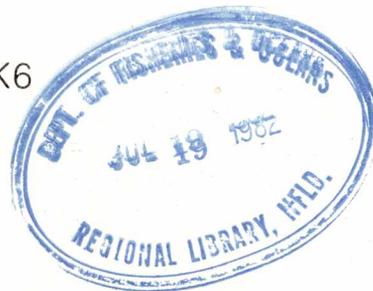


Observations of Sea Urchins, Other Invertebrates and Algae in an Area Inhabited by Sea Otters

E. A. Stewart, J. B. Foster, T. A. Carson, and P. A. Breen

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OBSERVATIONS OF SEA URCHINS, OTHER INVERTEBRATES AND ALGAE
IN AN AREA INHABITED BY SEA OTTERS

by



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ABSTRACT

Stewart, E. A., J. B. Foster, T. A. Carson, and P. A. Breen. 1982.
Observations of sea urchins, other invertebrates and algae in an area
inhabited by sea otters. Can. Aquat. Sci. MS Rep. No. 1655: iv + 28 p.

During September 1979 we dove at nineteen sites in Checleset Bay, just south of Cape Cook on the west coast of Vancouver Island, British Columbia (Fig. 1). The purposes of the study were to examine the effect of sea otter foraging on benthic subtidal communities and delineate the home range of the Bunsby Islands sea otter population.

Seven dive sites were located where sea otters had been previously observed feeding. In these locations red sea urchins (Stronglyocentrotus franciscanus) were rare and some other potential sea otter food items were scarce. Kelps extended into deep water. One site, Quineex Reef, was known to be outside the sea otter range and was examined for comparison. At this site red sea urchins were very numerous (at least 10/m²) below the surge zone, and they limited the vertical distribution of kelp as on much of B.C.'s outer coast.

From the pattern of sea urchin abundance, it was concluded that four sites had been subject to sea otter foraging. Five other sites were concluded not to be within the feeding range, because their community structure was very similar to Quineex Reef.

The report from a 1972 survey, which we used for comparison of our observations, is included as an appendix.

Key words: kelp, sea urchins, sea otters, community structure.

RÉSUMÉ

Stewart, E. A., J. B. Foster, T. A. Carson, and P. A. Breen. 1982.

Observations of sea urchins, other invertebrates and algae in an area inhabited by sea otters. Can. MS Rep. Fish. Aquat. Sci. No. 1655: iv + 28 p.

En septembre 1979, nous avons plongé à dix-neuf endroits dans la baie Checleset, juste au sud du cap Cook, sur la côte ouest de l'île Vancouver (Colombie-Britannique). Les buts de cette étude étaient d'examiner l'effet du comportement de la loutre de mer à la recherche de sa nourriture, sur les communautés benthiques infratidales et de délimiter l'aire de répartition natale de la population de loutres de mer des îles Bunsky.

Nous avons plongé à sept endroits où des loutres de mer avaient déjà été observées en train de se nourrir. À ces endroits, les oursins rouges (Stronglyocentrotus franciscanus) étaient rares et les autres aliments potentiels étaient peu nombreux. Le varech s'étendait dans les eaux profondes. Le récif Quineex, emplacement à l'extérieur de l'aire de répartition de la loutre de mer, a été étudié aux fins de comparaison. À cet endroit, les oursins rouges étaient nombreux (au moins 10/m²) sous la zone de houles et restreignaient la répartition verticale du varech, comme presque partout ailleurs sur la côte extérieure de la C.-B.

D'après la répartition de l'abondance des oursins, nous avons conclu que quatre emplacements avaient été fréquentés par la loutre de mer. De plus, nous avons déterminé que cinq autres emplacements n'étaient pas dans l'aire d'alimentation du fait que la structure de la communauté y était très semblable à celle du récif Quineex.

Le rapport d'une enquête de 1972, utilisé pour fins de comparaison, est joint en annexe.

Mots-clés: varech, oursins, loutres de mer, structure de la communauté.

INTRODUCTION

The extinction of the sea otter (Enhydra lutris) on the British Columbia coast was brought about by uncontrolled exploitation from 1778 to the early twentieth century. Before the re-introduction of 89 sea otters to the Bunsby Islands from 1969-1972, the most recent authentic record of a sea otter taken in British Columbia was in 1929 (Cowan and Guiguet 1965). Results of an aerial survey in 1977 in the Bunsby Islands area (Bigg and MacAskie 1978) indicated that 55 individuals remained. More recent population surveys have yielded confusing results.

The daily food requirement of a sea otter can be as much as 30% of its body weight, consisting primarily of benthic invertebrates and fish (Kenyon, 1969). Sea otter home ranges are often small (8-16 kilometers of shoreline) even if food resources in the area are seriously depleted (Kenyon 1969). Thus sea otters can have a major effect on the benthic ecology of an area. The impact of sea otters has been well documented in Alaska, (Estes and Palmisano 1974; Estes et al. 1978) and in California (Ebert 1968). In Alaska, areas with sea otters have few, small, well hidden sea urchins; whereas nearby areas without sea otters have large, easily accessible sea urchins in great numbers. In California, significant decreases in sea urchin numbers have been reported when sea otters have moved into new areas.

The red sea urchin, Strongylocentrotus franciscanus, limits the downward distribution of kelps and other upright macro-algae on most of the open outer coast of British Columbia, (Pace 1975; Low 1975; Druehl 1978; Breen 1980), hence affecting near-shore productivity and community structure. The impact of sea otters ecologically and commercially is of importance and should be carefully examined.

The purpose of this study was to examine the effects of sea otter foraging on benthic communities in B.C. and to delineate the home range of the Bunsby Islands sea otter population. The results of this survey, and our conclusions, are discussed in Breen et al. (1982). The present report describes observations in detail.

METHODS

This study was carried out in the Checleset Bay area just south of Cape Cook on the west coast of Vancouver Island, British Columbia (see Fig. 1). At each of the 19 sites examined, two SCUBA divers made notes on (1) substrate types and slopes; (2) algal cover; (3) depths at which major faunal and algal assemblages changed; (4) invertebrates and (5) fish. The intertidal areas at most sites could not be systematically investigated because of breaking swells. Observations were made on sea otters, seals, and sea lions within the study area as well, but no serious attempt was made at a sea otter census, which would require an aerial survey.

Depths were corrected from gauge readings in feet below the surface to meters below chart datum. At this location, chart datum was calculated to be 0.77 m below MLLW. All depths reported here are in meters below chart datum unless otherwise noted.

SITE DESCRIPTIONS

Station 1 Farout Rocks

Lat. 50° 02' 00" N; Long. 127° 33' 25" W

This site was a known sea otter feeding site (Morris et al., 1981 and our own observations).

Substrate: Bedrock with much relief and a few crevices descended from the islet with a variable slope, ranging from short vertical walls to flat areas, to a depth of 14 m (Fig. 2). From 8 to 11 m were pockets of shell and an occasional large boulder. Below 14 m the bedrock sloped off at about 35°.

Algae: From the upper subtidal zone to 6 m, Laminaria setchellii was the dominant species, forming 50% of the algal cover. Prionitis lanceolata was abundant in the understory. The turf was composed largely of articulated corallines which were patchy in distribution but covered nearly 50% of the bottom. With increasing depth L. setchellii decreased in abundance, while Pterygophora californica and Nereocystis luetkeana increased. At 7 m the Nereocystis canopy covered 50% of the water surface, but stipes were scant below. The understory kelps formed 40% cover. The turf covered about 60% and was a mixture of reds including Iridaea sp., Constantinea simplex, C. subulifera, Gigartina sp., Botryoglossum farlowianum, Rhodymenia californica and Callophyllis sp. The kelp forest continued from 10 to 14 m, with Nereocystis ending at 10 to 11 m and Pterygophora extending sparsely to 14 m. There was a large amount of kelp detritus lying in crevices and depressions in this area. Below 14 m the algal cover was light, approximately 25%, with no canopy. Tattered and stunted Laminaria sp. were the most abundant kelp here (10% cover) found in association with an occasional Pleurophyucus gardneri. Together with Dictyota binghamiae, Iridaea sp. and Rhodymenia pacifica, these made a total algal cover of 25%.

