s,%)	-	-	-	-	2.8 ± 4.4%	0	0	0		0.7%
	(x ± s)	-	-	-	-	2.4 ± 3.8	0	0	0		
	(no./m^2)	-	-	-	-	9.8	0	0	0	2.6	
Sertularella reticulata	($\bar{x}$ ± s,%)	-	-	-	-	0	0	3.6 ± 3.4%	0		1.0%
Sertulariidae, unid.	($\bar{x}$ ± s,%)	-	-	-	-	-	-	-	7.8 ± 4.6%		

TABLE 4 (Continued)

TAXA										Cumulative Data (no./m^2)	(%/m^2)
CNIDARIA - Anthozoa											
Anthozoa, unid.	($\bar{x} \pm s$)	0	0	1.8 ± 2.2	2.3 ± 1.7	0	0	0	0.3 ± 0.8		
	(no./m^2)	0	0	0.7	0.9	0	0	0	1.3	0.3	
Cribrinopsis sp	($\bar{x} \pm s$)	-	-	-	-	0	0.1 ± 0.3	0.7 ± 1.3	0		
	(no./m^2)	-	-	-	-	0	0.4	2.7	0	0.8	
Metridium senile	($\bar{x} \pm s$)	0	0	0	0	0	1.0 ± 3.2	0	3.2 ± 2.5		
	(no./m^2)	0	0	0	0	0	4.0	0	12.7	0.5	
Tealia crassicornis	($\bar{x} \pm s$)	0	0	0.4 ± 0.9	2.2 ± 0.4	0	0	0	0.3 ± 0.5		
	(no./m^2)	0	0	0.2	0.9	0	0	0	1.3	0.2	
ARTHROPODA - Crustacea											
Balanus nubilus	($\bar{x} \pm s$,%)	-	-	-	-	0	0	0.3 ± 0.7%	0		0.1%
	($\bar{x} \pm s$)	-	-	-	-	0	0	0.8 ± 2.0	0		
	(no./m^2)	-	-	-	-	0	0	3.1	0	0.8	
Balanus sp	($\bar{x} \pm s$)	-	-	-	-	0	0.2 ± 0.6	0	0		
	(no./m^2)	-	-	-	-	0	0.8	0	0	0.2	
Cancer oregonensis	($\bar{x} \pm s$)	-	-	-	-	0	0	0.9 ± 1.4	0		
	(no./m^2)	-	-	-	-	0	0	3.6	0	0.9	
Elassochirus gilli	($\bar{x} \pm s$)	0	0	0.6 ± 0.9	0.6 ± 0.9	0	0	0.7 ± 0.9	0.3 ± 0.5		
	(no./m^2)	0	0	0.2	0.2	0	0	2.7	1.3	0.2	
Oregonia gracilis	($\bar{x} \pm s$)	-	-	-	-	0	0	0.9 ± 1.4	0		
	(no./m^2)	-	-	-	-	0	0	3.6	0	0.9	
Paguridae, unid.	($\bar{x} \pm s$)	-	-	-	-	0	0	P*	2.7 ± 2.9		
	(no./m^2)	-	-	-	-	0	0	-	10.7	2.6	
Pugettia gracilis	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.8 ± 1.0		
	(no./m^2)	-	-	-	-	0	0	0	3.3	0.6	
MOLLUSCA - Cephalopoda											
Octopus dofleini	($\bar{x} \pm s$)	0	0	0.2 ± 0.4	0	0	0	0	0		
	(no./m^2)	0	0	0.1	0	0	0	0	0	0.02	
MOLLUSCA - Gastropoda											
Acmaea mitra	($\bar{x} \pm s$)	-	-	-	-	0	0	0.4 ± 0.9	2.7 ± 1.2		
	(no./m^2)	-	-	-	-	0	0	1.8	10.7	2.4	

TABLE 4 (Continued)

TAXA									Cumulative Data (no./m^2)	(%/m^2)
Acmaeidae, unid.	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.5 ± 1.2	
	(no./m^2)	-	-	-	-	0	0	0	2.0	0.4
Amphissa columbiana	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.2 ± 0.4	
	(no./m^2)	-	-	-	-	0	0	0	0.7	0.1
Cadlina luteomarginata	($\bar{x} \pm s$)	0	0	0	0.2 ± 0.4	0	0	0	0	
	(no./m^2)	0	0	0	0.1	0	0	0	0	0.02
Calliostoma ligata	($\bar{x} \pm s$)	0	0	0	0	0	0	0	0.3 ± 0.8	
	(no./m^2)	0	0	0	0	0	0	0	1.3	0.03
Fusitriton oregonensis	($\bar{x} \pm s$)	0	0	0.4 ± 0.5	0.4 ± 0.5	0	0	0.6 ± 1.3	0.3 ± 0.5	
	(no./m^2)	0	0	0.2	0.2	0	0	2.2	1.3	0.2
Hermissenda crassicornis	($\bar{x} \pm s$)	0	0	0.6 ± 0.5	0.2 ± 0.4	0	0	0	0	
	(no./m^2)	0	0	0.2	0.1	0	0	0	0	0.1
Margarites pupillus	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.7 ± 1.6	
	(no./m^2)	-	-	-	-	0	0	0	2.7	0.5
Neptunea lyrata	($\bar{x} \pm s$)	0.2 ± 0.4	0	0.2 ± 0.4	0.2 ± 0.4	0	0.1 ± 0.3	0	0.2 ± 0.4	
	(no./m^2)	0.1	0	0.1	0.1	0	0.4	0	0.7	0.1
Nudibranch, unid., white	($\bar{x} \pm s$)	0.2 0.4	0	0	0	0	0	0	0	
	(no./m^2)	0.1	0	0	0	0	0	0	0	0.02
Trichotropis cancellata	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.2 ± 0.4	
	(no./m^2)	-	-	-	-	0	0	0	0.7	0.1
MOLLUSCA - Pelecypoda										
Mya truncata	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.2 ± 0.4	
	(no./m^2)	-	-	-	-	0	0	0	0.7	0.7
Saxidomus giganteus	($\bar{x} \pm s$)	-	-	-	-	-	-	-	7.3 ± 3.1	
	(no./m^2)	-	-	-	-	-	-	-	29.3	-
MOLLUSCA - Polyplacophora										
Cryptochiton stelleri	($\bar{x} \pm s$)	0.5 ± 0.8	0.2 ± 0.4	0.6 ± 0.5	0.4 ± 0.5	0	0	0	0.2 ± 0.4	
	(no./m^2)	0.2	0.1	0.2	0.2	0	0	0	0.7	0.2
Mopalia sp	($\bar{x} \pm s$)	0	0	0	0	0	0	0	0.3 ± 0.8	
	(no./m^2)	0	0	0	0	0	0	0	1.3	0.03

TABLE 4 (Continued)

TAXA										Cumulative Data (no./m²)	(%/m²)
Placiphorella sp	($\bar{x} \pm s$)	0	0	0	0	0	0	0	0.2 ± 0.4		
	(no./m^2)	0	0	0	0	0	0	0	0.7	0.02	
Tonicella insignis	($\bar{x} \pm s$)	-	-	-	-	0	0	0	0.5 ± 0.2		
	(no./m^2)	-	-	-	-	0	0	0	2.0	0.4	
T. lineata	($\bar{x} \pm s$)	-	-	-	-	0	0	0	1.8 ± 1.6		
	(no./m^2)	-	-	-	-	0	0	0	7.3	1.3	
Tonicella sp	($\bar{x} \pm s$)	-	-	-	-	0	0	0.2 ± 0.7	0		
	(no./m^2)	-	-	-	-	0	0	0.9	0	0.2	
ECTOPROCTA											
Flustrella gigantea	($\bar{x} \pm s$,%)	-	-	-	-	-	-	5.8 ± 4.4%	6.3 ± 4.5%		6.0%
no. of colonies:	($\bar{x} \pm s$)	-	-	-	-	0.6 ± 0.9	0.5 ± 0.7	-	-		
	(no./m^2)	-	-	-	-	2.2	2.0	-	-	2.1	
Heteropora sp	($\bar{x} \pm s$,%)	-	-	-	-	0	0	1.4 ± 1.6%	1.2 ± 0.4%		0.6%
ECHINODERMATA - Asteroidea											
Crossaster papposus	($\bar{x} \pm s$)	0	0	0.4 ± 0.5	0.2 ± 0.4	0	0	0	0		
	(no./m^2)	0	0	0.2	0.1	0	0	0	0	0.05	
Evasterias troschelii	($\bar{x} \pm s$)	0	0	0.2 ± 0.4	0	0	0	0	0		
	(no./m^2)	0	0	0.1	0	0	0	0	0	0.02	
Henricia leviuscula	($\bar{x} \pm s$)	0	0	0	0.2 ± 0.4	0	0	0	0		
	(no./m^2)	0	0	0	0.1	0	0	0	0	0.02	
H. sanguinolenta	($\bar{x} \pm s$)	0	0	0	0.2 ± 0.4	0	0	0	0		
	(no./m^2)	0	0	0	0.1	0	0	0	0	0.02	
Henricia spp	($\bar{x} \pm s$)	0.7 ± 0.8	0.2 ± 0.4	0	0	0	0	0.2 ± 0.4	0		
	(no./m^2)	0.3	0.1	0	0	0	0	0.9	0	0.1	
Leptasterias ?hylodes	($\bar{x} \pm s$)	0	0	0.2 ± 0.4	0	0	0	0	0		
	(no./m^2)	0	0	0.1	0	0	0	0	0	0.02	
Orthasterias koehleri	($\bar{x} \pm s$)	0	0	0	0	0	0	0.1 ± 0.3	0		
	(no./m^2)	0	0	0	0	0	0	0.4	0	0.02	

TABLE 4 (Continued)

TAXA										Cumulative Data (no./m^2)	(%/m^2)
ECHINODERMATA - Echinoidea											
Strongylocentrotus drobachiensis	($\bar{x} \pm s$)	63.0 ± 17.7	42.5 ± 5.2	33.8 ± 9.1	45.8 ± 13.6	6.2 ± 4.2	3.1 ± 1.8	5.7 ± 3.9	9.0 ± 7.7		
	(no./m^2)	25.2	17.0	13.5	18.3	24.9	12.4	22.7	36.0	18.8	
ECHINODERMATA - Holothuroidea											
Cucumaria fallax	($\bar{x} \pm s$)	0	0.5 ± 0.8	0.4 ± 0.5	0.6 ± 0.9	0	0	0.1 ± 0.3	0		
	(no./m^2)	0	0.2	0.2	0.2	0	0	0.4	0	0.1	
C. miniata	($\bar{x} \pm s$,%)	-	-	-	-	-	-	-	34.0 ± 18.5%		-
	($\bar{x} \pm s$)	75.0 ± 15.6	21.0 ± 10.1	16.2 ± 6.8	47.6 ± 14.9	1.8 ± 2.4	2.2 ± 2.8	6.8 ± 7.7	11.3 ± 6.3		
	(no./m^2)	30.0	8.4	6.5	19.0	7.1	8.8	27.1	45.3	16.7	
Cucumaria sp. white	($\bar{x} \pm s$)	0	0	0	0	0	0	0.2 ± 0.7	0		
	(no./m^2)	0	0	0	0	0	0	0.9	0	0.03	
ECHINODERMATA - Ophiuroidea											
Ophiopholis sp.	(no./m^2)	-	-	-	-	0	0	P	0	-	
CHORDATA - Tunicata											
Ascidacea, unid.	($\bar{x} \pm s$)	-	-	-	-	0	0.2 ± 0.6	0	0		
	(no./m^2)	-	-	-	-	0	0.8	0	0	0.2	
Distaplia sp. colonial	($\bar{x} \pm s$)	-	-	-	-	0	1.8 ± 4.4	0	0		
	(no./m^2)	-	-	-	-	0	7.2	0	0	2.1	
Ritterella pulchra	($\bar{x} \pm s$,%)	-	-	-	-	10.0 ± 12.6%	0	7.3 ± 7.4%	3.0 ± 2.1%		5.1%
no. of colonies:	($\bar{x} \pm s$)	-	-	-	-	2.9 ± 3.8	0	-	-	-	
	(no./m^2)	-	-	-	-	11.6	0	-	-	5.5	
Tunicata, unid. compound	($\bar{x} \pm s$,%)	-	-	-	-	1.1 ± 3.3%	0	0	0		0.3%
no. of colonies:	($\bar{x} \pm s$)	-	-	-	-	0.1 ± 0.3	0	0	0		
	(no./m^2)	-	-	-	-	0.4	0	0	0	0.1	
CHORDATA											
Artedius sp.	($\bar{x} \pm s$)	0	0	0	0	0	0	0.3 ± 0.5	0		
	(no./m^2)	0	0	0	0	0	0	1.3	0	0.05	
Quadrat Size (m):		0.5 x 5	0.5 x 5	0.5 x 5	0.5 x 5	¼	¼	¼	¼		
No. of Quadrats		6	6	5	5	9	10	9	6		

* P = Present

regression from Bluff Point, the estimated biomass of Modiolus was around 430 g of wet tissue/m^2 (Rosenthal and Lees 1976).

The most abundant animal was the sea urchin, Strongylocentrotus drobachiensis, a herbivore that averaged 18.8 individuals/m^2 at the site surveyed in 1978, it probably grazed a substantial proportion of the macrophyte standing stocks. In 1976, the size distribution for urchins at Troublesome Creek was basically unimodal; the average test diameters ranging from 37.3 mm to 47.6 mm indicate mature populations. Eight other species of herbivores were recorded from the region, but their effects were probably minor in comparison to those of the urchins.

Predators were diverse and relatively abundant. About 40 species, primarily crustaceans, starfish, gastropods, and fish, were reported from the 1976 surveys. The starfish Crossaster and Evasterias occurred at densities up to 0.03/m^2. Size of Evasterias was impressively large compared to populations commonly seen in Kachemak Bay; the average diameter was 57 cm (Rosenthal and Lees 1976). Other common predators were the hermit crab Pagurus sp. and the starfish Henricia sanguinolenta. Fish were more abundant and diverse than at other locations in Kachemak Bay. Average size of cottids and greenlings was large.

5. The Biological Assemblage at Jakolof Bay

Most observations in Jakolof Bay were confined to the shallow reef that projects off the rocky headland on the northwest side of the bay. This geologic feature blocks nearly half the entrance on most tide cycles thereby creating strong currents as the flow jets through the narrow opening.

The macrophyte assemblage was multilayered with a surface canopy floating above a vegetative understory composed of shorter algae. The ribbon kelp Alaria fistulosa dominated the shallow reef substrate from 3 to 6 m below the sea surface. This species, along with the less common bull kelp Nereocystis luetkeana, formed a dense surface canopy visible on slack tides during the spring and summer. Densities of mature Alaria peaked at an average of about 2 individuals/m^2 during July-August. Adult plants of Agarum cribrosum and Laminaria groenlandica, smaller plants that form the understory canopy, attain densities exceeding 20/m^2. Beneath this brown algal canopy was another layer of smaller foliose reds such as Callophyllis, Kallymenia and Turnerella.

In the deeper waters of the entrance channel (8-12 m), the surface canopy was absent and understory densities were somewhat reduced. However, Laminaria plants were still quite robust and abundant.

Suspension feeders were very abundant and exhibited high species diversity; in several places they carpeted the bottom (Table 5). Dominant species included the sabellid polychaete Potamilla ?reniformis, the mussel Modiolus and the large anemone Metridium senile. Some of the common forms lived buried in the cobble/shell debris matrix; these included the clams Saxidomus giganteus, Humilaria kennerlyi, and Macoma the sipunculids Golfingia and Phascolosoma agassizii and the echiurid Bonelliopsis alaskanus The northern ugly clam Entodesma saxicola was common nesting on the cobble and on bedrock slopes. 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 vegae, various hydroids, sabellid worms and the brittlestar Ophiopholis aculeata.

The urchin Strongylocentrotus drobachiensis was the principal grazer on the reef. Densities of up to 50 individuals/m^2 were observed. Basically the size distribution were unimodal, and the large average diameter indicated that the populations were composed mainly of adults. Animals less than 12 mm were uncommon suggesting that successful recruitment was rare. Off the reef in the deeper water, densities dropped to 1.3/m^2.

The impact of urchin grazing became noticeable by summer 1977. By that time the urchins had completely grazed the macrophytes off some shallower portions of the reef and were advancing in high densities towards the deeper

TABLE 5

SUMMARY OF MAJOR ANIMAL SPECIES FROM JAKOLOF BAY 1/4 m^2, 1978

	Reef		Channel			
	2/2/79		10/7/79		11/28/79	
	$\bar{x} \pm s$	No./m^2	$\bar{x} \pm s$	No./m^2	$\bar{x} \pm s$	No./m^2
PORIFERA						
Halichondria panicea (%)			0.4 ± 1.4		1.0 ± 2.0	
CNIDARIA - Hydrozoa						
Abietinaria spp. (%)	5.2 ± 4.8		4.9 ± 3.6		3.3 ± 3.7	
Campanularia verticillata (%)			0.4 ± 1.4		1.2 ± 1.9	
Sertulariidae (%)	2.2 ± 5.1		0.8 ± 1.9		2.5 ± 2.3	
ECHIURA						
Bonelliopsis alaskanus	-	-	0.7 ± 1.7	2.7	0.8 ± 0.9	3.0
ARTHROPODA - Crustacea						
Caridea			P		P	
Elassochirus gilli			0.3 ± 0.5	1.0	0.1 ± 0.3	0.3
Pagurus sp.	P		P		P	
MOLLUSCA - Gastropoda						
Acmaea mitra	0.2 ± 0.4	0.9	0.2 ± 0.4	0.7	0.1 ± 0.3	0.3
Calliostoma ligata	0.1 ± 0.3	0.4	0.3 ± 0.8	1.3		
Dendronotus dalli			0.2 ± 0.4	0.7	0.1 ± 0.3	0.3
Fusitriton oregonensis	1.1 ± 1.8	4.4	0.3 ± 0.5	1.0	0.6 ± 1.0	2.3
Trophon sp.			0.3 ± 0.5	1.0	0.3 ± 0.5	1.3
MOLLUSCA - Pelecypoda						
Entodesma saxicola			0.2 ± 0.6	0.7	0.3 ± 0.6	1.0
Modiolus modiolus	0.2 ± 0.7	0.9	1.6 ± 1.7	6.3	0.4 ± 0.8	1.7
MOLLUSCA - Polyplacophora						
Tonicella sp.	0.1 ± 0.3	0.4	0.8 ± 1.1	3.0		
ECTOPROCTA						
Microporina borealis (%)					0.1 ± 0.3	
ECHINODERMATA - Asterozoa						
Evasterias troschelii	0.1 ± 0.3	0.4	0.2 ± 0.4	0.7	0.4 ± 0.7	1.7
Orthasterias koehleri			0.2 ± 0.4	0.7	0.1 ± 0.3	0.3
Pycnopodia helianthoides			0.2 ± 0.4	0.7		
ECHINODERMATA - Echinoidea						
Strongylocentrotus drobachiensis	0.4 ± 0.7	1.8	0.2 ± 0.4	0.7		
ECHINODERMATA - Ophiuroidea						
Ophiopholis aculeata			P		P	
Number of Quadrats:	9		12		12	
Depth (m below MLLW)	4.8-7.2		6-8		8-9	
Substrate						

perimeter of the reef. Casual observations seemed to indicate that the urchins preferred Alaria over Agarum or Laminaria; however, the latter species also were consumed eventually. Several times, aggregations of urchins were observed feeding on Cryptochiton and Fusitriton.

Other important herbivores included the chitons Cryptochiton stelleri, Tonicella spp., and the snails Calliostoma spp. and Margarites spp. In the channel, density of these species averaged less than $1.0/m^2$.

Asteroids and fishes were the most common and influential predators on the reef. The most abundant sea star was Evasterias troschelii; its density averaged $0.2/m^2$ on the reef and $0.7/m^2$ in the entrance channel. The population generally was composed of large specimens; the largest had a diameter of 67.6 cm. The sunstar Pycnopodia helianthoides, also typically large, occurred at densities averaging $0.14/m^2$ on the reef and $0.7/m^2$ in the entrance channel. The leather star Dermasterias imbricata was most common on the reef face and around rocky outcrops that supported large concentrations of the sea anemones Metridium senile, one of its common food items. In these areas, densities of Dermasterias averaged $0.06/m^2$, and again, average size of the individuals was large.

Other common predator/scavengers included the whelk Fusitriton oregonensis and the hermit crabs Elassochirus gilli and E. tenuimanus. Fusitriton averaged about 8 individuals/m^2 on the reef and $2.6/m^2$ off the reef. Maximum densities were recorded in July when large aggregated "pods" were observed engaged in reproductive activity. Size distributions for 1975, 1976, and 1978 indicate that the population was dominated by adults (e.g., 1978; shell length averaged 50.6 ± 5.9 mm) and that recruitment was low. Size structure in the Elassochirus gilli population was bimodal with strong recruitment; average cheliped length was 21.7 mm. Size structure in the E. tenuimanus population was unimodal and skewed towards juveniles; mean cheliped length was 9.6 mm. The adult mode for E. tenuimanus was slightly smaller than that of E. gilli.

Fish were seasonally important predators; they were generally present in summer and absent during winter and spring. The most abundant species were nesting rock and kelp greenling, Hexagrammos decagrammus and H. lagocephalus, which brooded egg clutched in the area during summer and competed very strongly for territories.

6. The Biological Assemblage at Barabara Bluff

The site surveyed at Barabara Bluff was a well-developed kelp bed located at the depth of approximately 10 meters. The study site was high relief bedrock and boulders (Figure 1).

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 to 3.6 individuals/m^2. Standing crop averaged 5438.4 g/m^2 and ranged from 0 to 20 kg/m^2 (Table 6; Appendix D-1 through D-5).

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 8.0 individuals/m^2; its standing crop averaged 312.8 g/m^2. Desmarestia aculeata, with 5.6 percent relative cover, averaged only 28.0 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 (Appendix D-5). Suspension feeders included the polychaete Thelepus cincinnatus, bivalves Protothaca staminea and Saxidomus giganteus, bryozoans Flustrella, Heteropora and Terminoflustra, the echiurid worm Bonelliopsis alaskanus, the tunicates Distaplia occidentalis and Halocynthia aurantium and the brittle star Ophiopholis aculeata.

TABLE 6 SPECIES COMPOSITION FOR BARABARA BLUFF SUBTIDAL AREA; 13 JULY 1978. APPROXIMATELY 10.0 M BELOW MLLW

TAXA							
ALGAE - Phaeophyta							
<u>Agarum cribrosum</u>	($\bar{x}$ ± s%)	-	-	-	-	-	22.6 ± 27.7%
	($\bar{x}$ ± s)	-	-	-	-	-	4.0 ± 4.8
	(no./m^2)	-	-	-	-	-	8.0
	($\bar{x}$ ± sg)	-	-	-	-	-	156.4 ± 229.5
	(g/m^2)	-	-	-	-	-	312.8
<u>Desmarestia aculeata</u>	($\bar{x}$ ± s%)	-	-	-	-	-	5.6 ± 5.7%
	($\bar{x}$ ± sg)	-	-	-	-	-	14.0 ± 21.8
	(g/m^2)	-	-	-	-	-	28.0
<u>Laminaria groenlandica</u>	($\bar{x}$ ± s%)	-	-	-	-	-	0.2 ± 0.6%
	($\bar{x}$ ± s)	-	-	-	-	-	0.1 ± 0.3
	(no./m^2)	-	-	-	-	-	0.2
	($\bar{x}$ ± sg)	-	-	-	-	-	0.6 ± 1.7
	(g/m^2)	-	-	-	-	-	1.2
<u>Nereocystis luetkeana</u>(a)*	($\bar{x}$ ± s)	3.8 ± 3.1	9.8 ± 6.8	4.4 ± 4.2	6.0 ± 8.7	-	1.8 ± 2.6
	(no./m^2)	0.4	1.0	0.4	2.4	1.7	3.6
(j)	($\bar{x}$ ± s)	1.8 ± 2.2	2.6 ± 1.1	2.4 ± 3.4	0	-	0
	(no./m^2)	0.2	0.3	0.2	0	-	0
	($\bar{x}$ ± sg)	-	-	-	-	-	2719.2 ± 6454.8
	(g/m^2)						5438.4
ALGAE - Rhodophyta							
<u>Pterosiphonia</u> sp	($\bar{x}$ ± s%)	-	-	-	-	-	37.2 ± 25.4%
MOLLUSCA - Polyplacophora							
<u>Cryptochiton stelleri</u>	($\bar{x}$ ± s)	-	-	-	-	-	0.1 ± 0.3
	(no./m^2)	-	-	-	-	-	0.2
ECHINODERMATA - Asteroza							
<u>Pycnopodia helianthoides</u>	($\bar{x}$ ± s)	0.2 ± 0.4	0	0	-	-	0
	(no./m^2)	0.02					

TABLE 6 (Continued)

TAXA							
ECHINODERMATA - Echinoidea							
Strongylocentrotus drobachiensis	($\bar{x} \pm s$)	-	-	-	-	-	7.1 ± 4.2
	(no./m^2)	-	-	-	-	-	14.2
CHORDATA - Pisces							
Bathymaster caerulofasciatus	($\bar{x} \pm s$)	0	0	0.2 ± 0.4	-	C**	0
	(no./m^2)	0	0	0.02	-		0
Hexagrammos decagrammus	($\bar{x} \pm s$)	0.2 ± 0.4	0.2 ± 0.4	0.6 ± 1.3	-	C	0
	(no./m^2)	0.02	0.02	0.06	-		0
H. lagocephalus	($\bar{x} \pm s$)	0	0.2 ± 0.4	0	-	C	0
	(no./m^2)	0	0.02	0	-		0
Sebastes melanops	($\bar{x} \pm s$)	0	0	0	0	C	0
	(no./m^2)	0	0	0	0		0
Quadrat size (m):		2 x 25	2 x 25	2 x 25	0.5 x 30	0.5 x 30	0.5 x 1

* (a) = adult
(j) = juvenile
** C = Common

The dominant grazer was the urchin Strongylocentrotus drobachiensis; average density was of $14.2/m^2$. 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 heliathoides. Also observed were kelp and rock greenlings, the searcher Bathymaster caerulofasciatus, a wolf-eel Anarrhichthys ocellatus, and several small rockfish Sebastes spp.

B. KAMISHAK BAY.

1. The Biological Assemblage at Scott Island

The study site at Scott Island was a fairly broad bedrock shelf extending from the base of the cliff at the SW end of Scott Island into the shallow subtidal zone (Figure 1). Boulders became common on the bedrock at about 1.5 m below MLLW. The rock substrate ended abruptly at about 3 m below MLLW, where the dominant substrate became sandy gravel.

In June, 1978, Laminaria plants were of moderate size and appeared healthy. Densities ranged from 1.6 to $4.0/m^2$ including juveniles (Table 7). Relative cover was estimated to average 54 percent while fresh biomass was $1040.6 \ g/m^2$. Also present were Agarum, Desmarestia, and four species of rhodophytes (Appendices E-1).

The channel on the southwest end of Scott Island has a flat current-swept, sandy gravel bottom with scattered cobble and boulders up to 2 m in diameter approximately 6 m deep. High turbidity was common. Laminaria and Agarum were scattered along a transect; densities averaged 0.6 and $0.3/m^2$, respectively. Macrophytes attached to a small rock or shell were being swept along by the currents (Appendix E-2).

TABLE 7 SPECIES COMPOSITION FOR SCOTT ISLAND SUBTIDAL AREA; 15 JUNE 1978, 2 M BELOW MLLW

TAXA				
ALGAE - Phaeophyta				
Agarum cribrosum	($\bar{x}$ ± s,%)	-	0	1.5 ± 4.7%
Desmarestia aculeata	($\bar{x}$ ± s)	-	0.6 ± 0.9	-
	(no./m^2)	-	0.2	-
Laminaria groenlandica				
adults	($\bar{x}$ ± s)	7.3 ± 5.9	10.0 ± 14.8	-
	(no./m^2)	2.9	4.0	-
juveniles	($\bar{x}$ ± s)	2.0 ± 1.0	-	-
	(no./m^2)	0.8	-	-
L. saccharina	($\bar{x}$ ± s,%)	-	-	54.0 ± 35.0%
	($\bar{x}$ ± s)	-	1.0 ± 1.4	4.0 ± 5.4
	(no./m^2)	-	0.4	16.0
	($\bar{x}$ ± s,g)	-	-	650.4 ± 694.6
	(g/m^2)	-	-	2601.5
ALGAE - Rhodophyta				
Callophyllis sp	($\bar{x}$ ± s)	-	0.8 ± 1.1	-
	(no./m^2)	-	0.3	-
Constantinea sp	($\bar{x}$ ± s)	-	0.2 ± 0.4	-
	(no./m^2)	-	0.1	-
Opuntiella californica	($\bar{x}$ ± s)	-	0.8 ± 1.3	-
	(no./m^2)	-	0.3	-
Rhodymenia palmata	($\bar{x}$ ± s)	-	3.8 ± 4.1	-
	(no./m^2)	-	1.5	-
Quadrat Size (m^2):		0.5 x 5	0.5 x 5	¼
No. of Quadrats:		3	5	10

Epifaunal animals were sparse and mosty clustered around larger cobble. Among the suspension feeders, some species of bryozoans, the hydroid Abietinaria, two sabellid polychaetes and an unidentified tunicate were important. Also present were the predatory snails Neptunea lyrata and Fusitriton, and the asteroids Leptasterias spp. and Henricia sanguinolenta (Table 8).

On a isolated large boulder in the channel, Agarum and Laminaria adults and several rhodophytes were present. Important epifaunal forms included the spong Mycale lingua, the hydroid Abietinaria gigantea, Balanus rostratus, Fusitriton (spawning), and large Strongylocentrotus drobachiensis. Also recorded were the greenlings, Hexagrammos stelleri and H. octogrammus. The latter individual was guarding an egg clutch in the Abientinaria colony.

An area observed during a reconnaissance survey in the channel on the northeast end of the island was very similar in appearance to the southwest end of the island (Appendix E-3).

2. The Biological Assemblage at Knoll Head Lagoon

The study site at Knoll Head Lagoon was a narrow rocky beach extending into the subtidal zone. Boulders became common on the bedrock at a depth of about 3 m, and the rock beach was replaced by a fine gravel/shell debris substrate with ripple marks at 7 m (Figure 1).

During the reconnaissance dive on 11 June, it was noted that the assemblage varied from 100 percent cover by various algal species at the shallow depths to no algae and heaby cover by suspension feeders and grazers at deeper levels (Appendix F-1).

In the shallow macrophyte zone, eight species of algae were common. The kelps Laminaria and Alaria praelonga were the dominant forms. In August, these two species averaged 31.7 and 62.5 percent relative cover and 13.6 and 17.2 individuals/m^2, respectively, at +0.3 to -0.6 m depths (Table 9).

TABLE 8 RECONNAISSANCE SURVEY FROM SCOTT ISLAND, SOUTH WEST END; 4 AUGUST 1978, APPROXIMATELY 6 M BELOW MLLW

TAXA	Substrate SG[a]	B[b]	R[c]
ALGAE - Phaeophyta			
Agarum cribrosum		X	
Laminaria groenlandica	X	X	
ALGAE - Rhodophyta			
Constantinea subulifera	X	X	
Coralline alga, encrust.	X	X	
Odonthalia lyalli	X	X	
Rhodymenia pertusae	X	X	
PORIFERA			
Mycale ?lingua		X	
CNIDARIA - Hydrozoa			
Abietinaria thujarioides		X	
A. turgida		X	
Calycella syringa	X		
Campanularia urceolata		X	
Sertularia cupressoides	X		
Thuiaria cylindrica		X	
CNIDARIA - Anthozoa			
Cribrinopsis similis		X	
Metridium senile, Juv.		X	
ANNELIDA - Polychaeta			
Laonome kroyeri	X		
Pseudopotamilla sp	X		
Syllidae, unid.	X		
ARTHROPODA - Crustacea			
Achelia chelata		X	
Balanus rostratus		X	
Elassochirus gilli		X	
Pagurus beringanus		X	
MOLLUSCA - Gastropoda			
Fusitriton oregonensis		X	
Neptunea lyrata	X		
MOLLUSCA - Polyplacophora			
Mopalia sp		X	
Tonicella lineata		X	
ECTOPROCTA			
Alcyonidium polyoum	X		
Carbasea carbasea	X		
Caulibugula sp	X		
Eucratea loricata	X		
Flustrella corniculata	X		
Hippothoa hyalina	X		
Rhynchozoon bispinosum		X	
Terminoflustra membranaceo - truncata	X		
ECHINODERMATA - Asteroidea			
Henricia sanguinolenta		X	
H. tumida		X	
Leptasterias polaris acervata	X	X	
L. polaris katharinae	X		
Solaster stimpsoni	X		
ECHINODERMATA - Echinoidea			
Strongylocentrotus drobachiensis		X	
ECHINODERMATA - Holothuroidea			
Eupentacta quinquesemita		X	
CHORDATA - Tunicata			
Pelonaia corrugata	X		
CHORDATA - Pisces			
Hexagrammos ?octogrammus		X	
H. stelleri		X	X

[a] SG = Sand and gravel

[b] B = Boulders

[c] R = Intertidal rock shelf

TABLE 9

SPECIES COMPOSITION OF KNOLL HEAD LAGOON STUDY AREA, AUGUST 1978

Dominant Taxa	Depth (m)		
	+0.3 to -0.6	-1.8	-3.6 to -4.8
ALGAE - Phaeophyta			
Agarum cribrosum - no/m^2	0	0.05	1.4
% cover	0	-	0.5 ± 1.6
g/m^2	0	-	15.9
Alaria praelonga - no/m^2	17.2	0.8	0
% cover	62.5 ± 30.3	33.8 ± 12.5	0
g/m^2	2044.8	-	0
Desmarestia aculeata - no/m^2	0	0.05	-
Laminaria groenlandica - no/m^2	13.6	4.7	0.1
% cover	31.7 ± 36.6	32.5 ± 8.7	-
g/m^2	2209.8	-	-
ALGAE - Rhodophyta			
Constantinea subulifera - % cover	-	4.8 ± 1.3	0
Corallina sp. - % cover	-	0.7 ± 0.6	0
encrusting coralline algae - % cover	-	62.5 ± 9.6	0
Hildenbrandia sp. - % cover	-	P	0
Odonthalia lyalli - % cover	-	13.3 ± 11.4	2.0 ± 4.7
Tokidadendron bullata - % cover	-	10.0 ± 5.8	0
CNIDARIA - no/m^2			
Anthopleura artemisia - no/m^2	0	8.0	0
Cribrinopsis similis/*Tealia crassicornis*	0.2	0	0.02
ARTHROPODA - no/m^2			
Pagurus hirsutiusculus	-	5.0	-
Telmessus cheiragonus	0.04	0	0
MOLLUSCA - GASTROPODA - no/m^2			
Acmaeidae, unid	-	4.0	-
Beringius kennicotti	0.04	0	0
Buccinum glaciale	0	0	0.02
Fusitriton oregonensis	0.2	1.0	1.0
Hermissenda crassicornis	0	0	0.02
Margarites pupillus	-	2.0	-
Neptunea lyrata	0.1	0	0.02
Trichotropis insignis	-	6.0	-
Trophonopsis lasius	-	1.0	-

TABLE 9
(continued)

SPECIES COMPOSITION OF KNOLL HEAD LAGOON STUDY AREA, AUGUST 1978

Dominant Taxa	Depth (m)		
	+0.3 to -0.6	-1.8	-3.6 to -4.8
MOLLUSCA - Pelecypoda - no/m^2			
Modiolus modiolus		261.0	
Musculus vernicosus		P	
Mya sp.		1.0	
Pododesmus macroschisma	0	1.0	0.2
MOLLUSCA - Polyplacophora - no/m^2			
Mopalia sp.		4.0	
Tonicella lineata		23.0	
ECTOPROCTA			
Costazia ?surcularis - % cover		0.3 ± 0.5	
ECHINODERMATA - no/m^2			
Crossaster papposus	0		0.02
Henricia sanguinolenta	0		0.05
Leptasterias ?hylodes	0	1.0	0.1
Ophiopholis aculeata	-	P	-
Strongylocentrotus drobachiensis	0.04	-	0.05

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 still relatively insignificant (Appendix F-2).

