# A Survey of Abalone Populations on the East Coast of the Queen Charlotte Islands, August 1978

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# A SURVEY OF ABALONE POPULATIONS ON THE EAST COAST OF THE QUEEN CHARLOTTE ISLANDS, AUGUST 1978

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## ABSTRACT

Breen, P. A., and B. E. Adkins. 1979. A survey of abalone populations on the east coast of the Queen Charlotte Islands, August 1978. Fish. Mar. Serv. MS Rep. 1490: 125 p.

This report presents our observations from a 20-day survey in the Queen Charlotte Islands. At most of 131 sites, we measured the abalone density from 16 quadrats and recorded the bottom type, slope, dominant plants, sea urchin abundance, and major grazing fauna. We took abalone samples for size frequency analysis at 46 sites. The methods used and descriptions of each site are given; detailed analysis will follow in a later report.

Key words: Abalone, Haliotis, populations, fisheries biology, sea urchins, kelp, algae, Queen Charlotte Islands.

## RÉSUMÉ

Breen, P. A., and B. E. Adkins. 1979. A survey of abalone populations on the east coast of the Queen Charlotte Islands, August 1978. Fish. Mar. Serv. MS Rep. 1490: 125 p.

En aout 1978, nous avons visité 131 stations de la côte est des îles Queen Charlotte. A chaque station, nous avons déterminé la densité de la population. Nous avons etudié le varech à chacun de ces endroits et les observations sont presentées ci-après.

Mots-clés: Ormeau, Haliotis, densité de population, oursin, varech, les îles Queen Charlotte.

# INTRODUCTION

In 1976, the B.C. fishery for abalone (Haliotis kamtschatkana) suddenly changed from one in which small boats landed about 100,000 pounds of fresh abalone annually for local fresh markets to one in which much larger boats with freezing units and self-contained air compressors landed 600,000 pounds, most of it for export to Japan. Despite a slightly shorter season and a freeze on the number of licenses (which prevented the certain inflow of more large boats with heavy capital investments), the fishery took over 900,000 pounds in 1977, and then took another 900,00 pounds during a 3 month season in 1978.

North coast landings were far less than south coast landings until 1973, when the two areas produced roughly the same amounts. In 1975 the north coast produced more, and in 1978 the south coast produced only 2% of the total landings. In both 1977 and 1978, the Queen Charlotte Islands yielded more than half the total. Many of the areas that produced the increased yields in 1976-1978 were areas that had never been commercially harvested before, except by persons working in the intertidal zone at low tide. Fisheries operated by Japanese-Canadians in the Queen Charlotte Islands had already ceased operation when W. F. Thompson made his study of the resource (Thompson 1914).

At present, the information necessary to predict the annual yield that could be expected from an equilibrium fishery is not complete. The best information concerns growth. Growth rates are known from tagging studies, examination of growth checks on the smallest sizes, and examination of size-frequency modes (Quayle 1971; our unpublished data). Where the studies were carried out, an abalone reached the present legal length of 4 inches (102 mm) in about 7 years. The results from widely different areas were very similar (Quayle 1971), and results from one area were identical when the study was repeated using a different tagging method 13 years later. However, from the appearance and shape of the shells of abalone growing in some locations in the Queen Charlotte Islands, it appears to us that there are populations in which growth ceases before legal size, resulting in stunting.

Recruitment and natural mortality rates have not been well studied. We carried out a study of mortality in a tagged population in Barkley Sound, but the results have not been fully analysed, and they are confounded by the high immigration and emigration rates across the boundaries of the study area.

Studies of abundance and size-frequency distributions have been made in various areas. Thompson (1914) studied the east coast of the Queen Charlotte Islands from the surface, using a water glass. Miller (unpublished MS) studied the west coast of Vancouver Island. Quayle (1971) gives size frequencies and morphometric information from several locations on all parts of the coast. The present authors have made informal observations during patrol boat surveys of the north coast (Adkins and Stefanson 1977; Adkins 1978; Breen et al. 1978). Many of these populations were observed before heavy fishing had taken place, and

their size structure is 'top-heavy'; with many individuals near asymptotic length, and few in the small size-classes. One interpretation of this observation is that recruitment is low and possibly erratic, while adult mortality rates are low, allowing old individuals to accumulate. There is unfortunately no practical way to determine the exact age of an abalone once it is past the first 2 or 3 years of life, so the age structure of these populations cannot be calculated.

From the phase of development of the fishery and our present knowledge of the relevant aspects of biology, there is little doubt that the fishery has been removing accumulations of old animals. The relative importance of annual production to the present fishery is probably low.

Two things are certain. First, the accumulated stock will eventually be depleted and the fishery will have to depend on annual production. It is not known how long or short a time this will take. Second, from the size-frequency observations it appears that annual production per unit area will be a small fraction of the yield which was realized in the present fishery. Low annual production could also be predicted from the relatively low growth and recruitment rates. Taken together, these statements mean that annual landings from the present fishery are much greater than those which can be sustained in the equilibrium fishery.

In this survey of the east coast of the Queen Charlotte Islands, we attempted to obtain information on the present state of accumulated stocks. We did this by returning to some sites that had been surveyed previously, and by comparing heavily fished areas with lightly fished and closed areas. This information is of prime importance in determining how stringently the present fishery should be regulated.

We had two other goals during this survey. In both California (Tegner, personal communication) and Australia (Shephard 1972), managers believe that intense fishing of abalone has led to invasion of abalone habitat by sea urchins, and that this prevents the full recovery of abalone. We were interested in finding any evidence which bore on this point. Second, we looked for generalizations which could be made about abalone and the communities in which they were found; and relations between abalone and their food supply, predators and competitors within their habitat.

This report presents the observations that we made at each site during the survey. Full analysis will be presented in a later publication (Breen 1979, in prep.). The preliminary analyses presented here were made for the public meeting held on November 7, 1978.

## METHODS

The vessel BASTION CITY was used as a base for 20 days, from August 5 to August 24, 1978. Two teams, each with two divers and a boat tender working from inflatable boats, made observations on 131 sites

during this period, in the area from Cumshewa Inlet to Carpenter Bay. Sites were chosen after examining local requests, closed areas, the compulsory log sheets provided by commercial abalone fishermen, previous surveys, and the appearance of areas both on the chart and at the sites. Sites were chosen:

1. in such a way that a wide range of habitats would be covered,
2. so that closed areas could be compared with other areas, and
3. so that heavily fished areas could be compared with lightly fished areas.

The survey procedure was designed to yield the most quantitative information in the shortest possible time, so that the greatest number of locations could be surveyed.

The procedure for measuring abalone density was developed from preliminary sampling carried out at Bamfield in July 1978 (details will be given in the final report). Abalone that could be seen without turning over rocks were counted in 16 square quadrats, each 1 $m^2$. The 16 quadrats were arranged in four transects, each 4 m apart; and each of the four quadrats within a transect were 1 m apart. The first quadrat was located as randomly as possible at the top or bottom of the habitat to be surveyed, and the transects ran up and down the vertical slope. If there was no slope, the direction of the first transect was chosen randomly, and then the pattern was followed.

This method covered an area 7 m by 17 m, which was larger than the scale of local aggregation. Only the position of the initial quadrat was subject to bias, as the locations of the following 15 were determined by the pattern. (An exception occurred when unsuitable habitat was encountered, for instance a gravel patch, and the quadrat had to be 'steered' onto proper substrate.) Sixteen was chosen as the number of quadrats because this number could be counted while using only 0.3-0.5 tanks of air, and because it gave reasonable confidence limits on the estimate of density, based on preliminary sampling. Quadrats were separated by 1 m to eliminate autocorrelation between adjacent squares, which increased variance. Based on preliminary sampling, the 95% confidence limits on a mean density of $5/m^2$ would be 4.18 and $5.82/m^2$. (The actual survey results gave a relation between mean and variance that produced almost identical confidence limits to those just stated.)

Rocks were not turned over while counting abalone, even though juveniles are often found beneath. This was because turning rocks slowed the survey, and so we sacrificed the information on juveniles for more information on adults. On the Fairbairn Shoals, however, we turned all rocks at all stations.

This method of counting abalone was carried out unless no abalone appeared in the first eight quadrats, if there were obviously too few abalone to count this way, or if the substrate was obviously unsuitable.

All abalone found in quadrats were collected at approximately 1/3 of the sites, determined beforehand. These abalone were measured after the day's diving, and were returned to the next site. The percentage of

legal size was estimated for each site where abalone were not collected. In addition, a few rocks were turned, outside quadrats, in order to determine the presence of juveniles (those less than 50 mm). Where the divers thought that the quadrat had underestimated density, or that the collection contained a misleading proportion of legal sizes, a note was made of this. A "legal density" was calculated by multiplying total density by the percentage of legals. We considered a legal density to be commercial if it existed in more than a narrow band along the shore, and if it was higher than $0.30\text{-}0.50/m^2$, depending on the difficulty of searching and the size of the legal abalone.