Sea urchins: Sea urchins were very scarce. One green sea urchin, (Strongylocentrotus droebachiensis) was found under a Constantinea plant. In total, eight small red sea urchins (S. franciscanus) were observed in rock crevices.

Abalone: Only one small abalone (Haliotis kamtschatkana) was seen.

Other fauna: Gooseneck barnacles Pollicipes polymerus formed 100% cover in the mid-intertidal region. Other potential food items for sea otters were scarce. The keyhole limpet Diodora aspera was the most abundant grazer, but less than twelve were seen on the dive. A few small limpets Acmaea mitra, chitons Tonicella sp., snails Tegula pulligo, six gumboot chitons Cryptochiton

stelleri and many hermit crabs Pagurus sp., were also observed. Deeper than 10 m, patches of barnacles Balanus nubilus were extensive (up to 75% bottom cover) and purple stars Pisaster ochraceus were seen feeding on these barnacles. Other starfish observed included a small number of sunflower stars (Pycnopodia helianthoides), (Orthasterias koehleri), some blood stars (Henricia leviuscula), one Dawson's star (Solaster dawsoni) and two leather stars (Dermasterias imbricata). Sedentary and encrusting invertebrates were important in the deeper regions. Below 10 m the anemone Metridium senile and cup coral Balanophyllia elegans increased in number, particularly on steep rock faces. Other invertebrates noted included the bryozoan Bugula sp., hydroid Plumularia sp., tunicate Styela montereyensis and other unidentified tunicates.

Fish observed were one kelp greenling, (Hexagrammos decagrammus), one lingcod (Ophiodon elongatus), several cabezon (Scorpaenichthys marmoratus), and a few small sculpins.

Station 2 Clara Islet group.

Lat. 50° 03' 28" N; Long. 127° 34' 08" W

This site was a known sea otter feeding area (Morris et al. 1981 and our own observations).

Substrate: Bedrock, with a roughly textured undulating surface, sloped gradually away from shore to 10 m. Below this the substrate changed to densely packed boulders on shell bottom.

Algae: A bed of Nereocystis luetkeana ranged from 7 to 10 m, with an understory of Laminaria setchellii and L. groenlandica. Dictyota binghamiae, Botryoglossum farlowianum, Constantinea simplex, Opuntia californica and Gigartina sp. formed a turf at about 25% cover. Below 10 m the boulder substrate was barren of algae except for crustose corallines and some Codium setchellii.

Sea urchins: None was seen.

Abalone: A very few abalone were seen in crevices near 10 m.

Other fauna: There were few potential food items for sea otters at this site except hermit crabs and abundant small Tegula pulligo. The encrusting fauna under the Nereocystis canopy was similar to the previous station. There were few starfish here.

Fish included black rockfish (Sebastes melanops), one cabezon and some greenlings.

Station 3, Clara Islet Group

Lat. 50° 03' 48" N; Long. 127° 35' 00" W

This site was a known sea otter feeding area (Morris et al. 1981 and our own observations).

Substrate: Same as Station 2.

Algae: A dense stand of the seagrass Phyllospadix sp. formed a narrow band with 100% cover at 2 m. Below this was a forest of Laminaria setchellii, with a turf composed primarily of articulated corallines and Gigartina sp. At 4 m L. setchellii had become much less numerous and Desmarestia ligulata was important. The L. setchellii forest continued to 7 m. Nereocystis luetkeana between 7 m and 10 m formed a dense surface canopy. The turf there was a mixture of red algae, which became more diverse between 10 m and 13 m. Some of these species were Constantinea sp., Callophyllis sp., Rhodymenia californica, R. pacifica, Lomentaria hakodatensis, Ahnfeltia gigartinoides, Gigartina exasperata, Laurencia spectabilis, Plocamium sp. and Iridaea sp.

Sea urchins: Sea urchins were scarce at this site. Two green sea urchins, (S. droebachiensis) were seen under Constantinea blades and four red sea urchins between 30 mm and 80 mm diameter were seen.

Abalone: None.

Other fauna: In the intertidal zone the gooseneck barnacle Pollicipes polymerus almost completely covered all available substrate to 0.75 m. The sea anemone Anthopleura elegantissima formed a dense mat below this to 2 m. In a gully area, encrusting bryozoans, hydroids, sponges and barnacles monopolized the bottom. Plumularia sp. were a dense part of the cover in the turf under L. setchellii. Solitary tunicates were common on the deeper boulders and a few large Diodora aspera were also seen there.

There was a large school of Sebastes melanops in the Nereocystis bed and schools of juvenile rockfish among the boulders.

Station 4 Clara Islet Group

Lat. 50° 04' 20" N; Long. 127° 35' 08" W

This area was a known sea otter feeding area (Morris et al. 1981 and our own observations).

Substrate: The bedrock surface was irregular and sloped at less than 10°.

Algae: We began this dive at 4 m under a Nereocystis luetkeana canopy, which had a thin understory of Laminaria setchellii. Turf algae included Desmarestia ligulata, Costaria costata, Gigartina sp., Constantinea simplex, Botryoglossum farlowianum, Iridaea sp. and Opuntiella californica. At 11 m Nereocystis had ended and the turf, covering only 15% of the bottom, was a mixture of Dictyota binghamiae, Opuntiella californica, Rhodymenia pacifica, Constantinea simplex and some small decrepit Laminaria sp.

Sea urchins: Two Strongylocentrotus droebachiensis were seen, one under a Constantinea blade and one under a shell.

Abalone: Only three abalone were seen on this dive. All were 40-70 mm long and were found at 5 m depth.

Other fauna: Once again, well attached invertebrates such as Styela montereyensis, sea anemones Tealia sp., Balanophyllia elegans, Bugula and other bryozoans predominated. Many Balanus nubilus grew between 8 m and 11 m. Grazers observed were small Ceratostoma foliatum, one Astraea gibberosa, many Tegula pulligo and many hermit crabs occupying Tegula shells.

Station 5 Quineex Reef

Lat. 50° 06' 00" N; Long. 127° 44' 24" W

This site was located well outside the known sea otter feeding area (Morris et al. 1981; our own observations; and E. Kayra, pers comm.).

Substrate: The reef was bedrock of varying texture and slope. There were large and small surge channels, outcroppings, gullies, and a few pockets of sand/shell (see Fig. 3).

Algae: The kelp forest, comprising Laminaria setchellii, Eisenia arborea, Pterygophora californica, Pleurophycus gardneri and the surfgrass Phyllospadix sp., was limited to a narrow band between 3 and 7 m. These canopy plants occurred in large single-species patches rather than in mixed stands. The understory and turf contained articulated corallines, Desmarestia ligulata, Rhodymenia pacifica, Fauchea sp., Botryoglossum farlowianum and Polyneura latissima. The total algal cover was estimated to be 70%, decreasing with depth. At the lower edge of the algal zone many of the kelps had been partially eaten and only stipes and holdfasts remained. Below 7 m were no macro-algae except for encrusting forms such as Hildenbrandia sp. and Lithothamnion sp.

Sea urchins: There were a few S. franciscanus in crevices within the lower part of the kelp forest. Below 7 m, we estimated red sea urchin density to be at least 10/m². The population contained a mixture of age classes with many juveniles. At the maximum depth surveyed (16 m) sea urchins were still numerous.

Abalone: Two abalone were seen on this dive, both between 5 and 6 m depth.

Other fauna: The kelp forest contained an abundance of grazers including Acmaea sp., Amphissa columbiana, Tonicella sp., Calliostoma foliatum and Cryptochiton stelleri. There were also hummocks of the polychaete Dodecaceria fewkesi, encrusting sponges, a variety of bryozoans, scattered Tealia sp., numerous anemones Epiactis prolifera, and the starfishes Pycnopodia helianthoides and Henricia leviuscula. In the kelp forest turf the bryozoan Hippodiplosia insculpta formed up to 50% cover in localized patches. In the sea urchin barrens below 7 m, hydroids such as Plumularia sp. and the cup coral Balanophyllia elegans were important. Fauna observed in the kelp forest also extended into this area.