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 an increasingly rich diversity of suspension feeders. Modiolus was patchy but extremely dense patches were observed. Estimated average density at 1.8 m was 261.0 individuals/m^2.

An additional 22 species of suspension feeders were recorded. Some of the major specieS were Balanus rostratus alaskanus, 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, the grazers, including the chitons Tonicella lineata and Mopalia sp., the gastropod Trichotropis insignis, and an unidentified limpet, were most abundant. Average densities were 23.0, 4.0, 8.0 and 4.0 individuals/m^2, respectively. Also abundant at this depth was the hermit crab Pagurus hirsutiusculus, with 5.0 indivuduals/m^2, and the small anemone Anthopleura artemisia, with 8.0/m^2.

At 3.6 to 4.8 m depths, the areas of cobble/gravel substrate areas were impoverished while bedrock and boulders had moderate epibenthic 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.

Fishes were uncommon throughout the area. Density of the whitespotted greenling Hexagrammos stelleri, most abundant fish, averaged 0.1/m (Table 10).

TABLE 10 FISH SPECIES COMPOSITION FOR KNOLL HEAD LAGOON SUBTIDAL AREA; 2 AND 5 AUGUST 1978

TAXA		Depth below MLLW (m) +0.3-0.6	1.8	1.8	3.6-4.8	3.6-4.8
CHORDATA						
Hexagrammos decagrammus	($\bar{x} \pm s$)	0	-	0	0	0
	(no./m^2)	0	0.02	0	0	0
H. octogrammus	($\bar{x} \pm s$)	-	-	0.1 ± 0.3	0	0
	(no./m^2)	0.02	0.02	0.05	0	0
H. stelleri	($\bar{x} \pm s$)	-	0	0.3 ± 0.5	0	0.2 ± 0.5
	(no./m^2)	0.02	0	0.1	0	0.1
Hexagrammos sp, juvenile	($\bar{x} \pm s$)	0	-	0	0	0
	(no./m^2)	0	0.02	0	0	0
Transect Size (m^2):		2 x 30	1 x 50	0.5 x 5	2 x 30	0.5 x 5
No. of Quadrats:		1	1	16	1	25

3. The Biological Assemblage at White Gull Island

Reconnaissance dives were made on the west of lee side of White Gull Island in June, and along the exposed east side of the island in August (Figure 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 the cobble and boulder field at 1.1 m below MLLW (Appendix G-1) but only extended to a depth of 3.6 m below MLLW. Important macrophyte species included Monostroma, Alaria taeniata, Desmarestia aculeata, and at deeper depth, Agarum cribrosum and Laminaria spp. 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 spp., Buccinum glacialis, Natica clausa and Neptunea ?lyrata, three species of Leptasterias and whitespotted greenlings.

The intertidal sheer rock face extended subtidally to 2.3 m below MLLW. The assemblage was similar to that reported for the boulder field below.

The small gravel/shell debris flat appeared to be typical of deeper portions of Iliamna Bay. Observations out to the middle of the southern entrance channel at a depth of 4 m below MLLW revealed no visual change in substrate. Near slack tide, a fine layer of silt covered the bottom.

Below -2.8 m, the flat was completely devoid of macroalgae. The macrofauna comprised numerous deposit and suspension feeders, including 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. 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. Hermit crabs and the snail Neptunea were occasionally observed in the midst of the clumps; both groups are reported to feed on Schizobranchia in this manner.

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 continued down to 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 (Appendix G-2).

On the vertical rock face, suspension feeders dominated. Young specimens of the anemone Metridium senile (<10 cm high) were the most abundant form. 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 of little importance.

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

The fine gravel/shell debris flat was not extensively surveyed, but had small rippled marks and a very thin deposit of silt. Numerous small pagurid crabs and Leptasterias polaris were observed occasionally.

4. The Biological Assemblage at Black Reef

Black Reef is a bedrock pinnacle surrounded by a talus slope. Subtidally, the reef has a vertical face with slight undercutting. The talus slope commences at a depth of about 4-6 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 (Figure 1).

The only significant macrophyte cover at the site occurred above 1.8 to 3.0 m. Algae included Laminaria groenlandica, Alaria taeniata, Rhodymenia palmata, and encrusting coralline algae. Macrophytes were totally lacking below 4.7 m (Appendix H).

Below the laminarian zone was located a zone of the anemone 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 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, specimens of many Boreotrophon clathrus were feeding on in small patches of barnacles.

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

Away from the boulders at 9.3 m, the fine sand/gravel/shell debris substrate appeared impoverished. Several small hermit crabs and a single Fusitriton were the only epifauna recorded.

5. The Biological Assemblage at Turtle Reef

In August 1978, a brief reconnaissance dive was made among the eastern pinnacles at Turtle Reef, a broad intertidal shelf of fairly flat rock (Figure 1). The biota, typically intertidal, was dominated by the macrophytes Fucus, Alaria, Rhodymenia palmata, the barnacle Balanus, the grazers Acmaea and Tonicella lineata and the gastropod Littorina. Spongomorpha and associated diatoms were abundant on top of rocks. The anemones Anthopleura artemisia, Tealia crassicornis and Cribrinopsis were common in protected, low sites. The sponge Halichondria panicea formed well-developed mats in channels between the eastern and western rocks (Appendix I). In the lower intertidal zone, Laminaria and several rhodophytes were more abundant. Clusters of tunicates were evident and comprised the most obvious and abundant epifauna. Also common were the anemone Cribrinopsis , the tunicate Styela sp., and the brittle star Ophiopholis aculeata.

C. THE BIOLOGY OF MODIOLUS MODIOLUS

1. Habitat

The horse mussel, Modiolus modiolus, is typically found in aggregated patches or beds. Individuals are joined to rocks or each other by networks of byssal threads. Often the beds examined were so well stabilized by byssal attachments that it required 45 to 60 minutes for a diver to excavate a 1/4m area. They are usually buried in a silt, sand, cobble and shell debris substrate with just the tips of their shells exposed. These tips may be encrusted with epibiotic forms such as encrusting coralline algae, hydroids, bryozoans, sponges or have macrophytes attached. In some areas, e.g., in the entrance channel to Jakolof Bay, an overburden of Modiolus shell debris up to 15 cm thick is present; its function will be discussed below.

Mature beds of _Modiolus_ form well-stabilized matrices attractive to numerous infaunal and epifaunal forms. Infaunal animals frequently encountered include sea cucumbers, brittle stars, sabellid and nereid polychaetes, nemerteans, echiurid worms, and the clams _Saxidomus_, _Hiatella_ and _Macoma_.

Some of the more prevalent epifaunal forms included sea urchins, the large snails _Fusitriton_ and _Neptunea_, various hermit crabs and other crustaceans, and the starfish _Evasterias_, _Pycnopodia_, _Orthasterias_, and _Leptasterias polaris_ var. _acervata_.

2. Distribution

The horse mussel was the dominant suspension feeder at several locations in Kachemak Bay, Kamishak Bay, and lower Cook Inlet generally (Table 11). It was generally observed at sites characterized by light to moderate turbidity, at least moderate tidal currents, and a gravel/cobble or bedrock substrate. It is therefore likely that it is common along the entire northern shelf of the Kachemak Bay and has, in fact, been observed in nearly every area examined there. In contrast, the only location in which it has been found on the south side of the bay was in the entrance to Jakolof Bay, a site exposed to strong tidal flow of moderately turbid water out of Jakolof Bay. However, _Modiolus_ was not observed at any of the "clean" water sites in Kachemak Bay, i.e., areas exposed directly to oceanic water flowing into Kachemak Bay out of Kennedy Entrance.

Contrary to expections, _Modiolus_ was not abundant at most sites examined along the west side of lower Cook Inlet. Although the species was reported in silty cobble substrates near Iniskin Bay, and two sites in Chinitna Bay, it was common only at one site (Lees and Houghton 1977). In northern Kamishak Bay, _Modiolus_ was noted subtidally at only one location (Knoll Head Lagoon site), where densities were moderate although distribution was quite patchy. Clumps tended to be associated with pockets in the bedrock. However, one large clump formed a dense pillow like mass on a large flat boulder; the shells were heavily encrusted with coralline algae. This mass, appearing to consist mainly of large adult mussels, strongly resembled the dense beds of _Mytilus_ observed in the intertidal zone on the east side of the inlet.

Modiolus was also observed in the low intertidal zone at Scott and Vert Island in pockets in the bedrock. Most of the remaining areas surveyed were vertical rock faces, boulder slopes, or sand or mud bottoms, i.e., apparently unsuitable for colonization by *Modiolus*. Thus, availability of suitable substrate impose a severe limitation on the distribution of *Modiolus* in the shallow inner portions of Kamishak Bay.

3. Size Structure

Specimens were collected at various sites to enable examination of distributions and biomass patterns. Strong geographic differences were apparent.

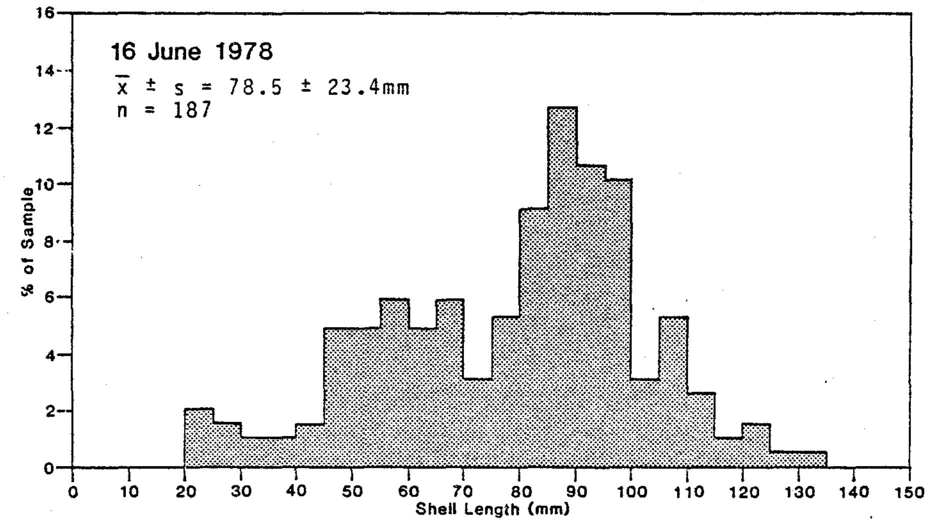
In the entrance channel of Jakolof Bay, collections were made on the shallow reef protruding into the channel (3 m deep) and along the base of that reef, on the floor of the channel (11 to 12 m deep). Both populations were dense and had high standing stocks (Table 11). The size frequency curve was bimodal and dominated by large individuals, but the populations contained a large proportion of younger animals, suggesting that recruitment, although not massive, was common and fairly reliable (Figures 2 and 3). Mean shell length was generally slightly larger in channel populations than in populations atop the shallow reef. This, coupled with generally higher densities, acted to produce higher standing stocks in the channel (Table 11). The populations in the channel had, in fact, the highest densities and biomass observed in lower Cook Inlet, i.e., 672 individuals/m^2 and 14,569.4 g wet tissue/m^2 .

On Archimandritof Shoals, the population trends were more variable. At a depth of 15.5 m, the population size structure was similar to that described for Jakolof Bay, i.e., although it was dominated by large adults, younger animals were common (Figure 4). Density and biomass were lower than at Jakolof Bay but average shell length was larger (Table 11). At shallower depths, average size, density and biomass were all substantially lower. In

TABLE 11

SUMMARY OF POPULATION DATA FOR MODIOLUS MODIOLUS FROM SUBTIDAL SITES IN KACHEMAK AND KAMISHAK BAY

Site	Collection Date	Approximate Depth (m)	n	Number per m	Mean Length (cm)	Population Type	Wet Tissue Weight (g/m)
Jakolof Bay							
Channel	6/16/78	11	187	374	78.4 23.4	1	6,766.2
	9/14/79	12	168	672	83.3 27.4	1	14,569.4
Reef							
	3/12/77	3	45	180	77.3 20.8	1	2,164.2
	3/29/79	3	300	600	82.4 20.9	1	11,587.9
	9/14/79	3	84	336	66.8 19.7	1	3,983.6
Archimandritof Shoals	8/03/76	4	-	∿ 2	-	-	-
	8/03/76	11	43	∿30	72.1 25.3	1	845
	6/28/78	5	-	18	-		-
	6/28/78	7	44	63	81.4 20.5	1	607.2
	7/10/78	15	169	134	90.3 25.5	1	3,238.0
Bishop's Beach	8/03/76	15	30	∿15	102.2 16.3	2	710
Bluff Point	10/25/75	12	45	57	124.3 11.8	2	4,347.5
	7/31/75	13	24	8	121.8 10.5	2	562.7
Anchor Point	7/22/76	15	15	10	97.0 12.9	2	430
Knoll Head Lagoon	8/02/78	2	37	148	51.9 24.0	1	870.8
	8/02/78	2	111	444	81.3 35.4	1	7,352.4
	8/05/78	2	141	564	77.3 13.6	1	6,646.0
	8/05/78	2	95	380	78.6 13.1	1	4,625.6



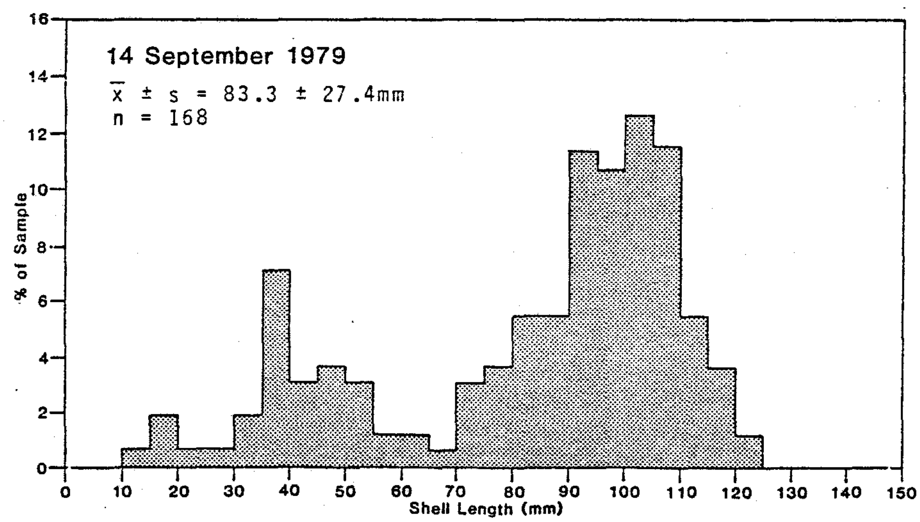


FIGURE 2

SIZE STRUCTURE OF *Modiolus modiolus* POPULATIONS
IN ENTRANCE CHANNEL TO JAKOLOF BAY; DEPTH ABOUT 10 m

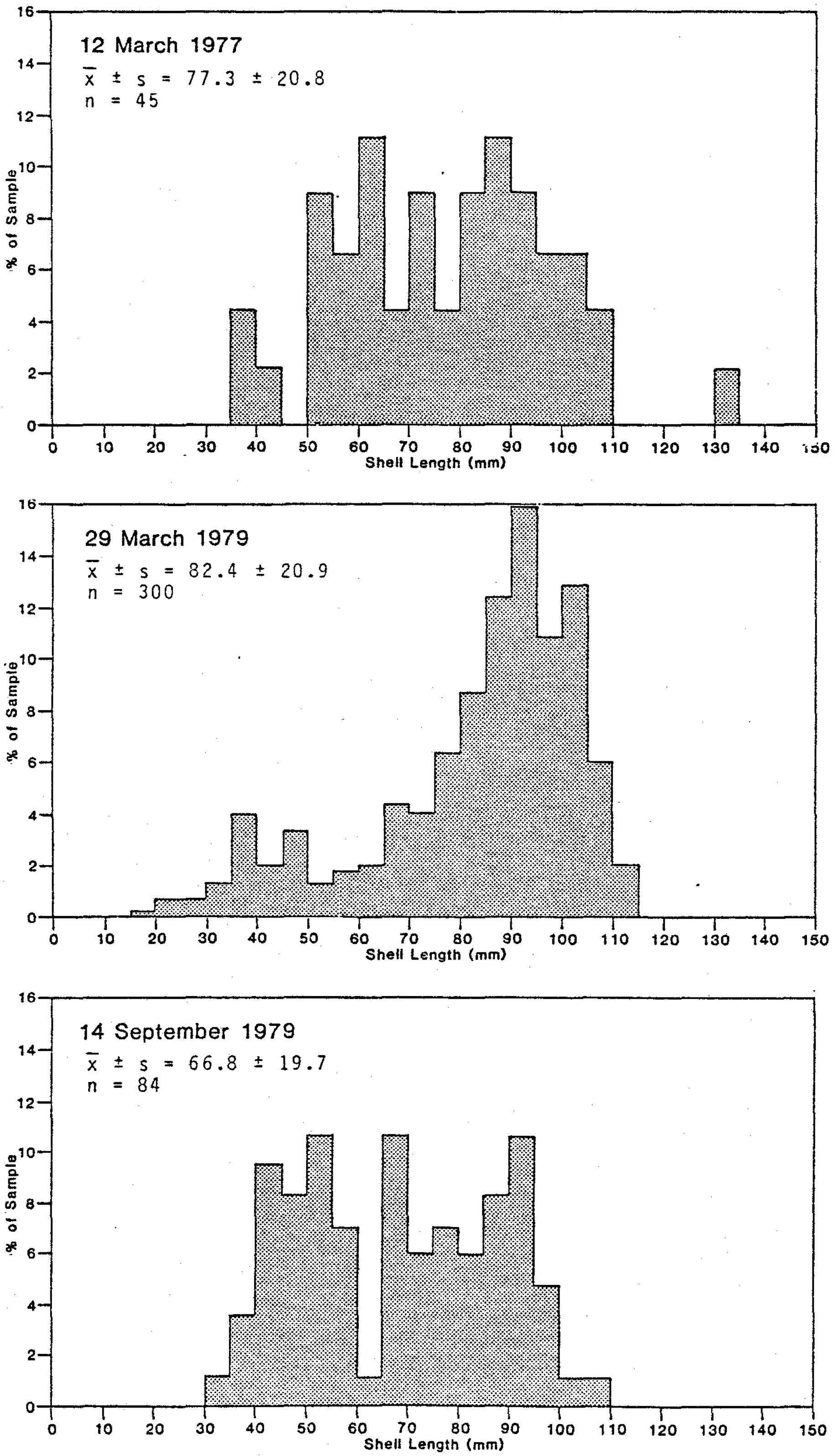


FIGURE 3

SIZE STRUCTURE OF *Modiolus modiolus* POPULATIONS ON REEF IN ENTRANCE TO JAKOLOF BAY; DEPTH ABOUT 2 m

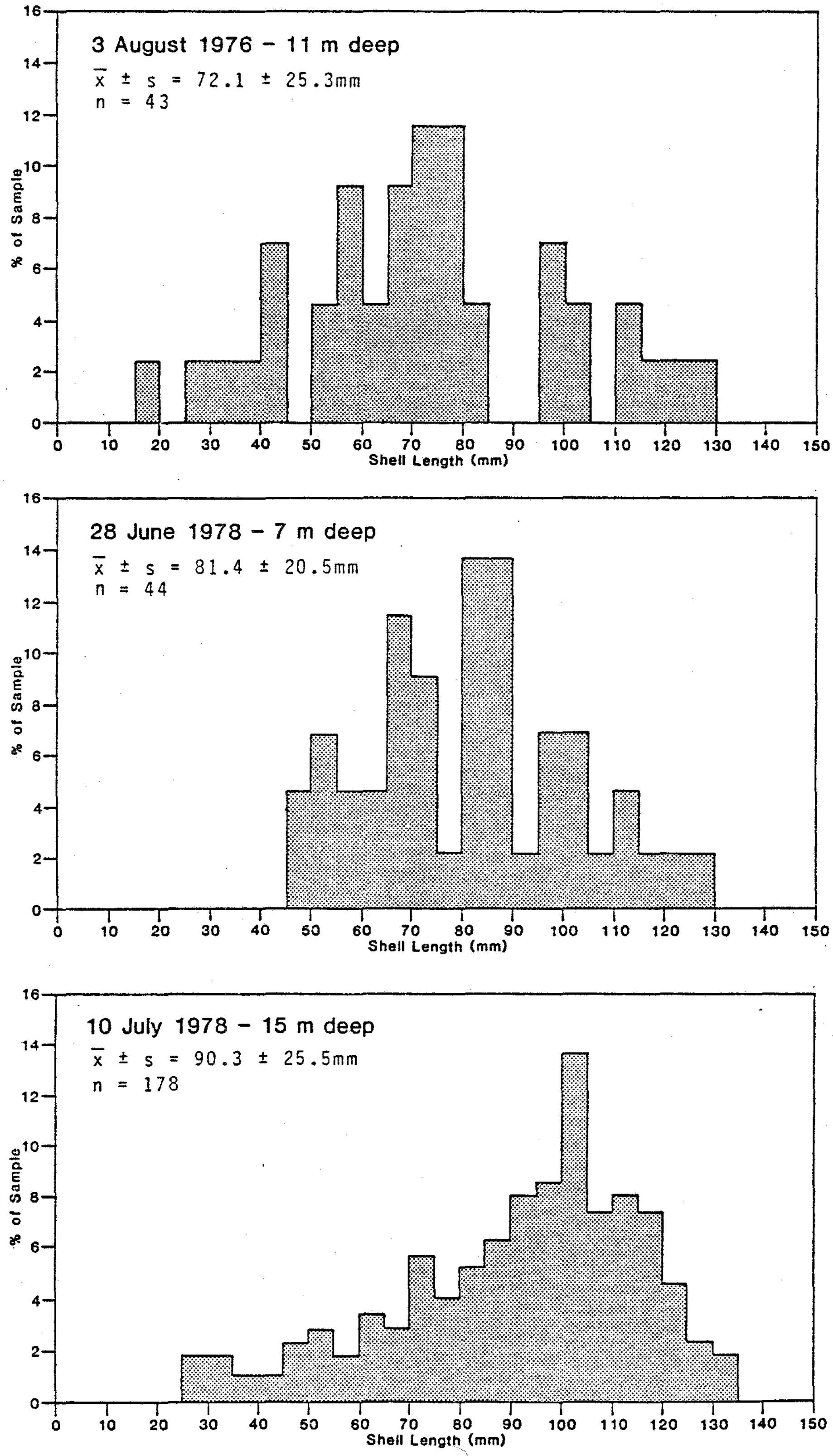


FIGURE 4

SIZE STRUCTURE OF *Modiolus modiolus* POPULATIONS ON ARCHIMANDRITOF SHOALS addition, loose shell debris became less abundant. Population size structures indicated that recruitment to the populations was commonplace but not massive. Density became greatly reduced at a depth of about 5 m, near the interface of the cobble and sand substrates. These trends probably are related to the patterns of physical rigors occurring on the shoals during fall and winter storms. Every year, waves generated by southwesterly storms sweep across the shoals during this period, bringing ashore large quantitites of coal from offshore coal seams. The migration of these blocks of coal undoubtedly becomes progressively more violent and damaging in shallow water, thus increasing mortality rates. Furthermore, with increasing proximity to the sandy substrate of the beaches on Homer Spit, the amount of large-grain suspended sediment increases, thereby increasing the probability of abrasion damage, temporary burial and suffocation. The consequences of these effects would be a progressive decrease in average age (and thus size), density and biomass in shallow water.

Off nearby Bishop's (Seafair) Beach, at a depth of 14.6 m, estimates of density and biomass based on visual counts and a removal were about 15 individuals/m^2 and 710 g tissue/m^2 (Table 11). The size frequency of this small sample was strongly unimodal; the population comprised mainly very large individuals. The virtual absence of small individuals implies that recruitment has occurred only infrequently in the recent past (Figure 5). Biomass and density were also low (Table 11).

Populations at Bluff Point were sampled only twice and the sampling times and locations differed considerably. However, the data indicate that these populations were composed of very large individuals (Figure 6). Densities were low and biomass was variable (Table 11). These patterns were observed in several other areas examined off Bluff Point where samples were not removed (Lees and Houghton 1977). Often, the areas were also inhabited by fairly dense populations of very large _Evasterias troschelii_, which were feeding on _Modiolus_. Also, the areas were littered with _Modiolus_ shell debris. The implication is that these areas once supported thriving populations of _Modiolus_ but that they are now overexploited by predators such as _Evasterias_, and that recruitment success is sporadic.

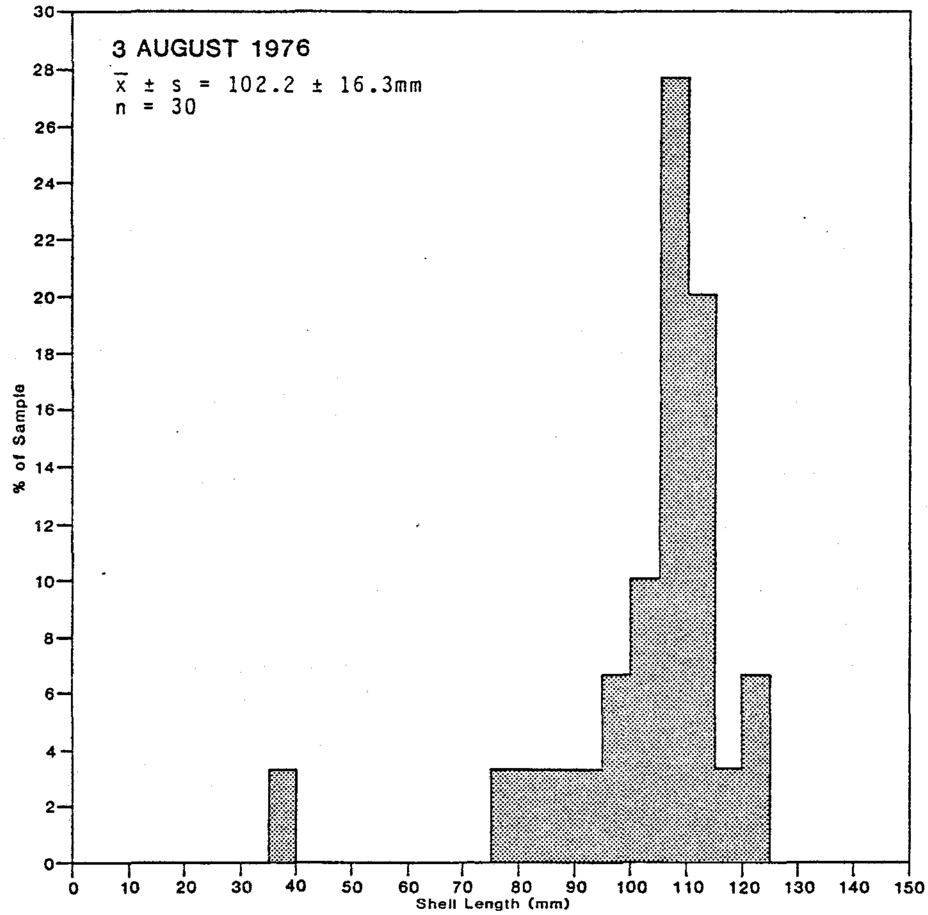


FIGURE 5

SIZE STRUCTURE OF A <u>Modiolus modiolus</u> POPULATION FROM OFF BISHOP'S BEACH; DEPTH ABOUT 14.6 m

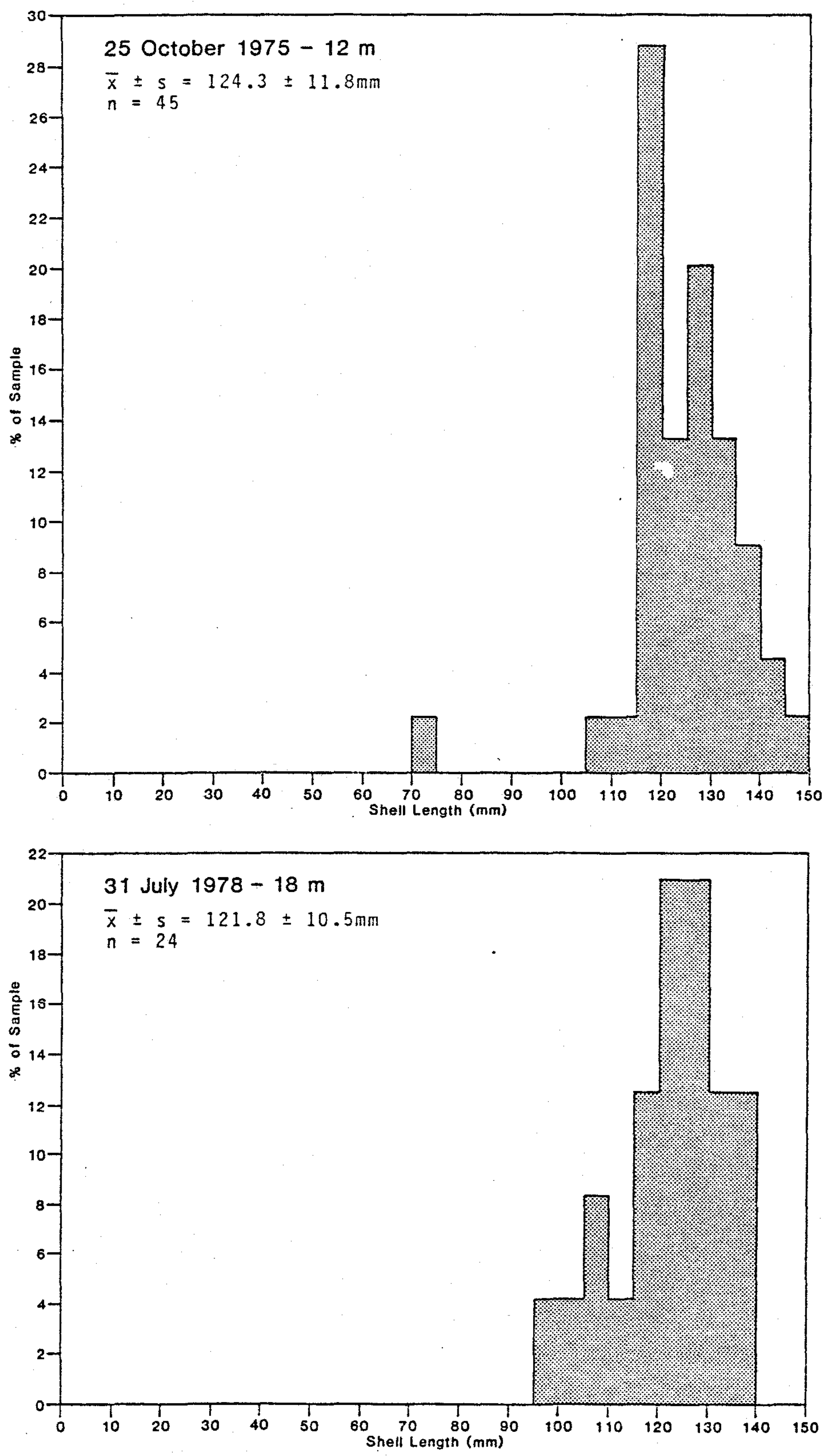


FIGURE 6

SIZE STRUCTURE OF Modiolus modiolus POPULATIONS OFF BLUFF POINT

Patterns observed off Troublesome Creek and Anchor Point were similar to those described for Bluff Point but recruitment may be successful occasionally (Figure 7). Average size was somewhat smaller (Table 11), and biomass was the lowest recorded.

On the west side of the inlet, the only well-developed subtidal beds of Modiolus were encountered at the Knoll Head Lagoon site, along the rocky shore between Iniskin and Iliamna Bays. However, sparse beds were encountered in the low intertidal zone at Scott and Vert Islands, in front of Iniskin Bay. Most of the beds observed at Knoll Head Lagoon were at a depth of about 2 to 3 m, just below the intertidal zone. All the populations sampled in this area gave evidence of successful recruitment (Figures 8 and 9), and some of the populations showed the strongest recruitment observed in any of the populations sampled, e.g., Figure 9. The populations were distributed patchily in small groups nestled in depressions in the bedrock. This may account for the strong difference in size structure between the groups sampled and represented in Figures 8 and 9. The effects of either ice scour or predation would be more discrete in such a habitat, leading to greater heterogeneity in size structure. Density and biomass were moderate, despite the patchiness (Table 11).