The algal community was described in four levels: the overhead canopy of floating kelps, the understory of large algae, the turf, and the encrusting algae. Identifications were made visually. In some cases specimens were collected for verification. Some identifications were not available at the time of writing (October 1978). Where a full name is given, we are confident that it is correct. Where only a genus name is given, then either there is only one species in the genus (e.g., Nereocystis), or we were not certain of the species (e.g., Laminaria). The terms 'lithothamnion' and 'coralline' refer to coralline algae resembling the genera Lithothamnion and Corallina, respectively; we did not identify these genera visually because we collected extensively in these groups. Percentage cover was estimated visually. The substrate was described in terms of composition, rock size, and slope, all of which were estimated visually. The depths which bounded algal communities were noted using calibrated divers' depth guages, later corrected to depth below datum from the time of the dive and from tide tables. The population density of red sea urchins (Strongylocentrotus franciscanus) was estimated visually, and the depths noted. If time permitted, the density of competitors was estimated visually.

This information was listed on a standard form, shown as Appendix 1, which was either written up in the boat immediately after the dive, or was written up that evening from notes made underwater.

The fishing history of each location was determined by collating the log sheets which fishermen are required to submit after each trip. These include the location, as shown on a chart tracing or on a sketch map, the number of diver hours expended by each diver, and the landings for each diver for each day. We collated only the total landings for each area for 1977 and 1978. There are some problems with these data: some landings were reported with no specific location given. The fishermen sometimes include on their maps both the areas that they actually fished, and the areas that were merely searched, without distinguishing the two; and this leads to erroneously high landings for parts of the area. There are minor discrepancies between the landings as read from log sheets and those reported on landings slips. However, the logs probably give a good general picture of where landings originated.

There were several problems in interpreting the results of the survey. First, in most cases there had been no previous survey at an exact site; and where there had been, the methods used were often different. In the frequent case where we found a site with no commercial density of abalone, it was not usually possible to say with certainty

whether heavy fishing had removed all the legal abalone or whether there had never been any legal abalone. Second, when we found abundant sub-legal abalone, it was not possible in most cases to determine whether they were young abalone or whether they were stunted abalone (fishermen called them 'surf abalone'). Third, it became obvious very quickly that the abalone habitats changed in very short distances; distances much shorter than we could make the intervals between our sites. It was quite possible for us to miss the few pockets of excellent habitat containing abundant abalone within the area that we were surveying. This problem was overcome, we hope, by surveying as many sites as we could.

## RESULTS

### A. DESCRIPTIONS OF STATIONS

Figures 1 through 4 show the locations of stations. In the following, the specific location is given in the title, followed by the general location in capital letters. Latitudes and longitudes are given in degrees, minutes, and seconds. All depths are given as meters below chart datum, and the term 'sea urchins' refers to red sea urchins unless another species is indicated. "Beneath" means directly underneath; "below" means at a deeper part of the shore.

#### STATION 1. McCoy Cove, east side, opposite light (CUMSHEWA INLET)

53 02 02 N; 131 39 30 W

The MEAN DENSITY was $0.69/m^2$ (variance 1.56). There were 75% legal size up to 140 mm, so the LEGAL DENSITY was $0.52/m^2$. No juveniles were seen, but rocks were not turned here.

The SUBSTRATE was tumbled boulders near the shore, changing near datum to sand and patches of small rocks lyin on sand, with a very gradual slope. The ALGAE were the bull kelp Nereocystis luetkaena and giant kelp Macrocystis integrifolia mixed together, forming a canopy that ranged from 10 to 40% of the surface cover. Kelp extended at least 200 m from shore. It grew only on the patches of small rocks, and abalone were found only under the kelp canopy. There was a 50% cover of Laminaria spp. beneath the canopy, and a variable (20-80%) cover of erect coralline algae beneath that. The rocks themselves were covered with encrusting lithothamnion at about 75% cover. SEA URCHINS were irregularly distributed, forming no consistent pattern, with a maximum density of $5/m^2$. The most abundant grazers after abalone were the top shell Astraea gibberosa and the gumboot chiton Cryptochiton stelleri.

COMMENTS

In 1978, all of Cumshewa Inlet was closed to the fishery. In 1977, 25,000 pounds were reported taken from the north shore of Cumshewa Inlet between Cumshewa Head and Conglomerate Point. Although abalone were not particularly abundant at this site, the large size and high proportion of legal individuals produced commercial densities. This was a common observation in Macrocystis communities such as this.

STATION 2. Rock east of Haans It. (CUMSHEWA INLET)

53 02 33 N; 131 41 04 W

The MEAN DENSITY was 1.06/$m^2$ (distribution was quite patchy: variance 3.66). No juveniles were found, and 50% of the population appeared to be legal size, reaching 145 mm. The LEGAL DENSITY was 0.53/$m^2$.

The SUBSTRATE was large boulders on a 45° slope in the intertidal zone, changing at datum to boulders and head-sized rocks sloping at about 30°. Both the slope and average rock size decreased with greater depth.

In the intertidal zone the ALGAE were the feather boa kelp Egregia menziesii and surf grass Phyllospadix scouleri. Near datum, Macrocystis began as a dense (40% cover) but narrow (about 5 m wide) band, with 50% cover of Laminaria saccharina beneath it, and sparse (10%) erect corallines under that. At approximately 2 m, these kelps ended and SEA URCHINS began at 3/$m^2$. There was a bit of polysiphonous red algal cover where the kelps ended, then Agarum began at up to 50% cover. The most abundant grazers were small limpets (Acmaea mitra and Collisella ochracea). We noted that sea cucumbers, Cucumaria miniata, were abundant in the sea urchin zone.

COMMENTS

Cumshewa Inlet was closed in 1978. In 1977, 25,000 lb were removed from the north shore. There was a commercial density of large abalone at this site, in a narrow but typical Macrocystis forest.

STATION 3. Haans Islet (CUMSHEWA INLET)

53 02 24 N; 131 40 08 W

The MEAN DENSITY was 2.69 (variance 5.83), but only 3% of these were legal size (see Fig. 5), and LEGAL DENSITY was 0.08/$m^2$.

The SUBSTRATE was round boulders and head-sized rocks, on nearly level ground for at least 50 m south of the light. The depth was approximately 1-2 m below chart datum. ALGAE were scarce, existing as patches of sparse Nereocystis with no understory. The greater part of the bottom was barren except for encrusting lithothamnion, and was dominated by SEA URCHINS at a high density, estimated to be 20-30/$m^2$. Other grazers were abundant, and they included the limpets Acmaea mitra and Collisella ochracea; the snails Calliostoma ligatum and Amphissa columbiana; and chitons, especially the lined chiton Tonicella lineata.

COMMENTS

For the fishing history of this shore see Station 1. This site was surveyed at or near site 1 of Breen, Adkins, and Stefanson (1978), and site 4 of Adkins and Stefanson (1977). Both the previous surveys reported dense beds of Macrocystis and Nereocystis, with abalone densities up to 5/$m^2$. It is possible that this survey was not on the exact site of the previous survyes; it is also possible that a change has occurred in the community here.

STATION 4. Just east of McLellan Island (CUMSHEWA INLET)

53 02 45 N; 131 44 12 W

The MEAN DENSITY was 0.63 (variance 0.92); of these 75% were legal, up to 140 mm. The LEGAL DENSITY was 0.47. We found no juveniles.

The SUBSTRATE was pavement bedrock, sloping at about 25° to just below datum, then a narrow band (5 m) of head and hand-sized rocks on sand, and finally gently sloping sand. The quadrats were taken on the rocks in 1-2 m below datum. The ALGAE were Macrocystis and Nereocystis mixed together in a very dense canopy (80% cover), with 75% cover beneath it consisting of a mixture of the kelps Cymathere triplicata, Laminaria spp., Agarum and Costaria costata. Underneath those were erect corallines at about 20% cover, then a mixture of lithothamnion and the encrusting red alga Hildenbrandia. SEA URCHINS were very unevenly distributed, and were found on the pavement bedrock above the kelp forest. The bat star, Patira miniata, was also abundant on the bedrock.

COMMENTS

For fishing history, see Station 2. This was a typical Macrocystis community. Abalone density was not high; but the abalone were mostly legal and many were large. There was a commercial density at this site. The observation of sea urchins on more solid rock above rather than below the kelp was repeated at similar sites later in the survey. The observation of abundant Patira on barren bedrock was also repeated later.

STATION 5. Between Haans Islet and McLellan Island (CUMSHEWA INLET)

53 02 35 N; 131 42 42 W

No abalone were seen at this site.

The SUBSTRATE was a rock intertidal zone changing to sand just below datum. ALGAE were present as a narrow but very dense band of Macrocystis growing on small stones. Some of the plants had grown holdfasts as large as 0.5 m across. Laminaria and Neoagardhiella bayleyi grew on the sand just below the kelp bed.