The only fish noted at this site was a large cabezon.

Station 6 Gull Rock (Southeast side)

Lat. 50° 04' 20" N; Long. 120° 32' 48" W

This site was within the known sea otter feeding area, (Morris et al. 1981 and our own observations).

Substrate: A bedrock incline sloping at 5° or less, with boulder-filled depressions and sand/shell patches, extended seaward from the island to 5.5 m depth. Below that the gradual slope continued but substrate changed to shell with some sand and pebbles.

Algae: On the shell slope below 5.5 m a variety of kelps were attached to larger shells and pebbles. These were Laminaria groenlandica (15% cover), Pterygophora californica (10% cover), and juvenile Nereocystis luetkeana (1% cover). The turf was composed of Iridaea sp., Gracilaria sp., and Constantinea simplex. Total algal cover was estimated to be 30%. On the bedrock shelf algal cover increased to 75%. Pterygophora californica formed a dense forest (55% cover) with less numerous L. groenlandica, L. setchellii and Costaria costata. Above these kelps was a dense surface ceiling of Nereocystis, although holdfasts and stipes were sparse on the bottom. A diverse turf of red algae included Constantinea simplex, Iridaea sp., Laurencia spectabilis, Opuntiella californica, Gigartina exasperata, Gymnogongrus platyphyllus, Callophyllis sp. and articulated corallines. Desmarestia ligulata, Dictyota binghamiae, Codium fragile, and Derbesia marina were also present. Inshore along the bedrock shelf, patches of Macrocystis integrifolia began to replace Nereocystis as the overhead canopy species while the understory and turf remained essentially unchanged. In the upper subtidal and intertidal zones, kelps gave way to 100% stands of Phyllospadix sp.

Sea urchins: Only one S. franciscanus was seen on this dive. It was less than 20 mm, wedged in a crevice in the bedrock.

Abalone: Several abalone were found by turning over boulders in the depressions. They were all 30-60 mm in length. Some abalone were also found among Macrocystis holdfasts. These ranged to 115 mm.

Other fauna: The shell bottom below 5.5 m did not appear to support any suitable food items for sea otters. Invertebrates observed on the bedrock shelf area included millions of Tegula pulligo, hermit crabs occupying Tegula shells, some tube worms Serpula vermicularis in a crevice, two small swimming scallops Chlamys sp., and sea cucumbers Eupentacta sp. lodged in Macrocystis holdfasts.

Numerous fish were present over the bedrock shelf. Several schools, each with at least 100 juvenile rockfish (Sebastes sp.) about 50 mm in length, were observed about 1 m above the bottom. Striped sea perch (Embiotoca lateralis) were seen cruising through the understory; we observed a small school of pipefish (Syngnathus griseolineatus), and a buffalo sculpin (Enophrys bison).

Station 7 Near Cautious Point

Lat. 50° 05' 00" N; Long. 127° 32' 58" W

Sea otters had not been observed feeding at this site. We inferred this to be a sea otter feeding area because of the lack of sea urchins and other preferred food items in otherwise suitable habitat.

Substrate: Bedrock sloped from the intertidal zone at approximately 25° to a large boulder scree. The scree ended at 5 m on a flat bottom composed primarily of a sand/shell mixture with some pebbles and cobbles. There were occasional bedrock outcroppings on this flat bottom which rose to the surface from 5-6 m.

Algae: The low intertidal zone was dominated by Egregia menziesii, Phyllospadix sp. and Alaria marginata. This gave way to a mixed stand of Lamaria setchellii and Pterygophora californica in the upper subtidal zone. These continued to the shell/sand at 5 m with a sparse Nereocystis luetkeana canopy on the bedrock area and Macrocystis integrifolia on the boulder area. L. groenlandica was also present on the boulder scree. There was a sparse algal turf, consisting of Prionitis lyallii, Constantinea spp., Callophyllis sp. and articulated corallines. At 5 m on the shell bottom the following species were found growing: Neoagardhiella baileyi, Gracilaria sp., L. groenlandica, Desmarestia ligulata, Rhodoglossum californica, Halymenia sp., Prionitis lyalli, Pikea californica and Palmaria palmata. A large amount of drift or detrital algae littered the bottom here. On rock outcroppings at this depth were large stands of Macrocystis integrifolia, with Desmarestia ligulata and Laminaria groenlandica as understory species below 3 m, and L. setchellii above 3 m.

Sea urchins: No sea urchins found at this site.

Abalone: Six small abalone were seen on the bedrock and boulders.

Other fauna: Tegula pulligo was extremely abundant at this site; it was the only abundant grazer observed. Potential sea otter food items were scarce: one Astraea gibberosa and some kelp crabs (Pugettia sp). Other fauna included tunicates such as Styela sp., bryozoans, the tubeworms Spirobis sp. and Serpula vermicularis, Pycnopodia helianthoides, Solaster sp. and one sea cucumber Cucumaria miniata.

Station 8 Northwest side of Clara Islet

Lat. 50° 04' 28" N; Long. 127° 35' 16" W

This site was well within the known sea otter feeding range (Morris et al., 1981 and our own observations). The purpose of this dive was to examine some deeper habitat in the known feeding area. However, the islet sloped only to 20 m before changing to a barren shell bottom.

Substrate: The substrate was steep, rough bedrock in the intertidal zone, continuing to 20 m with a variable slope ranging from 0°-90°. A plateau area occurred at 10 m. Below 10 m was a scree of very large boulders strewn on top of the bedrock, sloping at approximately 20° to a relatively flat shell bottom at 20 m composed of barnacle plates, mussel shells and abalone shells.

Algae: Upright macro-algae were not abundant below 10 m. At 20 m there were only encrusting reds such as Lithothamnion sp. and Hildenbrandia sp. growing on the boulders and bedrock. There were large deposits of kelp and surfgrass detritus at the base of the rock slope. Articulated corallines were present at 15 m and shallower but made up less than 1% cover at 15 m. By 12 m there were a few small patches of Codium setchellii and Constantinea simplex at 15% total cover. Nereocystis luetkeana began at 10 m but the bottom was still nearly barren of macro-algae at this depth. By 9 m the boulder bottom supported a more diverse assemblage of algae, including Desmarestia ligulata, Constantinea simplex, Callophyllis sp., Rhodymenia pacifica, Codium fragile and a variety of articulated corallines. We passed through a thermocline between 7 and 9 m, and above 7 m visibility was very much reduced. The effect of the surge was also strong above 7 m. Desmarestia ligulata was the visually dominant species at 7 m, accompanied by Constantinea simplex. Together they covered an estimated 5% of the bottom. Laminaria setchellii appeared at 6 m with a turf of D. ligulata and articulated corallines. Above 2 m, L. setchellii was joined by Lessionopsis littoralis, Costaria costata, Phyllospadix sp., Prionitis lanceolata, Constantinea simplex and Botryoglossum farlowianum. Algal cover was estimated to be 80% at this level.

Sea urchins: Between 9 and 15 m, S. franciscanus were observed lodged in spaces formed by the jumble of boulders. No sea urchins were seen outside such cover.

Abalone: One abalone was seen at 6 m on the steep bedrock slope.