4. Predation and Secondary Production

We attempted to determine growth rates for Modiolus in a plot in the entrance channel of Jakolof Bay by notching shells a predetermined distance from the shell margin at the exposed (posterior) end of the shell. The reason for notching the shell away from the margin was to preclude damaging the mantle or destroying the integrity of the mantle cavity and thus exposing the marked animals to increased predation rates. In order to obtain access to the animals for this operation, it was necessary to remove the epifauna (hydroids and bryozoans), small red algae and shell debris. The latter was in a loose layer nearly 10 cm thick. When we returned about a year later to recover the notched animals, all animals in the plot had been removed and

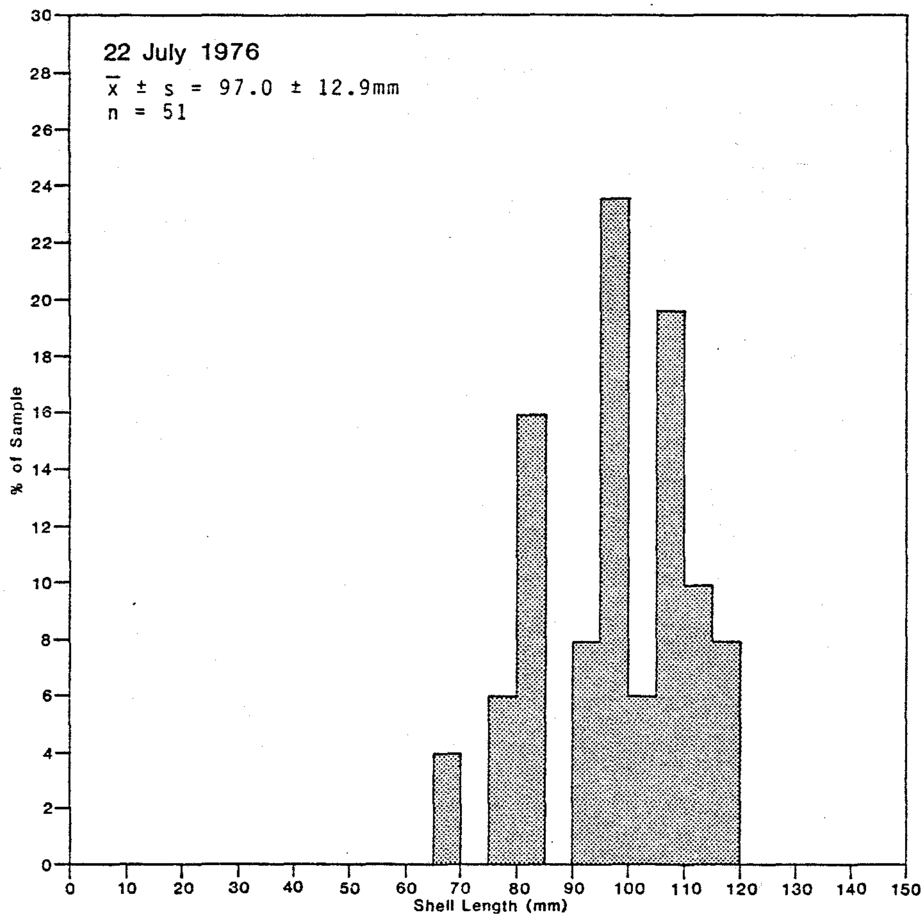


FIGURE 7

SIZE STRUCTURE OF A <u>Modiolus</u> <u>modiolus</u> POPULATION OFF ANCHOR POINT; DEPTH ABOUT 15 m

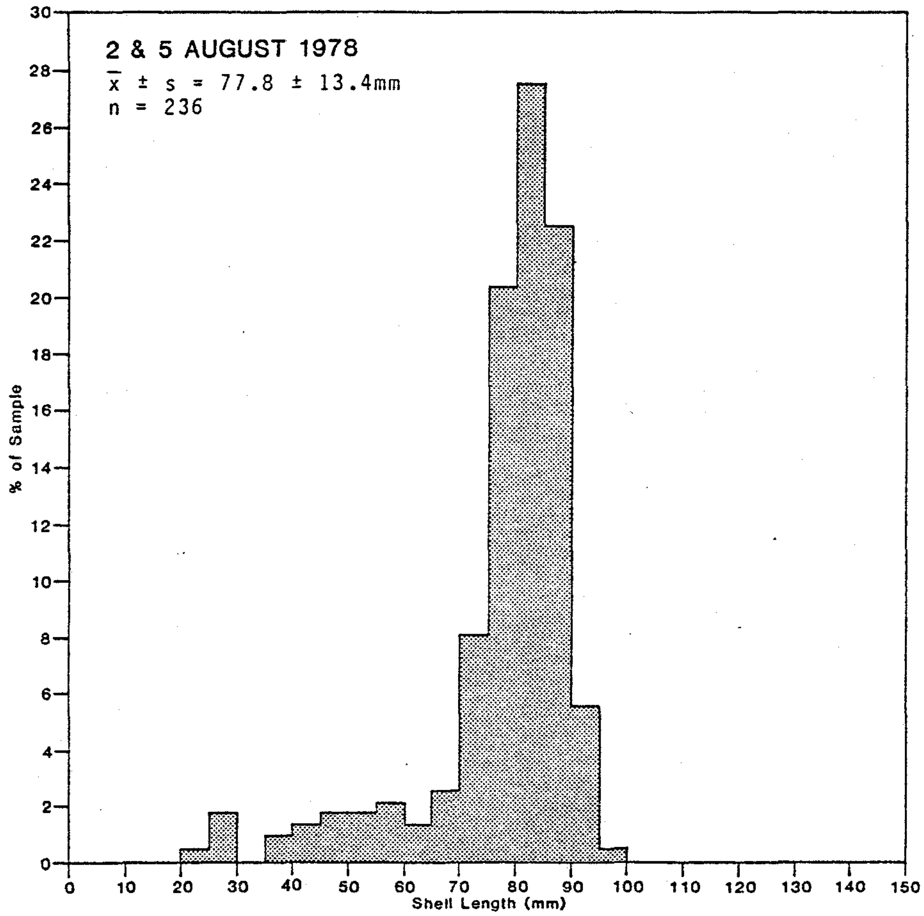


FIGURE 8

SIZE STRUCTURE OF SOME <u>Modiolus</u> <u>modiolus</u> POPULATIONS
AT THE INNER LEVEL AT THE KNOLL HEAD LAGOON SITE; DEPTH ABOUT 1.8 m

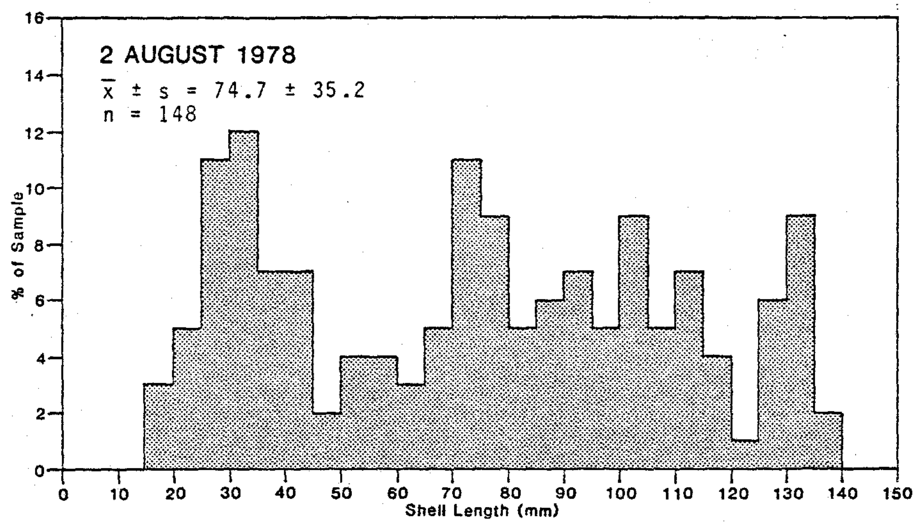


FIGURE 9

SIZE STRUCTURE OF Modiolus modiolus POPULATIONS
AT THE INNER LEVEL AT THE KNOLL HEAD LAGOON SITE; DEPTH ABOUT 1.8 m

consumed by starfish, leaving a conspicuous depression in the surrounding mussel bed, and exposing the cobble matrix. Thus, it appears that the epibiota and shell debris provide important protection against predation to *Modiolus*, at least in certain circumstances. However, in areas such as Archimandritof Shoals where surge action is a significant factor, shell material is frequently sparse or lacking as it is resuspended and swept out of the area by storms.

Although numerous actual or potential predators have been observed or recognized, the observed effect of predators on *Modiolus* varied from apparently low at Knoll Head to very intense at Jakolof Bay. At the latter, its major predators were the starfish *Pycnopodia helianthoides*, *Evasterias troschelii* and *Orthasterias koehleri*. The density relationships for these starfish were 1.25:6.125:1.0, respectively, and their actual densities in the channel approximated 0.20, 0.98, and 0.16 individuals/m^2 (Table 5). *Pycnopodia* had the most varied diet, feeding on 13 different species; of the 157 individuals examined, about 12.7 percent were consuming *Modiolus* and 56.7 percent were not feeding (Figure 10). *Evasterias* fed on only 3 species; of the 292 individuals examined, 20.9 percent were feeding on *Modiolus* and 75.7 percent were not feeding. *Orthasterias* fed on only 2 species; of the 42 individuals examined, 28.6 percent were feeding on *Modiolus* and 66.7 percent were not feeding. Thus, of the 491 starfish examined, 19.0 percent were feeding on *Modiolus* and 66.8 percent were not feeding at all (Figure 10).

Assuming a constant annual rate of consumption by all species, these consumption ratios in the channel extrapolate to 0.025 mussels consumed/m^2/-day by *Pycnopodia*, 0.205 mussels consumed/m^2/day by *Evasterias*, and 0.046 mussels consumed/ m^2/day by *Orthasterias*, or 9.3, 74.8, and 16.8 mussels/m^2/year, respectively. This totals about 100 mussels consumed/m^2/year, or about 19 percent of the population per year. From these data, it appears that *Evasterias* was the more important predator of the three from the viewpoint of *Modiolus*.

We examined size data collected during this study for relationships beween the size of a predator and its prey, and found that size is important.

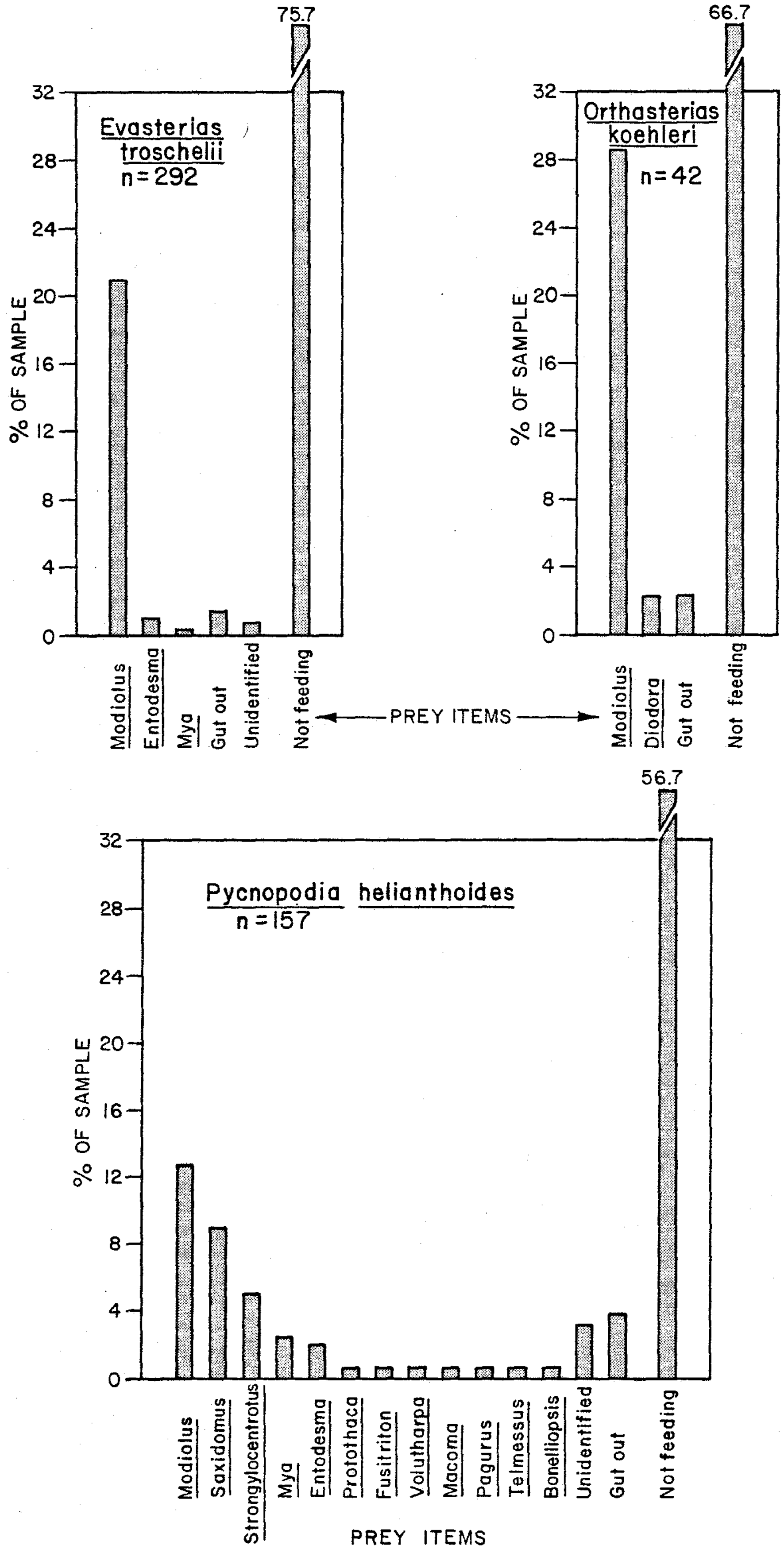


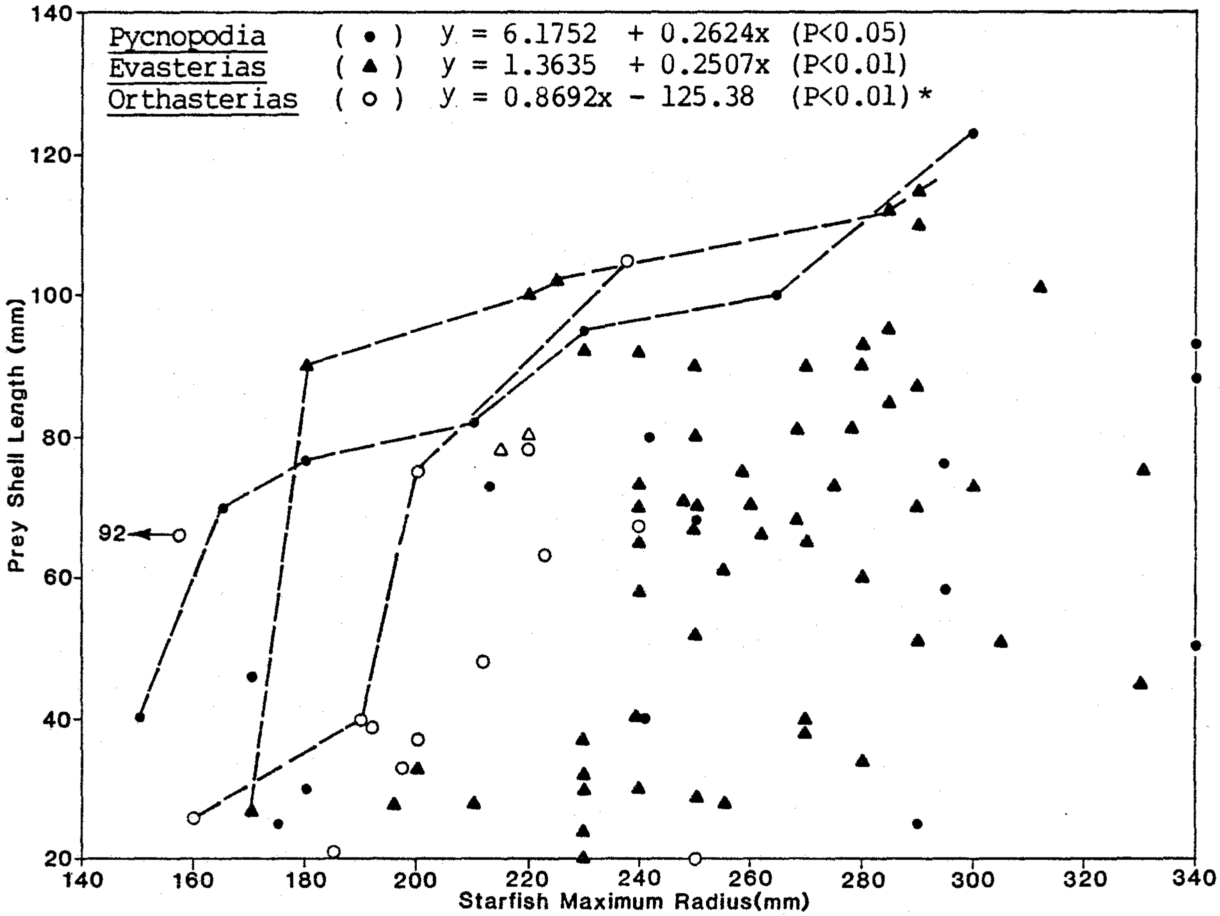
FIGURE 10

PREY ITEMS OF MAJOR STARFISH SPECIES AT JAKOLOF BAY SEPTEMBER–NOVEMBER 1978

In all three species, the correlation was positive and significant (Figure 11). As individuals of the predatory species become larger, they select for larger prey. However, these relationships do not appear to differ a great deal among the species. In fact, the agreement among the dashed lines describing the size-specific prey-size limitations for each predator is remarkable (Figure 11).

Size distributions of the prey populations were compared with that of the "source" population to examine prey selection strategies more closely. Analysis with the Kolmogorov-Smirnov two-sample test indicated that the size structures of all prey populations were significantly smaller than that of the source population (Figure 12). The probability that the prey selected by Pycnopodia and Evasterias represented a random selection from the source population was low ($P<0.01$), and by Orthasterias, quite low ($P<<0.001$). Nearly 50 percent of the mussels taken by Pycnopodia and Evasterias were below 65 mm shell length, in contrast to over 78 percent by Orthasterias. Over 70 percent of the prey were smaller than the average size for the source population. The size distributions of prey captured by Pycnopodia and Evasterias were not statistically distinct from each other ($P>0.3$), but Orthasterias differed from both of them strongly ($P<<0.001$). These patterns suggest that once Modiolus attains a certain size, it acquires a degree of protection from predation, i.e., it has a refuge in size. However, this "refuge" may be as much a result of probabilities as a matter of physical limitations for the predator. The density of large predators and prey is low and the probability encounter is thus low. Furthermore, it is obvious from the data points in Figure 11 that large starfish do not restrict prey capture to large prey.

This aspect of predation strategy has bearing on estimation of secondary production for Modiolus. Specifically, these starfish crop about 20 percent of the individuals in the prey populatations annually. However, because selection is biased toward smaller prey, it is probable that somewhat less than 20 percent of the biomass is removed. These estimates suggest a turn-over time in excess of five years and secondary production of somewhat less



Notes:

Dashed lines connect the data points describing the size-specific prey size limitations for each predator

* Data for the largest and smallest starfish omitted

FIGURE 11

RELATIONSHIPS BETWEEN SIZES OF STARFISH PREDATORS AND THEIR PREY, Modiolus FROM JAKOLOF BAY

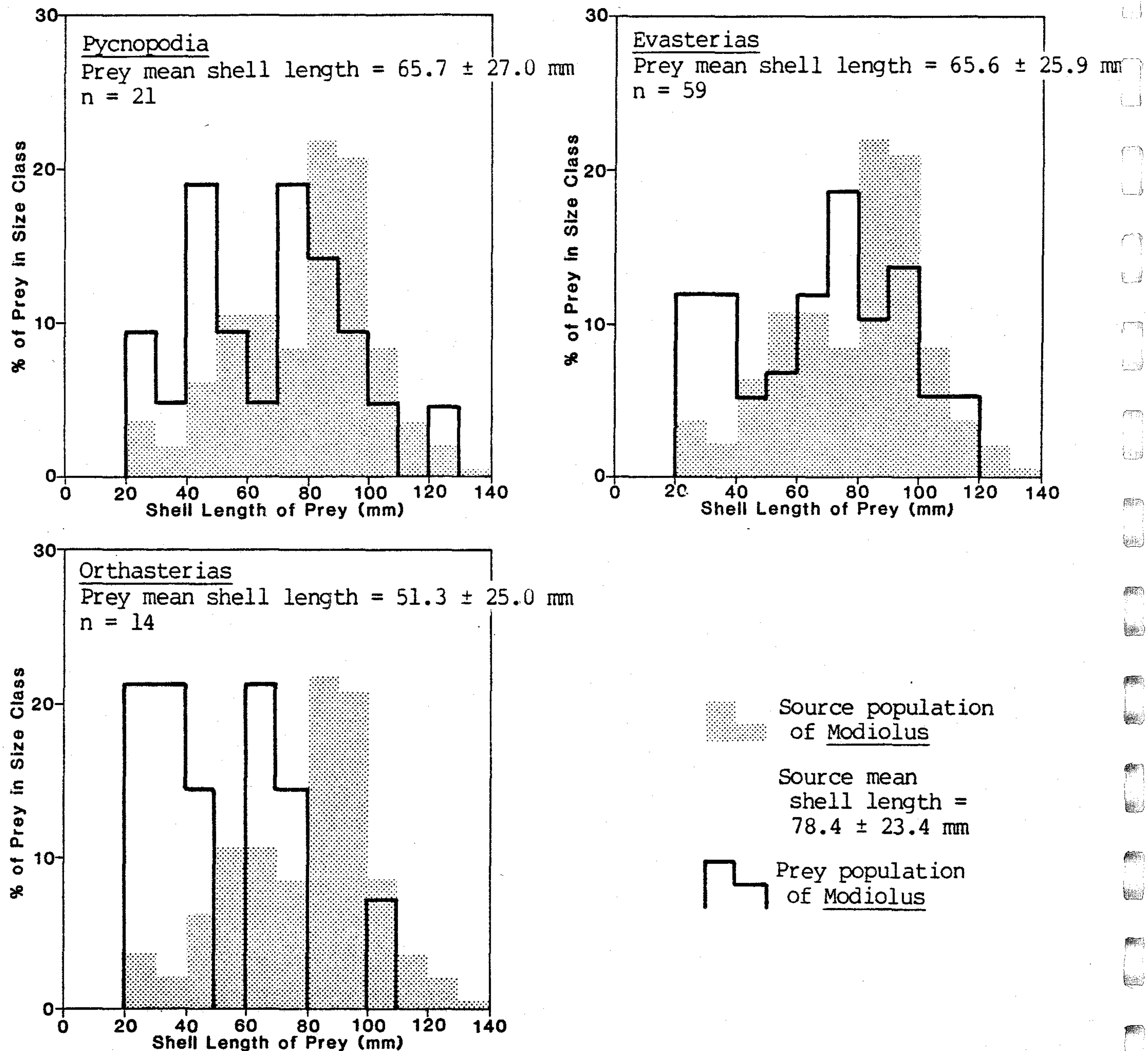


FIGURE 12

COMPARISONS OF SIZE DISTRIBUTIONS OF MODIOLUS SELECTED AS PREY BY STARFISH TO THAT OF THE NATURAL SOURCE POPULATION AT JAKOLOF BAY

2.0 kg wet tissue/m/year. In addition, the population produces a substantial quantity of gametes each year. In any event, however, the productivity: biomass ratio is probably considerably less than 0.5, despite the high level of tissue productivity.

Other predators are known or suspected to exert significant pressure on Modiolus populations in lower Cook Inlet. The starfish Leptasterias polaris var. acervata is important on Archimandritof Shoals, at Bluff Point, and on the west side of lower Cook Inlet. In some of these locations, it replaces Evasterias. Common eiders, the largest of the sea ducks, feed heavily on Mytilus, and flocks are commonly observed feeding in areas with Modiolus beds. This includes Archimandritof Shoals in winter and spring, and areas in Kamishak Bay during the winter, spring, and summer. Although consumption has not been observed directly, eiders have been observed feeding at the surface on mussels under conditions that would preclude taking Mytilus; however, removal of adult Modiolus from a bed might be quite difficult. Potentially important predators include sea otters, dungeness and king crabs, especially on the northern shelf of Kachemak Bay in late summer and fall.

D. Feeding Observations on Benthic Invertebrates

During this study, we collected numerous feeding data. In addition, we have summarized previously collected data as it pertains to the biotic assemblages above. Computer printouts of this summary are presented as appendices (Appendices J to M). Moreover, these data have been used to construct a summary of the trophic structure for each of the major assemblages described bove (See Discussion).

A considerable amount of feeding data was collected for sea stars because they are an abundant, important, conveniently observable predator. Diets of eleven abundant starfish are compared in Table 12. Basically four types of diets could be distinguished, namely, 1) sponge specialists, 2) specialists on soft-bodied animals, 3) specialists on echinoderms, and 4) generalists. Group 1, comprising only Henricia spp, is controversial

TABLE 12
(Continued)

PREDATOR

	Henricia leviuscula	*Henricia sanguinolenta*	*Pteraster tesselatus*	*Dermasterias imbricata*	*Solaster stimpsoni*	*Solaster dawsoni*	*Evasterias troschelii*	*Pycnopodia helianthoides*	*Orthasterias koehleri*	*Leptasterias polaris* var. *acervata*	*Crossaster papposus*
Pelecypoda											
Clinocardium spp.							x			x	
Entodesma saxicola							x	x	x		
Humilaria kennerlyi									12		
Macoma spp.							x	x		x	
Modiolus modiolus							43	23	53	12	
Musculus discors							x		6	x	x
Mya spp.							x	3		12	
Mytilus edulis							10				
Panomya ampla								x			
Pododesmus macroschisma									x		
Protothaca staminea							x	x		x	
Saxidomus giganteus							x	25			
Serripes spp.							x				
Tresus capax							x				
Crustacea											
Balanus sp., unid							x		4	28	
B. cariosus							6				
B. crenatus							14		x		
B. glandula										4	
B. nubilus									x		
B. rostratus										x	
Paguridae, unid								x			
Pandalus spp.							x				
Telmessus cheiragonus								x			
Echiura											
Bonelliopsis alaskanus					38			x			
Tunicata, unid					x				x		
Colonide tunicate			x								
Halocynthia aurantium									x		

TABLE 12

Comparison of Prey Species used by Predatory Starfish
Numbers are the Relative Frequency (%) at Which Each Prey Item
Was Found in Feeding Observations; "x" Indicates Occurrence

PREDATOR

	Henricia leviuscula	Henricia sanguinolenta	Pteraster tesselatus	Dermasterias imbricata	Solaster stimpsoni	Solaster dawsoni	Evasterias troschelii	Pycnopodia helianthoides	Orthasterias koehleri	Leptasterias polaris var. acervata	Crossaster papposus
Porifera, unid	50	78	21	10							
Cliona celata	50										
Esperiopsis spp.			32								
Mycale spp.		22		x							
Hydroida, unid				4							7
Abietinaria spp.			11	x							7
Actiniaria, unid			x		13						
Anthopleura artemisia				x							
Metridium senile				69							
Tealia crassicornis				10							
Ectoprocta, unid											14
Alcyonidium spp.											x
Flustrella gigantea			x								x
Microporina borealis			x								x
Polychaeta											
Cistenides granulata								c*		4	
Gastropoda											
Acmaeidae, unid							x		x		
Diodora aspera									x		
Fusitriton oregonensis								x			
Natica clausa							x	x			
Neptunea spp.											x
Rostanga pulchra											7
Volutharpa ampullacea								x			
Polyplacophora, unid											14
Katharina tunicata							x				
Mopalia spp.										x	

TABLE 12
(continued)

PREDATOR

	Henricia leviuscula	Henricia sanguinolenta	Pteraster tesselatus	Dermasterias imbricata	Solaster stimpsoni	Solaster dawsoni	Evasterias troschelii	Pycnopodia helianthoides	Orthasterias koehleri	Leptasterias polaris var. acervata	Crossaster papposus
Echinodermata											
Cucumaria spp.				3	38	67		x			
Dermasterias imbricata								x			
Evasterias troschelii					6	33					
Strongylocentrotus drobachiensis				x				25			x
Number of observed feedings	-	9	19	73	23	-	809	167	83	25	14
Number of prey species	2	2	7	8	5	2	18	17	12	11	11

* Common in other locations

because of its mode of feeding (Mauzey et al. 1968). Feeding observations are based on visual assessment of damage to the sponge under a specimen of Henricia; the surface of the sponges appeared bleached and damaged. In some cases, the stomach of H. sanguinolenta was partially extruded. Attempts to find spicules in the stomach were not successful, but it is possible that spicules are not "ingested". Group 2, a loose collection, comprises Pteraster and Dermasterias. The former appears to limit its prey to sponges, cnidarians and bryozoans, whereas the latter feed on a broader variety of taxa (Table 12; Rosenthal and Chess 1972). Group 3 was restricted to starfish of the genus Solaster; predation of this group on other echinoderms, especially starfish and sea cucumbers, has been well documented (Mauzey et al. 1968). Group 4 comprises Evasterias, Pycnopodia, Orthasterias, Leptasterias polaris var. acervata, and Crossaster. All but the latter fed on a broad variety of clams, snails and barnacles; only two fed on other echinoderms or on tunicates, and only Crossaster fed on cnidarians or bryozoans. Although the latter fed on a broad range of prey species, it exhibited no strong preferences in choice. Most of its prey were not selected by any other sea star. Therefore, although a generalist, it showed little relationship to the other generalists.

An interesting trend in these groups is that Groups 1, 2, and 3 included only members of the order Spinulosa whereas Group 4 included mainly members of the order Forcipulata. Group 4 alone fed on clams and snails, both of which include many community dominants and contribute substantially to biomass.

The remaining data are considered most useful for indicating some of the predator-prey interactions but should not be considered complete or repre-observations and collections have been too biased.

E. SOFT SUBSTRATES

1. The Biological Assemblage at Mud Bay

Mud Bay in upper Kachemak Bay has a flat mud bottom lacking in any surface relief except for sparsely scattered shell debris and small boulders.

These boulders were probably transported to the sea by ice rafting from local drainages.

Reconnaissance dives were made at sites 1.5, 4.6, 6.1, and 10.7 m below MLLW. Species composition of the assemblages observed in the three deeper dives was generally similar (Table 13). Common epifaunal forms included small specimens of the hermit crabs Labidochirus splendescens and Pagurus capillatus, and larger crabs such as Telmessus cheiragonus and Chionoecetes bairdi (young); juveniles of the sea pen Ptilosarcus gurneyi were sparse. Common infaunal forms included suspension-feeding brittle stars (?Amphiodia sp.), deeply buried but with erect, exposed arms, and small tubicolus spionid and maldanid polychaetes. At 6.1 and 10.7 m, a large assortment of the predatory snails (Oenopota spp.) was observed. Densities of 2.5 and 9.0 individuals/m^2, respectively, were estimated for the two sites. Small cottids and flatfish were present at densities of 0.1 and 0.2/m^2 (Table 13); Appendix N).

The available hard substrate at three deeper stations was fairly well covered by the barnacle Balanus rostratus alaskanus, the anemone Metridium senile, and the serpulid polychaete Crucigera zygophora. Strongylocentrotus drobachiensis was also common on these rocks. Plants were rare.

At a depth of about 1.5 m, large patches of Mytilus edulis were observed Growing attached to the mussels were the algae Monostroma fuscum, Porphyra sp., Spongomorpha, Desmarestia aculeata and Alaria taeniata. The sea stars Evasterias troschelii, Leptasterias hexactis, and L. ?hylodes were also present. This site was typical of the low intertidal zone in Mud Bay (Table 14).

2. The Biological Assemblage at Cottonwood Bay

At Cottonwood Bay, we examined a 1.2 km long transect through the low intertidal and shallow subtidal zones to (0.6 to 2.5 m below MLLW) during a high tide. The transect was divided into three sections, i.e., east of the base camp, in front of the base camp and west of the base camp.

TABLE 13 SPECIES COMPOSITION FOR MUD BAY SUBTIDAL AREA; 10 JULY 1978

TAXA		Depth below MLLW (m) 10.7	10.7	10.7	11.3
CNIDARIA - Hydrozoa					
Abietinaria spp	($\bar{x} \pm s$)	0	1.8 ± 1.3	-	-
	(no./m^2)	0	0.4	-	-
Tubularia sp	($\bar{x} \pm s$)	0	0.2 ± 0.4	-	-
	(no./m^2)	0	0.04	-	-
CNIDARIA - Anthozoa					
Metridium senile	($\bar{x} \pm s$)	0.3 ± 0.6	0.6 ± 1.3	-	-
	(no./m^2)	0.13	0.1	-	-
Ptilosarcus gurneyi	($\bar{x} \pm s$)	0.3 ± 0.5	0.2 ± 0.4	-	-
	(no./m^2)	0.13	0.04	-	-
ARTHROPODA - Crustacea					
Balanus rostratus, patches	($\bar{x} \pm s$)	0	1.0 ± 1.0	-	-
	(no./m^2)	0	0.2	-	-
Chionoecetes bairdi	($\bar{x} \pm s$)	0.1 ± 0.2	0.4 ± 0.9	-	-
	(no./m^2)	0.02	0.1	0.1	-
Labidochirus splendescens	($\bar{x} \pm s$)	0	2.8 ± 2.5	-	-
	(no./m^2)	0	0.6	-	-
Pagurus capillatus	($\bar{x} \pm s$)	0	0.8 ± 1.3	-	-
	(no./m^2)	0	0.2	-	-
Pugettia gracilis	($\bar{x} \pm s$)	0.1 ± 0.2	0	-	-
	(no./m^2)	0.02	0	-	-
Telmessus cheiragonus	($\bar{x} \pm s$)	0.1 ± 0.2	0	-	-
	(no./m^2)	0.02	0	-	-
MOLLUSCA - Gastropoda					
Neptunea lyrata	($\bar{x} \pm s$)	0.1 ± 0.3	0.2 ± 0.4	-	-
	(no./m^2)	0.04	0.04	-	-
Oenopota spp	($\bar{x} \pm s$)	-	-	-	2.3 ± 1.5
	(no./m^2)	-	-	-	9.1
CHORDATA - Pisces					
Cottidae, unid	($\bar{x} \pm s$)	0	0.4 ± 0.9	-	-
	(no./m^2)	0	0.1	-	-
Lepidopsetta bilineata	($\bar{x} \pm s$)	0.2 ± 0.5	0	-	-
	(no./m^2)	0.1	0	-	-
Pleuronectiformes, unid	($\bar{x} \pm s$)	0.1 ± 0.2	0.8 ± 0.4	-	-
	(no./m^2)	0.02	0.2	-	-
Fish, unid. elongate	($\bar{x} \pm s$)	0.1 ± 0.2	0	-	-
	(no./m^2)	0.02	0	-	-
Quadrat Size (m):		0.5 x 5	0.5 x 10	0.5 x 50	½ x ½
No. of Quadrats:		18	5	1	11

TABLE 14 RECONNAISSANCE SURVEY FROM MUD BAY, BASE OF HOMER SPIT; 30 JUNE 1978

TAXA	Depth (m)[a] 6.1	4.6	1.5
ALGAE - Chlorophyta			
Monostroma sp			X
Spongomorpha sp			X
ALGAE - Phaeophyta			
Alaria taeniata			X
Desmarestia aculeata	S[b]	X	X
Laminaria sp (unid. sporling)	X		
ALGAE - Rhodophyta			
Coralline alga, encrusting	S		
Porphyra sp			X
PROTOZOA			
Diatom film	X	X	
CNIDARIA - Hydrozoa			
Hydrozoa, unid.	X		
CNIDARIA - Anthozoa			
Anthopleura artemisia		C[c]	X
Halcampa decemtentaculata	X		X
Halcampa sp	S		
Metridium senile	C	X	X
Ptilosarcus gurneyi, (juvenile)	C		
NEMERTEA			
Paranemertes sp	X		
ANNELIDA - Polychaeta			
Crucigera zygophora	C		
Maldanidae, unid.	C		
Nereis sp			X
Phyllochaetopterus sp	X		
Phyllodoce groenlandica	X	S	
?Spionidae, unid.	A[d]	A	
ARTHROPODA - Crustacea			
Balanus rostratus alaskanus	X		
Crustacea cont.			
Balanus sp	X		
Caprellidae, unid. (2 - 3 spp)	X		
Crangon sp	X		
Discopagurus sp	S		
Elassochirus tenuimanus	C		
Euphausiacea, unid.	X		
Gammaridea, unid.	X		
Hyas lyrata	X		
Labidochirus splendescens	C	X	
Oregonia gracilis	X		
Pagurus capillatus	C		
Telmessus cheiragonus	C	X	X
MOLLUSCA - Gastropoda			
Admete couthouyi	X		
Aeolidia papillosa	X		X
Boreotrophon pacificus	X		
Coryphella sp	X		X
Mytilus edulis			C
Neptunea lyrata	X	C	
Oenopota alaskensis	X		
O. alitakensis	X		
O. bicarinata	X		
O. bicarinata var. *violacea*	X		
O. incisula	X		
O. solida	X		
O. turricula cf. *rugulata*	X		
O. sp H	X		
O. sp I	X		
O. sp J	X		
Oenopota unid.	X	X	
MOLLUSCA - Pelecypoda			
Macoma sp	X		
Mya spp		X	
Nuculana sp	X		
Pandora filosa	X		
Yoldia sp	X		

TABLE 14 (Continued)

TAXA	Depth (m) 6.1	4.6	1.5
ECHIURA			
Echiurus echiurus		X	
ECHINODERMATA - Asteroidea			
Asterias amurensis	X		
Asteroza, unid.	X		
Evasterias troschelii	X		X
Leptasterias hexactis occidentalis			X
L. ?hylodes	X		X
ECHINODERMATA - Echinoidea			
Strongylocentrotus drobachiensis	C	C	
ECHINODERMATA - Ophiuroidea			
?*Amphioidia* sp	X	C	
CHORDATA - Tunicata			
Distaplia ? *occidentale*	X		
CHORDATA - Pisces			
Agonus acipenserinus, juvenile		X	
Ammodytes hexapterus		X	
Cottidae, unid.	X	X	

Substrate: Flat mud bottom with boulders scattered sparsely about. Fecal pellets from worms and Echiurids form an unconsolidated slurry at the water-sand interface. Crab tracks common.