COMMENTS

Although this site was included in the area shown as harvested on 1977 log sheets, the abalone habitat was very narrow, and we found it to be totally unworkable because of the kelp density. This was marginal habitat.

STATION 6. Between Haans Islet and McLellan Island (CUMSHEWA INLET)

53 02 28 N; 131 42 00 W

No abalone were found at this site.

COMMENTS

This site was similar to Station 5. The band of Macrocystis was wider than at Station 5, but when we tried to count abalone within quadrats we found it impossible to see the bottom under the kelp, and also it was impossible to move the quadrat through the kelp. In random searching, we could find no abalone. Although this site was within the area shown as fished on 1977 log sheets, it probably has not been fished.

STATION 7. Fairbairn Shoals (CUMSHEWA INLET)

53 00 36 N; 131 41 18 W

We found no abalone at this site.

The SUBSTRATE was large gravel to rocks 150 mm across, on a flat bottom in approximately 2-3 m below datum. ALGAE were irregular Nereocystis, forming a 20% cover at the surface; Cymathere and eelgrass (Zostera sp.) forming 80% cover on the bottom; and a variable turf of Desmarestia viridis and Odonthalia sp. The rocks themselves were barren and smooth, probably from being ground together in storms.

COMMENTS

The Fairbairn Shoals yielded at least 160,000 lb of reported landings in 1976 and 1977. All of Cumshewa Inlet was closed in 1978. This part of the shoal was obviously unsuitable abalone habitat. Because in April we had seen rock outcroppings with dense abalone in a similar place, we swam for some distance over the shoals here, but the bottom remained constant. There were no small abalone on even the largest rocks here.

STATION 8. Fairbairn Shoals (CUMSHEWA INLET)

53 00 26 N; 131 41 06 W

The MEAN DENSITY here was $1.44/m^2$, (variance 1.86) including those that we found on the undersides of rocks. The sizes that we found are shown in Fig. 6. Of those, 61% were legal. LEGAL DENSITY was $0.88/m^2$.

The SUBSTRATE was mixed rocks, from large boulders down to cobble and gravel. The bottom was flat in approximately 3-4 m. ALGAE were sparse Nereocystis, forming 5% cover or less at the surface, a mixture of mostly Cymathere and lesser amounts of Desmarestia ligulata, D. viridis and Costaria covering 80% of the bottom; no turf; and a mixture of lithothamnion and the colonial polychaete Dodecaceria fewkesi on the rocks and boulders. SEA URCHINS were variable in distribution and abundance, reaching $2/m^2$. Green sea urchins, S. droebachiensis, were present at up to $30/m^2$ among the kelps. Chitons were found at densities up to $5/m^2$, and there were also A. mitra and Calliostoma.

COMMENTS

This site showed a commercial density of abalone. Although we did not sample the whole population very extensively, the juveniles found indicate a good potential for future production. For fishing history, see Station 7.

STATION 9. Fairbairn Shoals, near central rock (CUMSHEWA INLET)

53 00 48 N; 131 41 06 W

The MEAN DENSITY was $1.13/m^2$ (variance 1.05) those found under rocks. Sizes collected are shown in Fig. 7. Of these, 75% were of legal size, so the LEGAL DENSITY was $0.85/m^2$.

The SUBSTRATE was 50% cobble, the rest boulders and smaller rocks, on a flat bottom in less than 2 m. ALGAE were sparse Nereocystis, forming only a 10% cover; tree kelp (Pterygophora californica) on the

solid rocks at 30% cover, a light (20%) cover of Cymathere beneath that; no turf; and a mixture of lithothamnion and Dodecaceria on the rocks. SEA URCHINS were present but were irregularly distributed, and were not more than $1/m^2$.

COMMENTS

For fishing history, see Station 7. This site was typical of the bottom that we saw in the area around the central rock. Although the shoals have been heavily harvested, there was a commercial density at this site, and many of the legal abalone were large. The population was extremely "top-heavy." Many of the large abalone had eroded shells that appeared to be very old.

STATION 10. Fairbairn Shoals near central rock (CUMSHEWA INLET)

53 00 57 N; 131 40 57 W

The MEAN DENSITY was $2.88/m^2$ (variance 11.45), including all those that we found under rocks. This number included a lot of juveniles concentrated in two quadrats, hence the high variance. See Fig. 8 for sizes. The percentage of legals was 49%, so the LEGAL DENSITY was 1.41.

The SUBSTRATE was similar to Station 9: boulders as large as chest-size, through rocks down to cobble. There were gravel patches between areas with rock, and the pattern of the transects had to be changed to avoid the gravel. The bottom was flat, in approximately 3 m. The CANOPY was a 20% cover of Nereocystis; 10% cover of Pterygophora beneath it; a 50-75% cover of Cymathere beneath that; no turf; and a mixture of lithothamnion and Dodecaceria on the rocks. SEA URCHINS were very patchy, and did not reach a density greater than $2/m^2$.

COMMENTS

For fishing history see Station 7. This site was very similar to Station 9, except for the greater number of juveniles observed here. The juveniles were observed at this site were highly concentrated. The shells of the large legal sized abalone were again eroded.

STATION 11. Fairbairn Shoals (CUMSHEWA INLET)

53 00 16 N; 131 39 24 W

There were no abalone at this site.

The SUBSTRATE was hand and head-sized rocks set firmly in gravel and silt, on a flat bottom in approximately 6 m. The CANOPY was Macrocystis forming 25% cover at the surface; a 30% canopy of Pterygophora on the bottom; Laminaria covering 50% of the bottom beneath that; a dense turf of Microcladia coulteri, then a mixture of lithothamnion and Hildenbrandia on the rocks themselves. SEA URCHINS were absent.

COMMENTS

For fishing history see Station 7. This site appeared to be a good place for abalone, but we could find none in eight quadrats, and we saw none in a brief random search. This site was called unsuitable habitat.

STATION 12. Fairbairn Shoals (CUMSHEWA INLET)

53 01 08 N; 131 39 27 W

There were no abalone at this site.

The SUBSTRATE was flat, in approximately 6 m, composed of gravel with rocks up to chest-size. The CANOPY was Nereocystis and Macrocystis mixed together, with a dense layer of Cymathere beneath it. SEA URCHINS were absent.

COMMENTS

Like Station 11, this site must be called unsuitable habitat, although it does not appear so.

STATION 12a. Fairbairn Shoals (CUMSHEWA INLET)

53 00 52 N; 131 39 15 W

There were no abalone at this site.

The SUBSTRATE was flat gravel in approximately 6 m, with scattered individuals of Cymathere. There were no SEA URCHINS.

COMMENTS

Another unsuitable habitat.

STATION 13. Fairbairn Shoals (CUMSHEWA INLET)

53 00 28 N; 131 38 30 W

There were no abalone at this site.

There was a sparse CANOPY of Nereocystis, but no bottom cover. A few green sea urchins were present.

COMMENTS

This site was clearly on the outer edge of the shoals, and was not suitable habitat.

STATION 14. Fairbairn Shoals (CUMSHEWA INLET)

53 00 28 N; 131 39 12 W

There were no abalone at this site.

The SUBSTRATE was flat gravel in approximately 5 m. The CANOPY was a dense Nereocystis forest, with 100% cover of Laminaria and Cymathere beneath it. There were no SEA URCHINS.

COMMENTS

Another site with unsuitable habitat.

STATION 15. East of Girard Point (CUMSHEWA INLET)

53 00 02 N; 131 39 24 W

The MEAN DENSITY was $0.88/m^2$ (variance 0.65). The abalone we collected from quadrats were 85% legal size (see Fig. 9); the LEGAL DENSITY was $0.75/m^2$. We saw no juveniles even though we turned all the rocks found in the quadrats.

The SUBSTRATE was boulders lying on gravel. The bottom sloped at about 5-10°; the slope decreased with depth, and the proportion of gravel increased with depth. There was a CANOPY of Macrocystis, forming 25% cover at the surface, from near datum to approximately 3 m. There, barren rock and SEA URCHINS at $1-5/m^2$ began and continued deeper. The kelp canopy was about 100 m wide along the shore. Beneath it were Laminaria, Dictyota binghamiae and D. ligulata, covering 25% of the rocks; there was no turf beneath that and the rocks themselves were covered with pink

lithothamnion. In the sea urchin zone, the lithothamnion was white. The dominant grazers after abalone and sea urchins were Tonicella and Acmaea.

COMMENTS

This shore is included in the fishing history of the shoals; see Station 7. This site was a Macrocystis community. There was a good commercial density here. The population was very top-heavy.

STATION 16. Between Girard and Skedans points (CUMSHEWA INLET)

53 39 45 N; 131 39 55 W

The MEAN DENSITY was 1.00/$m^2$ (variance 1.87), including those that we found under rocks in the quadrats. Of these, 18% were legal sized, so the LEGAL DENSITY was 0.18/$m^2$. Sizes of abalone collected are shown in Fig. 10.