Other fauna: The shell bottom did not appear to support any macroscopic fauna other than scarce California sea cucumbers (Parastichopus californicus). At 20 m the boulders were heavily colonized by Spirobis sp., Balanophyllia elegans, bryozoans and Metridium senile. The density of M. senile was estimated to be 5/m². Starfish here were Pycnopodia helianthoides and Solaster dawsoni, neither numerous. By 15 m grazers were very abundant. Tegula pulligo density was estimated at close to 50/m² and Tonicella sp., Calliostoma sp., and hermit crabs were present. Small Metridium senile covered up to 50% of the rock surface at 12 m. Dodecaceria fewkesi also appeared at this depth and covered much of the bottom. The grazers present deeper were still abundant at 12 m. Other potential food items included one Hinnites giganteus, one large Mytilus californianus and several Cucumaria miniata under the smaller rocks. Plumularia sp. appeared at 9 m and was found growing with a variety of bryozoans, Balanophyllia elegans, scattered Metridium senile, Tealia sp., Dodecaceria fewkesi, serpulids and some Styela sp. Pycnopodia helianthoides were present at this depth up to 1/m² in localized patches. Balanus nubilus had appeared by 4 m, along with Pisaster ochraceus which were up to 2/m² in local patches. Much of the rock at this depth was covered with Dodecaceria fewkesi and hydroids. Diadora aspera and Anthopleura elegantissima were first seen at 4 m. At 2 m Calliostoma sp. was the dominant grazer. Henricia leviuscula was estimated to be 0.25/m² at this depth. The surge was too heavy to continue observations in shallow water.

Fish were plentiful and diverse. There were kelp and painted greenlings (Hexagrammos decagrammus and Oxylebius pictus), lingcod (Ophiodon elongatus), black, china, and copper rockfish (Sebastes melanops, S. nebulosus and S. caurinus) as well as numerous small sculpins.

Comments: It was interesting that between 20 and 9 m, where urchins were abundant in crevices and between boulders, the outside area without urchins still had the appearance of being heavily grazed.

Station 9 Acous Peninsula

Lat. 50° 06' 15" N; Long. 127° 35' 40" W.

From sea urchin density and distribution, it was concluded that this reef lay outside the sea otter feeding range. Harbour seals (Phoca vitulina richardi) were abundant in the vicinity, and a curious northern sea lion (Eumetopias jubatus) was seen at 8 m.

Substrate: The substrate was bedrock from the intertidal zone to 10 m. Intertidal slope was 0-30°. The subtidal bedrock dropped off steeply (70°) to 10 m depth, where a gradually sloping shell bottom with scattered cobbles began. Further to the east where we ended our dive, the bedrock plunged to 10 m and then changed to a striated reef with shell patches, which began to rise again beyond our area of exploration.

Algae: Erect macro-algae were limited to less than 2 m depth, their lower limit coincidental with the upper limit of red sea urchins. Encrusting algae such as Lithothamnion sp. and Hildenbrandia sp. were ubiquitous in the sea urchin grazed areas. In the sublittoral fringe, Laminaria setchellii was dominant, growing above a turf of articulated corallines. There were also large patches of Phyllospadix sp. Near datum, Lessoniopsis littoralis replaced Phyllospadix sp., with a turf of Prionitis sp., Gigartina sp. and Iridaea sp. Egregia menziesii was the important kelp at +1 m, growing with Halosaccion glandiforme, Iridaea sp. and a variety of articulated corallines. A narrow band of Hedophyllum sessile replaced the Egregia at +2 m; above this was a dense growth of gooseneck barnacles (Pollicipes polymerus) which excluded algae.

Sea urchins: S. franciscanus began sharply at 2 m depth and continued to the cobble/shell bottom at 10 m. Density on the bedrock face was estimated to be 25/m². Most were less than 100 mm test diameter and many were 0-3 year old individuals. Density seemed consistent over most of the vertical range on the bedrock but diminished on the shell/cobble bottom to 1/m².

Abalone: Abalone were present from the lower intertidal zone to 5 m depth. They were most abundant in the upper subtidal zone and decreased in numbers with depth. No juveniles were seen.

Other fauna: In the barren bedrock area was a band of Balanophyllia elegans from 3-6 m. They were most numerous (up to 100/m²) in crevices, corners and on steep places. At 6 m the grazers were Tegula pulligo, Acmaea mitra and Tonicella sp. Dodecaceria fewkesi extended from 5 m upward, reaching 50% cover at 3 m. Astraea gibberosa were as dense as 10/m² in the upper subtidal zone. Balanus nubilus were present under kelps, but were not an important cover species. Hinnites giganteus was also present. Anthopleura xanthogrammica and A. elegantissima were present in the intertidal zone along with Katherina tunicata and Pisaster ochraceus. Pollicipes polymerus began at +2.25 m, coincidental with the upper limit of Pisaster ochraceus, and formed 100% cover in the upper intertidal region.

Station 10 Double Rock

Lat. 50° 00' 45" N; Long. 127° 31' 25:

This site was very exposed, even on the inside sheltered sides of the islets where we dove, and the effects of surge were pronounced even 9 m below the surface on a relatively calm day. The absence of sea urchins in this area may thus have been due to extreme exposure rather than sea otter predation. A group of 8 northern sea lions, (Eumetopias jubatus) were hauled out on the islet nearest the dive site.

Substrate: The islets constituting Double Rock rose to the surface from a nearly flat shell bottom extending a considerable distance around the islets. There were enormous boulders on the flat shell bottom at the beginning of our dive; further to the north we found a continuous boulder bottom. The depth was 7 m below datum over the whole area examined.

Algae: Near the islets, Nereocystis luetkeana formed a dense canopy at the surface. The understory (50% cover) was made up of Laminaria setchellii, Pterygophora californica and Phyllospadix sp. Turf species included Gigartina sp., Prionitis filiformis and Rhodymenia californica. On the shell areas there were a few partially buried and stunted-looking L. setchellii with Gigartina sp. and Prionitis filiformis in the turf layer.

Sea urchins: None.

Abalone: None.

Other fauna: Some of the rocks near the islets were covered almost exclusively with invertebrates. Balanus nubilus was the most abundant, along with Plumularia sp., Bugula sp. and a few Balanophyllia elegans. Unidentified hydroids and encrusting sponges covered the remaining space. The starfishes Pycnopodia helianthoides and Pisaster ochraceus were numerous. A small patch of very large Mytilus californianus was found on the edge of a rock outcropping.

Station 11 Reef SSW of Can Buoy

Lat. 50° 02' 16" N; Long. 127° 20' 18" W

We inferred this site to be within the sea otter feeding area; if we are correct the site had not been foraged as heavily as the Gull or Clara Islet sites.

Substrate: Bedrock, quite rough in surface texture, sloped away at 30° overall, with many crevices, gullies and plateau areas. The minimum depth on the explored part of the reef was 12 m.

Algae: At 15 m depth, algal cover was estimated to be 35% and included the following species: Desmarestia ligulata, Opuntiella californica, Constantinea simplex, Dictyota binghamiae and Callophyllis sp., as well as the encrusting red algae Lithothamnion sp. and Hildenbrandia sp. There was no overhead canopy at this depth. Nereocystis luetkeana started near 12 m as we ascended, and it formed a dense surface canopy although stipes and holdfasts seemed sparse below. The understory was similar to the algal cover deeper. On the shoalest part of the reef at 7 m the surge was considerable. Although N.

luetkeana continued to form the canopy, the understory had changed by 7 m to a sparse cover of Laminaria setchellii, Eisenia arborea, Costaria costata and Pleurophycus gardneri. The turf species included Gigartina sp., Opuntia californica, Constantinea simplex, Callopyllis firma and a variety of articulated corallines.

Sea urchins: S. franciscanus was abundant in localized patches between 14 and 15 m depth. They ranged from 25-100 mm test diameter; their density was estimated to be 1-2/m² in patches. At 14.5 m was a freshly broken S. franciscanus test which appeared to have been smashed open, possibly a sign of sea otter predation.

Abalone: Several small abalone were observed in cracks and crevices between 12 and 14 m. They were all 30-50 mm in length.