[a] Below MLLW

[b] S = Sparse

[c] C = Common

[d] A = Abundant

From east of the base camp, near the confluence of Cottonwood and Iliamna Bays to directly in front of the base camp, the substrate was sandy mud or sandy, muddy cobble with scattered boulders. No attached macophytes were noted. However, specimens of the kelp Laminaria saccharina attached to small rocks were observed drifting along in the tidal currents. Other seaweeds observed in the area included a filamentous brown alga (Pylaiella littoralis) and an unidentified filamentous green alga (Appendix O).

Most of the epifaunal forms were associated with small rocks. The main species noted were a barnacle (Balanus ?rostratus), an erect, bushy bryozoan (Caulibugula sp.), and an unidentified encrusting orange sponge. Common motile forms included the asteroid Leptasterias polaris acervata and the crabs Telmessus cheiragonus and Pagurus ochotensis.

The infauna was dominated by soft shell clams Mya spp. and the cockle Clinocardium nuttallii, whose densities averaged 3.7 and 2.2 individuals/m^2, respectively (Table 15). Populations of both species were mainly comprised of large adult clams. A burrowing sea anemone Anthopleura artemisia was scattered sparsely throughout the area.

Despite the abundance of clams, predators appeared uncommon. In addition to the starfish Leptasterias, whitespotted greenling and rock sole were the only other predators noted; they were uncommon. However, numerous excavations measuring about 0.5 m wide by 0.1 m deep were observed scattered around the area. These may have resulted from the feeding activities of sea otters or rays.

West of the base camp, sandy areas with gravel were noted toward the head of the bay. In addition to Clinocardium and Mya, the clams Macoma balthica and M. ?obliqua, the echiurid Bonelliopsis alaskanus and the ice cream cone worm Cistenides granulata were common.

Farther west, the gravel became coarser and more abundant. In this area, algal cover averaged about 30 percent.

TABLE 15 SPECIES COMPOSITION FOR COTTONWOOD BAY SUBTIDAL AREA; 13 JUNE 1978, LESS THAN 1.5 M BELOW MLLW

TAXA			
Mollusca - Pelecypoda			
Clinocardium nuttallii	($\bar{x} \pm s$)	2.4 ± 3.3	-
	(no./m^2)	9.6	1.7
Mya spp	($\bar{x} \pm s$)	2.0 ± 2.0	-
	(no./m^2)	8.0	3.4
Quadrat Size (m^2):		¼	0.5 x 35
No. of quadrats:		5	1

3. The Biological Assemblage at Nordyke Island Channel

A brief dive was made in the channel west of Nordyke Island. At an approximate depth of 6 m, the substrate was an unconsolidated silt with heavy shell debris and small cobble. Heavy encrustations of small to medium-sized *Balanus* and occasional hydroids (*Abietinaria*) were observed on the shell and cobbles.

Between the 6 m and 9.1 m, the substrate graded from mixed silt and cobble to silt; correspondingly, the sessile epifaunal disappeared. No sign of epifaunal forms was observed from 9 m to 12.2 m, although local residents related that tanner crabs are seasonally abundant in the area.

The main indication of infaunal activity was the presence of sparsely distributed mud cones approximately 3 to 5 cm in height. These were probably produced by some large polychaete such as *Nephtys punctata*. The area was visually similar to the shallow subtidal slopes of Port Valdez, where *N. punctata* is abundant (Lees et al. 1979b).

4. The Biological Assemblage at Oil Bay

Reconnaissance dives were made in Oil Bay at depths of 1.2 and 2.7 m below MLLW. The substrate was a fine, silty sand with small ripple marks and moderate organic debris.

The impoverished assemblage comprised mainly of a few species of clams and predators/scavengers. The razor clam was most abundant; its density was about 0.07 siphons/m^2. Although not enumerated, the density of the redneck clam *Spisula polynyma* was probably about the same. The crab *Telmessus* and flatfish were next in abundance with only 0.03 individuals/m^2. Additional species observed included small hermit crabs, crangonid shrimp and gammarid amphipods, butter sole, rock sole, and snake prickleback (Appendix P).

VII. DISCUSSION

A. COMPARISON OF ASSEMBLAGES

The main habitat types examined included kelp and Modiolus beds on rocky substrate. In several locations, such as Jakolof Bay, these assemblages overlapped. Based on appearance and species composition, these assemblages fall into three geographically distinct groups, namely, 1) southern Kachemak Bay, 2) northern Kachemak Bay and 3) western Cook Inlet assemblages. Some of the major species characterizing each assemblage are listed in Table 16 and their distribution patterns indicated. The three assemblages can be distinguished on the basis of the composition and structure of both the macrophyte and the epifaunal components.

The southern Kachemak Bay assemblage was characterized by consistent development of a lush, fairly dense kelp bed consisting of both a canopy and an understory, a low diversity, poorly-developed epifaunal component, and a diverse, low-density predator/scavenger component (Table 16). Development of the canopy usually did not extend past a depth of about 12 m but the understory kelps extended past 21 m where appropriate substrate was available. The canopy was formed by Alaria fistulosa in areas of high current velocity and by Nereocystis in areas of lower velocity. Although both Laminaria and Agarum were frequently mixed in the understory, Laminaria was most successful in shallow, well-lighted situations and Agarum extended out to greater depths; Laminaria was more common and better developed in turbulent areas with good circulation.

The sedentary invertebrate component, mostly comprising suspension feeders, was generally poorly developed. The only two commonly observed species were the large fleshy bryozoan Flustrella gigantea and the butter clam Saxidomus giganteus. Diversity was higher at the two sites more exposed to tidal currents, but only at Jakolof Bay did the density or standing stocks of suspension feeders approach that observed at Archimandritof Shoals or Troublesome Creek. In fact, Jakolof Bay was a

TABLE 16

DOMINANT SPECIES IN MAJOR ROCK BOTTOM SUBTIDAL ASSEMBLAGES IN LOWER COOK INLET

	Southern Kachemak Bay			Northern Shelf of Kachemak Bay			West Side of Cook Inlet		
	Seldovia Point	Barbara Bluffs	Jakolof Bay	Archimanritof Shoals	Bluff Point	Troublesome Creek	Knoll Head Lagoon	White Gull Island	Black Reef
Kelps									
Surface canopy									
Nereocystis leutkeana	A(12)*	A	A	C(19)					
Alaria fistulosa	A(12)		A		C(12)	C			
Understory									
Agarum cribrosum	A(21)	A	A	C(13)	C(16)	C(14)	C(5)	C(3)	S(4)
Alaria spp. (not *fistulosa*)	Intertidal	Intertidal	Intertidal				A(2)	C(2)	S(2)
Laminaria groenlandica	A(20)	A	A	C(10)	C(12)	C(14)	C(4)	C(3)	S(2)
Maximum depth of kelps (m)	21	>14	>12	13	16	15	5	3	4
Sedentary Invertebrates									
Flustrella gigantea	A	C	P	C	A	C	P		
Microporina borealis	C				C	S			
Mycale spp.	C			C	P	C	C	C	C
Saxidomus giganteus	C	P	A	C-A	S	A			
Modiolus modiolus			A	A	C	C	A	S	S
Potamilla neglecta			A	A			C	C	
Halichondria panicea	S				S	A	P	C	C
Balanus rostratus				C	C		S-C	C	C
Dendrodoa pulchella								A	A
Costazia ?surcularis							C	A	A
Metridium senile	S		C		S	S		S	S
Cucumaria miniata			S	S	C	A		C	
C. fallax				S	C	A			
Bidenkapia spitsbergensis					P			C	C
Dendrobeanica murrayana				C	S			C	
Motile Invertebrates									
Evasterias troschelii	S		A		C	S			
Dermasterias imbricata			A			S			
Pycnopodia helianthoides	C	S	A			S			
Orthasterias koehleri	C	P	C			S			
Henricia leviuscula	C		C		S	S			P
Leptasterias polaris acervata				C	S	C	C	P	P
Solaster stimpsoni	S		C	S	S	S		P	
Crossaster papposus	C	P	C	C	C	S	C	P	P
Henricia sanguinolenta	S	P	A		C	C	C	C	P
Fusitriton oregonensis	C		A	C	C	C	C	S	P
Neptunea spp.				C	C	C	S	S	P
Buccinum glaciale				S	S	S	S	S	P
Beringius kennicotti				S	S		S	S	P
Tonicella spp.	C	P	C	C	C	C	C	S	P
Strongylocentrotus drobachiensis	C	C	A	A	C	A	S	S	P

A=Abundant; C=Common; S=Sparse; P=Present

*Parenthetic numbers represent maximum depth of occurrence in this area location where the kelp and Modiolus assemblages strongly overlapped. However, although Modiolus and several other suspension feeders had extremely robust populations, suspension-feeder diversity was not notably high.

The micrograzers Tonicella spp. and the macrograzer Strongylocentrotus drobachiensis were generally common to abundant.

The predator/scavenger component of the southern Kachemak Bay assemblage was generally diverse but, except at Jakolof Bay, exhibited low density. Sea stars were the dominant motile predatory invertebrates. Twelve species have been noted in southern Kachemak Bay; nine of these were common to abundant in subtidal habitats. Sea star densities and standing stocks at Jakolof Bay were among the highest observed in Cook Inlet or Prince William Sound. Fusitriton oregonensis, the only large predatory snail present, was generally common, but densities recorded at Jakolof Bay were quite high. Fish assemblages were fairly well developed; species richness and abundance were moderately high (Rosenthal and Lees 1979).

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 (Table 16). Canopy development, seldom extending past 10 m, was spatially patchy and temporally inconsistent. Although understory kelps were observed out to 16 m, actual beds were generally 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 were among the highest seen, at least 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, the sabellid worms Potamilla and Schizobranchia and 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 reflected accurately in Table 16 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 (Rosenthal and Lees 1976). 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 often, the density of these animals was high. Again, sea stars dominated the component but snails and crustaceans were important. Although about fifteen species of sea star were recorded from the northern shelf, only five were considered common (Table 16). Most important among these seemed to be Leptasterias polaris acervata, Crossaster and Henricia sanguinolenta. Conspicuously sparse were Evasterias, Pycnopodia and Orthasterias. Important predatory snails included 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 (Sundberg and Clausen 1977).

The western Cook Inlet assemblage was characterized by poor or no development of a kelp bed assemblage, no surface canopy species, a diverse, well-developed but thin veneer of sedentary invertebrates, and a moderately developed predator/scavenger component (Table 16). The understory species, Alaria praelonga, A. taeniata, Agarum and Laminaria, were observed to a maximum depth of about 5 m, but were sufficiently dense to form beds only to about 3 m. The depth limitation appeared to be imposed by turbidity as suitable substrate was observed to a depth of 15 m in several locations. However, most rocky surfaces were covered with a moderate dusting of sediments.

The sedentary invertebrate component, although diverse and covering a large proportion of the available rock, generally formed only a thin veneer over the surface. Standing stocks appeared low. The only exceptions were in the few locations where Modiolus and Potamilla beds developed consider-standing stocks (Table 11). Generally, these were not observed below a depth of about 5 m, occurring in or just below the kelp understory. The most important taxa below the kelp beds included the barnacle Balanus rostratus alaskanus, several encrusting, digitate, and laminate bryozoan species, several sponges, including Mycale and Halichondria, and some tunicates, including the social form Dendrodoa pulchella and some species of Synoicum (Table 16). The combination of the barnacles, encrusting digitate and laminate bryozoans and the silt gave this asseblage a dirty, drab, jagged appearance. Generally, encrusting forms such as bryozoans and tunicates were absent in the kelp bed, probably as a consequence of scour by ice and algae.

The microherbivorous chitons Tonicella spp. and the macroherbivorous sea urchin Strongylocentrotus drobachiensis, although frequently observed, were generally less abundant than on the east side of the inlet. This is probably a response to the small quantities of macrophytes available.

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 in this component. Of the eight species of starfish observed, only three were common. These were Leptasterias polaris acervata, Crossaster papposus and Henricia sanguinolenta; Solaster stimpsoni and L. ?hylodes were observed frequently. Most of the sea star species observed were brooders. Four species of predatory snail were observed commonly but densities appeared low (Table 16). The fish assemblage appeared poorly developed in rocky areas on the west side of the inlet; even on habitat that appeared excellent, fish diversity and density was low (Rosenthal and Lees 1979).

The strongest differences among these were between the Kachemak Bay assemblages and the west side assemblage. Although many of the species observed on the west side also were found in Kachemak Bay, especially at Archimandritof Shoals and Bluff Point, the absence there of numerous species dominant in Kachemak Bay and the abundance of numerous species more characteristic of the Bering and Beaufort Seas acted to create a dramatically different appearance. A comparison among the bryozoans reported for Point Barrow and the three assemblages in lower Cook Inlet illustrates this similarity (Table 17). In sharp contrast, the southern Kachemak Bay assemblage includes 20 percent of the bryozoan species dominating at Point Barrow whereas the west side assemblage includes over 65 percent. This is particularly important because most of thse species are erect forms, i.e., either bushy, foliaceous, digitate or head-forming, and therefore contribute a great deal more to biomass and habitat complexity than encrusting species.

Despite the contribution of bryozoans, the suspension-feeding component was most strongly developed in Kachemak Bay, at Jakolof Bay and along the northern shelf. In fact, these areas supported the most diverse, productive suspension-feeding assemblages observed by the authors in the eastern Pacific Ocean. Estimates of total standing stocks or production of suspension feeders have not been made, but would obviously be very high. However, it is probable that standing stocks and productivity of suspension feeders are higher on the west side than at Seldovia Point or Barabara Bluffs, and probably in other typical kelp bed assemblages.

TABLE 17

COMPARISON OF BRYOZOAN ASSEMBLAGES FOR COOK INLET AND POINT BARROW

Dominant Bryozoans off Point Barrow*	Southern Kachemak Bay	Northern Kachemak Bay	West Side of Inlet Kamishak Bay	Other
Eucratea loricata		x	x	xx
Carbasea carbasea		x	x	x
Terminoflustra membranaceo-truncata	x	x	x	x
Bidenkapia spitsbergensis		x	x	x
Tegella magnipora				x
Tricellaria erecta		?	?	
Dendrobeania murrayana	x	x	x	
Hippothoa hyalina			x	x
H. divaricata				
H. expansa				
Stomachetosella sinuosa				
S. distincta				
Ragionula rosacea				
Pachyegis princeps			x	
P. brunnea			x	
Porella compressa		x	x	x
Rhamphostomella gigantea				
R. bilaminata			?	?
Costazia nordenskjoldi			?	
C. surcularis			x	x
C. ventricosa			?	
Myriozoum subgracile		x		
Alcyonidium polyoum		x	x	x
A. disciforme	?			
A. pedunculatum	x	x	x	x
A. enteromorpha			x	x
Flustrella corniculata	x	x	x	x
F. gigantea	x	x	x	x
Bowerbankia gracilis				

*Based on MacGinitie (1955)

Development of the predator/scavenger components bears a direct correspondence to development of the epifaunal component. Densities of a wide variety of predator/scavengers were high at locations with well-developed suspension-feeding components, i.e., Troublesome Creek and Jakolof Bay. A strong qualitative difference in the sea star and snail fauna was obvious as well. Most of the sea stars observed on the west side of the inlet are thought to brood their eggs, rather than produce planktonic larvae. Nearly all of these species were reported from Point Barrow (MacGinitie 1955). Furthermore, only ten of the eighteen species found in Kachemak Bay were observed on the west side of the inlet and five of the missing species are dominant predators in some part of Kachemak Bay.

The conspicuous differences between development of the kelp assemblages were also quite important. The presence of a surface canopy and extension of the kelp assemblage down to at least 12 m in Kachemak Bay (vs. only 4 m on the west side of the inlet) mean that, in addition to influencing the appearance, primary productivity is much higher on rocky habitats in Kachemak Bay than on the west side of the inlet.

B. BIOLOGY OF MODIOLUS

A comparison of the size-frequency histograms for Modiolus indicates the occurrence of two general population types. Type 1 populations comprised significant quantities of both young and old individuals and Type 2 populations were almost totally dominated by old animals. However, nearly all populations were strongly dominated by older adult animals and it appears that, in contrast to the massive annual recruitment observed in Mytilus, annual recruitment is generally small and unpredictable for Modiolus; a population with a large proportion of juveniles was never observed. Size (and age) structure and development of the population in terms of biomass and density suggest that Type 1 populations are the most stable or viable, and that the areas in which they occur are presently the most suitable for Modiolus. The paucity of juveniles suggests that Type 2 populations are senescent or predator-dominated.

The importance of Modiolus in lower Cook Inlet cannot be assessed without better knowledge of its distribution. However, based on anecedotal reports from several halibut fishermen and other scientists (Driskell and Lees 1977; Bouma et al. 1978), Modiolus is common in 25 to 50 m of water on the northern shelf of Kachemak Bay, along the east side of inlet between Anchor Point and Ninilchik, and east of Chinitna Bay. Some of these areas are favored by commercial halibut fishermen, implying that halibut aggregate there. This is understandable if crustaceans are as common in deeper Modiolus beds as was observed off Bluff Point; crustaceans constitute a sizable proportion of the diet of halibut. Furthermore, migration "routes" of king and tanner crabs seem to pass through several suspected or known Modiolus beds in Kachemak Bay.

In any event, in terms of biomass and secondary production, Modiolus must be among the most important species on subtidal rocky or mixed coarse substrates. No other subtidal suspension feeder has been observed to contribute as much to standing stocks over as large an area, or is suspected of having such high productivity.

C. TROPHIC STRUCTURE OF INVERTEBRATE ASSEMBLAGES ON ROCKY SUBSTRATES IN LOWER COOK INLET

A comparison of the generalized food webs constructed for the three major shallow water rock bottom assemblages in lower Cook Inlet indicates basic similarity but some important differences (Figures 13 and 14). The two assemblages from Kachemak Bay, in particular, are quite similar. The main differences are probably quantitative; kelp assemblages on the south side of Kachemak Bay produce greater quantities of plant materials (Lees et al. 1979), thus contributing more energy to detrital reserves in other locations (e.g., deep benthic assemblages, sand beaches or mud flats). On the other hand, suspension-feeding and predator/scavenger components on the north side of Kachemak Bay are better developed (Table 16; Rosenthal and Lees 1976; Lees and Houghton 1977). Both assemblages contribute considerable quantities of plant, suspended and dissolved organic material to the consumer

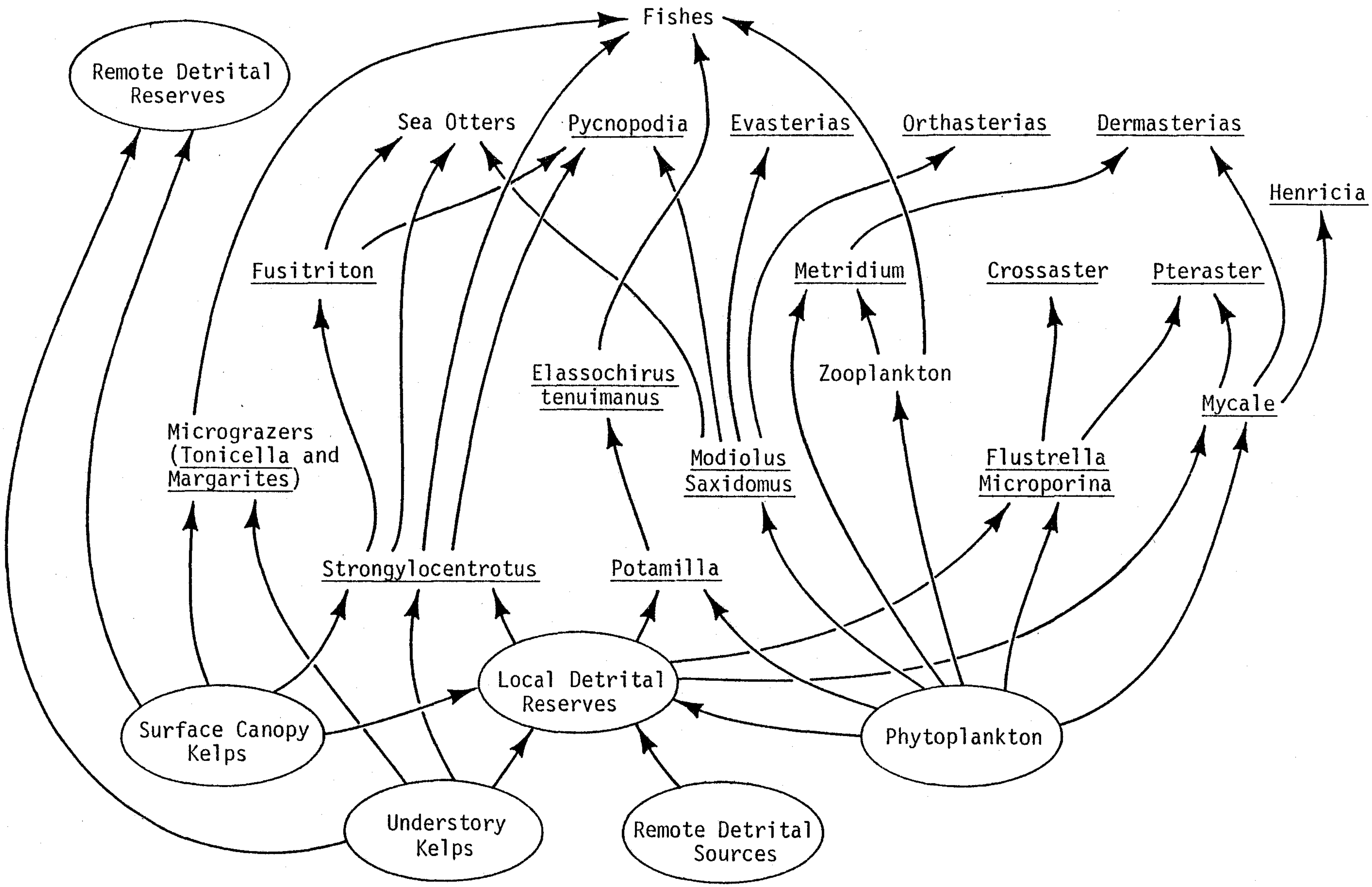


FIGURE 13

GENERALIZED FOOD WEB FOR THE SHALLOW SUBTIDAL ASSEMBLAGE IN THE SOUTHERN KACHEMAK BAY

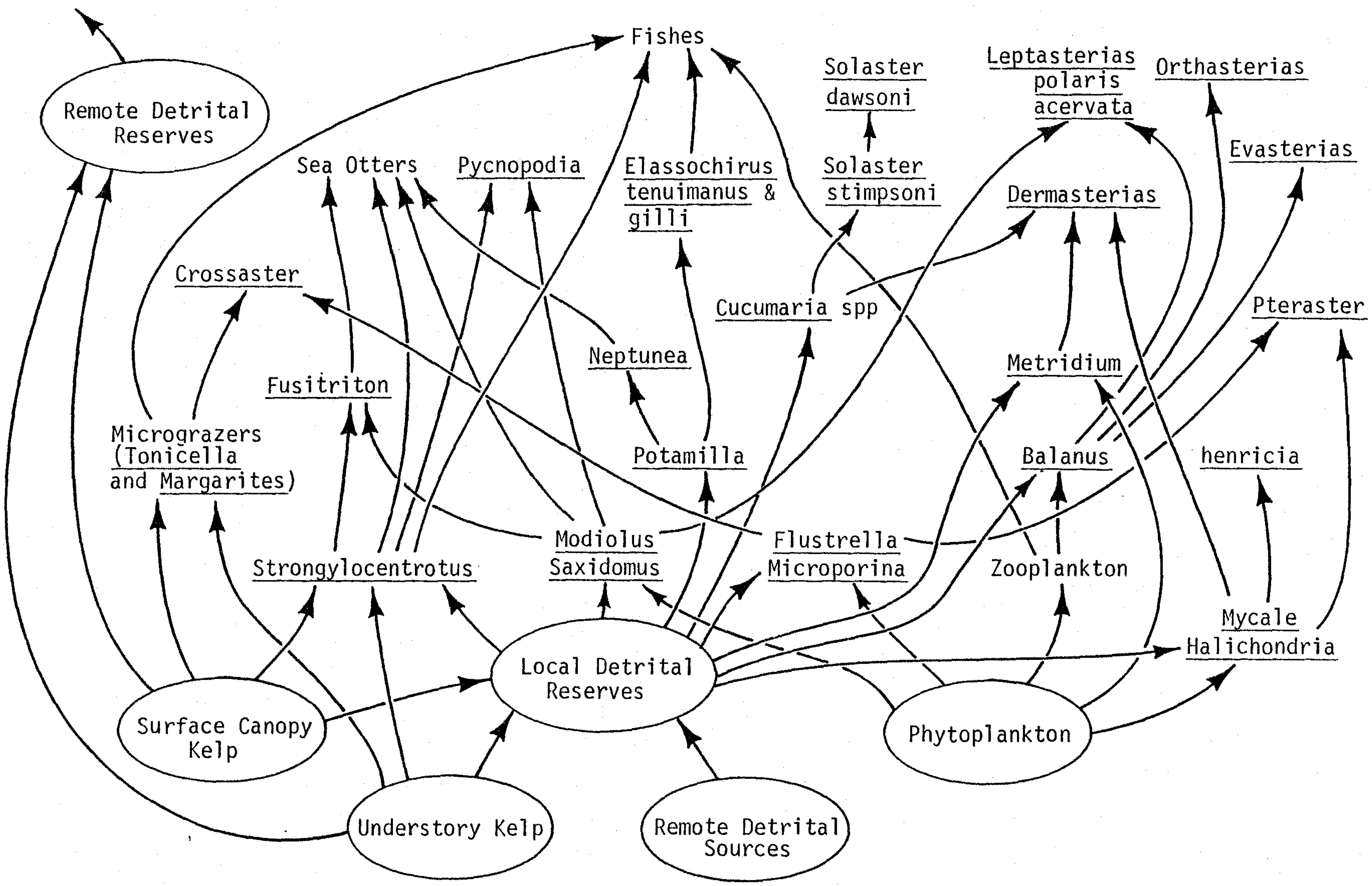


FIGURE 14

GENERALIZED FOOD WEB FOR THE SHALLOW SUBTIDAL ASSEMBLAGE ON THE NORTHERN SHELF OF KACHEMAK BAY organisms of lower Cook Inlet. In both cases, the suspension-feeding assemblage probably depends very heavily on organic materials of marine origin. However, the proportion of terrigenous materials in the water mass is probably substantially higher on the north side of Kachemak Bay. Because of prevailing currents and productivity patterns, the quantity of organic debris available to suspension feeders is probably higher on the northern shelf than on the southern side, except at sites like Jakolof Bay. Water passing through Kachemak Bay picks up organic materials from the estuaries, rivers and the high phytoplankton production in Kachemak Bay. It also picks up a substantial quantity of suspended sediments in its progress through the bay. These conditions promote microbial activity and flocculation. These waters move rapidly across the northern shelf of the bay, providing great quantities of suspended organic matter to the suspension feeders living there. The differences in the development of kelp assemblages are also important in explaining the differences in the development of the suspension-feeding assemblages. The heavy growth of kelps along much of the south side of Kachemak Bay substantially decreases the current velocity in the kelp beds; this is particularly noticeable in the understory near the dense kelp bed between Seldovia and Barabara Point where tidal currents are greatly reduced. The effect of this on suspension feeders is to reduce the amount of food to which they are exposed. This factor and the relative paucity of organic matter in the impinging oceanic water mass are probably the major factors responsible for the poor development of the suspension-feeding assemblage on the south shore of Kachemak Bay. The extraordinary development of suspension feeders at Jakolof Bay (>10 kg tissue/m^2) is probably due to its proximity to the rich, estuarine embayment, the strong tidal currents resulting from the constricted entrance, and fact that the kelp bed is not large enough to produce an effective reduction in current velocity. On the northern shelf, however, current velocity is essentially unimpeded by the poorly-developed, scattered kelp beds (personal observation). Thus, the nutrient-rich waters leaving Kachemak Bay are more directly in contact with the suspension feeders and exposure to food particles is greater.

Despite the basic similarity between the food web for the west side of the inlet (Figure 15) and those for Kachemak Bay, some strong qualitative

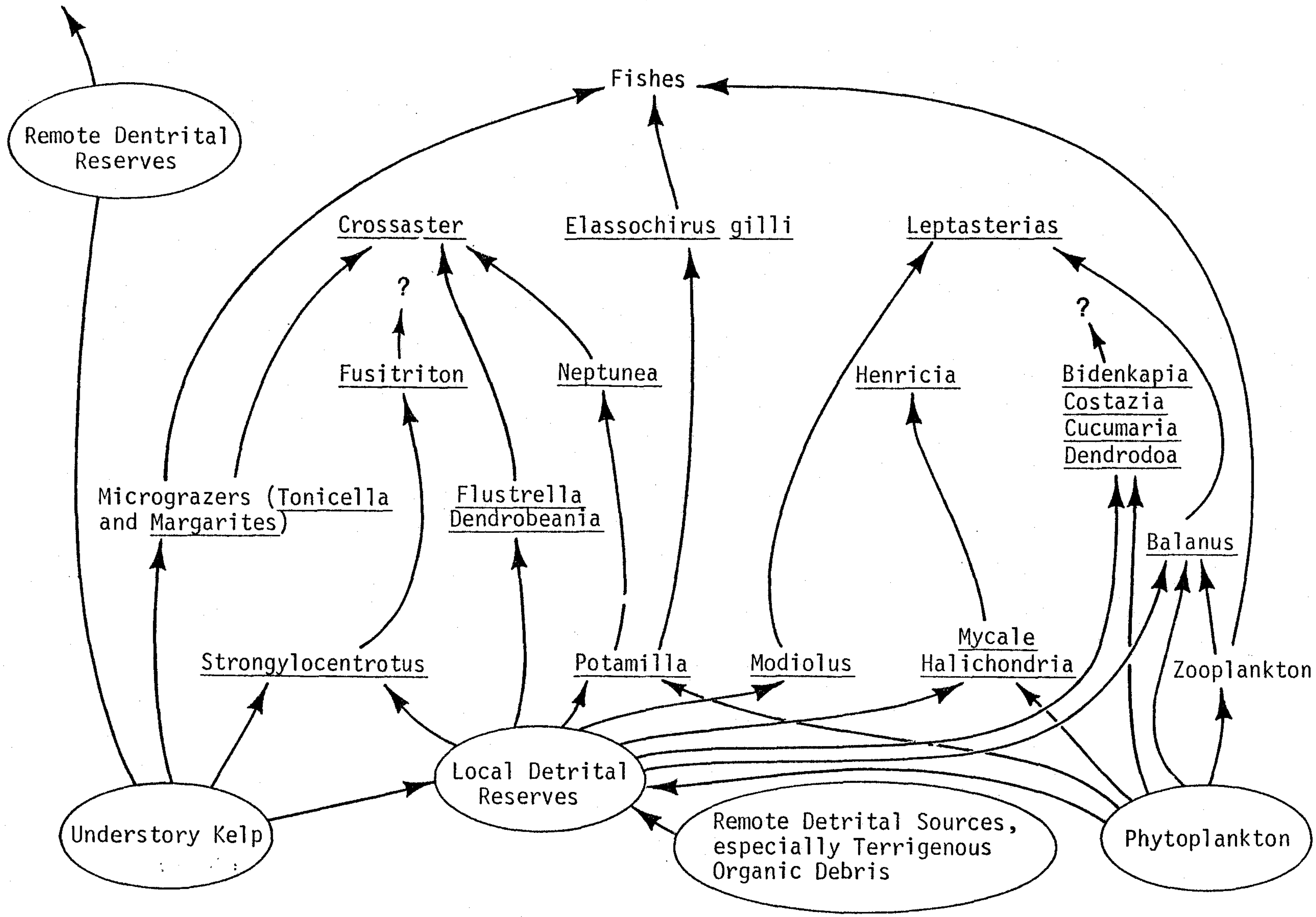


FIGURE 15

GENERALIZED FOOD WEB FOR THE SHALLOW SUBTIDAL ASSEMBLAGE ON THE WEST SIDE OF LOWER COOK INLET and quantitiative differences are apparent. The contribution of the kelp assemblage to remote detrital reserves is much smaller; probably a greater proportion of the available detrital material is terrigenous. This is a consequence of the numerous rivers, especially the Susitna River, which also contributes considerable fresh water to the water mass of Cook Inlet. Also, based on the generally poor development and limited standing stocks of the suspension-feeding assemblages observed on the west side of the inlet, the quantity of available detritus is probably considerably smaller than on the northern shelf in Kachemak Bay. Larrance and Chester (1979) reported that phytoplankton contribution to the benthos was lower in Kamishak Bay. Both density and species richness of predator/ scavenger component, including fishes, are generally rather impoverished on rocky substrates.