The SUBSTRATE was boulders and smaller rocks lying on sand. Slope was gentle, and a CANOPY of Nereocystis extended for up to 300 m from shore. Quadrats were made under this canopy in approximately 1-2 m. Beneath the canopy was a sparse cover of Dictyota and a few small Macrocystis plants. There was no turf, and the rocks were covered with a mixture of lithothamnion and Dodecaceria. SEA URCHINS were present at up to 4/$m^2$ beneath the canopy. The other grazers were Tonicella and Acmaea.

COMMENTS

Landings from this shore are included in the total for the shoals: see Station 7. Unlike nearby Station 15, this site did not have commercial densities of abalone. However, the juveniles found indicate some prospect of recovery.

STATION 17. West of Skedans Point (CUMSHEWA INLET)

52 58 48 N; 131 36 57 W

The MEAN DENSITY was 0.58/$m^2$ (variance 0.81, based on 12 quadrats). Half the abalone collected for measuring were of legal size (see Fig. 11), so the LEGAL DENSITY was 0.29/$m^2$.

The SUBSTRATE was mixed boulders and rocks on a nearly level bottom approximately 2 m below datum. The CANOPY was a mixture of Macrocystis and a lesser amount of Nereocystis, forming a 60% cover at the surface. This extended for a couple of hundred meters from shore. Beneath it were Pterygophora, forming 50% cover, and a 10% cover of

Laminaria and small Macrocystis plants; a 40% turf of erect corallines, and then lithothamnion. There were no SEA URCHINS in the area surveyed.

COMMENTS

In 1977, the Skedans Point area had reported landings of 15,000 lb. In 1978, this part of the shore was included in the Cumshewa Inlet closure. Abalone density was below commercial values. Divers ran out of air before the 16 quadrats could be completed.

STATION 18. Near Skedans Point (CUMSHEWA INLET)

52 58 10 N; 131 36 24 W

The MEAN DENSITY was 1.38/$m^2$ (variance 1.72), including those that we found under rocks in the quadrats. For sizes, see Fig. 12. There were 10% legal sizes within the quadrats, so the LEGAL DENSITY was 0.13/$m^2$.

The SUBSTRATE was mixed rock sizes, sloping quite steeply in the intertidal zone, then becoming almost level near 2 m. Gravel between the rocks increased at greater depths. The CANOPY was a band of Nereocystis forming 25% cover at the surface. This was present from datum to about 2 m. There was no understory, and the turf of polysiphonous red algae was variable in abundance beneath the canopy. The kelp band was about 5 m wide, ending near 2 m where SEA URCHINS began at 2-5/$m^2$.

COMMENTS

For fishing history see Station 17. Both divers thought that the abalone were more abundant than the quadrats would indicate. There were small areas where density appeared to be 5/$m^2$. The presence of polysiphonous red algae, and also the presence of thick diatom films over some areas under the kelp, give the site an "under-grazed" appearance. This and the very patchy distribution of abalone leads us to say that the site has been harvested.

STATION 19. Limestone Island, southwest corner (LIMESTONE)

52 54 20 N; 131 36 54 W

The MEAN DENSITY was 0.94/$m^2$ (variance 2.06). We estimated 15% legal size, so the LEGAL DENSITY was 0.14/$m^2$. We saw no juveniles.

The SUBSTRATE was very large boulders, larger than 1 m across, sloping at about 45°. ALGAE were Fucus in the intertidal zone, then a Nereocystis canopy forming 50% cover at the surface, extending from datum

to approximately 2 m. Beneath it were Laminaria and Costaria, forming 50% cover, then a dense turf of erect corallines, and pink lithothamnion on the rocks. At 2 m, SEA URCHINS began at $2/m^2$, and the rock was barren. We noted that the boulders were cemented together by the heavy crust of lithothamnion and Dodecaceria.

COMMENTS

The area from Skedans Bay to Haswell Island, herein called "Limestone," had reported landings of about 15,500 lb in 1977 and 2,500 lb in 1978. This station did not have a commercial density of abalone at this survey.

STATION 20. Rock on north side of Vertical Point (LIMESTONE)

52 54 22 N; 131 37 35 W

The MEAN DENSITY was too low to measure, as we found only one abalone in the first eight quadrats, and saw few others in a random search.

The SUBSTRATE was rough, solid bedrock lying in 4-6 m. The site was a submerged rock detached from shore. There was a light Nereocystis CANOPY, forming up to 50% cover at the surface (but the plants were very sparse at the bottom). Beneath it were Laminaria and Agarum, at up to 50% cover. There was no turf, and the rocks were covered with a mixture of lithothamnion and Dodecaceria. There were no SEA URCHINS.

COMMENTS

Although it supported a good kelp canopy, this appeared to be an unsuitable habitat.

STATION 21. Vertical Point, eastern tip (LIMESTONE)

52 54 07 N; 131 37 07 W

The MEAN DENSITY was $2.69/m^2$ (variance 7.03). We collected all visible abalone from the quadrats, and their sizes are shown in Fig. 13. There were 19% legal size, so the LEGAL DENSITY was $0.51/m^2$.

The SUBSTRATE was solid rough bedrock, nearly sheer in the intertidal zone, then sloping at roughly 20° and overlain with round boulders in the subtidal zone. There was a CANOPY of dense Nereocystis from near datum to 2-3 m, and beneath it Laminaria formed an 80% cover. There was no turf, and the rocks themselves were covered with pink

lithothamnion. SEA URCHINS began at the lower edge of the kelp at $2/m^2$. Quadrats were made both in the kelp forest and in the upper sea urchin zone. Abalone density was higher in the kelp ($3.75/m^2$) than in the barren sea urchin zone ($0.81/m^2$).

COMMENTS

For fishing history see Station 19. This site had a high commercial density of abalone. The site showed a pattern that was repeated at several later sites: round boulders with a dense Nereocystis forest and a dense kelp understory, abundant abalone whose shells appeared to be fast-growing; and a population with a high proportion of juveniles and sub-legal sizes. This habitat was not continuous along the shore in this area, but rather was restricted to small coves such as this one.

STATION 22. Vertical Point, south side (LIMESTONE)

52 54 02 N; 131 37 32 W

The MEAN DENSITY was $0.69/m^2$ (variance 1.83). There were no legal sized abalone, and half the population was less than 50 mm.

The SUBSTRATE was a very irregular bottom formed by bedrock and deep crevices, with car-sized boulders on it. There was a CANOPY of Nereocystis from near datum to approximately 3 m, with an understory of mostly Laminaria forming 75% cover. There was no turf, and the rock was covered with lithothamnion. SEA URCHINS began at 3 m, at a density of $2/m^2$, and here the Laminaria stopped but the Nereocystis continued for a short distance. The dominant grazers in the kelp were Cryptochiton and the keyhole limpet Diadora aspera.

COMMENTS

We saw no legal sized abalone at all. Considering the nature of the substrate at this site, it would have been impossible for harvesters to take all the legal abalone, so we conclude that this was never a commercial site.

STATION 23. Northeast from Nelson Point (LIMESTONE)

52 53 08 N; 131 40 04 W

The MEAN DENSITY was $3.25/m^2$ (variance 7.80). Half these were legal; so the LEGAL DENSITY was $1.67/m^2$. We saw no juveniles.

The SUBSTRATE was round boulders sloping at about 15°. There was a dense CANOPY of Nereocystis, 50% cover at the surface; with a complete cover beneath it of Cymathere. There was no turf, and the rocks were covered with pink lithothamnion and a bit of Hildenbrandia. The kelp bed was about 10 m wide. Cymathere ended at 3 m, where SEA URCHINS began, while Nereocystis continued for a short distance. The rocks in shallow water were very round, smooth, and clean, probably showing the effects of grinding in surge.

COMMENTS

For fishing history, see Station 19. This site had an excellent commercial density of abalone. We observed casually that the abalone seemed to be most abundant at the lower edge of the Cymathere.

STATION 24. South side of Rockfish Harbour (SELWYN INLET)

52 52 57 N; 131 47 18 W

There were no abalone at this site.

The SUBSTRATE was loose rock and gravel and sand sloping at 30-45°. The ALGAL COVER was Fucus in the intertidal zone, then beginning at 1-2 m there was a very dense mat of Macrocystis that did not float freely toward the surface, but instead lay on the bottom in a nearly impenetrable tangle. We called this "bottom-form" Macrocystis, and encountered it at several other sites in very sheltered locations. There was no turf, and the rocks were covered with pink lithothamnion. There were no SEA URCHINS.

COMMENTS

This site was very sheltered, as indicated by its protected location, the dense Fucus on the shore, and the "dustiness" of the plants lying on the bottom. It was obviously unsuitable abalone habitat.

STATION 25. South shore Rockfish Harbour (SELWYN INLET)

52 52 58 N; 131 47 48 W

This site was identical with Station 24.