Other fauna: A wide variety of invertebrates was noted between 15 and 13 m including Diodora aspera, Parastichopus californicus, Plumularia sp., Dodecaceria sp., Cryptochiton stelleri, Henricia leviuscula, Orthasterias koehleri, Pycnopodia helianthoides, Balanopyllia elegans, Calliostoma sp. and Tegula sp. At 12 m Balanus nubilus began, covering up to 75% of the bottom in localized patches above this depth. Pisaster ochraceus, observed preying on B. nubilus, was also abundant at this level: density was estimated to be 1/m². Other invertebrates at this depth included Calliostoma sp., Orthasterias koehleri, Thais emarginata, encrusting yellow sponges and Ceratostoma foliatum.

Station 12 Thomas (Whiteface) Island

Lat. 50° 03' 44" N; Long. 127° 29' 05" W

This site was a small subtidal reef off the western corner of Thomas Island. The island itself was not approached because of dangerous surge. It was concluded that this area was not within the sea otter feeding range.

Substrate: The reef rose from deep water at steep variable pitch between 0° and 25°, then flattened between 4 and 5 m.

Algae: The flattened reef top was marked at the surface by a dense canopy of Nereocystis luetkeana. Underneath was an open forest with very little understory or turf extending from 4 to 5 m. Very large Desmarestia ligulata plants covered up to 40% of the bottom in localized areas. In the very center of the kelp bed were a few scattered clumps of erect corallines and scarce tattered and stunted Laminaria setchellii, Laminaria sp., one Alaria marginata and one Pterygophora californica. There were also a few small patches of polysiphonous red algae. The rock itself was encrusted with Lithothamnion sp. and Hildenbrandia sp. There was considerable benthic diatom growth over the crustose corallines on the seaward side of the reef, while on the lee side they were clean.

Sea urchins: S. franciscanus was present from underneath the Nereocystis to 7 m, at densities reaching 15/m². On the landward side of the reef sea urchins started at 4 m, well inside the kelp bed, and extended deeper. On the seaward side of the reef there were fewer sea urchins within the kelp, but densities were high below the lower edge of the bed.

Abalone: Some abalone, stunted in appearance, were found just below the lower edge of the N. luetkeana bed.

Other fauna: Sedentary invertebrates inside the kelp bed included Tealia sp., Balanophyllia elegans, large patches of Dodecaceria sp., a diversity of hydroids, Bugula-type bryozoans, serpulid worms, Hinnites giganteus, and Styela sp. Starfish included Pycnopodia helianthoides, Dermasterias imbricata and Henricia leviuscula. Grazers included Calliostoma sp., Tegula sp., Astraea gibberosa and Tonicella sp. Below the kelp bed there were few invertebrates except for sea urchins. Balanophyllia elegans was found on some vertical walls, and there were occasional splashes of colour from hydrocorals, colonial ascidians and sponges. Other invertebrates noted here included the nudibranch Archidoris sp., boring clams and the polychaete Myxicole infundibulum.

Fish included a kelp greenling, (Hexagrammos decagrammus), a lingcod (Ophiodon elongatus), a small school of black rockfish (Sebastes melanops), and some perch thought to be Cymatogaster aggregata.

Station 13 Rock off easternmost Bunsby Island
Lat. 50° 05' 44" N; Long. 127° 29' 40" W

Sea urchins and abalone were present in sufficient numbers to indicate that this area had not been foraged by sea otters.

Substrate: A vertical bedrock wall dropped from the top of the rock to 3 m where a boulder scree with 45° slope began. At 12 m the bottom flattened out and was composed of boulders, pebbles and shell fragments. Also encountered were several shelving bedrock reefs which rose from the flat bottom around the rock.

Algae: On the vertical wall was a narrow band of Laminaria setchellii between +2.25 m and +0.75 m. From +0.75 m deeper, encrusting and articulated coralline algae comprised the major algal cover. At 2 m encrusting corallines such as Lithothamnion sp. were the only macro-algae present and at 3 m they covered up to 80% of the bottom. The boulders at 11 m were entirely covered with encrusting corallines.

The two reef areas investigated supported more algal growth than the rock wall itself. The tops of the reefs came up to 1 m depth and were covered to 60% with an assortment of kelps. These were L. setchelli, Egregia menziesii, Costaria costata and Alaria marginata. The understory was 60% covered with articulated corallines and foliose red algae such as Gigartina sp., Opuntia californica and Constantinea simplex. By 4 m the upright macro-algae had disappeared and encrusting corallines covered up to 80% of the bottom.

Sea urchins: S. franciscanus had an upper limit at 6 m on the rock wall; density was 1/m². At 11 m depth on the boulder scree, density was 0.5-1/m². On the flat shell/pebble bottom, density was reduced to 0.2/m², and sea urchins were seen only on the larger boulders.

One green sea urchin (S. droebachiensis) was seen at 5 m near the cliff-boulder interface. S. purpuratus were present also.

Abalone: Two abalone were seen in shallow water (+1 m) on the rock wall. At 2 m there were many small abalone with a density of $1/m^2$. In one area at 7 m density reached $10/m^2$. Other parts of the same reef had densities of $1-2/m^2$. The shallow reef areas also supported large numbers of small abalone.

Other fauna: The predominant invertebrate species in the intertidal zone were Anthopleura elegantissima, Pisaster ochraceus and unidentified bryozoans. Other species included A. xanthogrammica, Dermasterias imbricata, Leptasterias hexactis and hydrozoans. Further down the rock wall to 2-3 m depth, hummocks of Dodecaceria fewkesi became important cover. Balanophyllia elegans were scattered on the rock face along with an occasional Hinnites giganteus. Tealia crassicornis and a few Epiactis prolifera had joined them by 5 m. Two nudibranchs, Archidoris montereyensis and Triopha carpenteri, were also seen at 5 m. Solaster stimpsoni, Tealia piscivora and colonial tunicates were also seen here.

The reef areas were slightly different from the rock wall. Some of the different species included the bat star (Patira miniata), red star (Mediaster aequalis), Pycnopodia helianthoides, Cryptochiton stelleri, Tegula funebris and the decorator crab (Oregonia gracilis).

The only fish noted were a large school of black rockfish (Sebastes melanops) swimming near the boulder/cliff interface.

Station 14 Western Acous Peninsula

Lat. $50^{\circ} 06' 54''$ N; Long. $127^{\circ} 36' 30''$ W

It was inferred that this area had not been used by sea otters, as sea urchins and abalone were abundant.

Substrate: The intertidal zone from +3.3 m to datum was solid bedrock sloping at 45° . From datum was a short scree of medium sized boulders which sloped to a fine shell bottom at 1 m. The shell bottom was composed largely of mussel shells and pebbles, and continued to 7 m where it became flat.

Algae: The upper intertidal zone was dominated by Fucus distichus covering 30% of the bedrock. Below this was scant algal cover to +0.75 m, where articulated corallines covered 50%, Codium fragile 10% and Halosaccion glandiforme covered 5% of the bedrock. Macrocystis integrifolia began on the boulders at datum and formed a canopy with 50% surface cover. Foliose red algae such as Gigartina sp. and Constantinea simplex formed a 10% turf on the boulders, and coralline algae covered 80% of the bedrock. A bed of Zostera sp. was found on the shell bottom from about 3-4 m. Below 4 m were occasional M. integrifolia plants with Agarum fimbriatum in the understory.

Sea urchins: S. franciscanus was abundant on the boulder scree at densities of $5-10/m^2$.

Abalone: Abalone were also abundant on the boulders (no density estimate).

Other fauna: In the upper intertidal zone below the Fucus, there was a band of Mytilus californianus with numerous associated Piaster ochraceus and Balanus cariosus. Serpula vermicularis was present in the lower intertidal zone. Balanophyllia elegans was present on vertical faces of boulders along with the ascidian Cnimidocarpa finmarkiensis. One nudibranch Dirona albolineata was seen. Many Tegula pulligo were attached to the Macrocystis and some Tegula shells on the bottom were inhabited by hermit crabs (Pagurus sp.). Cucumaria miniata were seen amongst boulders from 0-11 m. Astraea gibberosa and Acmaea mitra were also seen on the boulder area. In the shell/pebble habitat below 4 m, A. gibberosa, Archidoris montereyensis and Parastichopus californicus were present.