The food webs exclude the relationships and effect of several important groups within the various trophic levels because of inadequate information. The effects of migratory crustaceans such as king and dungeness crabs have not been considered because they have not been encountered in the study areas. However, commercial fishing activities suggest that these species pass through some of the areas examined, especially along the northern shelf of Kachemak Bay. It is probable that they feed on at least some of the dominant suspension feeders listed. Fishes have been considered by other studies (Rosenthal and Lees, 1979; Blackburn, 1977) and so were omitted from this discussion. However, it should be noted that fish on rocky habitats are important consumers of crustaceans such as amphipods, isopods, shrimp, small crabs and hermit crabs, and small snails (Rosenthal and Lees 1979). Marine birds have also been examined in other projects and so have not been discussed in detail. Generally, diving birds are reported to concentrate on small molluscs, crustaceans and fishes (Sanger, Jones, and Wiswar 1979, David Erikson, personal communication, Paul Arneson, personal communication). Many of the inshore birds feed on benthic forms of fish and crustaceans. Finally, a number of the less conspicuous predators and scavengers have not been examined or considered. The influence of micro-grazers such as limpets and chitons is not clear in these habitats but may be substantial in the determination of algal development (Smith, 1968, Nelson-Smith, 1972). The influence of small predatory snails, crustaceans and polychaetes is unknown in these habitats; because of their abundance, they could be very important as predators on larval, juvenile or young forms of the dominant species, and could be important to energy flow as well as species composition.

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

The susceptibility of the assemblages described above 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), 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 (1979). Although some data are available for some of the species considered important in the three main rocky subtidal assemblages, in fact, very little is known directly and 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.

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 Iliamna Bay 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 1976; 1979). Exposure at these sites would generally occur in 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. Additional areas of concern are near Harriet Point, Anchor Point and on the NE quadrant of

Augustine Island. An important finding of the 1979 study was that the trajectories 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 1979).

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 Kamishak Bay and on the northern side of Kachemak Bay (NAS 1975). As a consequence, the benthic assemblages on the west side of lower Cook Inlet have a greater vulnerability to exposure than in Kachemak Bay, where the northern shelf assemblages are at greatest risk. 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 great water clarity would tend to minimize the amount and duration of contact.

2. Sensitivity to Oil

a. Southern Kachemak Bay Assemblage

The southern Kachemak Bay subtidal assemblage is dominated heavily by kelps, which are generally 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 to the epifauna. The red algae that do occur might be seriously effected, however, (Smith 1968). Herbivores moderately abundant in this assemblage, are fairly sensitive to oil exposure (Rice et al. 1979; Smith 1968; Nelson-Smith 1972). Thus, in the event of a large spill, moderate damage to the herbivore component might occur. The suspension-feeding and predator/scavenger components although probably fairly sensitive to oil exposure, are generally poorly developed except at Jakolof Bay. Thus, damage to the assemblage would be slight, except at Jakolof Bay. At sites like Jakolof Bay, however, suspension-feeding and predator/scavenger components are exceptionally well-developed and complex and, although little is known about the sensitivity of the species comprising the components, subtidal clams, starfish, and snails may be moderately sensitive (Rice et al. 1979; Smith 1968; Nelson-Smith 1972) and thus considerable damage could occur.

Recovery times in these systems would vary. The initial results in a "standard" kelp bed, because of a reduction in grazing pressure and reduced competition for space beetween suspension-feeders and kelps, would probably lead to increased plant production. Although development of the herbivore component in this assemblage 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 areas. Therefore, recovery of the herbivore populations probably could require between five and ten 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 the kelp because of reduced consumption of spores, as suggested by North et al. (1964), and increased availability of 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, 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-sized clams (Baxter 1971). Thus, it is still possible to examine the density and size structure of the pre-quake populations. Densities and size structures of pre-earthquake populations, examined in many uplifted areas during the summer of 1979, indicate that, although limited recruitment is occurring in these areas, attainment of the previous high densities and large average shell size has not occurred and 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.

b. Northern Kachemak Bay Assemblage

The kelp component of the northern Kachemak Bay 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 oil spill in this area could have a severe effect upon the appearance and productivity of the assemblage. 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 exhibit moderate to severe damage. Because the overlying waters in this area are characteristically somewhat turbid, a substantial proportion of the oil entering the area would be adsorbed and enter the water column; the turbulence characteristic of the area would then tend to bring much of this oil into contact with that substrate and the benthic animals. This is of special concern since this area appears to be 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 crab may be moderately sensitive to damage from crude oil and that subtidal animals are more sensitive than their intertidal counterparts. Crustaceans, which constitute a large proportion of the predator/scavenger component of this shelf, and, to a lesser extent, sea stars, 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 because of decreased competition for space and grazing pressure; thus primary production might increase. However, the loss of the robust suspension-feeding component probably would result in reduced secondary production for a period of time.

Recovery time would probably be substantial. North et al. (1964) reported that the subtidal epifaunal assemblage or a kelp bed was far from recovery seven years after a catastrophic spill of diesel oil. Mann and Clark (1978) estimated recovery of a bed assemblage kelp 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.

c. Assemblage from 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, although the herbivore component generally is poorly developed, 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. Sensitivity to oil for the suspension-feeding component at the upper level probably is pretty similar to that predicted for Jakolof Bay, but the amount of impact would be less in the event of a spill on the west side of the inlet because of poorer development. Subtidally, the damage to the suspension-feeding and predator/scavenger components probably would be very great. Because of high turbidity year-round, a large proportion of the oil entering the area following a spill would 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. 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 following a major spill would probably require at least 25 years. The assemblages are dominated by high arctic species, growth rates are probably low and many of the species are brooders, implying that recolonization 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 only slowly.

3. Specific Activities or Developments

Exploration and development of an oil field involve 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.

a. Drilling Platforms

The projected locations of exploratory drilling rigs in lower Cook Inlet (Warren 1978) are indicated in Figure 16. 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. Potential effects of an acute oil spill have been discussed generally for Kennedy Entrance, Kachemak and Kamishak Bays in Section VII.D.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 similar; 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 Sanctuary 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 (Lees et al. 1979a). King crab enter the shallow habitats in February to molt and breed; they remain for several months. 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

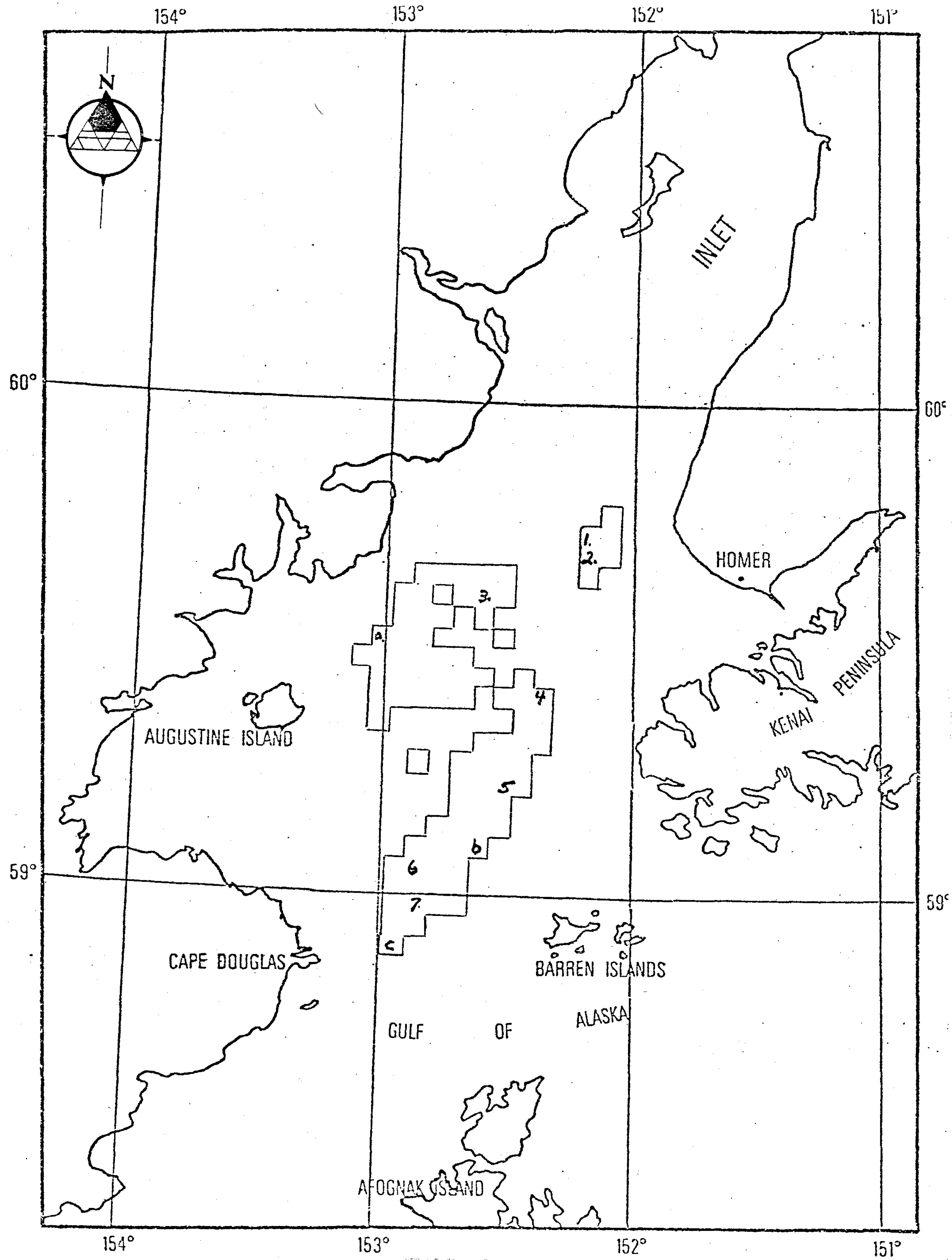


FIGURE 16

PROJECTED LOCATIONS OF EXPLORATORY DRILLING RIGS AND POTENTIAL SPILL LOCATIONS IN LOWER COOK INLET THROUGH 1979

(from Warren, 1978)

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.

Several organisms perceived by regulatory or decision-making agencies as "key" species occur periodically in the shallow subtidal rocky habitats; most 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 Section VII.D.2, and further discussion would be repetitious.

b. Shore-based Facilities and Tanker Terminals

Potential new locations of shore-based facilities and tanker terminals (Warren 1978) are indicated in Figure 17. 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 (disposal of production water) and at tanker terminals (disposal of ballast water and numerous minor spills).

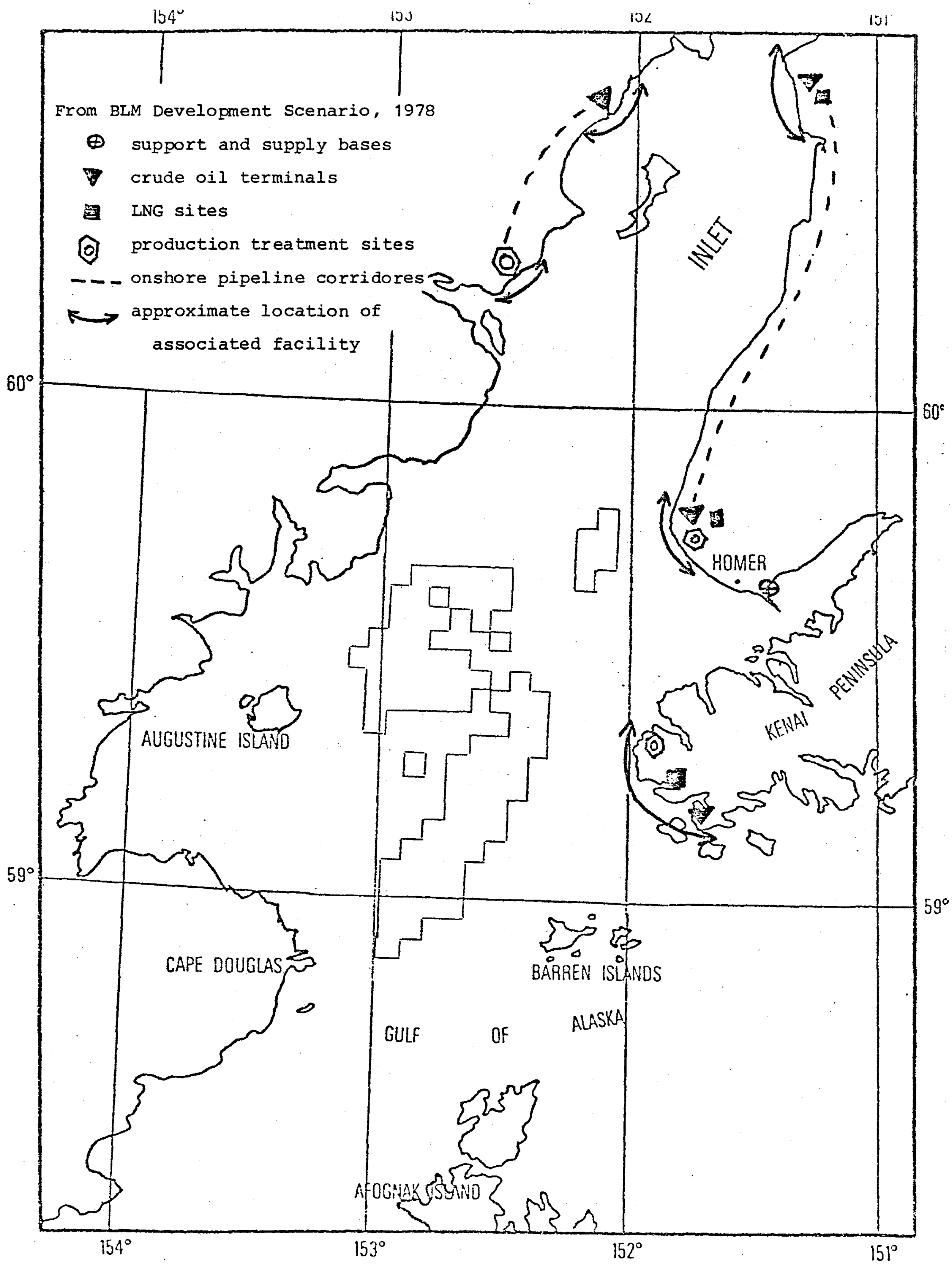


FIGURE 17

POTENTIAL LOCATIONS FOR ONSHORE FACILITIES ASSOCIATED WITH OIL EXPLORATION, DEVELOPMENT AND PRODUCTION IN LOWER COOK INLET

(from Warren, 1978)

Although the 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 (Lees 1977). Furthermore, these assemblages would probably 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 VII.D.2. The extreme turbulence of this area would probably 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, but large concentrations of larvae (Haynes 1977) suggest that it also 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 VII.D.2.

c. 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 18 (Warren 1978). The only areas in which pipelines might affect shallow subtidal rocky habitats are in Kennedy Entrance and at Anchor Point. Pipelines would have to cross wide bands of rocky substrate in both locations (about 5 km and 10 km, respectively).

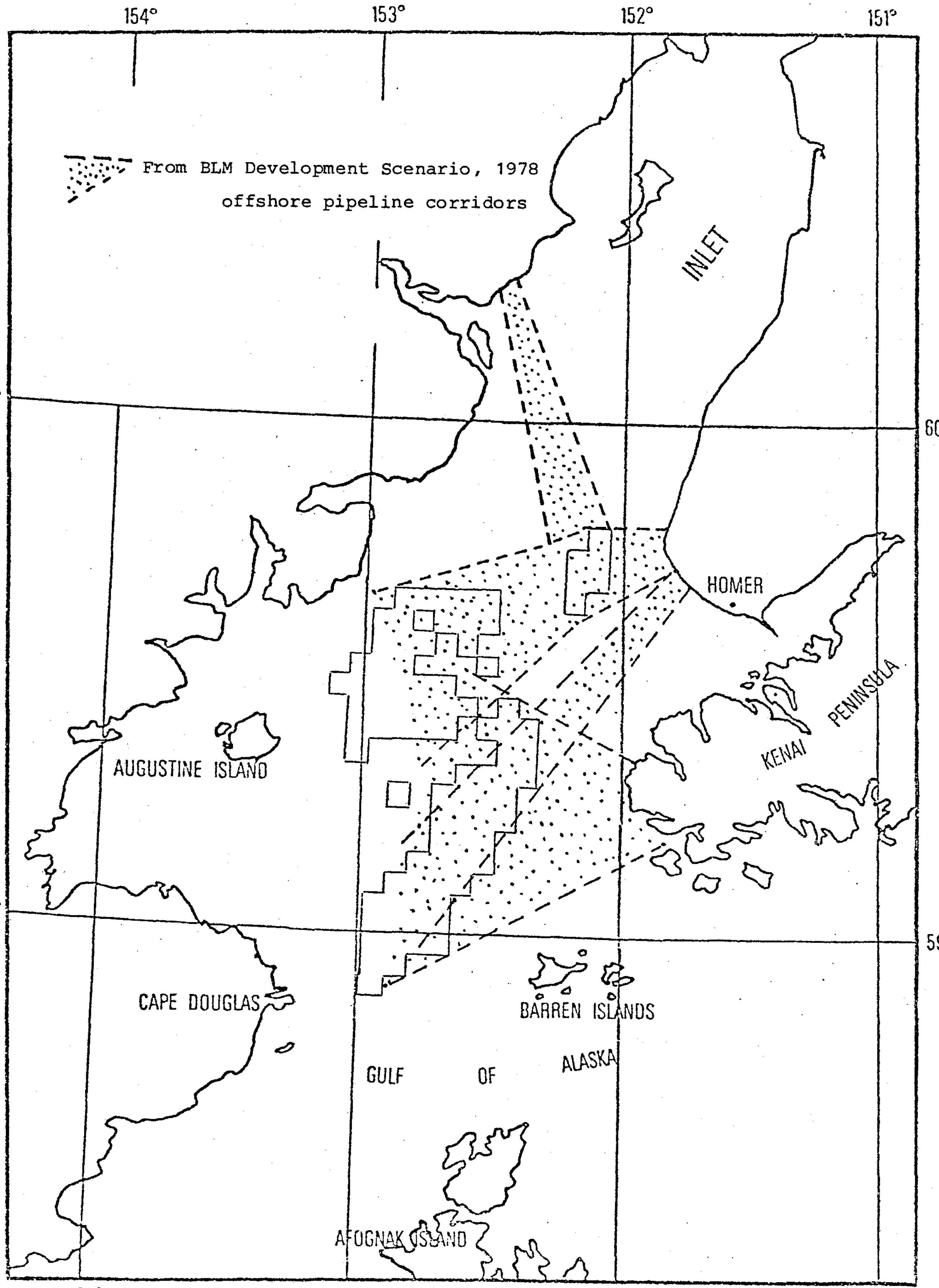


FIGURE 18

POTENTIAL OFFSHORE PIPELINE CORRIDORS IN LOWER COOK INLET

(from Warren, 1978)

Activities associated with laying pipelines (blasting and dredging) would be restricted to pipeline routes and thus would affect rather limited areas.

A break 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 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 be actively mixed with water and sediment particles as it rose to the surface. 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.

d. 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, 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.

VIII. CONCLUSIONS

A. The three basic assemblages delimited in rocky, shallow subtidal habitats in lower Cook Inlet were generally geographically distinct.

1. The southern Kachemak Bay assemblage was generally characterized by a dense, well-developed, productive kelp component, a moderately well-developed sparse to abundant herbivore component, and poorly to well-developed suspension-feeding and predator/scavenger components. The kelp component included a well-developed surface canopy of *Alaria fistulosa* and/or *Nereocystis luetkeana*, and understory kelps extending deeper than 20 m. Factors influencing species composition and structure probably include strong tidal currents, and the oceanic characteristics of the water mass, i.e., the low concentrations of suspended solids and detritus, and high variability in suspended organic materials.

2. The northern Kachemak Bay assemblage was characterized by a moderately well-developed kelp component, a moderately well-developed and dense herbivore component, a moderate to massive development of the suspension-feeding component, and a well-developed predator/scavenger component. Surface canopies are patchy in time and space and understory kelps are common only to about 15 m. Species composition of the predator/scavenger component differs strongly on the northern and southern sides of Kachemak Bay. Factors that influence species composition and structure probably include the strong tidal currents, the moderate turbidity and dependable, abundant supply of suspended organic materials, and the density of herbivores.

3. The western Cook Inlet assemblage was characterized by poor development of the kelp component or its absence, a moderately diverse but sparse herbivore component, a complex, but thinly developed suspension-feeding component, and a poorly developed predator/scavenger component. The kelp component lacks a surface canopy and extends only slightly below 3 m. Factors influencing species composition and structure probably include ice scour, high turbidity, low salinity, seasonal alteration in periods of turbulence, sediment deposition and abrasion.

4. Rocky, shallow subtidal assemblages in Kachemak Bay (and probably Kennedy Entrance) (the southeastern quadrant of lower Cook Inlet) differ strongly from those observed in Kamishak Bay and at other locations examined on the western side of lower Cook Inlet. Fundamental differences are apparent in species composition, primary and secondary production, and probably exist in the level of complexity development, i.e., the level of succession attained.

5. Assemblages in the southeastern quadrant are closely allied to others in the northeastern Pacific Ocean whereas assemblages on the western side of lower Cook Inlet are more closely allied with assemblages described for the Bering and Beaufort Seas. No evidence is available to indicate a connection between the populations in lower Cook Inlet and the Bering Sea, so it appears that this assemblage may be a relict of an earlier geological period when sea level was appreciably higher.

6. The data base for Kennedy Entrance and the Barren Islands is insufficient.

B. The large horse mussel, *Modiolus modiolus*, an important, widespread suspension feeder on current-swept, cobble, gravel and bedrock, habitats bathes with turbid water. It is often found in association with high densities of several other suspension feeders.

1. *Modiolus* has been observed or reported in dense beds out to a depth of at least 40 m on the northern shelf of Kachemak Bay, along the eastern side of lower Cook Inlet between Anchor Point and Ninilchik, east of Chinitna Bay, and in low intertidal and shallow subtidal rocky habitats in northern Kamishak Bay out to a depth of about 5 m. A dense bed of *Modiolus* was observed in the entrance to Jakolof Bay but otherwise appeared uncommon on the southern side of Kachemak Bay.

2. Based on a comparison of size structures, the populations sampled were separated into two categories, i.e., bimodal Type 1 populations,

in which large adults dominated but juvenile or younger animals were common, and unimodal Type 2 populations, in which the population was limited to very large adults. Type 2 populations were only observed on the northern shelf of Kachemak Bay. In all populations, size structures indicated that recruitment rates were slow.

3. The starfish Evasterias troschelii, Orthasterias koehleri and Pycnopodia helianthoides appear to be the most important invertebrate predators on Modiolus. In the Jakolof Bay bed, these three species probably consume nearly 20 percent of the population. Although prey size is directly correlated with predator size, effort is biased toward Modiolus smaller than 65 mm shell length; approximately half the animals consumed are below 65 mm shell length whereas only about a third of the source population is below this size.

4. Based on the feeding observations at Jakolof Bay, the P:B ratio is somewhat less than 0.5, but production approaches 2 kg wet tissue/year.

C. Starfish, among the most important invertebrate predators in lower Cook Inlet, could be separated into three categories on the basis of food selection.

1. Henricia spp. appeared to specialize on sponges, although the validity of this observation is still somewhat questionable.

2. Pteraster and Dermasterias appeared to specialize on soft-bodied forms such as sponges, cnidarians, bryozoans, and tunicates, although Dermasterias is also known to feed on sea urchins.

3. Members of the genus Solaster fed on soft-bodied invertebrates but concentrated on other echinoderms, especially other starfish and sea cucumbers.

4. The last group, species with broad dietary selectivity, included Evasterias, Pycnopodia, Orthasterias, Leptasterias polaris and Crossaster. These species fed on a broad variety of mollusks and barnacles; many of the prey items were community dominants.

5. Groups 1, 2, and 3 comprised only starfish from the order Spinulosa whereas Group 4 comprised mainly forcipulate starfish.

D. The vulnerability of the shoreline to oil exposure in the event of a catastrophic oil spill is highest on the west side of lower Cook Inlet, especially from Chinitna Bay to Ursus Cove, intermediate on the northern shelf of Kachemak Bay, and low on the southern side of Kachemak Bay, and probably in Kennedy Entrance and on the Barren Islands; however, little information is available for Kennedy Entrance and the Barren Islands.

1. The most highly sensitive faunal assemblages probably are located on the northern shelf of Kachemak Bay and on the western side of lower Cook Inlet. The richest assemblages were observed on the northern shelf, and these assemblages would probably require the longest period of time to recover from damage. Except at Jakolof Bay, the southern side of Kachemak Bay was mainly dominated by kelp assemblages which have been generally recognized as fairly tolerant to the effects of acute oil spills. This situation is probably true in Kennedy Entrance and the Barren Islands.

2. Recovery of the shallow subtidal assemblages on rock habitats might require from five to ten years at most sites on the southern side of lower Cook Inlet to more than 20 years on the northern shelf of Kachemak Bay and on the western side of lower Cook Inlet. Because of the possibility that the latter assemblage is a relict, having a disjunct distribution from the Bering Sea and includes many species without planktonic larvae, recovery could require an extremely long time.

3. The main impact of concern from drilling platforms would be an acute oil spill, which could affect all of lower Cook Inlet as described

above. The main impacts of concern from shore-based facilities and tanker terminals are chronic and acute spills. In view of projected siting of such facilities, the main areas of concern are in Kennedy Entrance, in Kachemak Bay, and near Anchor Point. Because of the high degree of turbulence in these locations, chronic contamination may be of little importance. The most serious concern associated with underwater pipelines would be the possibility of a break, which could constitute an acute spill, but be more severe because of the release and subsequent mixture of large quantities of raw, unweathered crude oil into the water column in locations where mixing would be great. This could be extremely damaging to the benthic assemblages and planktonic larvae on the northern shelf of Kachemak Bay, where the higher turbidity of the water mass would increase the amount of oil retained in the water column.

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X. APPENDICES

APPENDIX A-1 COVER AND ABUNDANCE DATA FOR ARCHIMANDRITOF SHOALS; 28 JUNE 1978. ¼ M^2 SQUARE QUADRATS FROM 4.6 M BELOW MLLW

TAXA						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta							
Agarum cribrosum	(%)	0	10%	10%	15%	8.8 ± 6.3%	
		0	1	0	1	0.5 ± 0.6	2.0
ALGAE - Rhodophyta							
Coralline alga, encrusting	(%)	40%	40%	30%	60%	42.5 ± 12.6%	
INVERTEBRATA							
Abietinaria spp.	(%)	5%	T	0	3%	2.1 ± 2.3%	
Leptasterias polaris acervata		0	1	0	0	0.3 ± 0.5	1.0
Modiolus modiolus		2	8	4	4	4.5 ± 2.5	18.0
Potamilla ?reniformis	(%)	55%	45%	70%	40%	52.5 ± 13.2%	
Saxidomus giganteus		8	2	4	9	5.8 ± 3.3	23.0
Schizoplax brandtii		1	0	0	2	0.8 ± 1.0	3.0
Strongylocentrotus drobachiensis		13	12	10	12	11.8 ± 1.3	47.0
Tonicella lineata		5	3	1	12	5.3 ± 4.8	21.0
Trichotropis cancellata		1	0	0	0	0.3 ± 0.5	1.0

EXTRALIMITAL SPECIES:

ALGAE

Constantinea simplex
Desmarestia aculeata
Hildenbrandia sp
Nereocystis luetkeana
Pterosiphonia ?baileyi
Schizymenia sp

INVERTEBRATA

Abietinaria gigantea
A. kincaidi
Acmaea mitra
Buccinum glaciale
Cryptochiton stelleri
Elassochirus gilli
E. tenuimanus
Hyas lyrata
Neptunea lyrata
Owenia collaris
Panomya ampla
Pododesmus macroschisma
Pugettia gracilis
Sertularella reticula

CHORDATA

Lepidopsetta bilineata

Substrate: *Modiolus* bed, cobble with scattered boulders.

APPENDIX A-2a   ABUNDANCE DATA FOR ARCHIMANDRITOF SHOALS; 28 JUNE 1978. 1 x 5 M^2 CONTIGUOUS QUADRATS FROM 6.7 M BELOW MLLW

TAXA	Frequency						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta								
Agarum cribrosum, adult	0	1	0	0	1	0	0.3 ± 0.5	0.1
A. cribrosum, juvenile	2	2	3	3	2	1	2.2 ± 0.8	0.4
Laminaria groenlandica, juvenile	2	1	3	5	7	1	3.2 ± 2.4	0.6
Nereocystis luetkeana, juvenile	1	3	1	5	2	0	2.0 ± 1.8	0.4
INVERTEBRATA								
Crossaster papposus	0	1	0	1	0	0	0.3 ± 0.5	0.1
Fusitriton oregonensis	0	4	1	7	0	0	0.2 ± 2.9	0.4
Leptasterias polaris acervata	0	0	0	1	0	0	0.2 ± 0.4	0.03
L. ?hylodes	0	0	0	1	0	0	0.2 ± 0.4	0.03
Neptunea lyrata	1	4	0	1	0	0	1.0 ± 1.5	0.2
Solaster stimpsoni	0	0	0	0	1	0	0.2 ± 0.4	0.03

EXTRALIMITAL SPECIES:

ALGAE

Coralline alga, encrusting
Desmarestia aculeata
Pterosiphonia baileyi
Rhodymenia pertusae

INVERTEBRATA

Abietinaria gigantea
Acmaea mitra
Archidoris sp
Buccinum glaciale
Cribrinopsis similis
Crucigera zygophora
Cryptochiton stelleri
Elassochirus gilli
E. tenuimanus
Golfingia margaritacea
?*Hymedesanisochela* sp
Lebbeus grandimanus
Modiolus modiolus
Mycale lingua
Natica clausa
Oenopota spp
Oregonia gracilis
Owenia collaris
Pododesmus macroschisma
Psolus chitonoides
Saxidomus giganteus
Thelepus ?cincinnatus
Tonicella insignis
T. lineata
Trichotropis cancellata
T. insignis

Substrate: *Modiolus* bed, cobble matrix with scattered boulders; seaweed sparse

APPENDIX A-2b ABUNDANCE DATA FOR SELECTED SPECIES FROM ARCHIMANDRITOF SHOALS; 28 JUNE 1978

TAXA	Frequency										$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA												
Modiolus modiolus	18	8	13	26	14	20	16	21	5	17	15.8 ± 6.2	63.2
Quadrat Size (m): ½ x ½ Depth below MLLW (m): 9.1												
Strongylocentrotus drobachiensis			35	34	43	38	25	30			34.2 ± 6.2	13.7
Quadrat Size (m): 0.5 x 5 Depth below MLLW (m): 6.7												
CHORDATA												
Cottidae, unid.						1						0.03
Lepidopsetta bilineata						1						0.03
Quadrat Size (m): 1 x 30 Depth below MLLW (m): 6.7												

APPENDIX A-3a FISH ABUNDANCE DATA FOR ARCHIMANDRITOF SHOALS; 10 JULY 1978. TWO 1 x 25 M^2 QUADRATS FROM 15.5 M BELOW MLLW

TAXA	Frequency		Density (no./m^2)
Fish	0	0	0

EXTRALIMITAL SPECIES:

ALGAE - Rhodophyta

Coralline alga, encrust.
Rhodymenia palmata

INVERTEBRATA

Abietinaria giganteus
Abietinaria spp - C[a]
Balanus rostratus alaskanus - juv. common
Boreotrophon ?stuarti
Buccinum glaciale - C
Calycella syringa
Campanularia verticillata
Cancer oregonensis - C
Chlamys ?hastatus - C
Crepidula nummaria - C
Cryptobranchia concentrica - A[b]
Dendrobeania murrayana - C
Dendronotus ?dalli - S
Elassochirus gilli - S
E. tenuimanus - C
Flustrella gigantea - C
Fusitriton oregonensis - C
Halecium muricatum
Halocynthia aurantia - S[c]
Henricia sanguinolenta
Hyas lyrata
Ischnochiton albus
I. ?trifidus - S
Lafoea fruticosa
Leptasterias polaris acervata
L. ?hylodes
Modiolus modiolus - A
Musculus discors - S
Mycale lingua - C
Myxicola infundibulum
Natica clausa
Neptunea lyrata - C
Ophiopholis aculeata - C
Oregonia gracilis - C
Pagurus ?dalli - A
P. trigonocheirus
Pandalidae, unid. - S
Pododesmus macroschisma - C
Pteraster tesselatus
Serripes laperousii
Solaster dawsoni
Suberites ficus
Terminoflustra membranaceo truncata
Thuiaria articulata - C
T. carica
T. distans
Tonicella insignis
Trophonopsis lasius

CHORDATA

Cottidae, unid. - 3
Lepidopsetta bilineata - 2

Substrate: Silty cobble with scattered boulder and mounds of Modiolus modiolus

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[a] C = Common
[b] A = Abundant
[c] S = Sparse

APPENDIX A-3b ABUNDANCE DATA FOR *MODIOLUS MODIOLUS* FROM ARCHIMANDRITOF SHOALS; 10 JULY 1978. ¼ M^2 SQUARE QUADRATS FROM 15.5 M BELOW MLLW

TAXA	Frequency										$\bar{x} \pm s$	Density (no./m^2)
Modiolus modiolus	54	93	37	33	4	21	32	19	22	21	33.6 ± 24.7	134.4

EXTRALIMITAL SPECIES:

INVERTEBRATA

- *Abietinaria* spp - common
- *Balanus* spp - common
- *Crossaster papposus*
- *Dendronotus dalli*
- *Fusitriton oregonensis*
- *Halocynthia aurantia*
- *Mycale lingua* - common
- *Pteraster tesselatus*
- *Solaster* sp
- *Trichotropis cancellata*
- *Triopha carpenteri*

CHORDATA

- *Lepidopsetta bilineata*
- ?*Myoxocephalus* sp

APPENDIX B-1 ABUNDANCE DATA FOR BLUFF POINT SUBTIDAL AREA; 31 JULY 1978. ¼ M^2 SQUARE QUADRATS FROM 10.1 M BELOW MLLW

TAXA		Frequency							$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta										
Agarum cribrosum	(%)	0	2%	0	0	0	0	0	0.3 ± 0.8%	
		0	1	0	0	0	0	0	0.1 ± 0.4	0.6
ALGAE - Rhodophyta										
Coralline alga, encrusting	(%)	70%	40%	30%	70%	60%	75%	80%	60.7 ± 18.8%	
Hildenbrandia sp	(%)	10%	0	10%	20%	0	20%	0	8.6 ± 9.0%	
Rhodophyta, foliose	(%)	5%	5%	0	10%	0	0	0	2.9 ± 3.9%	
INVERTEBRATA										
Abietinaria sp	(%)	0	0	0	0	5%	0	15%	2.9 ± 5.7%	
Acmaea mitra		0	0	2	0	0	0	0	0.3 ± 0.8	1.1
Alcyonidium pedunculatum	(%)	0	0	2%	0	0	0	0	0.3 ± 0.8%	
Calliostoma ligatum		0	0	P	0	0	0	0	-	P
Campanularia sp	(%)	0	2%	0	0	2%	5%	0	1.3 ± 1.9%	
Cancer oregonensis		0	1	0	0	0	1	0	0.3 ± 0.5	1.1
Elassochirus gilli		0	1	0	0	0	0	0	0.1 ± 0.4	0.6
Flustrella gigantea	(%)	15%	5%	2%	30%	15%	15%	0	7.9 ± 6.8%	
Fusitriton oregonensis		0	1	0	1	0	0	0	0.3 ± 0.5	1.1
Henricia sanguinolenta		1	0	0	0	0	0	0	0.1 ± 0.4	0.6
Heteropora sp	(%)	0	0	2%	0	0	0	0	0.3 ± 0.8%	
Microporina borealis	(%)	0	10%	0	0	5%	2%	2%	2.7 ± 3.7%	
Modiolus modiolus		3	0	2	3	3	3	0	2.0 ± 1.4	8.0
Neptunea lyrata		0	0	0	0	0	1	0	0.1 ± 0.4	0.6
Ophiopholis aculeata		P	0	0	0	P	0	0	-	P
Sabellidae, unid.	(%)	10%	0	5%	0	0	2%	0	2.4 ± 3.8%	
Strongylocentrotus drobachiensis		1	3	0	0	0	4	5	1.9 ± 2.1	7.4
Tonicella lineata		3	2	2	3	0	4	0	2.0 ± 1.5	8.0
Trichotropis cancellata		0	0	0	0	0	P	0	-	P
CHORDATA										
Artedius sp		0	0	1	0	0	2	0	0.4 ± 0.8	1.7

EXTRALIMITAL SPECIES: Bathymaster sp Hexagrammos stelleri

APPENDIX B-2 ABUNDANCE DATA FOR CONSPICUOUS ANIMALS FROM BLUFF POINT SUBTIDAL AREA; 31 JULY 1978. 0.5 X 25 M^2 BAND TRANSECTS FROM 15.6 M BELOW MLLW

TAXA	Frequency		$\bar{x} \pm s$	Density (no./m^2)
Fusitriton oregonensis				
(not on egg masses)	10	18	14.0 ± 5.7	1.1
(on egg masses)	3	5	4.0 ± 1.4	0.3
Nucella lamellosa	8	5	6.5 ± 2.1	0.5
Strongylocentrotus drobachiensis	5	0	2.5 ± 3.5	0.2
Trophon orpheus	1	1	1.0 ± 0.0	0.1

EXTRALIMITAL SPECIES:

Archidoris odneri
Cribrinopsis similis in association with *Lebbeus grandimanus*
Crossaster papposus
Triopha carpenteri

APPENDIX C-1 ABUNDANCE DATA FOR TROUBLESOME CREEK SUBTIDAL AREA; 1 AUGUST 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 8 M BELOW MLLW

TAXA	Frequency						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta								
Laminaria groenlandica	7	0	0	0	0	0	1.2 ± 2.9	0.5
INVERTEBRATA								
Cryptochiton stelleri	0	2	0	1	0	0	0.5 ± 0.8	0.2
Cucumaria miniata	61	74	91	97	66	61	75.0 ± 15.6	30.0
Henricia sp	1	1	0	0	2	0	0.7 ± 0.8	0.3
Neptunea lyrata	1	0	0	0	0	0	0.2 ± 0.4	0.1
Nudibranch, Dorid, white	0	1	0	0	0	0	0.2 ± 0.4	0.1
Strongylocentrotus drobachiensis	46	45	63	59	92	73	63.0 ± 17.7	25.2

Extralimital Species:

Nudibranch, Dorid, yellow

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	1	1	0	3	0	1.0 ± 1.2	0.4
Desmarestia aculeata	0	0	4	0	0	0.8 ± 1.8	0.3
D. ligulata	1	0	0	0	0	0.2 ± 0.4	0.1
INVERTEBRATA							
Anthozoa, unid., white	0	4	3	2	-	2.3 ± 1.7	0.9
Cadlina ?luteomarginata	0	0	1	0	0	0.1 ± 0.4	0.1
Crossaster papposus	0	0	1	0	0	0.1 ± 0.4	0.1
Cryptochiton stelleri	1	0	0	1	0	0.4 ± 0.5	0.2
Cucumaria fallax	0	0	1	0	2	0.6 ± 0.9	0.2
C. miniata	31	39	59	67	42	47.6 ± 14.9	19.0
Elassochirus gilli	1	2	0	0	0	0.6 ± 0.9	0.2
Fusitriton oregonensis	0	1	0	1	0	0.4 ± 0.5	0.2
Henricia leviuscula	0	0	0	1	0	0.2 ± 0.4	0.1
H. sanguinolenta	0	0	0	1	0	0.2 ± 0.4	0.1
Hermissenda crassicornis	0	0	0	1	0	0.2 ± 0.4	0.1
Neptunea lyrata	0	1	0	0	0	0.2 ± 0.4	0.1
Strongylocentrotus drobachiensis	31	64	45	43	-	45.8 ± 13.6	18.3
Tealia sp.	2	2	2	2	3	2.2 ± 0.4	0.9

APPENDIX C-3 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 C-4 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	2	1	1	0	3	0	1.2 ± 1.2	0.5
INVERTEBRATA								
Cryptochiton stelleri	0	0	1	0	0	0	0.2 ± 0.4	0.1
Cucumaria fallax	0	0	0	0	2	1	0.5 ± 0.8	0.2
C. miniata	28	23	6	12	24	33	21.0 ± 10.1	8.4
Henricia sp	0	0	0	1	0	0	0.2 ± 0.4	0.1
Strongylocentrotus drobachiensis	41	39	36	47	50	42	42.5 ± 5.2	17.0
Extralimital Species:								
Tonicella insignis								

APPENDIX C-5 ABUNDANCE DATA FOR TROUBLESOME CREEK SUBTIDAL AREA; 1 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 8.0 M BELOW MLLW

TAXA		Frequency						x ± s	Density (no./m^2)
ALGAE - Phaeophyta									
Agarum cribrosum	(%)*	2%	0	5%	0	5%	0	2.0 ± 2.4%	
		2	0	1	0	3	0	1.0 ± 1.3	4.0
ALGAE - Rhodophyta									
Coralline alga, encrusting	(%)	50%	50%	80%	50%	40%	-	54.0 ± 15.2%	
INVERTEBRATA									
Acmaea mitra		1	4	4	2	3	2	2.7 ± 1.2	10.7
Acmaeidae, unid.		3	0	0	0	0	0	0.5 ± 1.2	2.0
Amphissa columbiana		1	0	0	0	0	0	0.2 ± 0.4	0.7
Anthozoa, unid., white		2	0	0	0	0	0	0.3 ± 0.8	1.3
Calliostoma ligata		0	0	0	2	0	0	0.3 ± 0.8	1.3
Cryptochiton stelleri		0	0	0	1	0	0	0.2 ± 0.4	0.7
Cucumaria miniata	(%)	-	35%	40%	60%	25%	10%	34.0 ± 18.5%	
		3	12	15	20	13	5	11.3 ± 6.3	45.3
Elassochirus gilli		0	0	0	1	1	0	0.3 ± 0.5	1.3
Flustrella gigantea	(%)	5%	15%	5%	2%	6%	5%	6.3 ± 4.5%	
Fusitriton oregonensis		1	0	1	0	0	0	0.3 ± 0.5	1.3
Heteropora sp	(%)	1%	1%	2%	1%	1%	1%	1.2 ± 0.4%	
Margarites pupillus		4	0	0	0	0	0	0.7 ± 1.6	2.7
Metridium senile, juv.		3	1	6	0	6	3	3.2 ± 2.5	12.7
Mopalia sp		0	0	0	2	0	0	0.3 ± 0.8	1.3
Mya truncata		0	1	0	0	0	0	0.2 ± 0.4	0.7
Neptunea lyrata		1	0	0	0	0	0	0.2 ± 0.4	0.7
Paguridae, unid.		3	3	2	0	0	8	2.7 ± 2.9	10.7
Placiphorella sp		0	0	0	1	0	0	0.2 ± 0.4	0.7
Pugettia gracilis		1	2	2	0	0	0	0.8 ± 1.0	3.3
Ritterella ?pulchra	(%)	3%	6%	5%	1%	1%	2%	3.0 ± 2.1%	
Saxidomus giganteus		8	6	3	9	6	12	7.3 ± 3.1	29.3
Sertulariidae, unid.	(%)	7%	4%	2%	15%	10%	9%	7.8 ± 4.6%	

APPENDIX C-5 (Continued)

TAXA	Frequency						$\bar{x} \pm s$	Density (no./m²)
Strongylocentrotus drobachiensis	3	7	24	4	7	9	9.0 ± 7.7	36.0
Tealia crassicornis	0	1	1	0	0	0	0.3 ± 0.5	1.3
Tonicella insignis	1	0	0	2	0	0	0.5 ± 0.8	2.0
T. lineata	0	2	3	2	0	4	1.8 ± 1.6	7.3
Trichotropis cancellata	0	1	0	0	0	0	0.2 ± 0.4	0.7

Extralimital Species:

ALGAE

Codium ritteri
Desmarestia ligulata
Hildenbrandia sp

INVERTEBRATA

Alcyonidium pedunculatum
Archidoris sp
Balanus nubilus
Cadlina luteomarginata
Crossaster papposus
Cucumaria fallax
Dendronotus alba
Elassochirus tenuimanus
Entodesma saxicola
Esperiopsis sp
Evasterias troschelii
Fusitriton oregonensis
Halcampa sp
Halocynthia aurantium
Henricia leviuscula
H. sanguinolenta
Hermissenda crassicornis
Macoma sp
Microporina borealis
Mycale lingua - common
Neptunea pribilofftensis-egg cases
Ophiopholis sp - abundant
Oregonia gracilis
Orthasterias koehleri
Rhynchozoon bispinosum
Sertularella reticulata
Solaster dawsoni
S. stimpsoni
Tealia lofotensis
Terebratalia transversa
Tresus capax
Velutina laevigata

CHORDATA

Hexagrammos stelleri
Liparis sp, orange

*Unless noted, numbers indicate number of individuals.

APPENDIX C-6 ABUNDANCE DATA FROM TROUBLESOME CREEK SUBTIDAL AREA; 1 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 8.0 M BELOW MLLW

TAXA	Frequency										$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA												
Ascidacea, unid.	0	0	0	0	0	0	0	0	0	2	0.2 ± 0.6	0.8
Balanus sp	0	0	0	0	0	0	0	0	2	0	0.2 ± 0.6	0.8
Cribrinopsis fernaldi	0	0	0	0	0	0	0	0	1	0	0.1 ± 0.3	0.4
Cucumaria miniata	4	2	6	1	0	1	8	0	0	0	2.2 ± 2.9	8.8
Distaplia sp	0	0	0	3	0	0	1	14	0	0	1.8 ± 4.4	7.2
Flustrella gigantea (no. of colonies):	0	0	0	2	0	1	1	0	1	0	0.5 ± 0.7	2.0
Halichondria panicea (%)	0	0	0	0	0	0	0	0	0	70%	7.0 ± 22.1%	
Metridium senile	0	0	0	0	0	0	0	0	10	0	1.0 ± 3.2	4.0
Neptunea lyrata	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.4
Strongylocentrotus drobachiensis	1	4	4	4	5	0	5	4	1	3	3.1 ± 1.8	12.4

EXTRALIMITAL SPECIES:

Acmaea mitra
Anisodoris nobilis
Archidoris odhneri
Beringius kennicotti
Buccinum plectrum
Cancer oregonensis
Cribrinopsis similis
Crossaster papposus
Cryptochiton stelleri
Cucumaria fallax
Dermasterias imbricata
Elassochirus gilli
Evasterias troschelli
Fusitriton oregonensis
Gersemia sp
Henricia leviuscula
Neptunea pribiloffensis & eggs
Orthasterias koehleri
Solaster stimpsoni
Styela montereyensis
Tealia crassicornis
Tealia sp
Triopha carpenteri

CHORDATA

Hemilepidotus jordani
Hexagrammos lagocephalus

Substrate: Rock and cobble

APPENDIX C-7 ABUNDANCE DATA FROM TROUBLESOME CREEK SUBTIDAL AREA; 1 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 8.0 M BELOW MLLW

TAXA		Frequency									$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA												
Abietinaria sp		3	0	0	10	0	0	3	4	0	2.2 ± 3.3	8.9
Cucumaria miniata		0	1	1	0	0	4	7	3	0	1.8 ± 2.4	7.1
Flustrella gigantea		0	0	2	0	2	1	0	0	0	0.6 ± 0.9	2.2
Hydrozoa, unid.	(%)	0	0	0	0	0	0	10%	5%	10%	2.8 ± 4.4%	
		0	0	0	0	0	0	6	6	10	2.4 ± 3.8	9.8
Mycale ?lingua	(%)	20%	0	0	0	0	0	0	0	0	2.2 ± 6.7%	
Porifera, unid.	(%)	10%	0	0	0	0	0	0	0	0	1.1 ± 3.3%	
		1	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.4
Ritterella pulchra	(%)	10%	0	0	-	-	-	20%	0	30%	10.0 ± 12.6%	
no. of colonies:		5	0	0	1	2	2	6	0	10	2.9 ± 3.4	11.6
Strongylocentrotus drobachiensis		10	2	6	6	6	0	8	4	14	6.2 ± 4.2	24.9
Tunicata, unid., compound	(%)	10%	0	0	0	0	0	0	0	0	1.1 ± 3.3%	
no. of colonies:		1	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.4

EXTRALIMITAL SPECIES:

INVERTEBRATA

- Archidoris odhneri
- Artedius sp
- Calliostoma ligatum
- Ceramaster arcticus
- Cryptobranchia sp
- Cucumaria fallax
- Dermasterias imbricata
- Doto cf columbiana
- Eupentacta sp
- Evasterias troschelli
- Gersemia sp
- Halocynthia aurantium
- Ischnochiton albida
- Neptunea lyrata
- Ophiopholis aculeata
- Paralithodes camtschatica
- ?Petricola sp
- Phyllolithodes papillosus
- Tonicella insignis
- Tubularia sp

Substrate: Cobble and rock

APPENDIX C-8 ABUNDANCE DATA FROM TROUBLESOME CREEK SUBTIDAL AREA; 1 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 8.0 M BELOW MLLW

TAXA		Frequency									$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Chlorophyta												
Codium ritteri	(%)	0	5%	0	2%	0	0	0	0	0	0.8 ± 1.7%	
ALGAE - Phaeophyta												
Agarum cribrosum	(%)	0	0	0	0	0	15%	0	0	0	1.7 ± 5.0%	
		0	0	0	0	0	2	0	0	0	0.2 ± 0.7	0.9
ALGAE - Rhodophyta												
Coralline alga, encrust.	(%)	70%	60%	85%	0	50%	80%	60%	65%	80%	61.1 ± 25.6%	
INVERTEBRATA												
Abietinaria sp	(%)	10%	0	0	0	0	0	0	0	0	1.1 ± 3.3%	
Acmaea mitra		0	0	0	0	0	0	0	2	2	0.4 ± 0.9	1.8
Balanus nubilus	(%)	2%	0	0	-	0	0	0	0	0	0.3 ± 0.7%	
		1	0	0	6	0	0	0	0	0	0.8 ± 2.0	3.1
Cancer oregonensis		1	0	0	4	0	1	0	0	2	0.9 ± 1.4	3.6
Cribrinopsis similis		0	0	3	0	0	3	0	0	0	0.7 ± 1.3	2.7
Cucumaria fallax		0	0	0	1	0	0	0	0	0	0.1 ± 0.3	0.4
C. miniata		9	4	19	0	0	0	17	12	0	6.8 ± 7.7	27.1
Cucumaria sp, white		0	0	0	2	0	0	0	0	0	0.2 ± 0.7	0.9
Elassochirus gilli		0	1	0	2	0	0	2	0	1	0.7 ± 0.9	2.7
Flustrella gigantea	(%)	0	5%	5%	10%	0	2%	10%	10%	10%	5.8 ± 4.4%	
Fusitriton oregonensis		0	0	0	1	0	0	0	0	4	0.6 ± 1.3	2.2
Henricia sp		1	1	0	0	0	0	0	0	0	0.2 ± 0.4	0.9
Heteropora sp	(%)	5%	0	2%	0	0	2%	1%	2%	1%	1.4 ± 1.6%	
Ophiopholis sp		P	P	P	0	0	0	0	0	0	-	P
Oregonia gracilis		0	0	3	0	0	0	2	0	3	0.9 ± 1.4	3.6
Orthasterias koehleri		0	0	0	0	0	1	0	0	0	0.1 ± 0.3	0.4
Paguridae, unid.		P	0	0	0	0	0	0	0	0	-	P
Ritterella pulchra	(%)	15%	0	5%	5%	20%	1%	5%	0	15%	7.3 ± 7.4%	
Sertularella reticulata	(%)	0	10%	0	0	5%	2%	5%	5%	5%	3.6 ± 3.4%	
Strongylocentrotus drobachiensis		8	11	0	7	3	9	7	6	0	5.7 ± 3.9	22.7
Tonicella sp.		0	2	0	0	0	0	0	0	0	0.2 ± 0.7	0.9
CHORDATA												
Artedius sp		1	0	0	1	0	0	1	0	0	0.3 ± 0.5	1.3

Substrate: Rock

APPENDIX D-1 ABUNDANCE DATA FOR <u>NEREOCYSTIS LUETKEANA</u> FROM BARABARA BLUFF; 13 JULY 1978. 0.5 X 5 M QUADRATS FROM 9.8 - 10.7 M BELOW MLLW

TAXA	Frequency						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta								
Nereocystis luetkeana (adults)	1	0	3	7	23	2	6.0 ± 8.7	2.4

Substrate: Bedrock and boulders

APPENDIX D-2 COVER AND ABUNDANCE DATA FOR BARABARA BLUFF; 13 JULY 1978. ½ X 1 M QUADRATS FROM 9.8 - 10.7 M BELOW MLLW

TAXA												x ± s	Biomass (g/m)	Density (no./m)
ALGAE - Phaeophyta														
Agarum cribrosum (a)*	(%)	0	0	35	5	40	15	0	50	80	T**	22.6 ± 27.7%		
		0	0	6	2	10	4	0	4	14	0	4.0 ± 4.8		8.0
	(g)	-	0	225.7	19.5	290.7	30.5	0	146.1	695.3	0	156.4 ± 229.5	312.8	
Desmarestia aculeata	(%)	10	15	0	1	2	1	10	2	-	10	5.6 ± 5.7%		
	(g)	-	63.7	0	0	7.7	0	11.7	7.6	0	35.5	14.0 ± 21.8	28.0	
Laminaria	(%)	0	0	0	0	0	0	0	2	0	0	0.2 ± 0.6%		
groenlandica (a)		0	0	0	0	0	0	0	1	0	0	0.1 ± 0.3		0.2
	(g)	-	0	0	0	0	0	0	5.2	0	0	0.6 ± 1.7	1.2	
Nereocystis luetkeana		4	8	0	0	0	0	1	0	3	2	1.8 ± 2.6		3.6
	(g)	5281.1	20469.0	0	0	0	0	1.8	0	1431.6	8.4	2719.2 ± 6454.8	5438.4	
ALGAE - Rhodophyta														
?Pterosiphonia sp	(%)	10	0	20	60	50	80	35	50	-	30	37.2 ± 25.4%		
INVERTEBRATA														
Cryptochiton stelleri		0	0	0	0	0	0	1	0	0	0	0.1 ± 0.3		0.2
Strongylocentrotus drobachiensis		10	2	8	3	11	14	11	4	4	4	7.1 ± 4.2		14.2

Substrate: Bedrock and boulders, good fish habitat; many crevices and high relief

*(a) = adult
** T = Trace

APPENDIX D-3 ABUNDANCE DATA FOR PLANTS AND FISH FOR BARABARA BLUFF; 13 JULY 1978. 0.5 X 30 M^2 QUADRAT FROM 9.8 - 10.7 M BELOW MLLW

TAXA	Frequency	Density (no./m^2)
ALGAE - Phaeophyta		
Nereocystis luetkeana	26	1.7
CHORDATA - Pisces		
Bathymaster sp	C*	
Hexagrammos decagrammus	C	
H. lagocephalus	C	
Sebastes melanops (juv.)	C	

Substrate: bedrock and boulder

*C = Common

APPENDIX D-4 ABUNDANCE DATA FOR PLANTS AND ANIMALS FOR BARABARA BLUFF SUBTIDAL AREA; 13 JULY 1978. 2 X 5 M^2 CONTIGUOUS QUADRATS FROM 10.1 M BELOW MLLW

TAXA		Frequency					$\bar{x} \pm s$	Density (no./m^2)
Transect 1								
ALGAE - Phaeophyta								
Nereocystis luetkeana	(a)*	6	1	3	1	8	3.8 ± 3.1	0.4
	(j)**	1	0	3	0	5	1.8 ± 2.2	0.2
INVERTEBRATA								
Pycnopodia helianthoides		0	0	0	0	1	0.2 ± 0.4	0.02
CHORDATA - Pisces								
Hexagrammos decagrammus		1	0	0	0	0	0.2 ± 0.4	0.02
Transect 2								
ALGAE - Phaeopyta								
Nereocystis luetkeana	(a)	1	15	18	7	8	9.8 ± 6.8	1.0
	(j)	1	2	3	3	4	2.6 ± 1.1	0.3
CHORDATA - Pisces								
Hexagrammos decagrammus		0	1	0	0	0	0.2 ± 0.4	0.02
H. lagocephalus		1	0	0	0	0	0.2 ± 0.4	0.02
Transect 3								
ALGAE - Phaeophyta								
Nereocystis luetkeana	(a)	0	2	4	11	5	4.4 ± 4.2	0.4
	(j)	0	0	1	3	8	2.4 ± 3.4	0.2
CHORDATA - Pisces								
Bathymaster caerulofasciatus		0	1	0	0	0	0.2 ± 0.4	0.02
Hexagrammos decagrammus		3	0	0	0	0	0.6 ± 1.3	0.06

Extralimital species: Anarrhichthys ocellatus - female

*(a) = adult
**(j) = juvenile

APPENDIX D-5 RECONNAISSANCE SURVEY FROM BARABARA BLUFF; 13 JULY 1978. 9.8 - 10.7 M BELOW MLLW

TAXA

ALGAE - Chlorophyta

- Codium ritteri

ALGAE - Phaeophyta

- Agarum cribrosum
- Desmarestia aculeata
- Laminaria groenlandica
- Nereocystis luetkeana
- Thalassiophyllum clathrus

ALGAE - Rhodophyta

- Constantinea rosa-marina
- Coralline alga, encrust.
- Pterosiphonia sp
- Ptilota sp
- Schizymenia sp

CNIDARIA - Hydrozoa

- Polyorchis sp

CNIDARIA - Scyphozoa

- Aurelia labiata
- Cyanea capillata
- Haliclystus stejnegri

CNIDARIA - Anthozoa

- Cribrinopsis similis
- Tealia lofotensis

NEMERTEA

- Tubulanus sexlineatus

TAXA

ANNELIDA - Polychaeta

- Thelepus cincinnatus

ARTHROPODA - Crustacea

- Elassochirus gilli
- Lebbeus grandimanus

MOLLUSCA - Gastropoda

- Acmaea mitra
- Hermissenda crassicornis
- Trichotropis cancellata

MOLLUSCA - Pelecypoda

- Protothaca staminea
- Saxidomus giganteus

MOLLUSCA - Polyplacophora

- Cryptochiton stelleri
- Tonicella insignis
- T. lineata

ECTOPROCTA

- Flustrella gigantea
- Heteropora sp
- Terminoflustra membranacea-truncata

ECHIURA

- Bonelliopsis sp

TAXA

BRACHIOPODA

- Terebratalia transversa

ECHINODERMATA - Asteroza

- Crossaster papposus
- Henricia sanguinolenta
- Orthasterias koehleri
- Pycnopodia helianthoides

ECHINODERMATA - Echinoidea

- Strongylocentrotus drobachiensis
- S. franciscanus

ECHINODERMATA - Ophiuroidea

- Ophiopholis aculeata

CHORDATA - Tunicata

- Distaplia occidentalis
- Halocynthia aurantium

CHORDATA - Pisces

- Anarrhichtys ocellatus
- Bathymaster caerulofasciat
- Hexagrammos decagrammus
- H. lagocephalus
- Sebastes melanops
- Sebastes sp A
- Sebastes sp B

APPENDIX E-1a ABUNDANCE DATA FOR LAMINARIA GROENLANDICA FROM SCOTT ISLAND SUBTIDAL AREA; 15 JUNE 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 2 M BELOW MLLW

TAXA		Frequency		$\bar{x} \pm s$	Density (no./m)
Laminaria groenlandica					
adults	5	14	3	7.3 ± 5.9	2.9
juveniles	1	3	2	2.0 ± 1.0	0.8

APPENDIX E-1b ABUNDANCE DATA FOR SCOTT ISLAND SUBTIDAL AREA; 15 June 1978. 0.5 x 5 M^2 QUADRATS FROM 2 M BELOW MLLW

TAXA						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta							
Desmarestia aculeata	0	2	1	0	0	0.6 ± 0.9	0.2
Laminaria groenlandica	0	0	1	34	15	10.0 ± 14.8	4.0
L. ?saccharina	0	0	2	0	3	1.0 ± 1.4	0.4
ALGAE - Rhodophyta							
Callophyllis sp	0	2	0	0	2	0.8 ± 1.1	0.3
Constantinea sp	1	0	0	0	0	0.2 ± 0.4	0.1
Opuntiella californica	0	3	1	0	0	0.8 ± 1.3	0.3
Rhodymenia palmata	10	6	2	1	0	3.8 ± 4.1	1.5

APPENDIX E-1c COVER AND ABUNDANCE DATA FOR SCOTT ISLAND SUBTIDAL AREA; 15 JUNE 1978. ¼ M^2 SQUARE QUADRATS FROM 2 M BELOW MLLW

TAXA		Frequency										$\bar{x} \pm s$	Biomass (g/m^2)	Density ($no./m^2$)
ALGAE - Phaeophyta														
<u>Agarum</u> <u>cribrosum</u>	(%)*	0	0	0	0	0	0	15%	0	0	0	1.5 ± 4.7%		
		0	0	0	0	0	0	0	0	0	0			0.0
<u>Laminaria saccharina</u>	(%)	80%	100%	40%	30%	0	100%	80%	20%	60%	30%	54.0 ± 35.0%		
		0	2	0	0	0	0	1	1	12	0	1.6 ± 3.7		6.4
	(g)	0	315.6	0	0	0	0	566.4	72.1	1647.4	0	260.2 ± 523.1	1040.6	

* Unless noted, numbers indicate number of individuals

APPENDIX E-2   ABUNDANCE DATA FOR SCOTT ISLAND SUBTIDAL AREA, SOUTHWEST END; 4 AUGUST 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 6 M BELOW MLLW

TAXA													$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta														
Agarum cribrosum	0	0	1	0	0	0	0	2	1	0	0	2	0.5 ± 0.8	0.2
Laminaria groenlandica	4	9	3	5	1	0	3	2	1	1	2	1	2.7 ± 2.5	1.1
INVERTEBRATA														
Anthozoa, unid., red	0	2	0	0	0	0	0	0	0	0	0	0	0.2 ± 0.6	0.1
Fusitriton oregonensis	0	3	0	0	0	0	0	0	0	0	0	1	0.3 ± 0.9	0.1
Henricia sanguinolenta	0	2	0	0	0	0	0	0	0	0	0	0	0.2 ± 0.6	0.1
Leptasterias sp	0	0	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	0.03
Pagurus sp	0	0	0	2	0	0	0	0	0	0	0	0	0.2 ± 0.6	0.1
Strongylocentrotus drobachiensis	0	2	0	0	0	0	0	0	0	0	0	0	0.2 ± 0.6	0.1
CHORDATA														
Hexagrammos stelleri	0	0	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	0.03

Extralimital Species:

Crossaster papposus
Elassochirus gilli
Naticidae egg
Solaster stimpsoni
Telmessus cheiragonus

ALGAE

Laminaria
Agarum cribrosum

INVERTEBRATA

Balanus sp
Elassochirus gilli
Hydrozoa, unid.
Leptasterias sp
Mopalia sp
Neptunea pribiloffensis-eggs
Porifera, unid.
Strongylocentrotus drobachiensis

Substrate: Sand bottom with occassional boulders

(500)

APPENDIX E-3 RECONNAISSANCE SURVEY FROM SCOTT ISLAND SUBTIDAL AREA, NORTHEAST END OF CHANNEL; 4 AUGUST 1978

TAXA	Depth Below MLLW (m) 4	6
ALGAE - Phaeophyta		
Alaria taeniata	X	
Laminaria groenlandica	X	X
CHORDATA - Pisces		
Cottidae, unid.		X
Hexagrammos sp, juvenile	X	

Substrate: Bedrock and boulders with 3 ft. relief at 4 m and flat gravel area with shell debris and little silt at 6 m

APPENDIX F-1 RECONNAISSANCE SURVEY FROM KNOLL HEAD LAGOON REEF; 11 JUNE 1978

TAXA	Depth (m)* 1.1	2.6	3.0	3.3
ALGAE - Phaeophyta				
Agarum cribrosum	X		X	X
Alaria taeniata	X			
Laminaria groenlandica	X			
ALGAE - Rhodophyta				
Constantinea sp	X			X
Corallina sp	X			
Coralline alga, encrust.	X	X	X	X
Hildenbrandia sp		X		X
Odonthalia lyalli	X			
Tokidadendron bullata	X			
PORIFERA				
Halichondria panicea		X	X	
?*Mycale* sp (gray)		X		
Porifera, unid.		X		
Suberites ficus		X		
CNIDARIA - Hydrozoa				
Abietinaria filicula		X		
A. turgida		X		
Abietinaria spp			X	
CNIDARIA - Anthozoa				
?*Cribrinopsis similis*	X			
Tealia crassicornis	X			
ANNELIDA - Polychaeta				
?*Potamilla* sp			X	
ARTHROPODA - Crustacea				
Balanus hesperius laevidomus			X	
B. rostratus alaskanus		X		
Elassochirus gilli		X		
Pagurus beringanus		X		
MOLLUSCA - Gastropoda				
Buccinum glaciale		X		
Fusitriton oregonensis		X		
Neptunea borealis		X	X	
N. lyrata		X	X	
Nucella lima		X		
MOLLUSCA - Gastropoda cont.				
Trichotropis cancellata		X		
T. insignis		X		
MOLLUSCA - Pelecypoda				
Cyclocardia ?stearnsi			X	
Macoma obliqua			X	
Modiolus modiolus			X	
Pododesmus macroschisma		X		
MOLLUSCA - Polyplacophora				
Cryptochiton stelleri		X	X	
Ischnochiton albus		X	X	
Mopalia ciliata		X		
M. mucosa		X		
Tonicella insignis		X	X	
T. lineata		X		
ECTOPROCTA				
Costazia ?surcularis			X	
Flustrella gigantea		X		
Hippothoa hyalina		X		
BRACHIOPODA				
Terebratalia transversa		X		
ECHINODERMATA - Asteroidea				
Henricia sanguinolenta		X		
Leptasterias ?hylodes	X			
L. polaris acervata		X	X	
Leptasterias sp		X		
ECHINODERMATA - Echinoidea				
Strongylocentrotus drobachiensis		X	X	
ECHINODERMATA - Ophiuroidea				
Ophiopholis aculeata		X		
CHORDATA				
Hexagrammos stelleri		X		
Lepidopsetta bilineata		X		

Substrate: Boulder field at 1.1 m extending into gravel at 3.0 m below MLLW

* Below MLLW

APPENDIX F-2a RECONNAISSANCE SURVEY FROM KNOLL HEAD LAGOON SUBTIDAL AREA; 2 AUGUST 1978.