STATION 26. North shore Rockfish Harbour (SELWYN INLET)

52 53 07 N; 131 47 58 W

The MEAN DENSITY was 0.75/$m^2$ (variance 1.53); an estimated 70% of these were legal size, for a LEGAL DENSITY of 0.53/$m^2$. The maximum size was about 140 mm. There were no juveniles present.

The SUBSTRATE was small head-sized rocks on a gentle slope. There was a very dense Macrocystis CANOPY, forming 50-75% cover at the surface, with Agarum and Laminaria beneath it at 25% cover. There was no turf, and the rocks were completely covered with lithothamnion and Hildenbrandia. The bed was 10-20 m wide, and ended at approximately 3 m, where SEA URCHINS began at 5/$m^2$. All the quadrats were made under the Macrocystis canopy. The only grazer noted in the kelp was Astraea, present in low abundance but as large (100 mm) individuals.

COMMENTS

Rockfish Harbour was lightly fished in 1977, then was closed to the 1978 fishery because of its recreational value to the Sewell Inlet community. This site showed a commercial density of abalone in a typical Macrocystis forest. A recreational limit of 24 abalone could easily be collected by a sports diver.

STATION 27. North shore of Rockfish Harbour (SELWYN INLET)

52 53 08 N; 131 47 36 W

The MEAN DENSITY was 0.50/$m^2$ (variance 0.53); LEGAL DENSITY was estimated to be 0.35/$m^2$. In all other aspects the site was identical with Station 26.

STATION 28. North shore of Rockfish Harbour (SELWYN INLET)

52 53 06 N; 131 47 09 W

The MEAN DENSITY was 1.56/$m^2$ (variance 1.46). Only 8% were of legal size, for a LEGAL DENSITY of 0.12/$m^2$. Sizes of abalone collected from the quadrats are shown in Fig. 14. There were no juveniles under rocks.

The SUBSTRATE was round rocks and boulders sloping gradually. Quadrats were made from near datum out to 4 m. There was no CANOPY, no understory, and no turf; and the rocks were covered with white lithothamnion (80%) and Dodecaceria (20%). SEA URCHINS began near datum, and were present at about 2/$m^2$.

COMMENTS

This area showed small reported landings in 1977, and then was closed in 1978. This site was further toward the mouth of the harbour, and so was more exposed than the two previous sites. (Winds were southeast 30 during this survey, and we could feel a large difference in surge between this site and Station 27.) The site was typical of barren grounds dominated by sea urchins, and had only a small quantity of legal abalone.

STATION 29. Rock just south of Skedans Point (CUMSHEWA INLET)

52 57 27 N; 131 36 32 W

The MEAN DENSITY was 1.25/$m^2$ (variance 2.33). Sizes of abalone collected are shown in Fig. 15. Only 10% were legal size, so LEGAL DENSITY was 0.13/$m^2$. Juveniles were visible, and there were none under rocks.

The SUBSTRATE was boulders and head-sized rocks on a bedrock floor, sloping gently from the foot of the rock. The CANOPY was a very dense forest of Nereocystis, forming 75% cover at the surface, with only a 10% cover of Dictyota beneath it, no turf, and a dense covering of pink lithothamnion on the rocks. SEA URCHINS were sparse above 2 m depth, but were 5/$m^2$ within the Nereocystis below that depth. The kelp continued as far as we surveyed, between 1 and 3 m.

COMMENTS

The Skedans Point area had reported landings of 15,000 lb in 1977. In 1978 this site was open to fishing, but none was reported. This site did not have a commercial density of abalone. This exact site may have been fished, or alternatively it may be so exposed that legal size abalone are rare, as Fig. 15 suggests.

STATION 30. Bay inside northwest corner of Vertical Point (LIMESTONE)

52 54 10 N; 131 38 57 W

The MEAN DENSITY was 1.06/$m^2$ (variance 2.06). We estimated that no more than 10% were legal, for a LEGAL DENSITY of 0.05/$m^2$. Juveniles were present in low abundance under rocks. The maximum size of the legals was 130 mm.

The SUBSTRATE was head-sized rocks and boulders sloping at 20° down to a sand-shell floor at approximately 3 m. There was no CANOPY, but a complete cover of Laminaria saccharina grew from near datum to

approximately 2 m. There was no turf, and the rocks were covered with lithothamnion and Dodecaceria. SEA URCHINS began at 2 m, at the edge of the Laminaria, and varied in density from 2-10/$m^2$. Quadrats were made throughout the area from datum to 3 m. The dominant grazer after sea urchins was Tonicella.

COMMENTS

This site lies within the area described in Station 19. It did not have a commercial density of abalone.

STATION 31. Bay just west of Vertical Point (LIMESTONE)

52 54 06 N; 131 38 55 W

The MEAN DENSITY was 0.63/$m^2$ (variance 0.38); half were legal size and LEGAL DENSITY was 0.31/$m^2$. A few juveniles were present in the open.

The SUBSTRATE was rough bedrock with boulders and patches of gravel, sloping at 20-30°. There was no CANOPY, only a sparse and scattered understory of Phyllospadix, a sparse turf of erect corallines, and a cover of 50% white lithothamnion and 50% Dodecaceria. SEA URCHINS at about 5/$m^2$ dominated the whole site, with Tonicella being the next most abundant grazer.

COMMENTS

For fishing history of the area, see Station 19. This site came close to having a commercial density of abalone. It was within a protected tiny bay.

STATION 32. Breaker Bay (LIMESTONE)

52 52 50 N; 131 41 00 W

The MEAN DENSITY was 3.88/$m^2$ (variance 8.25). We estimated the modal size of abalone at this site to be about 60 mm and only 10% of the population to be legal. The LEGAL DENSITY was 0.39/$m^2$. Some juveniles near 10 mm were present in the open but were not abundant.

The SUBSTRATE comprised large boulders sloping at about 35° from the intertidal down to 3 m. A CANOPY of Nereocystis produced 30% cover in a narrow band along the shore. Beneath this, Laminaria, Cymathere, Costaria and Pleurophycus formed a thick understory (50% cover). The encrusting algae lithothamnion and Hildenbrandia covered 75% of the rock

surface beneath the kelps. At about 2 m the kelps ended and SEA URCHINS began at 5/$m^2$. Patches of S. droebachiensis were also present in the sea urchin zone.

COMMENTS

For fishing history see Station 19. We found a low commercial density of abalone here.

STATION 33. Vertical Point (LIMESTONE)

52 53 38 N; 131 39 12 W

The MEAN DENSITY was 3.63/$m^2$ (variance 10.38). We estimated 15% of the abalone to be of legal size; the LEGAL DENSITY was 0.54/$m^2$. Juveniles were abundant at this site; 75% of the population were 50 mm and less. The SUBSTRATE was solid bedrock sloping at 35° to 9 m.

A light CANOPY of Nereocystis was present in patches producing up to 30% cover in a 5 m wide band on the surface. Costaria and Desmarestia formed a light (5% cover) understory beneath the canopy, tufts of Calliarthron and Bossiella occurred on about 10% of the rock surface and lithothamnion covered 100% of the rock surface. The kelp cover stopped at about 2 m. SEA URCHINS began at this depth at a density of 3/$m^2$. Serpula and Dodecaceria (30% cover) were noted in both the kelp and sea urchins zones.

COMMENTS

For fishing history of this site see Station 19.

We found a commercial density at this site; however, distribution was highly patchy.

STATION 34. Breaker Bay (LIMESTONE)

52 52 20 N; 131 41 30 W

The MEAN DENSITY was 1.13/$m^2$ (variance 1.98). Distribution was quite patchy. Of the abalone collected from quadrats, 35% were of legal size (Fig. 16); the LEGAL DENSITY was 0.40/$m^2$. No juveniles were found here.

The SUBSTRATE was solid white boulders, pebbles, and sand/shell in the lower areas. Slope varied from 45° near datum to 5° at 3 m. A CANOPY of 25% Macrocystis and 75% Nereocystis produced about 20% cover in

a narrow band along the shore. Laminaria, Codium, Egregia, andZostera occurred beneath the canopy producing up to 40% cover. Corallina and Calliarthron occurred in tufts on the rock surface beneath the kelps and lithothamnion covered up to 80% of the exposed rock surface. The kelps stopped at depths between 2.0 and 2.5 m where SEA URCHINS began at a density of $4/m^2$. S. droebachiensis, Pycnopodia, Cryptochiton, Tealia, Cancer productus, and Pagurus occurred throughout this site.

COMMENTS

For fishing history, see Station 19. A commercial density was found at this site.

STATION 35. Powrivco Bay (ATLI INLET)

52 41 40 N; 131 33 55 W

The MEAN DENSITY was $1.94/m^2$ (distribution was patchy: variance 7.13). About 90% of the abalone seen were of legal size; no juveniles were noted. The LEGAL DENSITY was $1.75/m^2$.