Station 15 Cuttle Islets: 115' Islet, northwest side.
Lat. 50° 06' 34" N; Long. 127° 37' 08" W

It was inferred from the concentrations of sea urchins that this area had not been used by sea otters. The dive site was a shallow exposed area with heavy surge.

Substrate: This site had shelving bedrock sloping at 45° to boulders, which began from 0-2 m. The boulder area was interspersed with pockets of fine shell.

Algae: There were several variations on the same basic vegetation pattern. In one area a bed of Phyllospadix sp. extended from +1.0-+0.5 m. The turf under this surfgrass contained foliose red algae such as Gigartina sp.; the rest of the rock surface was covered with encrusting corallines. In an adjacent area at +0.5 m encrusting corallines were the only vegetative cover present. On a rock shelf was a patch of L. setchellii at datum with 20% cover. Articulated corallines and a few small red algae formed the turf. Another localized area at datum had 2% Egregia menziesi, 5-10% L. setchellii and a 50% turf composed of Gigartina sp., Codium fragile and articulated corallines. The rock underneath this growth was 80% covered with encrusting corallines. Below 1 m there were occasional patches of Desmarestia ligulata on an otherwise coralline covered substrate. Patchy areas of Nereocystis luetkeana were scattered throughout the area at 3 m depth. These Nereocystis patches were restricted to the tops of high boulders.

Sea urchins: Both S. franciscanus and S. droebachiensis were abundant on this dive. The upper limit of their distribution was +0.5 m, coinciding with the lower limit of most of the upright algae. Near this upper limit, density of both species together was estimated at 5/m², with a ratio of red to green sea urchins of 10:1. At 3 m red sea urchins were 5-10/m² and were grazing on Nereocystis plants growing on the tops of boulders.

Abalone: Near datum on the coralline covered boulders, the density of abalone was estimated to be 1-2/m². They ranged in length to 130 mm.

Other fauna: Invertebrates in the intertidal zone included a colonial tunicate, Tegula funebris, and Anthopleura xanthogrammica in the Phyllospadix bed. Starfish observed in the upper subtidal zone included Pycnopodia helianthoides, Patira miniata, and Dermasterias imbricata. Grazers other than abalones and sea urchins were Acmaea mitra and Astraea gibberosa.

Many juvenile rockfish were observed in this area.

Station 16 Outer rock between O'Leary and Cuttle Islands
Lat. 50° 06' 04" N; Long. 127° 37' 42" W

From the abundance of sea urchins we inferred that this site had not been used by sea otters. Two distinct habitat types were seen at this site: high current surge channels with numerous filter feeders and no sea urchins, and sloping bedrock with abundant sea urchins.

Substrate: This exposed site was located on a series of irregular reefs whose topography contributed to the great turbulence. The bedrock sloped at about 45° to boulders in some areas, uneven bedrock in others, and surge channels in still others.

Algae: At +3.0 m was an extensive Phyllospadix sp. bed similar to that described for site 15. Below the Phyllospadix was a band of Laminaria setchellii with 20% cover. Small foliose red algae formed a 20% turf here. A single Macrocystis integrifolia plant was found growing on a boulder at +2 m. Below +1 m, encrusting corallines were the most important algal species and the bedrock/boulder substrates were entirely barren except for one small patch of Desmarestia ligulata and another of Nereocystis luetkeana.

Sea urchins: The red sea urchins began at +2.0 m and continued to at least 6 m, the maximum depth explored. They were particularly abundant (20/m²) on uneven bedrock near datum. The occasional purple sea urchin (S. purpuratus) was observed in the upper parts of surge channels. Green sea urchins were seen at 6 m on the exposed edge of a vertical wall.

Abalone: Abalone were abundant at this site. At +2 m on boulders and bedrock they occurred irregularly from 1-4 m². In a surge channel at 1 m depth, abalone were present in densities of less than 1/m². On the boulder rubble near datum abalone densities reached 10/m².

Other fauna: Predominant cover on the walls of surge channels were colonial tunicates, sponges and the bryozoan Hippodiplosia infundibulum. There were also patches of Dodecaceria fewkesi, Epiactis prolifera, Tealia crassicornis, Metridium senile, hydrozoans, Serpula vermicularis, Dermasterias imbricata, Dirona albolineata and Pycnopodia helianthoides.

On the western side of the reef on sloping boulder and bedrock there were also Evasterias troschellii, Henricia leviuscula, and Bugula sp. in barren areas. Serpula vermicularis, Calliostoma ligatum, Hinnites giganteus and kelp crabs occurred near the kelp. P. helianthoides was observed near a group of Balanus nubilus. The encrusting sponge Ophlita spongia pennata was found here.

At 5 m depth the surge channel to the north of the rock supported a variety of tunicates including Styella gibbsii, Didemnum sp., the colonial tunicate Aplidium sp., and an unidentified yellow compound tunicate. Dodecaceria fewkesi and sponges were also found.

Station 17 Block Island

Lat. 50° 04' 58" N; Long. 127° 31' 36" W

It was inferred from the density and distribution of sea urchins that sea otters had used this area for feeding.

Substrate: A steep bedrock wall sloped at 60° to 8 m, where a scree of large boulders began. The boulders extended down to a nearly flat sand/shell bottom at 13.5 m.

Algae: The kelp forest, starting at +1 m, was a mixed stand of L. setchellii (20% cover), Egregia menziesii (20% cover), and Alaria marginata (2% cover). The turf was composed of Codium fragile (10% cover), Halosaccion glandiforme and articulated corallines (20% cover). Encrusting corallines covered 80% of the bedrock beneath all this. At datum was a narrow band of Phyllospadix sp. Deeper was a band of kelps composed of L. groenlandica, L. setchellii and Costaria costata. Foliose red algae formed a turf and encrusting reds covered 60% of the bottom. Large Desmarestia ligulata formed a band below these kelps. On the boulder scree at 8 m, one Marocystis integriofolia plant was found. Several groups of Nereocystis luetkeana were scattered on the boulders at this level.

Sea urchins: Scarce red sea urchins were observed in cracks in the bedrock around 6 m. In the boulder scree from 8-14 m they were lodged between boulders at densities less than 1/m². Only one sea urchin was seen outside such cover.

Abalone: None was observed.

Other fauna: Invertebrates noted in the upper subtidal kelp forest were the tunicates Metandrocarpa taylori and Styela gibbsii, bryozoans, and Serpula vermicularis. Under the surfgrass were clumps of Dodecaceria fewkesi, bryozoans, encrusting sponges, the colonial tunicates Aplidium sp. and Didemnum sp., the grazers Diadora aspera, Tegula funebris and Tonicella lineata, the starfish Leptasterias hexactis and the two sedentary cnidarians Epiactis prolifera and Balanophyllia elegans. Near the lower edge of the kelp forest the anemones Tealia crassicornis and Anthopleura elegantissima were observed, and the cushion star Pteraster tessellatus. In the boulder scree from 8-14 m were three Astraea gibberosa, two Pycnopodia helianthoides, two Cucumara miniata, one Parastichopus californicus, Dermasterias imbricata, Mediaster aequalis and Solaster stimpsoni. Styela gibbsii, Hinnites giganteus, B. elegans and Tealia piscivora were attached to vertical faces of boulders. Several Pycnopodia helianthoides were observed on the sand/shell bottom below 14 m.

Juvenile rockfish (Sebastes sp.) were abundant on the bedrock slope. There was a large school of black rockfish (S. melanops), a kelp greenling (Hexagrammos decagrammus), and hundreds of small rockfish in the boulder area.

Station 18 Rock (10') between Thomas and Bunsby Islands
Lat. 50° 04' 45" N; Long. 127° 30' 52" W

From the absence of sea urchins on otherwise suitable habitat, it was inferred that this site had been used by sea otters.

Substrate: The smooth bedrock face dropped steeply (60°-90° slope) to 9 m, where it levelled out and became angular and creviced. There were some boulder areas near 10 m, with occasional patches of shell bottom.