TAXA	Depth (m)* 2.7–3.6	5.7
ALGAE - Phaeophyta		
Agarum cribrosum	X	
Laminaria groenlandica	X	
ALGAE - Rhodophyta		
Coralline alga, encrust.	X	X
Hildenbrandia sp	X	
Opuntiella californica	X	
PORIFERA		
Esperiopsis sp	X	
Halichondria panicea		X
Mycale ?lingua	X	
Porifera, unid., yellow	X	
CNIDARIA - Hydrozoa		
Abietinaria filicula		X
A. gigantea	X	
A. variabilis	X	
Sertularia cupressoides		X
CNIDARIA - Anthozoa		
Cribrinopsis sp	X	
ANNELIDA - Polychaeta		
Gattyana sp		X
ARTHROPODA - Crustacea		
Balanus rostratus alaskensis	X	
Balanus sp, juvenile		X
Elassochirus tenuimanus		X
Pagurus beringanus	X	X
P. kennerlyi	X	
Pagurus spp		X
MOLLUSCA - Gastropoda		
Acmaea mitra		X
Beringius kennicotti		X
Boreotrophon sp		X
Epitonium groenlandicum	X	
Fusitriton oregonensis	X	

TAXA	Depth (m) 2.7–3.6	5.7
MOLLUSCA - Gastropoda cont.		
Margarites pupillus	X	
Natica clausa		X
Neptunea lyrata		X
N. pribiloffensis	X	
Searlesia dira		X
Trichotropis cancellata	X	
T. insignis	X	
Trophonopsis lasius	X	
MOLLUSCA - Pelecypoda		
Modiolus modiolus	X	
Pododesmus macroschisma	X	
MOLLUSCA - Polyplacophora		
?Ischnochiton trifidus	X	
Mopalia ciliata	X	X
Tonicella insignis	X	
ECTOPROCTA		
Alcyonidium pedunculatum		X
Costazia surcularis	X	
Dendrobeania murrayana		X
Heteropora sp	X	
Hippothoa hyalina	X	
BRACHIOPODA		
Terebratalia transversus	X	
ECHINODERMATA - Asteroidea		
?Asterias amurensis, juv.		X
Henricia sanguinolenta		X
Leptasterias polaris acervata	X	X
Leptasterias ?hylodes		X
Pteraster tesselatus	X	
ECHINODERMATA - Echinoidea		
Strongylocentrotus drobachiensis	X	X
ECHINODERMATA - Ophiuroidea		
Ophiopholis sp	X	

Substrate: Large boulder at 2.7 m and gravel bed with scattered boulders at 5.7 m

* Below MLLW

APPENDIX F-2b — COVER AND ABUNDANCE DATA FOR KNOLL HEAD LAGOON, INNER STATION; 2 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM +0.3 - 0.6 M BELOW MLLW

TAXA		Frequency										$\bar{x} \pm s$	Biomass (g/m^2)	Density ($no./m^2$)
ALGAE - Phaeophyta														
Alaria praelonga	(%)	*80%	100%	30%	50%	90%	75%	30%	10%	80%	80%	62.5 ± 30.3%		
		0	4	4	9	2	2	13	1	0	8	4.3 ± 4.3		17.2
	(g)	0	509.5	287.9	2717.8	197.8	130.8	57.3	187.1	0	1.4	409.0 ± 826.7	1635.8	
Laminaria groenlandica	(%)	10%	100%	25%	50%	20%	2%	20%	90%	0	0	31.7 ± 36.6%		
		0	4	10	13	1	2	1	3	0	0	3.4 ± 4.5		13.6
	(g)	0	698.2	1125.1	1152.3	38.4	426.0	122.7	856.9	0	0	442.0 ± 478.4	1767.8	

* Unless noted, numbers indicate number of individuals.

APPENDIX F-2c ABUNDANCE DATA FOR KNOLL HEAD LAGOON, INNER STATION; 2 AUGUST 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM +0.3 - 0.6 M BELOW MLLW

TAXA	Frequency										$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA												
Beringius kennicotti	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.04
Fusitriton oregonensis	5	0	0	0	0	0	0	0	0	1	0.6 ± 1.6	0.2
Neptunea lyrata	1	0	0	0	0	0	0	0	0	1	0.2 ± 0.4	0.1
Strongylocentrotus drobachiensis	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.3	0.04
Tealia/Cribrinopsis sp.	0	0	0	1	1	3	0	0	0	0	0.5 ± 1.0	0.2
Telmessus cheiragonus	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	0.04

Substrate: bedrock and boulders

APPENDIX F-2d ABUNDANCE DATA FOR KNOLL HEAD LAGOON SUBTIDAL AREA; 5 AUGUST 1978. 0.5 x 5 M^2 QUADRATS FROM 1.8 M BELOW MLLW

TAXA																	$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta																		
Agarum cribrosum	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0.1 ± 0.3	0.05
Alaria praelonga	5	2	1	0	0	0	0	4	0	2	4	4	6	1	1	2	2.0 ± 2.0	0.8
Desmarestia aculeata	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.05
Laminaria groenlandica	10	9	17	23	8	8	12	6	6	16	21	7	5	18	14	5	11.6 ± 5.9	4.6
CHORDATA																		
Hexagrammos octogrammus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.1 ± 0.3	0.05
H. stelleri	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0.3 ± 0.5	0.1

APPENDIX F-2e COVER AND ABUNDANCE DATA FOR KNOLL HEAD LAGOON SUBTIDAL AREA; 2 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 1.8 M BELOW MLLW

TAXA						$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta							
Alaria praelonga	(%)	20%	50%	35%	30%	33.8 ± 12.5%	
		0	1	0	0	0.3 ± 0.5	1.0
Laminaria groenlandica	(%)	40%	40%	25%	25%	32.5 ± 8.7%	
		2	3	2	1	2.0 ± 0.8	8.0
ALGAE - Rhodophyta							
Constantinea subulifera	(%)	5%	3%	5%	6%	4.8 ± 1.3%	
Coralline alga, articulated	(%)	0	1%	1%	P	0.7 ± 0.6%	
Coralline alga, encrusting	(%)	70%	50%	60%	70%	62.5 ± 9.6%	
Hildenbrandia sp	(%)	0	0	P	0	P	
Odonthalia lyalli	(%)	10%	5%	8%	30%	13.3 ± 11.4%	
Tokidadendron bullata	(%)	15%	5%	15%	5%	10.0 ± 5.8%	
INVERTEBRATA							
Acmaeidae, unid		0	2	2	0	1.0 ± 1.2	4.0
?Anthopleura artemisia		3	0	3	2	2.0 ± 1.4	8.0
Costazia ?surcularis	(%)	0	0	0	1%	0.3 ± 0.5%	
Fusitriton oregonensis		0	1	0	0	0.3 ± 0.5	1.0
Leptasterias ?hylodes		0	1	0	0	0.3 ± 0.5	1.0
Margarites pupillus		0	0	2	0	0.5 ± 1.0	2.0
Modiolus modiolus		84	30	83	64	65.3 ± 25.2	261.0
Mopalia sp		1	1	2	0	1.0 ± 0.8	4.0
Musculus vernicosus		P	0	P	0		P
Mya sp		0	1	0	0	0.3 ± 0.5	1.0
Ophiopholis aculeata		P	P	P	P		P
Pagurus hirsutiusculus		0	2	0	3	1.3 ± 1.5	5.0
Pododesmus macroschisma		0	0	0	1	0.3 ± 0.5	1.0
Tonicella lineata		5	8	10	0	5.8 ± 4.3	23.0
Trichotropis insignis		4	1	0	1	1.5 ± 1.7	6.0
Trophonopsis lasius		0	0	0	1	0.3 ± 0.5	1.0

EXTRALIMITAL SPECIES: Hexagrammos lagocephalus H. octogrammus

Substrate: Bedrock and boulders with some cobble, shell and gravel

APPENDIX F-2f COVER AND ABUNDANCE DATA FOR KNOLL HEAD LAGOON OUTER STATION; 2 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 3.6 - 4.8 M BELOW MLLW

TAXA		Frequency										$\bar{x}$ ± s	Biomass (g/m^2)	Density ($no./m^2$)
ALGAE - Phaeophyta														
<u>Agarum</u> <u>cribrosum</u>	(%)*	5%	0	0	0	0	0	0	0	0	0	0.5 ± 1.6%		
		3	0	0	0	0	0	0	0	0	0	0.3 ± 0.9		1.2
	(g)	39.7	0	0	0	0	0	0	0	0	0	4.0 ± 12.6	15.9	
ALGAE - Rhodophyta														
<u>Odonthalia</u> <u>lyalli</u>	(%)	15%	1%	0	0	T**	0	0	0	0	3%	2.0 ± 4.7%		

* Unless noted, numbers indicate number of individuals.
** T = Trace (<1%)

APPENDIX F-2g ABUNDANCE DATA FOR KNOLL HEAD LAGOON, OUTER STATION; 2 AUGUST 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 3.6 TO 4.8 M BELOW MLLW

TAXA																										$\bar{x} \pm s$	Density (no./m^2)
ALGAE - Phaeophyta																											
<u>Agarum cribrosum</u>	0	0	0	0	0	0	3	0	0	0	0	1	0	0	7	15	2	0	26	7	6	0	0	0	22	3.6 ± 7.1	1.4
<u>Laminaria groenlandica</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	1	1	0.3 ± 0.5	0.1
INVERTEBRATA																											
<u>Bucinnum glaciale</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.04 ± 0.2	0.02
<u>Crossaster papposus</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.04 ± 0.2	0.02
<u>Fusitriton oregonensis</u>	0	0	0	0	1	0	3	0	0	0	0	2	0	0	1	3	9	4	12	4	6	0	0	5	10	2.4 ± 3.5	1.0
<u>Henricia</u> spp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0.1 ± 0.3	0.05
<u>Hermissenda crassicornis</u>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04 ± 0.2	0.02
<u>Leptasterias</u> sp	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	2	0	0	2	0	0	0	0	0	0.4 ± 0.6	0.1
<u>Neptunea lyrata</u>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04 ± 0.2	0.02
<u>Pododesmus macroschisma</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	1	1	0	0	0	0	0	2	0.5 ± 1.0	0.2
<u>Strongylocentrotus drobachiensis</u>	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.05
<u>Tealia/Cribrinopsis</u> sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0.04 ± 0.2	0.02
CHORDATA																											
<u>Hexagrammos stelleri</u>	0	0	0	0	0	0	0	2	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0.2 ± 0.5	0.1

Substrate: Gravel, cobble and boulders

APPENDIX G-1 RECONNAISSANCE SURVEY FROM WHITE GULL ISLAND SUBTIDAL AREA, WEST SIDE; 12 JUNE 1978

TAXA	Depth (m)* 0.2	1.1	1.2	2.3	1.2-3.6	2.8-4.0
ALGAE - Chlorophyta						
Chlorophyta, unid., filamentous			X			
Monostroma sp		X	X		X	
ALGAE - Phaeophyta						
Agarum cribrosum			X	X	X	
Alaria taeniata		X	X		X	
Desmarestia aculeata		X	X	X	X	
Laminaria groenlandica					X	
L. saccharina		X			X	
Laminaria sp				X		
ALGAE - Rhodymenia						
Coralline alga, encrust.					X	
R. palmata					X	
PROTOZOA						
Diatom cover			X			
PORIFERA						
Sigmadocia sp					X	
Porifera, unid., encrust. orange					X	
CNIDARIA - Hydrozoa						
Abietinaria variabilis					X	
Abietinaria sp						X

TAXA	Depth (m) 0.2	1.1	1.2	2.3	1.2-3.6	2.8-4.0
CNIDARIA - Hydrozoa cont.						
Calycella syringa					X	
Campanularia urceolata					X	
Lafoea fruticosa					X	
Obelia ?longissima					X	
Obelia sp					X	X
Sertularia cupressoides					X	
Thuiaria cylindrica					X	
CNIDARIA - Anthozoa						
Tealia lofotensis						X
ANNELIDA - Polychaeta						
Schizobranchia ?insignis					X	X
Terebellidae, unid.						X
ARTHROPODA - Crustacea						
Balanus ?crenatus					X	
B. rostratus					X	
Balanus sp			X	X		
Elassochirus tenuimanus					X	X
Hyas lyrata			X		X	
Pagurus beringanus					X	
P. hirsutiusculus					X	
P. ochotensis						X
Pagurus spp						X
Telmessus cheiragonus		X			X	

APPENDIX G-1 (Continued)

TAXA	Depth (m) 0.2	1.1	1.2	2.3	1.2-3.6	2.8-4.0
MOLLUSCA - Gastropoda						
Boreotrophon ?clathrus			X			
B. pacificus			X			
B. glaciale			X			
Fusitriton oregonensis				X		
Lacuna sp				X		
Littorina sitkana	X					
Margarites pupillus					X	
Natica clausa			X		X**	
Neptunea lyrata			X		X	X
Oenopota levidensis						X
O. turricula						X
Oenopota spp						X
MOLLUSCA - Pelecypoda						
Astarte sp			X			
Clinocardium sp						X
Macoma sp			X			
?*Modiolus modiolus*						X
Pododesmus macroschisma					X	
MOLLUSCA - Polyplacophora						
Mopalia lignosa				X		
Tonicella lineata				X		

TAXA	Depth (m) 0.2	1.1	1.2	2.3	1.2-3.6	2.8-4.0
ECTOPROCTA						
Caulibugula sp			X	X	X	
Cystisella bicornis					X	
Dendrobeania murrayana					X	X
Eucratia loricata					X	X
Hippothoa hyalina					X	
ECHINODERMATA - Asteroidea						
Crossaster papposus				X		
Leptasterias hexactis			X			
L. polaris acervata			X	X		X
L. ?hylodes			X		X	
ECHINODERMATA - Echinoidea						
Strongylocentrotus drobachiensis, juvenile					X	
CHORDATA - Pisces						
Cottidae, unid.					X	
Hexagrammos stelleri				X	X	X
Lepidopsetta bilineata						X

Substrate: 0.2 m = Sand and gravel
1.1 m = Sand, gravel and shell debris shelf
1.2 m = Boulder field
2.3 m = Rock wall
1.2 - 3.6 m = Sand and gravel flats, boulder outcrops
2.8 - 4.0 m = Muddy gravel flats

* Below MLLW
** Egg cases

APPENDIX G-2a RECONNAISSANCE SURVEY FROM WHITE GULL ISLAND SUBTIDAL AREA; 3 and 5 AUGUST 1978

TAXA

ALGAE - Phaeophyta

- Alaria taeniata
- Desmarestia viridis
- Laminaria sp, juvenile

ALGAE - Rhodophyta

- Schizymenia pacifica

PORIFERA

- Esperiopsis quatsinoensis
- Mycale lingua
- Porifera, unid.,
- Suberites ficus

CNIDARIA - Hydrozoa

- Abietinaria variabilis
- Irene ?indicans
- Lafoea dumosa
- Sertularella tenella
- Sertularia cupressoides

CNIDARIA - Anthozoa

- Anthozoa, unid., white
- Cribrinopsis fernaldi
- Cribrinopsis sp
- Esperiopsis sp
- Metridium senile
- Tealia crassicornis

ANNELIDA - Polychaeta

- Sabellidae, unid.
- Schizobranchia sp

ARTHROPODA - Crustacea

- Balanus rostratus
- Caprella ?gracilior
- Caridea, unid.
- Elassochirus gilli
- E. tenuimanus
- Lebbeus sp
- Pagurus beringanus
- P. kennerlyi

TAXA

MOLLUSCA - Gastropoda

- Aeolidia sp
- Beringius kennicotti
- Dendronotus sp
- Dirona aurantia
- Fusitriton oregonensis
- Margarites pupillus
- Neptunea lyrata
- Velutina ?prolonga

MOLLUSCA - Pelecypoda

- Modiolus modiolus
- Musculus vernicosus

MOLLUSCA - Polyplacophora

- Mopalia ciliata
- Tonicella lineata

MOLLUSCA - Cephalopoda

- Octopus dofleini

ECTOPROCTA

- Alcyonidium polyoum
- Bidenkapia sp
- Dendrobeania murrayana
- Ectoprocta, unid.
- Eucratea loricata
- Hippothoa hyalina
- Lichenopora sp
- Lagenipora ?socialis
- Porella sp

ECHINODERMATA - Asteroidea

- Crossaster papposus
- Henricia sanguinolenta
- Leptasterias polaris acervata
- Solaster stimpsoni

ECHINODERMATA - Holothuroidea

- Cucumaria miniata
- Eupentacta quinquesemita
- Psolus chitinoides

TAXA

ECHINODERMATA - Ophiuroidea

- Ophiopholis aculeata

CHORDATA - Tunicata

- Alcyonidium polyoum
- Cnemidocarpa sp
- Dendrodoa pulchella
- Halocynthia aurantium
- Styela montereyensis
- Tunicata, unid.

CHORDATA - Pisces

- Hexagrammos stelleri
- Hexagrammos sp
- Myoxocephalus spp
- Ronquilus sp

APPENDIX G-2b   COVER AND ABUNDANCE DATA FOR WHITE GULL ISLAND SUBTIDAL AREA; 3 AUGUST 1978. ¼ M^2 SQUARE QUADRATS FROM 0.4 - 5.0 M BELOW MLLW

TAXA						$\bar{x}$ ± s		Density (no./m^2)
ALGAE - Rhodophyta								
Coralline alga, encrust.	(%)*	0	0	1	0	0.3	0.5%	
Hildenbrandia sp	(%)	0	0	2%	0	0.5	1.0%	
INVERTEBRATA								
Abietinaria sp	(%)	0	2%	5%	3%	2.5	2.1%	
Alcyonidium pedunculatum	(%)	0	0	T**	T	0.3	0.3%	
Balanus rostratus	(%)	-	15%	10%	25%	16.7	7.6%	
Boreotrophon sp		0	0	1	4	1.3	1.9	5.0
Costazia ?surcularis	(%)	10%	10%	4%	3%	6.8	3.8%	
Cribrinopsis similis	(%)	0	0	0	15%	3.8	7.5%	
		0	0	0	1	0.3	0.5	1.0
Ectoprocta, unid., encrusting, orange	(%)	-	2%	1%	0	1.0	1.0%	
Esperiopsis ?laxa	(%)	0	1%	10%	3%	3.5	4.5%	
Margarites pupillus		0	0	1	3	1.0	1.4	4.0
Metridium senile, juv.		0	0	0	1	0.3	0.5	1.0
Mycale ?lingua	(%)	4%	6%	3%	2%	3.8	1.7%	
Sertulariidae, unid.	(%)	0	0	0	2%	0.5	1.0	2.0
Tonicella insignis		0	0	1	0	0.3	0.5	1.0
Dendrodoa pulchella	(%)	10%	28%	70%	15%	30.8	27.2%	
Tunicata, unid., white	(%)	0	3%	0	0	0.8	1.5%	

EXTRALIMITAL SPECIES:

INVERTEBRATA

?Halocynthia aurantia
Henricia sanguinolenta
Leptasterias ?hylodes
Sertularia cupressoides
Styela montereyensis
Tealia crassicornis

CHORDATA - Pisces

Bathymaster sp
Hexagrammos stelleri

Substrate: Sheer rock face from 0.4m - 4.4m, boulder field slope from 4.4m out to gravel at 11.1m below MLLW

* Unless noted, numbers indicate number of individuals
** T = Trace

APPENDIX H RECONNAISSANCE SURVEY FROM BLACK REEF; 12 JUNE 1978

TAXA	Depth (m)* above 1.8	2.5	4.7	4.0	9.3
ALGAE - Phaeophyta					
Agarum cribrosum			X		
Alaria taeniata	X				
Laminaria groenlandica	X				
Laminaria sp		X			
ALGAE - Rhodophyta					
Coralline alga, encrust.	X		X		
Rhodymenia palmata	X		X		
PORIFERA					
Esperiopsis sp		X		X	
Halichondria panicea			X		
?*Halichondria* sp			X		
Hymendectyon ?*lyoni*			X		
?*Hymendesmia* sp			X		
Mycale sp			X		
Myxilla incrustans			X		
Porifera, unid., yellow			X		
Porifera, unid., orange			X		
Suberites sp			X		
CNIDARIA - Hydrozoa					
Abietinaria ?*amphora*			X		
A. variabilis			X		
Calycella syringa			X		
Eudendrium ?*irregulare*			X		
Hybocodon sp		X			

TAXA	Depth (m) above 1.8	2.5	4.7	4.0	9.3
CNIDARIA - Hydrozoa cont.					
Hydrallmania distans			X		
Lafoea fruticosa			X		
Sertularella tenella			X		
CNIDARIA - Anthozoa					
Anthopleura artemisia		X		X	
Cribrinopsis fernaldi		X			
Metridium senile		X			
Tealia sp		X			
ANNELIDA - Polychaeta					
Owenia collaris			X		
Platynereis bicaniculata			X		
Terebellidae, unid.		X			
ARTHROPODA - Crustacea					
Balanus rostratus		X	X		
Balanus sp		X			
Cancer oregonensis			X		
Elassochirus gilli		X			
Oregonia gracilis			X		
Pagurus hirsutiusculus			X		
P. kennerlyi			X		
Paguridae, unid.					X
Pandalidae, unid.		X		X	
Phyllolithodes papillosus				X	
Placetron wosnesenskii				X	

APPENDIX H (Continued)

TAXA	Depth (m) above 1.8	2.5	4.7	4.0	9.3
MOLLUSCA - Gastropoda					
Acanthodoris ?pillosa		X			
?Beringius kennicotti			X		
Boreotrophon ?clathrus		X			
Buccinum glaciale			X		
Calliostoma ligata				X	
Coryphella sp		X			
Diaulula sandiegensis		X			
Dirona aurantia		X			
Fusitriton oregonensis			X		X
Margarites pupillus				X	
Neptunea lyrata, egg cases		X			
Nudibranchia, unid.		X			
Trichotropis cancellata		X		X	
T. insignis				X	
Trophonopsis lasius			X		
Velutina laevigata				X	
V. rubra				X	
Volutopsius castaneus, shell only			X		
MOLLUSCA - Pelecypoda					
Hiatella arctica				X	
Modiolus modiolus			X		
Musculus discors			X		
Mya truncata			X		
Pododesmus macroschisma		X			

TAXA	Depth (m) above 1.8	2.5	4.7	4.0	9.3
MOLLUSCA - Polyplacophora					
Ischnochiton trifidus			X		
Mopalia spp		X	X		X
Tonicella insignis			X		
T. lineata			X		
ECTOPROCTA					
Alcyonidium polyoum			X		
Bidenkapia spitsbergensis			X	X	
Costazia surcularis			X		
Ectoprocta, unid., digitate			X		
Ectoprocta, unid., encrust.			X		
Heteropora sp			X		
Hippothoa hyalina			X		
Lagenipora ?socialis			X		
Microporella sp			X		
M. plana			X		
Phidolopora sp			X		
Porella compressa			X		
Porella sp			X		
Terminoflustra membranacea truncata			X	X	
ENTOPROCTA					
Barentsia ?ramosa			X		
BRACHIOPODA					
Diastothyrus sp			X		
Hemithyrsis psittacea		X	X		
Terebratalia transversus		X	X		

APPENDIX H (Continued

TAXA	Depth (m) above 1.8	2.5	4.7	4.0	9.3
ECHINODERMATA - Asteroidea					
Crossaster papposus		X		X	
Henricia leviuscula			X	X	
H. sanguinolenta		X	X		
H. tumida				X	
Leptasterias polaris acervata		X		X	
ECHINODERMATA - Echinoidea					
Strongylocentrotus drobachiensis			X		
ECHINODERMATA - Holothuroidea					
Eupentacta sp				X	
Psolus sp		X		X	

TAXA	Depth (m) above 1.8	2.5	4.7	4.0	9.3
ECHINOIDEA - Ophiuroidea					
Ophiopholis aculeata			X		X
CHORDATA - Tunicata					
?*Cnemidocarpa* sp			X		
Dendrodoa sp			X		
Halocynthia aurantia		X	X		
Styela montereyensis			X	X	
Tunicata, unid., colonial		X		X	
CHORDATA - Pisces					
Cottidae, unid.		X			
Hexagrammos stelleri		X			

Substrate: Above 1.8 m = Rock
2.5 m = Vertical Face
4.7 m = Boulder
4.0 m = Overhang
9.3 m = Sand, gravel and silt with ripple marks

* Below MLLW

APPENDIX I RECONNAISSANCE SURVEY FROM TURTLE REEFS; 5 AUGUST 1978

TAXA	Station I*	Station S**	TAXA	Station I	Station S
ALGAE - Chlorophyta			MOLLUSCA - Gastropoda		
<u>Spongomorpha</u> sp	X		<u>Acmaea</u> spp	X	
ALGAE - Phaeophyta			<u>Calliostoma</u>		X
			<u>littorina</u>	X	
<u>Alaria</u> <u>taeniata</u>	X		MOLLUSCA - Polyplacophora		
<u>Fucus</u> <u>distichus</u>	X				
<u>Laminaria</u>	X	X	<u>Tonicella</u> <u>lineata</u>	X	
ALGAE - Rhodophyta			BRACHIOPODA		
<u>Rhodymenia</u> <u>palmata</u>	X		Brachiopoda, unid.		X
PORIFERA			<u>Terebratalia</u> sp		X
<u>Halichondria</u> <u>panicea</u>	X		ECHINODERMATA - Asteroidea		
CNIDARIA - Anthozoa			<u>Crossaster</u> <u>papposus</u>		X
			<u>Henricia</u> <u>sanguinolenta</u>		X
<u>Anthopleura</u> <u>artemisia</u>	X		ECHINODERMATA - Ophiuroidea		
<u>Cribrinopsis</u> sp	X	X			
<u>Tealia</u> <u>crassicornis</u>	X		<u>Ophiopholis</u> <u>aculeata</u>		X
ARTHROPODA - Crustacea			CHORDATA - Tunicata		
<u>Balanus</u> sp	X		<u>Styela</u> sp		X
			Tunicata, unid.		X

* I = Intertidal
** S = Subtidal, less than 2 m below MLLW

APPENDIX J SUMMARY OF PREY SPECIES AND THEIR MAJOR PREDATORS

TISSUE UNID N = 17 PREDATOR SPECIES = 2
94.1 % ELASSOCHIRUS GILLI
5.9 % CANCER MAGISTER

FORAMINIFERA UNID N = 8 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

DIATOMS UNID N = 5 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

ORGANISMS UNID N = 4 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

TEREBRATALIA TRANSVERSUS N = 1 PREDATOR SPECIES = 1
100 % ORTHASTERIAS KOEHLERI

HEMITHYRIS PSITTACEA N = 1 PREDATOR SPECIES = 1
100 % PTERASTER TESSELATUS

CORALLINE ALGA N = 1 PREDATOR SPECIES = 1
100 % PTERASTER TESSELATUS

LAMINARIA GROENLANDICA N = 2 PREDATOR SPECIES = 2
50 % STRONGYLOCENTROTUS DROBACHIENSIS
50 % STRONGYLOCENTROTUS PALLIDUS

ALARIA FISTULOSA N = 4 PREDATOR SPECIES = 4
25 % AMPHIPODA UNID
25 % GAMMARIDAE UNID
25 % LACUNA SP
25 % STRONGYLOCENTROTUS DROBACHIENSIS

AGARUM CRIBROSUM N = 6 PREDATOR SPECIES = 2
83.3 % STRONGYLOCENTROTUS DROBACHIENSIS
16.7 % STRONGYLOCENTROTUS PALLIDUS

ALARIA SP N = 5 PREDATOR SPECIES = 1
100 % KATHARINA TUNICATA

FUCUS DISTICHUS N = 1 PREDATOR SPECIES = 1
100 % SIPHONARIA THERSITES

PORPHYRA SP N = 1 PREDATOR SPECIES = 1
100 % LITTORINA SITKANA

RHODOPHYTA UNID N = 1 PREDATOR SPECIES = 1
100 % STRONGYLOCENTROTUS SP

PLANT UNID N = 3 PREDATOR SPECIES = 2
66.7 % ELASSOCHIRUS GILLI
33.3 % NEPHTYS SP

PORIFERA UNID N = 15 PREDATOR SPECIES = 5
46.7 % DERMASTERIAS IMBRICATA
26.7 % PTERASTER TESSELATUS
13.3 % HENRICIA SANGUINOLENTA
6.7 % ELASSOCHIRUS GILLI
6.7 % HENRICIA LEVIUSCULA

MYCALE LINGUA N = 8 PREDATOR SPECIES = 2
87.5 % HENRICIA SANGUINOLENTA
12.5 % DERMASTERIAS IMBRICATA

ESPERIOPSIS LAXA N = 2 PREDATOR SPECIES = 1
100 % PTERASTER TESSELATUS

MYCALE HISPIDA N = 3 PREDATOR SPECIES = 2
66.7 % PTERASTER TESSELATUS
33.3 % DERMASTERIAS IMBRICATA

ESPERIOPSIS SP N = 4 PREDATOR SPECIES = 1
100 % PTERASTER TESSELATUS

HALICHONDRIA PANICEA N = 1 PREDATOR SPECIES = 1
100 % ARCHIDORIS MONTEREYENSIS

CLIONA CELATA N = 1 PREDATOR SPECIES = 1
100 % HENRICIA LEVIUSCULA

LEUCOSOLENIA SP N = 1 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

HYDROZOA UNID N = 7 PREDATOR SPECIES = 3
42.9 % ELASSOCHIRUS GILLI
42.9 % DERMASTERIAS IMBRICATA
14.3 % CROSSASTER PAPPOSUS

ANTHOZOA UNID N = 3 PREDATOR SPECIES = 2
66.7 % SOLASTER STIMPSONI
33.3 % PTERASTER TESSELATUS

METRIDIUM SENILE N = 50 PREDATOR SPECIES = 1
100 % DERMASTERIAS IMBRICATA

TEALIA CRASSICORNIS N = 7 PREDATOR SPECIES = 1
100 % DERMASTERIAS IMBRICATA

ANTHOPLEURA SP N = 1 PREDATOR SPECIES = 1
100 % DERMASTERIAS IMBRICATA

ABIETINARIA VARIABILIS N = 5 PREDATOR SPECIES = 1
100 % DENDRONOTUS DALLI

ABIETINARIA SP N = 9 PREDATOR SPECIES = 6
33.3 % ELASSOCHIRUS GILLI

22.2 % PTERASTER TESSELATUS
11.1 % DENDRONOTUS DALLI
11.1 % NUDIBRANCH UNID
11.1 % CROSSASTER PAPPOSUS

HYBOCODON PROLIFER N = 1 PREDATOR SPECIES = 1
100 % AEOLIDIDA UNID

POLYCHAETA UNID N = 4 PREDATOR SPECIES = 3
50 % ELASSOCHIRUS GILLI
25 % NEPHTYS SP
25 % SEARLESIA DIRA

SABELLIDAE UNID N = 5 PREDATOR SPECIES = 3
40 % ELASSOCHIRUS GILLI
40 % ELASSOCHIRUS TENUIMANUS
20 % NEMERTEA UNID

NEPHTYS SP N = 1 PREDATOR SPECIES = 1
100 % PAGURIDAE UNID

PLATYNEREIS BICANICULATA N = 1 PREDATOR SPECIES = 1
100 % PARANEMERTES SP

SPIRORBINAE UNID N = 1 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

CISTENIDES GRANULATA N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

BONELLIOPSIS SP N = 9 PREDATOR SPECIES = 3
66.7 % SOLASTER STIMPSONI
22.2 % PYCNOPODIA HELIANTHOIDES
11.1 % TELMESSUS CHEIRAGONUS

ECHIURUS ECHIURUS N = 2 PREDATOR SPECIES = 1
100 % NEPHTYS SP

CRUSTACEAN UNID N = 7 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

OSTRACODA UNID N = 2 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

COPEPODA UNID N = 2 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

CIRRIPEDIA UNID N = 1 PREDATOR SPECIES = 1
100 % CANCER MAGISTER

ISOPODA UNID N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

AMPHIPODA UNID N = 1 PREDATOR SPECIES = 1

100 % ELASSOCHIRUS GILLI

BALANUS SP N = 98 PREDATOR SPECIES = 6
54.1 % LEPTASTERIAS HEXACTIS
18.4 % EVASTERIAS TROSCHELII
17.3 % NUCELLA LAMELLOSA
7.1 % LEPTASTERIAS POLARIS ACERVATA
2 % ORTHASTERIAS KOEHLERI

GAMMARIDAE UNID N = 9 PREDATOR SPECIES = 4
44.4 % ELASSOCHIRUS GILLI
33.3 % LEPTASTERIAS HEXACTIS
11.1 % NEREIS SP
11.1 % CANCER MAGISTER

PAGURIDAE UNID N = 1 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

CANCER OREGONENSIS N = 1 PREDATOR SPECIES = 1
100 % OCTOPUS RUBESCENS

TELMESSUS CHEIRAGONUS N = 2 PREDATOR SPECIES = 2
50 % CRIBRINOPSIS SIMILIS
50 % PYCNOPODIA HELIANTHOIDES

BALANUS NUBILUS N = 3 PREDATOR SPECIES = 2
66.7 % ORTHASTERIAS KOEHLERI
33.3 % NUCELLA LAMELLOSA

PENTIDOTEA WOSNESENSKII N = 10 PREDATOR SPECIES = 2
90 % LEPTASTERIAS HEXACTIS
10 % TEALIA CRASSICORNIS

BALANUS CARIOSUS N = 30 PREDATOR SPECIES = 2
73.3 % EVASTERIAS TROSCHELII 22
26.7 % NUCELLA LAMELLOSA 8

PENTIDOTEA SP N = 3 PREDATOR SPECIES = 2
66.7 % VOLUTHARPA SP
33.3 % LEPTASTERIAS HEXACTIS

ANISOGAMMARUS SP N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

DECAPODA UNID N = 3 PREDATOR SPECIES = 2
66.7 % ELASSOCHIRUS GILLI
33.3 % EVASTERIAS TROSCHELII

TANAID UNID N = 1 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

BALANUS CRENATUS N = 54 PREDATOR SPECIES = 2
98.1 % EVASTERIAS TROSCHELII
1.9 % ORTHASTERIAS KOEHLERI

BALANUS GLANDULA N = 5 PREDATOR SPECIES = 4
40 % NUCELLA EMARGINATA
20 % TEALIA CRASSICORNIS
20 % LEPTASTERIAS POLARIS ACERVATA
20 % LEPTASTERIAS HEXACTIS

BALANUS ROSTRATUS N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

PANDALUS HYPSINOTUS N = 1 PREDATOR SPECIES = 1
100 % EVASTERIAS TROSCHELII

GNORIMOSPHAEROMA OREGONENSIS N = 3 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

TROPHONOPSIS LASIUS N = 3 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

VOLUTHARPA AMPULLACEA N = 5 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

VOLUTHARPA SP N = 1 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

BUCCINUM SP N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

FUSITRITON OREGONENSIS N = 5 PREDATOR SPECIES = 4
40 % PYCNOPODIA HELIANTHOIDES
20 % PAGURIDAE UNID
20 % OCTOPUS SP
20 % STRONGYLOCENTROTUS DROBACHIENSIS