The SUBSTRATE was large boulders down to 2.5 m where mud began. A CANOPY of Macrocystis formed a bed about 10 m wide with up to 20% cover on the surface. Agarum and Laminaria occurred beneath the canopy at about 10% cover. Agarum continued down below the canopy cover onto the mud substrate at 2.5-3.0 m where patches of Zostera were noted. On the rock surfaces beneath the kelps was a 50% cover of the erect corallines Calliarthron, Bossiella and Corallina. Hildenbrandia (75%) and lithothamnion (25%) encrusted the exposed rock surfaces. The canopy stopped at 3 m. SEA URCHINS began at this depth and continued down to the mud substrate; their density was about $1/m^2$. Astraea, Serpula, and Parastichopus were noted throughout this area.

COMMENTS

The fishing intensity here was light. In 1978, less than 800 lb were reported harvested from a small area around our sampling site. (According to local residents our station was in the area that had been harvested in 1978.) In 1977, no harvesting was reported here. We found a high commercial density beneath the thick kelp canopy.

STATION 36. Powrivco Point (ATLI INLET)

52 42 24 N; 131 35 30 W

Although no abalone were found in eight quadrats, some were present here. Of the few seen, all were of legal size.

The SUBSTRATE was large boulders on a 40° slope. A CANOPY of Macrocystis in a 5 m wide band produced up to 40% cover. Beneath this, bottom-form Macrocystis formed a 60% cover, occurring down to 3 m where large Agarum plants continued down the slope to 10 m at 60% cover. Some tufts of Corallina and Calliarthron were found beneath the kelps; lithothamnion (50%) and Hildenbrandia (50%) covered all the exposed rock surface. Parastichopus and several species of tunicates were noted; however, no SEA URCHINS were seen.

COMMENTS

Fishing intensity here was light. Only 3,000 lb were reported from the whole of Atli Inlet in 1977; at least 1,200 lb were reported from the same area in 1978. Because of the low abalone density and the very high density of kelp, it is possible that this site was not fished during the past two seasons.

## STATION 37. Beljay Point (ATLI INLET)

52 42 28 N; 131 37 50 W

Abalone were present but DENSITY was too low to measure. Of the few abalone seen, 90% were of legal size.

The SUBSTRATE was solid smooth bedrock with boulders occurring near datum and cobbles and pebbles beginning at 5 m. The slope was 50°; decreasing slightly with depth. A CANOPY of Macrocystis formed a narrow band producing 20% cover on the surface. Bottom-form Macrocystis occurred beneath this at 30% cover to 3 m, giving way to large Agarum plants which formed 80% cover. Desmarestia, Dictyota, Leathesia, and Corallina occurred beneath both the Macrocystis and Agarum. Lithothamnion covered 50% of the rock surface in this area.

COMMENTS

Fishing intensity was light (see Station 36). It is not likely that intense harvesting has occurred at this exact site, in view of the low abalone density and the very high density of kelp here.

## STATION 38. Tsinga Point (ATLI INLET)

52 43 37 N; 131 35 05 W

The MEAN DENSITY was $1.44/m^2$ (variance 1.73). Only 5% of the abalone collected from quadrats (Fig. 17) were of legal size; and LEGAL DENSITY was $0.07/m^2$. Some juveniles were found, mainly on the exposed

surface of rocks. Transects were placed both in the kelp zone and below it, between datum and 3 m.

The SUBSTRATE was solid smooth bedrock with boulders and large cobbles strewn along it. The slope was about 20° from datum to 1 m, where it became almost level. A light (5%) CANOPY of Nereocystis occurred over a dense understory of Costaria, Laminaria, Alaria, and Pterygophora which produced up to 60% cover. Tufts of Codium fragile and erect corallines occurred in patches near datum and lithothamnion occurred everywhere on the exposed rock surfaces. SEA URCHINS were present but not abundant; density was less than $1/m^2$ at depths between 2 and 3 m. Other grazers present were S. drochachiensis and Astraea. Dodecaceria was noted here but was not abundant.

COMMENTS

For fishing history of the area see Station 36. No commercial fishing was reported at this site either 1977 or 1978. We did not find a commercial density of abalone here.

STATION 39. Northeast corner of Lyell Island (ATLI INLET)

52 44 48 N; 131 28 38 W

The MEAN DENSITY was $0.56/m^2$ (variance 0.66). We estimated that half were of legal size, and LEGAL DENSITY was $0.42/m^2$. The largest abalone was about 130 mm. We saw no juveniles here.

The SUBSTRATE was flat head-sized rocks on sand, on a very gentle slope from 2 to 5 m. There was a thick CANOPY of Nereocystis, forming a 50% cover at the surface, with a mixture of Laminaria and Cymathere covering half the rock surface beneath it; a 25% turf of erect corallines and Odonthalia; and 80% cover of pink lithothamnion. Pterygophora grew above 3 m. There were no red SEA URCHINS, but S. droebachiensis was present at densities of $10-20/m^2$ above 3 m. The other grazers noted were Tonicella and Cryptochiton.

COMMENTS

From the 1978 and 1977 log sheets, no fishing was reported from this specific area (see Station 36). The site had a commercial density of abalone.

STATION 40. South side of KUNGA ISLAND

52 45 20 N; 131 34 56 W

The MEAN DENSITY was 1.44/$m^2$ (variance 1.73). Legals were 25-50% of the whole population (this was hard to judge because so many were just under legal size), and we estimate LEGAL DENSITY to be 0.36/$m^2$. There were no juveniles under rocks, but a few were seen in the open.

The SUBSTRATE was uneven bedrock sloping at about 20°, with chest-sized boulders appearing at 2 m. There was a thin band of Nereocystis forming a surface CANOPY with 50% cover; beneath it were Pterygophora, Dictyota and Costaria at about 25% cover; an erect coralline turf at 10%; and white lithothamnion on the rocks. SEA URCHINS began at 3 m, at a density of 2-5/$m^2$, and the kelps ended. Tegula pulligo was an abundant grazer on the Pterygophora plants. All the quadrats were made in the kelp band.

COMMENTS

Reported landings from all of Kunga Island were 16,000 lb in 1977 and 12,000 lb in 1978. This site had a legal density that was just below what we considered to be commercial.

STATION 41. Northwest corner of KUNGA ISLAND

52 46 16 N; 131 34 50 W

The MEAN DENSITY was 2.19/$m^2$. Because there were 14 in one quadrat and only 4 in the next highest count, the variance was 11.50. Sizes of the abalone collected from quadrats are shown in Fig. 18. Legal sizes were 56% of the population, and LEGAL DENSITY was 1.23/$m^2$. No juveniles were seen under rocks.

The SUBSTRATE was chest to hand sized rocks, sloping at about 20°. There was a very sparse Nereocystis CANOPY; but a complete cover of Laminaria; no turf, and pink lithothamnion on the rocks. SEA URCHINS were found below 1 m, where the kelp ended, at 2-5/$m^2$. All quadrats were made in the kelp. The intertidal zone was a cobble beach in the upper part, with Phyllospadix and Egregia in the lower part. Astraea was abundant in the kelp.

COMMENTS

For fishing history see Station 40. This site had a good commercial density of abalone. The high variance may have resulted from patchy fishing.

STATION 42. Lyell Island (ATLI INLET)

52 43 52 N; 131 32 22 W

The MEAN DENSITY was 2.63/$m^2$; distribution was quite patchy (variance 8.92). None of the abalone collected from quadrats were of legal size; however, large numbers of juveniles were present (Fig. 19). All of these were visible on the exposed rock surfaces at depth between 1 and 2 m.

The SUBSTRATE was solid undulating bedrock with large boulders in the level spots. Slope was about 15° between the depths of 1 and 2 m. There was no CANOPY. Only a light (10%) cover of Phyllospadix, Egregia, Codium fragile, and Corallina occurred near datum. White lithothamnion and Hildenbrandia covered the rock surfaces near datum and below. SEA URCHINS were present at a density of 8-12/$m^2$ beginning at 1 m and occurring down the rock slope to 4 m. Other grazers present were Astraea and Tonicella lineata.

COMMENTS

For fishing history of the area see Station 36. This site was within the specific area reported fished in 1977. We found no legal abalone and it appears from Fig. 19 that this site does not produce legal abalone.

STATION 43. Porter Head

52 48 10 N; 131 39 06 W

The MEAN DENSITY was 0.69/$m^2$ (variance 0.63). All abalone found were less than 50 mm.

The SUBSTRATE was rough bedrock with huge boulders, sloping at 30° but very irregular. There was a thin band of Nereocystis in the CANOPY, forming 50% cover at the surface; and a complete cover of Pterygophora and Pleurophycus on the bottom; there was no algal turf, but a very rick assemblage of encrusting bryozoans, ascidians and anemones, with 25% pink lithothamnion. SEA URCHINS appeared below 4 m, where there was no kelp. Small S. droebachiensis were present at 10-20/$m^2$ within the kelp. All the quadrats were made under the algal canopy.