Algae: Nereocystis luetkeana formed a 60% surface canopy. One L. groenlandica was observed at 8 m amongst N. luetkeana holdfasts. The scant turf consisted of foliose red algae including Gigartina sp., and the brown Dictyota binghamiae. The rock itself was covered with encrusting Lithothamnion sp. and Hildenbrandia sp.

Sea urchins: None.

Abalone: None.

Other fauna: Metridium senile was common on vertical walls at this site. One wall was almost entirely covered with small Metridium. Other invertebrates noted were Pisaster ochraceus, Solaster stimpsoni, Dermasterias imbricata, Serpula vermicularis, Anthopleura xanthogrammica, various unidentified sponges, bryozoans, and Styela gibbsii.

Station 19 Gull Island (south end)
Lat. 50° 04' 14" N; Long. 127° 33' 20" W

This site was within the known feeding range of sea otters (Morris et al. 1981 and our own observations).

Substrate: This dive was made along a straight line from the main island and the southern-most rock. The bottom was uneven bedrock with many undulations, vertical walls, surge channels, shelves, a few flat shell areas and an area with boulders.

Algae: Some isolated patches of N. luetkeana provided a canopy of 50%. At +1 m was a small Phyllospadix sp. bed. Between +1 m and 2 m were localized patches of L. setchellii, of up to 50% cover. The turf was articulated corallines (5% cover), foliose red algae including Gigartina sp. (15% cover) and the green Ulva sp. and Codium fragile (1% cover). At the beginning of one surge channel was a mixed stand of kelps including L. setchellii, Egregia menziesii, L. groenlandica and Pterygophora californica. Small foliose reds and Codium fragile formed the turf with a 30% cover. Deeper than 2 m encrusting corallines covered all available rock; and upright algae were absent.

Sea urchins: One large red sea urchin was found in an inaccessible crevice underneath an overhang.

Abalone: Three small (45-90 mm) abalone were found in crevices in the surge channels.

Other fauna: In the mid-intertidal zone was a bed of Mytilus californianus with many Pisaster ochraceus. Below this, an intertidal rock shelf was covered with Anthopleura elegantissima. Invertebrates near the shallow Laminaria patches included Tegula pulligo, Calliostoma ligatum, Serpula vermicularis and Pycnopodia helianthoides.

In the more shallow surge channel the walls were covered with various species of colonial tunicates and multitudes of bryozoans. Evasterias troschellii and Henricia leviuscula were also present. Balanophyllia elegans was scattered over the vertical walls with Tealia crassicornis. Dirona albolineata were observed at the base of the channel. Pycnopodia helianthoides were found in the deeper areas on the boulders and on the shell bottom.

DISCUSSION

In areas where sea otters were known to feed, preferred food items and red sea urchins in particular were scarce. Red sea urchins in such areas were hidden in crevices or under boulders, and did not limit the downward distribution of macro-algae. In comparable areas not foraged by sea otters, sea urchins were dense. The kelps and most other upright macro-algae were limited to a narrow band in the upper subtidal and lower intertidal zones. That the paucity of sea urchins and other food items in the sea otter feeding range is indeed the result of sea otter activity is substantiated by observations of fishermen (Kayra, pers. comm.) made since the 1972 transplant. Before the transplant, sea urchins could easily be seen from the surface and were very dense in the vicinity of Gull and Clara Islets and the distribution of bull kelp (Nereocystis luetkeana) was limited to more shallow waters. The observations of D. C. Miller recorded in 1972 (Appendix I) are similar.

The area identified to be the sea otter feeding range represents approximately 26 km². In December 1981, this area was incorporated into an ecological reserve.

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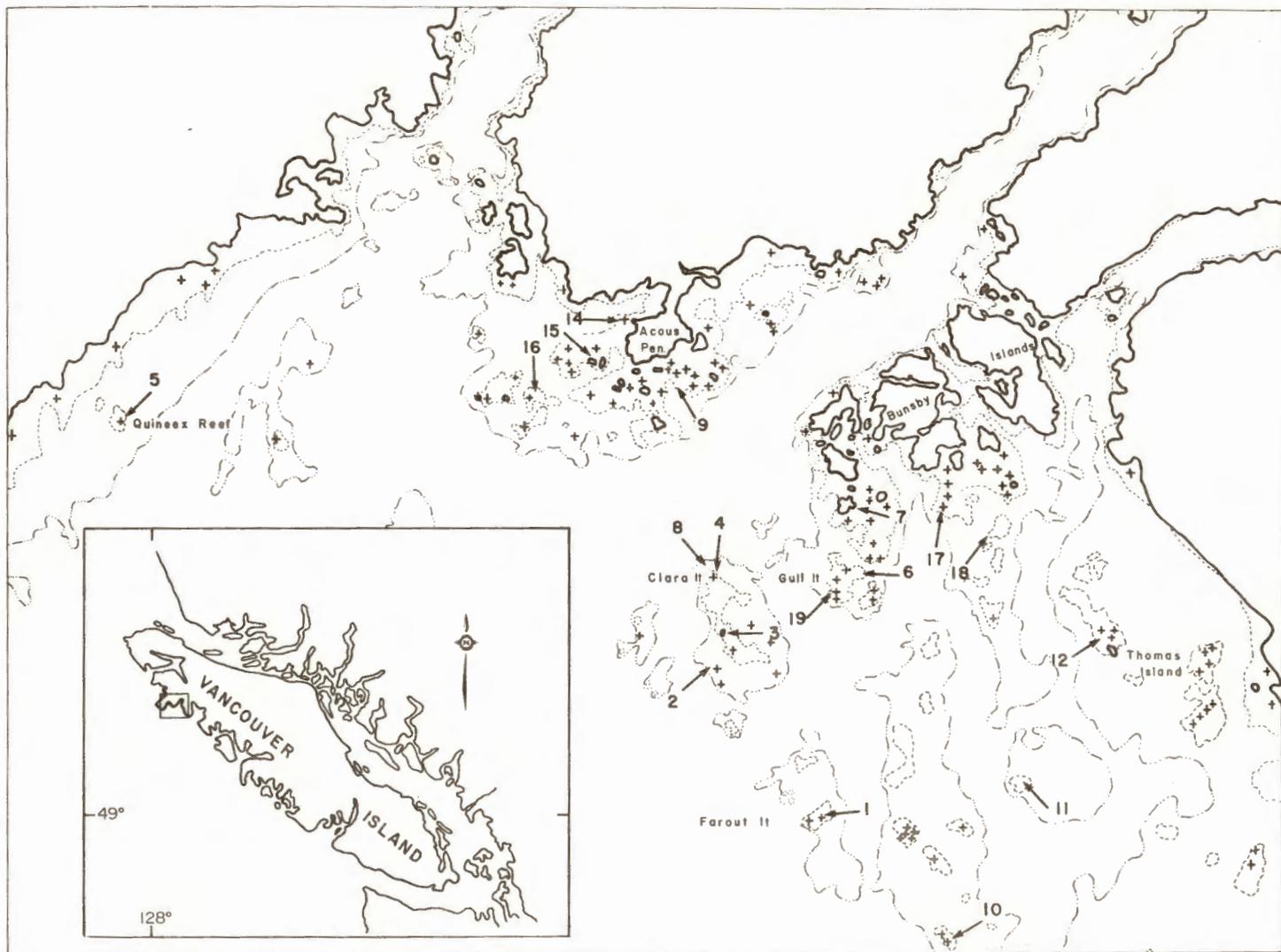


Fig. 1. Map of the area examined. The numbers indicate stations.