ACMAEIDAE UNID N = 7 PREDATOR SPECIES = 2
85.7 % LEPTASTERIAS HEXACTIS
14.3 % ORTHASTERIAS KOEHLERI

NATICA CLAUSA N = 1 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

NUDIBRANCH UNID N = 1 PREDATOR SPECIES = 1
100 % PUGETTIA GRACILIS

ACMAEA SCUTUM N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

LITTORINA SITKANA N = 31 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

ROSTANGA PULCHRA N = 1 PREDATOR SPECIES = 1
100 % CROSSASTER PAPPOSUS

MARGARITES HELICINUS N = 1 PREDATOR SPECIES = 1

100 % ELASSOCHIRUS GILLI

MARGARITES PUPILLUS N = 2 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

DIODORA ASPERA N = 1 PREDATOR SPECIES = 1
100 % ORTHASTERIAS KOEHLERI

NEPTUNEA SP N = 1 PREDATOR SPECIES = 1
100 % PAGURIDAE UNID

NATICA SP N = 7 PREDATOR SPECIES = 1
100 % EVASTERIAS TROSCHELII

NEPTUNEA LYRATA N = 3 PREDATOR SPECIES = 3
33.3 % OCTOPUS SP
33.3 % CROSSASTER PAPPOSUS
33.3 % LEPTASTERIAS HEXACTIS

TROPHON MULTICOSTATUS N = 1 PREDATOR SPECIES = 1
100 % SPINULOSA UNID

ACMAEA PELTA N = 1 PREDATOR SPECIES = 1
100 % EVASTERIAS TROSCHELII

PELECYPODA UNID N = 1 PREDATOR SPECIES = 1
100 % CANCER MAGISTER

MODIOLUS MODIOLUS N = 230 PREDATOR SPECIES = 8
69.1 % EVASTERIAS TROSCHELII
16.5 % PYCNOPODIA HELIANTHOIDES
11.7 % ORTHASTERIAS KOEHLERI
.9 % LEPTASTERIAS POLARIS ACERVATA
.4 % TROPHONOPSIS LASIUS

ENTODESMA SAXICOLA N = 20 PREDATOR SPECIES = 3
75 % EVASTERIAS TROSCHELII
20 % PYCNOPODIA HELIANTHOIDES
5 % ORTHASTERIAS KOEHLERI

MUSCULUS DISCORS N = 6 PREDATOR SPECIES 4
50 % ORTHASTERIAS KOEHLERI
16.7 % CROSSASTER PAPPOSUS
16.7 % EVASTERIAS TROSCHELII
16.7 % LEPTASTERIAS POLARIS ACERVATA

SAXIDOMUS GIGANTEA N = 48 PREDATOR SPECIES = 4
87.5 % PYCNOPODIA HELIANTHOIDES
8.3 % EVASTERIAS TROSCHELII
2.1 % SCYRA ACUTIFRONS
2.1 % FUSITRITON OREGONENSIS

MYA TRUNCATA N = 6 PREDATOR SPECIES = 3
66.7 % PYCNOPODIA HELIANTHOIDES

APPENDIX J (Continued)

16.7 % EVASTERIAS TROSCHELII
16.7 % LEPTASTERIAS POLARIS ACERVATA

PANOMYA AMPLA N = 1 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

PODODESMUS MACROSCHISMA N = 2 PREDATOR SPECIES = 1
100 % ORTHASTERIAS KOEHLERI

MACOMA SP N = 12 PREDATOR SPECIES = 4
66.7 % EVASTERIAS TROSCHELII
16.7 % PYCNOPODIA HELIANTHOIDES
8.3 % TELMESSUS CHEIRAGONUS
8.3 % NATICA CLAUSA

MYA SP N = 9 PREDATOR SPECIES = 3
55.6 % PYCNOPODIA HELIANTHOIDES
33.3 % LEPTASTERIAS POLARIS ACERVATA
11.1 % EVASTERIAS TROSCHELII

HUMILARIA KENNERLYI N = 6 PREDATOR SPECIES = 1
100 % ORTHASTERIAS KOEHLERI

MYTILUS EDULIS N = 109 PREDATOR SPECIES = 7
47.7 % NUCELLA LAMELLOSA
33.9 % EVASTERIAS TROSCHELII
14.7 % LEPTASTERIAS HEXACTIS
.9 % METRIDIUM SENILE
.9 % HYAS LYRATUS

PROTOTHACA STAMINEA N = 9 PREDATOR SPECIES = 3
55.6 % EVASTERIAS TROSCHELII
33.3 % PYCNOPODIA HELIANTHOIDES
11.1 % LEPTASTERIAS POLARIS ACERVATA

CLINOCARDIUM SP N = 13 PREDATOR SPECIES = 1
100 % EVASTERIAS TROSCHELII

TRESUS CAPAX N = 4 PREDATOR SPECIES = 2
75 % EVASTERIAS TROSCHELII
25 % CHIONOECETES BAIRDI

SERRIPES GROENLANDICUS N = 1 PREDATOR SPECIES = 1
100 % EVASTERIAS TROSCHELII

CLINOCARDIUM CALIFORNIENSE N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

MACOMA BALTHICA N = 2 PREDATOR SPECIES = 2
50 % NATICA SP
50 % LEPTASTERIAS POLARIS ACERVATA

MACOMA OBLIQUA N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

MYA ARENARIA N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

POLYPLACOPHORA UNID N = 2 PREDATOR SPECIES = 1
100 % CROSSASTER PAPPOSUS

CRYPTOCHITON STELLERI N = 3 PREDATOR SPECIES = 2
66.7 % STRONGYLOCENTROTUS DROBACHIENSIS
33.3 % FUSITRITON OREGONENSIS

KATHARINA TUNICATA N = 6 PREDATOR SPECIES = 3
66.7 % LEPTASTERIAS HEXACTIS
16.7 % METRIDIUM SENILE
16.7 % EVASTERIAS TROSCHELII

MOPALIA CILIATA N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS HEXACTIS

SCHIZOPLAX BRANDTII N = 1 PREDATOR SPECIES = 1
100 % FLIES UNID

MOPALIA SP N = 1 PREDATOR SPECIES = 1
100 % LEPTASTERIAS POLARIS ACERVATA

ECTOPROCTA UNID N = 3 PREDATOR SPECIES = 2
66.7 % CROSSASTER PAPPOSUS
33.3 % ELASSOCHIRUS GILLI

FLUSTRELLA GIGANTEA N = 2 PREDATOR SPECIES = 2
50 % CROSSASTER PAPPOSUS
50 % PTERASTER TESSELATUS

ECTOPROCTA ENCRUSTING N = 1 PREDATOR SPECIES = 1
100 % STRONGYLOCENTROTUS DROBACHIENSIS

ALCYONIDIUM SP N = 1 PREDATOR SPECIES = 1
100 % CROSSASTER PAPPOSUS

FLUSTRELLA SP N = 6 PREDATOR SPECIES = 1
100 % ELASSOCHIRUS GILLI

MICROPORINA BOREALIS N = 1 PREDATOR SPECIES = 1
100 % PTERASTER TESSELATUS

ALCYONIDIUM PEDUNCULATUM N = 1 PREDATOR SPECIES = 1
100 % CROSSASTER PAPPOSUS

DERMASTERIAS IMBRICATA N = 1 PREDATOR SPECIES = 1
100 % PYCNOPODIA HELIANTHOIDES

EVASTERIAS TROSCHELII N = 2 PREDATOR SPECIES = 2
50 % SOLASTER DAWSONI
50 % SOLASTER STIMPSONI

STRONGYLOCENTROTUS DROBACHIENSIS N = 50 PREDATOR SPECIES = 7

84	%	PYCNOPODIA HELIANTHOIDES
4	%	ELASSOCHIRUS GILLI
4	%	FUSITRITON OREGONENSIS
2	%	CRIBRINOPSIS SIMILIS
2	%	ACTINIARIA UNID

STRONGYLOCENTROTUS SP N = 6 PREDATOR SPECIES = 2

83.3	%	ELASSOCHIRUS GILLI
16.7	%	CROSSASTER PAPPOSUS

CUCUMARIA SP N = 18 PREDATOR SPECIES = 5

38.9	%	LEPTASTERIAS HEXACTIS
27.8	%	SOLASTER STIMPSONI
11.1	%	DERMASTERIAS IMBRICATA
11.1	%	PYCNOPODIA HELIANTHOIDES
11.1	%	SOLASTER DAWSONI

CUCUMARIA VEGAE N = 1 PREDATOR SPECIES = 1

100	%	SOLASTER STIMPSONI

OPHIUROIDEA UNID N = 6 PREDATOR SPECIES = 1

100	%	ELASSOCHIRUS GILLI

TUNICATA UNID N = 1 PREDATOR SPECIES = 1

100	%	SOLASTER STIMPSONI

HALOCYNTHIA AURANTIUM N = 1 PREDATOR SPECIES = 1

100	%	ORTHASTERIAS KOEHLERI

CNEMIDOCARPA FINMARKIENSIS N = 1 PREDATOR SPECIES = 1

100	%	FUSITRITON OREGONENSIS

MYOXOCEPHALUS POLYACANTHOCEPHALUS N = 4 PREDATOR SPECIES = 3

50	%	AMPHISSA SP
25	%	BUCCINUM SP
25	%	FUSITRITON OREGONENSIS

PHOLIS LAETA N = 1 PREDATOR SPECIES = 1

100	%	OCTOPUS SP

note: data does not include vertebrate predators

APPENDIX K SUMMARY OF PREY GROUPS WITH MAJOR PREDATOR SPECIES

ALGAE N = 24 PREDATOR SPECIES = 12

29.2	%	STRONGYLOCENTROTUS DROBACHIENSIS
20.8	%	KATHARINA TUNICATA
8.3	%	ELASSOCHIRUS GILLI
8.3	%	STRONGYLOCENTROTUS PALLIDUS
4.2	%	NEPHTYS SP

FORAMINIFERA N = 8 PREDATOR SPECIES = 1

100	%	ELASSOCHIRUS GILLI

PORIFERA N = 35 PREDATOR SPECIES = 6

34.3	%	PTERASTER TESSELATUS
25.7	%	DERMASTERIAS IMBRICATA
25.7	%	HENRICIA SANGUINOLENTA
5.7	%	ELASSOCHIRUS GILLI
5.7	%	HENRICIA LEVIUSCULA

HYDROZOA N = 22 PREDATOR SPECIES = 7

27.3	%	ELASSOCHIRUS GILLI
27.3	%	DENDRONOTUS DALLI
18.2	%	DERMASTERIAS IMBRICATA
9.1	%	CROSSASTER PAPPOSUS
9.1	%	PTERASTER TESSELATUS

ANTHOZOA N = 61 PREDATOR SPECIES = 3

95.1	%	DERMASTERIAS IMBRICATA
3.3	%	SOLASTER STIMPSONI
1.6	%	PTERASTER TESSELATUS

POLYCHAETA N = 13 PREDATOR SPECIES = 8

38.5	%	ELASSOCHIRUS GILLI
15.4	%	ELASSOCHIRUS TENUIMANUS
7.7	%	NEMERTEA UNID
7.7	%	PARANEMERTES SP
7.7	%	NEPHTYS SP

ECHIURA N = 11 PREDATOR SPECIES = 4

54.5	%	SOLASTER STIMPSONI
18.2	%	NEPHTYS SP
18.2	%	PYCNOPODIA HELIANTHOIDES
9.1	%	TELMESSUS CHEIRAGONUS

CRUSTACEA N = 240 PREDATOR SPECIES = 14

39.6	%	EVASTERIAS TROSCHELII
30	%	LEPTASTERIAS HEXACTIS
10.8	%	NUCELLA LAMELLOSA
7.9	%	ELASSOCHIRUS GILLI
3.8	%	LEPTASTERIAS POLARIS ACERVATA

APPENDIX K (Continued)

GASTROPODA N = 74 PREDATOR SPECIES = 11

67.6	%	LEPTASTERIAS HEXACTIS
10.8	%	EVASTERIAS TROSCHELII
5.4	%	PYCNOPODIA HELIANTHOIDES
2.7	%	PAGURIDAE UNID
2.7	%	OCTOPUS SP

PELECYPODA N = 482 PREDATOR SPECIES = 20

51.5	%	EVASTERIAS TROSCHELII
20.5	%	PYCNOPODIA HELIANTHOIDES
10.8	%	NUCELLA LAMELLOSA
8.1	%	ORTHASTERIAS KOEHLERI
3.3	%	LEPTASTERIAS HEXACTIS

POLYPLACOPHORA N = 14 PREDATOR SPECIES = 8

35.7	%	LEPTASTERIAS HEXACTIS
14.3	%	CROSSASTER PAPPOSUS
14.3	%	STRONGYLOCENTROTUS DROBACHIENSIS
7.1	%	FLIES UNID
7.1	%	METRIDIUM SENILE

ECTOPROCTA N = 15 PREDATOR SPECIES = 4

46.7	%	ELASSOCHIRUS GILLI
33.3	%	CROSSASTER PAPPOSUS
13.3	%	PTERASTER TESSELATUS
6.7	%	STRONGYLOCENTROTUS DROBACHIENSIS

ASTEROIDEA N = 3 PREDATOR SPECIES = 3

33.3	%	PYCNOPODIA HELIANTHOIDES
33.3	%	SOLASTER DAWSONI
33.3	%	SOLASTER STIMPSONI

ECHINOIDEA (STRONGYLOCENTROTUS SPP) N = 56 PREDATOR SPECIES = 8

75	%	PYCNOPODIA HELIANTHOIDES
12.5	%	ELASSOCHIRUS GILLI
3.6	%	FUSITRITON OREGONENSIS
1.8	%	CRIBRINOPSIS SIMILIS
1.8	%	ACTINIARIA UNID

HOLOTHUROIDEA N = 19 PREDATOR SPECIES = 5

36.8	%	LEPTASTERIAS HEXACTIS
31.6	%	SOLASTER STIMPSONI
10.5	%	DERMASTERIAS IMBRICATA
10.5	%	PYCNOPODIA HELIANTHOIDES
10.5	%	SOLASTER DAWSONI

OPHIUROIDEA N = 6 PREDATOR SPECIES = 1

100	%	ELASSOCHIRUS GILLI

TUNICATA N = 3 PREDATOR SPECIES = 3

33.3	%	FUSITRITON OREGONENSIS
33.3	%	ORTHASTERIAS KOEHLERI
33.3	%	SOLASTER STIMPSONI

APPENDIX K (Continued)

PISCES		N = 5	PREDATOR SPECIES = 4*
40	%	AMPHISSA SP	
20	%	BUCCINUM SP	
20	%	FUSITRITON OREGONENSIS	
20	%	OCTOPUS SP	

* - does not include vertebrate predator data

APPENDIX L SUMMARY OF PREDATOR SPECIES AND THEIR MAJOR PREY

NEMERTEA UNID N = 1 PREY SPECIES = 1
100 % SABELLIDAE UNID

PARANEMERTES SP N = 1 PREY SPECIES = 1
100 % PLATYNEREIS BICANICULATA

FLIES UNID N = 1 PREY SPECIES = 1
100 % SCHIZOPLAX BRANDTII

METRIDIUM SENILE N = 2 PREY SPECIES = 2
50 % MYTILUS EDULIS
50 % KATHARINA TUNICATA

TEALIA CRASSICORNIS N = 2 PREY SPECIES = 2
50 % PENTIDOTEA WOSNESENSKII
50 % BALANUS GLANDULA

CRIBRINOPSIS SIMILIS N = 2 PREY SPECIES = 2
50 % TELMESSUS CHEIRAGONUS
50 % STRONGYLOCENTROTUS DROBACHIENSIS

ACTINIARIA UNID N = 1 PREY SPECIES = 1
100 % STRONGYLOCENTROTUS DROBACHIENSIS

NEREIS SP N = 1 PREY SPECIES = 1
100 % GAMMARIDAE UNID

NEPHTYS SP N = 11 PREY SPECIES = 4
63.6 % NOT FEEDING
18.2 % ECHIURUS ECHIURUS
9.1 % PLANT UNID
9.1 % POLYCHAETA UNID

AMPHIPODA UNID N = 1 PREY SPECIES = 1
100 % ALARIA FISTULOSA

ELASSOCHIRUS GILLI N = 95 PREY SPECIES = 25
16.8 % TISSUE UNID
11.6 % SAND UNID
8.4 % FORAMINIFERA UNID
7.4 % CRUSTACEAN UNID
6.3 % FLUSTRELLA SP

PUGETTIA GRACILIS N = 1 PREY SPECIES = 1
100 % NUDIBRANCH UNID

GAMMARIDAE UNID N = 1 PREY SPECIES = 1
100 % ALARIA FISTULOSA

PAGURIDAE UNID N = 3 PREY SPECIES = 3
33.3 % NEPHTYS SP

APPENDIX L (Continued)

33.3 % FUSITRITON OREGONENSIS
33.3 % NEPTUNEA SP

TELMESSUS CHEIRAGONUS N = 2 PREY SPECIES = 2
50 % BONELLIOPSIS SP
50 % MACOMA SP

ELASSOCHIRUS TENUIMANUS N = 2 PREY SPECIES = 1
100 % SABELLIDAE UNID

CANCER MAGISTER N = 4 PREY SPECIES = 4
25 % TISSUE UNID
25 % CIRRIPEDIA UNID
25 % GAMMARIDAE UNID
25 % PELECYPODA UNID

CHIONOECETES BAIRDI N = 1 PREY SPECIES = 1
100 % TRESUS CAPAX

HYAS LYRATUS N = 1 PREY SPECIES = 1
100 % MYTILUS EDULIS

SCYRA ACUTIFRONS N = 1 PREY SPECIES = 1
100 % SAXIDOMUS GIGANTEA

TROPHONOPSIS LASIUS N = 1 PREY SPECIES = 1
100 % MODIOLUS MODIOLUS

VOLUTHARPA AMPULLACEA N = 1 PREY SPECIES = 1
100 % MODIOLUS MODIOLUS

AMPHISSA SP N = 2 PREY SPECIES = 1
100 % MYOXOCEPHALUS POLYACANTHOCEPHALUS

BUCCINUM SP N = 1 PREY SPECIES = 1
100 % MYOXOCEPHALUS POLYACANTHOCEPHALUS

DENDRONOTUS DALLI N = 6 PREY SPECIES = 2
83.3 % ABIETINARIA VARIABILIS
16.7 % ABIETINARIA SP

LACUNA SP N = 1 PREY SPECIES = 1
100 % ALARIA FISTULOSA

FUSITRITON OREGONENSIS N = 7 PREY SPECIES = 6
28.6 % STRONGYLOCENTROTUS DROBACHIENSIS
14.3 % MODIOLUS MODIOLUS
14.3 % SAXIDOMUS GIGANTEA
14.3 % CRYPTOCHITON STELLERI
14.3 % CNEMIDOCARPA FINMARKIENSIS

NATICA CLAUSA N = 1 PREY SPECIES = 1
100 % MACOMA SP

APPENDIX L (Continued)

NUDIBRANCH UNID N = 1 PREY SPECIES = 1
100 % ABIETINARIA SP

LITTORINA SITKANA N = 1 PREY SPECIES = 1
100 % PORPHYRA SP

ARCHIDORIS MONTEREYENSIS N = 1 PREY SPECIES = 1
100 % HALICHONDRIA PANICEA

VOLUTHARPA SP N = 2 PREY SPECIES = 1
100 % PENTIDOTEA SP

SIPHONARIA THERSITES N = 1 PREY SPECIES = 1
100 % FUCUS DISTICHUS

NUCELLA LAMELLOSA N = 80 PREY SPECIES = 5
65 % MYTILUS EDULIS
21.3 % BALANUS SP
10 % BALANUS CARIOSUS
2.5 % UNID PREY
1.3 % BALANUS NUBILUS

SEARLESIA DIRA N = 1 PREY SPECIES = 1
100 % POLYCHAETA UNID

NATICA SP N = 1 PREY SPECIES = 1
100 % MACOMA BALTHICA

AEOLIDIDA UNID N = 1 PREY SPECIES = 1
100 % HYBOCODON PROLIFER

NUCELLA EMARGINATA N = 4 PREY SPECIES = 3
50 % BALANUS GLANDULA
25 % BALANUS SP
25 % MYTILUS EDULIS

KATHARINA TUNICATA N = 5 PREY SPECIES = 1
100 % ALARIA SP

OCTOPUS SP N = 3 PREY SPECIES = 3
33.3 % FUSITRITON OREGONENSIS
33.3 % NEPTUNEA LYRATA
33.3 % PHOLIS LAETA

OCTOPUS RUBESCENS N = 1 PREY SPECIES = 1
100 % CANCER OREGONENSIS

CROSSASTER PAPPOSUS N = 14 PREY SPECIES = 11
14.3 % POLYPLACOPHORA UNID
14.3 % ECTOPROCTA UNID
7.1 % HYDROZOA UNID
7.1 % ABIETINARIA SP
7.1 % ROSTANGA PULCHRA

DERMASTERIAS IMBRICATA N = 73 PREY SPECIES = 9

68.5	%	METRIDIUM SENILE
9.6	%	PORIFERA UNID
9.6	%	TEALIA CRASSICORNIS
4.1	%	HYDROZOA UNID
2.7	%	CUCUMARIA SP

EVASTERIAS TROSCHELII N = 809 PREY SPECIES = 20

53.8	%	NOT FEEDING
19.7	%	MODIOLUS MODIOLUS
6.6	%	BALANUS CRENATUS
4.6	%	MYTILUS EDULIS
2.7	%	BALANUS CARIOSUS

ORTHASTERIAS KOEHLERI N = 83 PREY SPECIES = 13

38.6	%	NOT FEEDING
32.5	%	MODIOLUS MODIOLUS
7.2	%	HUMILARIA KENNERLYI
3.6	%	MUSCULUS DISCORS
2.4	%	BALANUS SP

PTERASTER TESSELATUS N = 19 PREY SPECIES = 10

21.1	%	PORIFERA UNID
21.1	%	ESPERIOPSIS SP
10.5	%	ESPERIOPSIS LAXA
10.5	%	MYCALE HISPIDA
10.5	%	ABIETINARIA SP

PYCNOPODIA HELIANTHOIDES N = 167 PREY SPECIES = 18

25.1	%	SAXIDOMUS GIGANTEA
25.1	%	STRONGYLOCENTROTUS DROBACHIENSIS
22.8	%	MODIOLUS MODIOLUS
3.6	%	NOT FEEDING
3	%	MYA SP

SOLASTER DAWSONI N = 3 PREY SPECIES = 2

66.7	%	CUCUMARIA SP
33.3	%	EVASTERIAS TROSCHELII

SOLASTER STIMPSONI N = 23 PREY SPECIES = 6

30.4	%	NOT FEEDING
26.1	%	BONELLIOPSIS SP
21.7	%	CUCUMARIA SP
8.7	%	ANTHOZOA UNID
4.3	%	EVASTERIAS TROSCHELII

HENRICIA LEVIUSCULA N = 2 PREY SPECIES = 2

50	%	PORIFERA UNID
50	%	CLIONA CELATA

HENRICIA SANGUINOLENTA N = 9 PREY SPECIES = 2

77.8	%	MYCALE LINGUA
22.2	%	PORIFERA UNID

APPENDIX L (Continued)

LEPTASTERIAS POLARIS N = 1 PREY SPECIES = 1

100	%	MODIOLUS MODIOLUS

LEPTASTERIAS POLARIS ACERVATA N = 24 PREY SPECIES = 15

29.2	%	BALANUS SP
12.5	%	MYA SP
8.3	%	MODIOLUS MODIOLUS
4.2	%	CISTENIDES GRANULATA
4.2	%	BALANUS GLANDULA

SPINULOSA UNID N = 1 PREY SPECIES = 1

100	%	TROPHON MULTICOSTATUS

LEPTASTERIAS HEXACTIS N = 181 PREY SPECIES = 21

29.3	%	BALANUS SP
17.1	%	LITTORINA SITKANA
16.6	%	NOT FEEDING
8.8	%	MYTILUS EDULIS
5	%	PENTIDOTEA WOSNESENSKII

STRONGYLOCENTROTUS DROBACHIENSIS N = 25 PREY SPECIES = 6

60	%	FUSITRITON OREGONENSIS
20	%	AGARUM CRIBROSUM
8	%	CRYPTOCHITON STELLERI
4	%	LAMINARIA GROENLANDICA
4	%	ALARIA FISTULOSA

STRONGYLOCENTROTUS SP N = 1 PREY SPECIES = 1

100	%	RHODOPHYTA UNID

STRONGYLOCENTROTUS PALLIDUS N = 2 PREY SPECIES = 2

50	%	LAMINARIA GROENLANDICA
50	%	AGARUM CRIBROSUM

Note: Data does not include vertebrate predators.

APPENDIX M SUMMARY OF PREDATOR GROUPS WITH MAJOR PREY SPECIES

NEMERTEA N = 2 PREY SPECIES = 2

50	%	SABELLIDAE UNID
50	%	PLATYNEREIS BICANICULATA

ANTHOZOA N = 7 PREY SPECIES = 6

28.6	%	STRONGYLOCENTROTUS DROBACHIENSIS
14.3	%	TELMESSUS CHEIRAGONUS
14.3	%	PENTIDOTEA WOSNESENSKII
14.3	%	BALANUS GLANDULA
14.3	%	MYTILUS EDULIS

POLYCHAETA N = 12 PREY SPECIES = 5

58.3	%	NOT FEEDING
16.7	%	ECHIURUS ECHIURUS
8.3	%	PLANT UNID
8.3	%	POLYCHAETA UNID
8.3	%	GAMMARIDAE UNID

CRUSTACEA N = 112 PREY SPECIES = 37

15.2	%	TISSUE UNID
9.8	%	SAND UNID
7.1	%	FORAMINIFERA UNID
6.3	%	CRUSTACEAN UNID
5.4	%	FLUSTRELLA SP

GASTROPODA N = 113 PREY SPECIES = 23

46.9	%	MYTILUS EDULIS
15.9	%	BALANUS SP
7.1	%	BALANUS CARIOSUS
4.4	%	ABIETINARIA VARIABILIS
3.5	%	MYOXOCEPHALUS POLYACANTHOCEPHALUS

POLYPLACOPHORA N = 5 PREY SPECIES = 1

100	%	ALARIA SP

CEPHALAPODA (OCTOPUS SPP) N = 4 PREY SPECIES = 4

25	%	CANCER OREGONENSIS
25	%	FUSITRITON OREGONENSIS
25	%	NEPTUNEA LYRATA
25	%	PHOLIS LAETA

ASTEROIDEA N = 890 PREY SPECIES = 87*

25.5	%	MODIOLUS MODIOLUS
9	%	BALANUS SP
6.1	%	BALANUS CRENATUS
6.1	%	MYTILUS EDULIS
5.6	%	METRIDIUM SENILE

* - does not include 'not feeding' data

APPENDIX M (Continued)

ASTEROIDEA	N = 1513	PREY SPECIES = 89
40.4 %	NOT FEEDING	
15 %	MODIOLUS MODIOLUS	
5.3 %	BALANUS SP	
3.6 %	BALANUS CRENATUS	
3.6 %	MYTILUS EDULIS	
ECHINOIDEA	(STRONGYLOCENTROTUS SPP) N = 28	PREY SPECIES = 7
53.6 %	FUSITRITON OREGONENSIS	
21.4 %	AGARUM CRIBROSUM	
7.1 %	LAMINARIA GROENLANDICA	
7.1 %	CRYPTOCHITON STELLERI	
3.6 %	ALARIA FISTULOSA	
PICES	N = 318	PREY SPECIES = 102
10.1 %	GAMMARIDAE UNID	
5.7 %	EGGS UNID	
3.5 %	PELECYPODA UNID	
2.8 %	HIPPOLYTIDAE UNID	
2.8 %	CLADOCERA UNID	
AVES	N = 55	PREY SPECIES = 12
72.7 %	STRONGYLOCENTROTUS DROBACHIENSIS	
7.3 %	MACOMA BALTHICA	
3.6 %	MODIOLUS MODIOLUS	
1.8 %	BRACHYURA UNID	
1.8 %	BALANUS SP	

APPENDIX N-1 ABUNDANCE DATA FOR MUD BAY; 10 JULY 1978. 0.5 x 10 M^2 CONTIGUOUS QUADRATS FROM 10.7 M BELOW MLLW

TAXA	Frequency					$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA							
Abietinaria spp	3	2	3	1	0	1.8 ± 1.3	0.4
Balanus rostratus (patches)	0	2	2	1	2	1.0 ± 1.0	0.2
Chionoecetes bairdi	0	0	0	0	2	0.4 ± 0.9	0.1
Labidochirus splendescens	1	1	3	7	2	2.8 ± 2.5	0.6
Metridium senile	0	3	0	0	0	0.6 ± 1.3	0.1
Neptunea lyrata	0	0	0	1	0	0.2 ± 0.4	0.04
Pagurus capillatus	0	3	0	1	0	0.8 ± 1.3	0.2
Ptilosarcus gurneyi (juvenile)	0	1	0	0	0	0.2 ± 0.4	0.04
Tubularia sp	0	0	1	0	0	0.2 ± 0.4	0.04
CHORDATA							
Cottidae, unid., small	0	0	0	2	0	0.4 ± 0.9	0.1
Pleuronectiformes, unid. (juvenile)	1	0	1	1	1	0.8 ± 0.4	0.2

EXTRALIMITAL SPECIES:

INVERTEBRATA

Asterias amurensis
Evasterias troschelii
Fusitriton oregonensis
Oenopota spp
Pagurus aleuticus
P. ochotensis
Phyllochaetopterus sp
Pugettia gracilis

Substrate: Flat mud bottom with scattered, sparse boulders and shell debris

APPENDIX N-2 ABUNDANCE DATA FOR MUD BAY; 10 JULY 1978. 0.5 x 5 M^2 CONTIGUOUS QUADRATS FROM 10.7 M BELOW MLLW

TAXA	Frequency																		$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA																				
Chionoecetes bairdi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.2	0.02
Metridium senile	1	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0	0.3 ± 0.6	0.13
Neptunea lyrata	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.3	0.04
Neptunea egg case	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-	-
Ptilosarcus gurneyi	0	0	1	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0.3 ± 0.5	0.13
Pugettia gracilis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.2	0.02
Telmessus cheiragonus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0.1 ± 0.2	0.02
CHORDATA																				
Lepidopsetta bilineata	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2 ± 0.5	0.07
Pleuronectiformes unid.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.2	0.02
Fish, unid.,elongate	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1 ± 0.2	0.02

APPENDIX N-3 ABUNDANCE DATA FOR SELECTED SPECIES FROM MUD BAY; 10 JULY 1978

TAXA	Frequency											$\bar{x} \pm s$	Density (no./m^2)
INVERTEBRATA													
Chionoecetes bairdi						2						-	0.1

Quadrat Size (m): 0.5 x 50
Depth below MLLW (m): 10.7
Substrate: Flat mud bottom with scattered, sparse boulders and shell debris

Oenopota spp	4	3	1	1	3	0	4	1	1	3	4	2.3 ± 1.5	9.1

Quadrat Size (m): ½ x ½
Depth below MLLW (m): 11.3

EXTRALIMITAL SPECIES:

INVERTEBRATA

Admete couthoyi
Chionoecetes bairdi
Metridium senile
Neptunea lyrata
Nuculana hamata
Odostomia sp
Oenopota alaskensis
O. alitakensis
O. bicarinata
O. incisula
O. solida
O. turricula cf. *rugulata*
O. sp H
Ptilosarcus gurneyi - few, juvenile

CHORDATA

Bathymaster sp
Lepidopsetta bilineata
Pleuronectiformes, unid., juv.

APPENDIX O-1 RECONNAISSANCE SURVEY FOR COTTONWOOD BAY; 13 JUNE 1978, LESS THAN 1.5 M BELOW MLLW

TAXA	Substrate code a	b	c	d	e	f
ALGAE - Chlorophyta						
Chlorophyta, unid., filamentous			X	X	X	
Monostroma sp			X	X		
ALGAE - Phaeophyta						
Laminaria saccharina					X	X
Pylaiella littoralis			X	X	X	
ALGAE - Rhodophyta						
Rhodophyta, unid., filamentous			X	X		
PORIFERA						
Porifera, unid., orange				X		X
CNIDARIA - Anthozoa						
Anthopleura artemisia				X		X
ANNELIDA - Polychaeta						
Cistenides sp		X				
Nephtys sp					X	
ECHIURA						
?*Echiurus echiurus*					X	
Bonelliopsis		X				

TAXA	Substrate code a	b	c	d	e	f
ARTHROPODA - Crustacea						
Balanus sp						X
Pagurus ochotensis					X	X
Pagurus sp						X
Telmessus cheiragonus	X			X	X	
MOLLUSCA - Gastropoda						
?*Acanthodoris* sp						X
MOLLUSCA - Pelecypoda						
Clinocardium nuttalli	X	X			X	X
Macoma balthica shells		X				
M. ?obliqua shells		X				
Mya priapus shells		X				
Mya sp	X	X			X	X
Panomya ampla					X	
ECTOPROCTA						
Caulibugula sp					X	X
ECHINODERMATA - Asteroidea						
Leptasterias polaris acervata		X				X
CHORDATA - Pisces						
Hexagrammos stelleri						X
Lepidopsetta bilineata						X
Pleuronectiformes, juv.		X				

Depth (m) below MLLW: a - d = 0.6
e - f = 1.5

Substrate: a = W. of camp, mud
b = " " " , sand
c = " " " . gravel band
d = Offshore from OCS camp, silty sand with scattered boulders, cobble
e = " " " " , sand/mud flat
f = E. of camp, sandy cobble, mud and silty areas with rocks

APPENDIX O-2 ABUNDANCE DATA FOR SELECTED SPECIES FROM COTTONWOOD BAY SUBTIDAL AREA; 13 JUNE 1978. ¼ M^2 SQUARE QUADRATS FROM LESS THAN 1.5 M BELOW MLLW

TAXA						$\bar{x} \pm s$	Density (no./m^2)
MOLLUSCA - Pelecypoda							
Clinocardium nuttallii	0	0	0	6	6	2.4 ± 3.3	9.6
Mya spp	5	3	1	1	0	2.0 ± 2.0	8.0

APPENDIX P-1 ANIMAL ABUNDANCE DATA FOR OIL BAY SUBTIDAL AREA; 4 AUGUST 1978. 0.5 X 30 M^2 BAND TRANSECTS FROM 1.2 M BELOW MLLW

TAXA	Frequency		$\bar{x} \pm s$	Density (no./m^2)
Siliqua patula	1	1	1.0 ± 0.0	0.07
Telmessus cheiragonus	0	1	0.5 ± 0.7	0.03
Pleuronectiformes, unid.	0	1	0.5 ± 0.7	0.03

EXTRALIMITAL SPECIES:

INVERTEBRATA
- *Pagurus* sp
- *Spisula polynyma*

CHORDATA - Pisces
- *Isopsetta isolepis*
- *Lumpenus sagitta*

Substrate: Fine, silty sand with ripple marks, moderate organic debris

APPENDIX P-2 RECONNAISSANCE SURVEY FROM OIL BAY SUBTIDAL AREA; 4 AUGUST 1978

TAXA	TAXA
ANNELIDA - Polychaeta	MOLLUSCA - Pelecypoda
Polychaeta, unid.	<u>Siliqua patula</u>
ARTHROPODA - Crustacea	CHORDATA - Pisces
<u>Crangon</u> sp	<u>Lepidopsetta bilineata</u>
Cumacea, unid.	Pleuronectiformes, unid.
Gammaridea, unid.	

Depth below MLLW (m): 1.7 - 2.7

Substrate: Silty sand, firm with ripple marks