COMMENTS

This site was not reported to have been harvested in either 1977 or 1978. The bryozoan fauna, the presence of Pleurophycus, and the location of the site all indicate an exposed habitat, unsuitable for producing legal abalone.

STATION 44. Near Dodge Point (ATLI INLET)

52 44 02 N; 131 30 30 W

The MEAN DENSITY was 1.63/$m^2$; distribution was fairly even (variance 1.32). Quadrat counts were made between datum and 2 m, beneath the kelp cover. We estimated 75% of the abalone to be legal sized. Juveniles were present but not abundant; all were visible on the exposed surface of rocks. The LEGAL DENSITY was 1.22/$m^2$.

The SUBSTRATE was broken bedrock with boulders, changing to cobbles at 3 m near the bottom of the 15° slope. A sparse (1%) CANOPY of Nereocystis and Macrocystis formed a 15 m wide band along the shore. Pterygophora and Alaria occurred beneath this with erect corallines beneath them, together producing a 10% cover. White lithothamnion, Hildenbrandia and Ralfsia encrusted the exposed rock surfaces beneath the kelps and below. At 3 m, SEA URCHINS began at a density of 2/$m^2$. S. droebachiensis occurred in patches of 10/$m^2$ in the kelp zone and below. We also noted Tegula on Pterygophora, Pagurus sp., Pycnopodia, Tealia sp., and Tonicella lineata.

COMMENTS

For fishing history of the area see Station 36. This specific area was not reported fished either in 1977 or 1978, and had excellent commercial densities as well as moderate numbers of juveniles. We noted heavy silting at this site; an apparent result of recent logging operations on the mountain slopes directly above. Kelp, abalone, and other invertebrates were covered with a layer of fine silt.

STATION 45. Flower Pot Island

52 47 00 N; 131 38 55 W

The MEAN DENSITY was 4.63/$m^2$ (variance 20.78). Only 5% were judged to be legal size; the population mode was near 80 mm and there were numerous individuals less than 50 mm. LEGAL DENSITY was 0.23/$m^2$.

The SUBSTRATE was bedrock pavement in the intertidal and upper subtidal zones, becoming irregular with depth. Slope was variable, averaging 30°. ALGAE were widely scattered Nereocystis plants and a very dense turf of erect corallines and polysiphonous red algae to 1 m; then the rock was barren and SEA URCHINS began at 5-10/$m^2$. Abalone were equally abundant in both zones, and quadrats were made in both areas.

COMMENTS

There are no reports of fishing from this exact site, but the general area has landings of about 10,000 lb in 1977 and 1978 with no

locations given. This station did not have a commercial density of abalone. As we found abalone to 119 mm, the site is capable of producing legal abalone, but we noted that even the small abalone appeared old. The presence of polysiphonous red algae may reflect a reduction in grazing pressure caused by abalone harvesting.

STATION 46. Dodge Point (ATLI INLET)

52 44 10 N; 131 29 00 W

The MEAN DENSITY was 1.81/$m^2$; distribution was patchy (variance 3.90). We estimated 40% of the abalone to be of legal size; the LEGAL DENSITY was 0.72/$m^2$. Juveniles were present on the exposed surfaces of rocks; none was found under any of the rocks we overturned.

The SUBSTRATE was formed by large boulders, then smaller boulders and cobbles in increasing depth along a 20° slope. A light CANOPY of Nereocystis formed a narrow band extending from near datum to 1.5 m. A dense (80%) cover of Cymathere, Alaria, and Costaria occurred beneath the canopy; erect corallines, Dictyota and Desmarestia spp. covered about 10% of the area beneath the kelps. Lithothamnion encrusted the entire substrate both beneath the kelps and below. SEA URCHINS were present at 2/$m^2$. Dense patches of S. droebachiensis occurred along the kelp-sea urchin interface at 1.5-2 m. We also noted Solaster stimpsoni and Tonicella lineata at this site.

COMMENTS

For fishing history of the area see Station 36. No commercial fishing was recorded at this specific site in either 1977 or 1978. We found commercial densities at this site.

STATION 47. West side of KUNGA ISLAND

52 45 46 N; 131 35 18 W

The MEAN DENSITY was 0.69/$m^2$ (variance 1.56). Most of the abalone seen were around 90 mm; none was legal size.

The SUBSTRATE was smooth pavement bedrock sloping at about 10°. The ALGAE were a thin band of Macrocystis varying in width up to 8 m, forming 75% cover at the surface; a 75% cover of Laminaria beneath it, a dense turf of erect corallines at 80% cover; and pink lithothamnion. Egregia marked the intertidal zone. SEA URCHINS began less than 1 m below datum, and marked the end of the algal forest. Their density was very high, at 15-25/$m^2$. Abalone were present in both the kelp and sea urchin zones, and quadrats were made in both.

COMMENTS

For fishing history see Station 40. The very low density of abalone and complete absence of legal sizes suggest that this was never a commercial site.

STATION 48. Northeast side of KUNGA ISLAND

52 45 54 N; 131 33 07 W

The MEAN DENSITY was 4.63/$m^2$; distribution was highly patchy (variance 15.58). Only 20% of the abalone were legal; the LEGAL DENSITY was 0.93/$m^2$. Quadrat counts were made between the depths of 0.2 and 2.0 m, beneath the kelp cover where abalone were most abundant. Juveniles were present either exposed on the rock surface or in deep crevices.

The SUBSTRATE was broken and solid bedrock with a slope varying between 20° and 30°. A dense (40%) CANOPY of Macrocystis covered most of this area. Hedophyllum, Pleurophycus, Egregia, Alaria, Phyllospadix, and Pterygophora produced a 60% cover beneath the canopy. Erect corallines, Leathesia and polysiphonious reds covered up to 50% of the area beneath the kelps. All the rocks were encrusted with lithothamnion. SEA URCHINS began at 2 m at a density of 10/$m^2$.

COMMENTS

For fishing history see Station 40. We found a good commercial density at this site.

STATION 49. Northeast corner of KUNGA ISLAND

52 46 17 N; 131 32 55 W

The MEAN DENSITY was 0.25/$m^2$ (variance 0.20, based on 12 quadrats only). All three of the abalone seen were 70-80 mm long.

The SUBSTRATE was rough bedrock with irregular formations, sloping at up to 45° to a sand-shell floor at 4 m. This supported a CANOPY of Nereocystis, forming 50% cover at the surface; a 50% cover of Cymathere and L. setchellii in the understory; only sparse erect corallines, and pink lithothamnion mixed with bryozoans and small anemones. There were no SEA URCHINS.

COMMENTS

For fishing history see Station 40. This station was obviously unsuitable habitat for legal abalone, being too exposed. Low spots in the bedrock had been ground very smooth by gravel.

STATION 50. Tanu Island, inside Tanu rock

52 45 52 N; 131 36 38 W

The MEAN DENSITY was 1.53/$m^2$ (variance 2.71, based on 32 quadrats). The abalone were collected from the quadrats, and their sizes are shown in Fig. 20. The legal sizes were 24% of the population, and LEGAL DENSITY was 0.37/$m^2$.

The SUBSTRATE varied here from irregular pavement bedrock to head-sized rocks on flat cobble, and the slopes were equally variable. Patches of sand were also present, and these supported very dense populations of Patiria. The ALGAE were Macrocystis, in very dense forests with 50% cover of Laminaria beneath, a dense turf of erect corallines and bright pink lithothamnion. This community was typical of the small rock and cobble areas with gentle slope. The solid bedrock supported only erect corallines, with dense SEA URCHINS below the bottom of the turf. Abalone were very variable in distribution, and quadrats were made throughout the areas with rock substrates.

COMMENTS

The log sheets show 4,000 lb taken from the east end of Tanu Island in 1977 and 1978. The uneven distribution of abalone within the Macrocystis community suggests that fishing probably occurred at this exact site. The site had a marginal commercial density of abalone remaining, and shows a good healthy sub-legal population.

STATION 51. Tar Islands (JUAN PEREZ SOUND)

52 40 05 N; 131 25 00 W

The MEAN DENSITY was 3.38/$m^2$; distribution was highly patchy (variance 49.58). Of the abalone collected, only 3% were legal (Fig. 21). Juveniles were 13% of the population. They were found on the exposed surface of rocks and in crevices, mainly at the bottom edge of the kelp zone. The LEGAL DENSITY was 0.10/$m^2$. Quadrat counts were made at depths between 1.8 m above datum and 1.8 m, both in the kelp zone and below.

The SUBSTRATE was undulating broken bedrock with shallow crevices; the slope was 20°. A light (2%) CANOPY of Nereocystis formed a narrow band along the shore. Laminaria, Cymathere, and Phyllospadix

formed a dense (75%) understory beneath. Up to 80% of the rock surface under the kelps was covered with erect corallines and polysiphonous reds. At 2 m the kelps stopped; lithothamnion continued below, covering 100% of the exposed substrate. Below the kelp zone, SEA URCHINS were at a density of 5-10/$m^2$. Green sea urchins S. droebachiensis occurred in patches along the kelp-sea urchin interface. We also noted Tealia, Tegula, Cucumaria miniata, Balanophyllia, Cryptochiton, and Pycnopodia in the sea urchin zone.