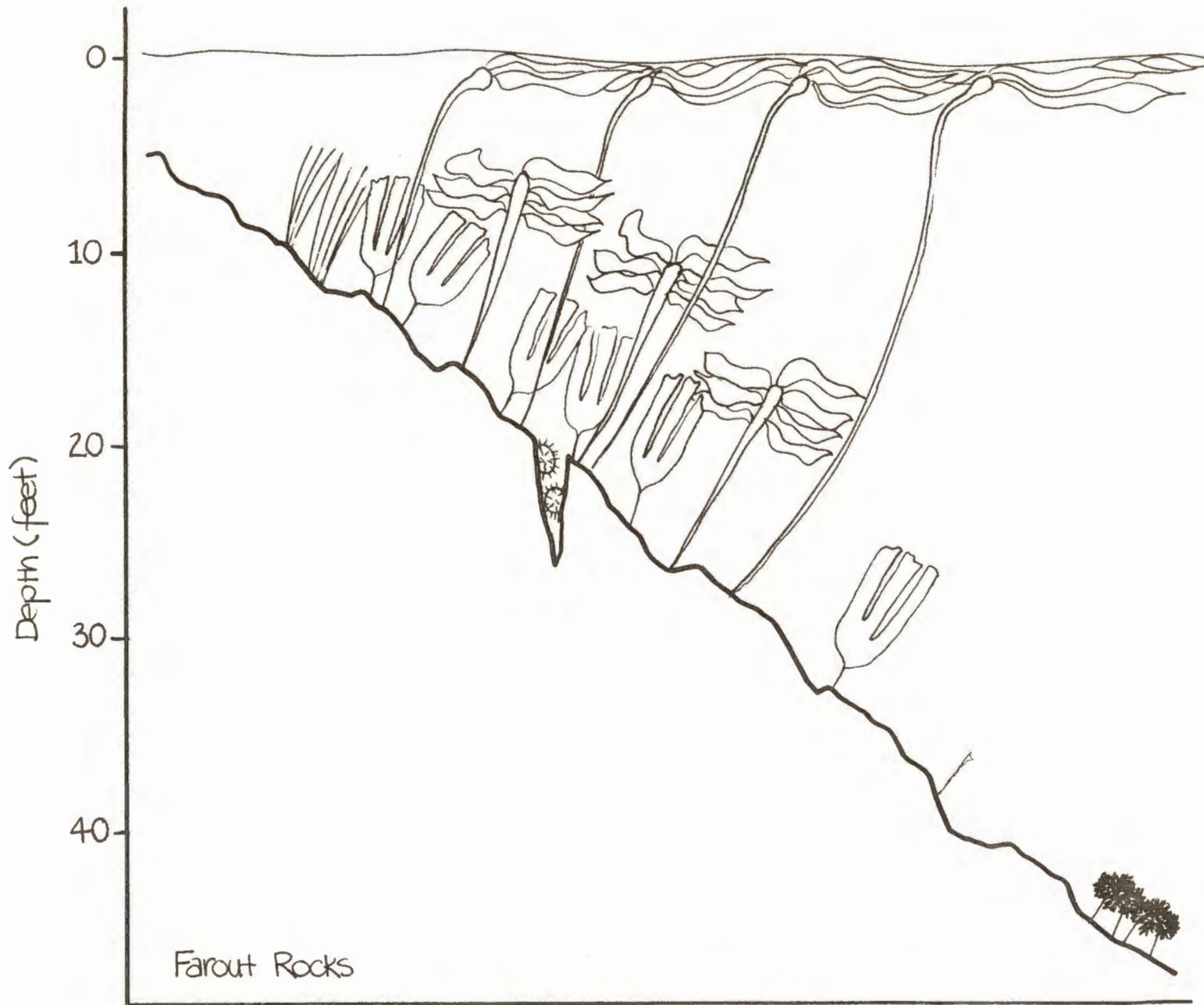


Fig. 2. Profile of Station 1.



Fig. 3. Profile of Station 5.

APPENDIX I.

Observations made in the area at the time of the 1972 transplant by D. C. Miller.

The 1972 transplant was carried out using the research trawler G.B. REED as a base of operations. D. C. Miller, at that time a technician with the Marine Invertebrate Investigation at the Pacific Biological Station, was sent to the Bunsby Islands as part of the transplant team in order to make a brief survey of the invertebrates (especially red sea urchins) of the area, and to find sites suitable for future monitoring. This is his report.

G.B. REED. July/72

"The following areas were searched in the Checleset Bay area, using a water glass at low tide:

- a) Acous Pen.
- b) South Bunsby Anchorage
- c) Kelp reefs approx. 1 mile south of Burial Cave Is.
- d) Reefs and rocks to north east of Burial Cave Is.

"These observations were followed by dives and samples from:

- a) 50°05.6' 127°32.6'
- b) 50°05.2' 127°32.8'
- c) 50°04.3' 127°34.2'
- d) 50°04.9' 127°32.6'

"In general there were few or no intertidal urchins of any species. Strongylocentrotus franciscanus was the dominant urchin sub-tidally and usually fell between -2 meters⁽¹⁾ and -12 meters unless limited by gravel or sand. The dominant bottom algae appeared to be a white encrusting coralline algae, and the urchins are separate from the main beds of kelp (Nereocystis).

"a) Acous Peninsula - there appeared to be no urchins close to shore and the water was a dark brown colour from muskeg seepage.

"b) Diver area (a) - there was a fairly heavy band of urchins immediately below the kelp (Nereocystis) of 20-24 urchins/m² and smaller "pockets" below this (10-15/m²) which extended down to approximately 10 meters depth. Scattered between were lesser concentrations of urchins at 2-4/m².

"c) Diver area (b) - the urchins are in a comparatively narrow band along the rocks, immediately sub-tidal and bounded below by sand and mud at estimated 10-25/m². While these urchins would be convenient to monitor, they are not evenly distributed in size or concentration with small changes in locality.

"d) Dive area (d) - the urchins are fairly uniform in concentration at 6-10/m² and are readily accessible for monitoring.

"e) Dive area (c) - the urchins are fairly uniform in concentration and very dense: 20-35/m² and there are significant numbers of S. purpuratus present (occasional "pockets" of 15-20/m² and more commonly 1-5/m². The pockets may comprise up to 30% of the S. franciscanus beds in area in this outer region). The depth of the beds appears to be from -2 meters to -12 meters or possibly deeper.

"f) The reefs and rocks to the south east of Burial Cave Is. contain urchins but their numbers diminish rapidly towards the more protected waters of Gay Passage.

"The major beds of these urchins seem limited to areas of rock, exposed to surge, and particularly to currents. Thus the urchins were not found in the immediate area of the otter pens of 1972⁽²⁾ or 1970. While they are frequently found near kelp beds, they rarely seem to penetrate into the kelp beds but rather on the fringes of the beds. The material in the digestive tract is usually is 2-3 mm diameter fragments of a thick leafed algae.

"The urchins in the outer areas were significantly smaller than those in the anchorage⁽³⁾ as well as more numerous. The outer area urchins are similar in size to the population sampled at Fleming Pass, Barkley Sound but markedly smaller than those at Amphitrite Point⁽⁴⁾. At this date the Checleset Bay urchins appeared spawned out but still retained recognizable amounts of sex products in the gonads.

"In terms of other foods suitable for otters, there were large numbers of top shells Astraea gibberosa and abalone Haliotis kamtschatkana in the rocky portions of the area, although the abalone are comparatively small. There are numerous beds of mussels Mytilus californianus in the area.

"The area immediately south of the Burial Cave Is. is recommended as suitable for monitoring urchin populations, combining accessibility, fairly representative of the feeding areas of otters, and fairly uniform beds of urchins.

Footnotes:

1) Miller uses "-2m" to indicate a depth of 2m. Depths were not corrected to depths below chart datum.

2) The pens were located at Lat. 50°05'50"N; Long. 127°32'36"W.

3) The anchorage was located at Lat. 50°05'36"N; Long. 127°32'18"W.

4) For the sizes of sea urchins that had been sampled in Fleming Pass and at Amphitrite Point, see F. R. Bernard and D. C. Miller, 1973.

Preliminary investigation on the red sea urchin resources of British Columbia (Strongylocentrotus franciscanus [Agassiz]). Fish. Res. Board Can. Tech. Rep. 400: 37 p.