COMMENTS

This site is within the Juan Perez Sound closure, which was made in 1973. It is at the exact location of site 8 of Adkins and Stefanson 1977. We noted no major changes in either the abalone population or the community structure here during the present survey. There was not a commercial density of abalone.

STATION 52. Southeast side of RAMSAY ISLAND

52 33 00 N; 131 20 49 W

The MEAN DENSITY was 1.81/$m^2$ (variance 4.56). All the abalone seen appeared to be in the first three age groups. Eight only were collected: their lengths were 5-7 mm, 13-14 mm, and around 30 mm, respectively. These lengths may correspond to the current year-class (settled in June), and the 1977 and 1976 year-classes respectively.

The SUBSTRATE was solid bedrock, flat or gently undulating, in 5 m. Relief was provided by small fissures, a very few small boulders, and holes made by rock-boring clams. The ALGAE were Nereocystis forming a 50% cover at the surface; Pterygophora to 75% cover on the bottom; and scattered Dictyota to 25% cover beneath that. On the rock there were two types of cover: a dense turf of erect corallines and foliose red algae, alternating with barren patches maintained by SEA URCHINS at up to 5/$m^2$. Pink lithothamnion covered the rocks. Sea urchins were found right among the Pterygophora plants and Nereocystis stipes.

The other grazers noted were large and abundant (1-2/$m^2$) Astraea, Acmaea at 10/$m^2$, Tonicella present but not abundant, Amphissa and Calliostoma. Several cabezon (Scorpaenicthys marmoratus) were seen on this station.

COMMENTS

This part of Ramsay Island has not produced any reported landings in the past 2 yr. It is clearly too exposed for legal abalone, but is very interesting because of the relatively high numbers of young. It may be that the cabezon is an important predator that limits the numbers of larger abalone at this kind of site.

STATION 53. Tar Islands (JUAN PEREZ SOUND)

52 39 50 N; 131 24 54 W

The MEAN DENSITY was 2.63/$m^2$; distribution was highly patchy (variance 17.18). Only 5% of the abalone were found to be legal sized; the LEGAL DENSITY was 0.13/$m^2$. Juveniles were abundant at this site occurring in cracks and crevices, mainly at depths around 6 m, at the bottom edge of the kelp zone.

The SUBSTRATE was solid smooth bedrock with some small crevices. The slope varied from 45° near datum to almost 0° at 6 m. At this depth the substrate changed to large cobbles and boulders. A thick (40%) CANOPY of Nereocystis occurred mainly over the cobbles and boulder substrate at 6 m. Desmarestia, Costaria, Laminaria, and Lessoniopsis produced a 10% cover on the solid substrate at depths between datum and 6 m; erect corallines covered 60% of the rock surface down to the lower edge of the kelp zone. Lithothamnion and Hildenbrandia encrusted the exposed substrate to below 6 m. SEA URCHINS occurred at a density of 5/$m^2$; beginning at 3 m, within the kelp zone. Dense patches (20/$m^2$) of S. droebachiensis were also present at this depth.

COMMENTS

This site lies within the Juan Perez Sound closure; commercial densities were not observed here.

STATION 54. West side of Ramsay Island

52 34 09 N; 131 20 42 W

The MEAN DENSITY was 2.38/$m^2$ (variance 7.18). All were less than legal size, and we noted some juveniles in the sea urchin zone.

The SUBSTRATE was solid bedrock sloping irregularly at about 45°. ALGAE were Lessoniopsis in the intertidal zone; a mixture of Nereocystis, Pterygophora and L. setchellii to 3 m, with a dense turf of erect corallines beneath it; and pink lithothamnion on the rocks. SEA URCHINS began at 3 m and continued deeper, and the kelp stopped at the same depth. In the sea urchin zone the only alga was white lithothamnion. Sea urchin density was 5-10/$m^2$. No invertebrate at this site was abundant enough to note.

COMMENTS

This site was too exposed for legal abalone, and no landings have been reported. Lessoniopsis is a good indicator of heavy surge conditions. The Pterygophora/coralline community was one seen frequently later, and also is associated with exposure to wave action.

STATION 55. Southeast Lyell Island (JUAN PEREZ SOUND)

52 38 25 N; 131 27 20 W

The MEAN DENSITY was 5.88/$m^2$ (variance 19.32). Distribution was patchy; abalone were found mainly in large crevices at depths between 1.3 m above datum and 2.0 m. About 60% of the abalone were of legal size; the LEGAL DENSITY was 3.53/$m^2$. Juveniles were present, but mainly confined to crevices in the rock.

The SUBSTRATE was solid bedrock with large boulders and wide shallow crevices. The bedrock sloped down gradually at 5°. A 10% CANOPY of Nereocystis occurring at depths between 0.5 and 2.0 m formed a band up to 20 m wide on the surface. The kelps Pterygophora, Alaria, Phyllospadix, Laminaria, Egregia, Lessoniopsis, Costaria, and Hedophyllum produced up to 40% cover from 1.0 m above datum to the bottom edge of the Nereocystis zone. Erect corallines occurred beneath the kelps and lithothamnion encrusted 100% of the exposed rock surface. SEA URCHINS began at 2.0 m at a density of 10/$m^2$. S. droebachiensis occurred at densities of 5/$m^2$ along the kelp sea urchin zone interface. We noted Cucumaria miniata and Pycnopodia in the sea urchin zone.

COMMENTS

This site lies within the Juan Perez Sound closure. We found very high commercial densities here; mainly in the Pterygophora forest. The kelp bed at this site extends for a considerable distance along the southeast shore of Lyell Island. It may contain commercial densities throughout, similar to those seen here. Legal density at this spot was the highest seen during this survey.

STATION 56. Northeast corner of Ramsay Island, inside Kloo Islet

52 35 18 N; 131 22 10 W

The MEAN DENSITY was 8.9/$m^2$, but this was based on only six quadrat counts and part of a seventh. The transect operation was interrupted by the discovery of more than 30 very small abalone in the seventh quadrat. Collecting from this quadrat used up the divers' remaining air. Sizes are shown in Fig. 22; there were no legals. The lengths are consistent with those seen at Station 52: the first group is between 5-10 mm, the second group is represented only by one individual of 14 mm, and the third group is near 25-30 mm.

The SUBSTRATE was irregular bedrock with little slope in 2 m. Chest-sized and smaller boulders lay on the bedrock. The ALGAE were Nereocystis forming 50% cover at the surface; a 25% cover of D. ligulata; a few erect corallines under that and pink lithothamnion on the rock. Cabezon were present. SEA URCHINS were up to 5/$m^2$ even among the Nereocystis.

COMMENTS

This site, like the last two, is probably too exposed for legal abalone. The density of juveniles here was higher than anywhere else surveyed on this trip. It was interesting to find them in such shallow water, as all other concentrations of juveniles were found in water deeper than 10 m.

STATION 57. Southeast Lyell Island (JUAN PEREZ SOUND)

52 37 40 N; 131 27 38 W

The MEAN DENSITY was 7.25/$m^2$ (variance 20.33); only 5% of these were of legal size so the LEGAL DENSITY was 0.36/$m^2$. Juveniles were present at depths down to 2.0 m on the exposed surface of rocks. None were seen under any of the rocks we overturned.

The SUBSTRATE was solid bedrock with shallow, wide crevices and a slope of 5°. A light CANOPY of Nereocystis occurred around the edges of this small bay. Alaria, Egregia, Hedophyllum, Phyllospadix, Costaria, and Laminaria produced an 80% cover beneath the canopy to a depth of 2.5 m. Polysiphonious reds and erect corallines covered up to 75% of the rock surface beneath the kelps and white lithothamnion covered the entire substrate under the canopy and below. SEA URCHINS began at depths between 2.5 m and 3.0 m; density was 10-15/$m^2$.

COMMENTS

This site lies within the Juan Perez Sound closure area. A low commercial density was found here.

STATION 58. North side of HUXLEY ISLAND

52 27 46 N; 131 22 32 W

The MEAN DENSITY was 1.00/$m^2$ (variance 1.33). All abalone found were collected and sizes are shown in Fig. 23; there were no legals. This station showed a mixture of sublegal sizes, including the zero year-class.

The SUBSTRATE was bedrock in the intertidal zone, changing to head and hand-size boulders in the upper subtidal zone. The slope was 20° and steady. This site was completely dominated by SEA URCHINS at 1-3/$m^2$, so there were no macrophytes except for white lithothamnion on the rocks. The dominant grazers after sea urchins were Acmaea mitra and Tonicella.

COMMENTS

The entire shore of Huxley Island yielded 16,000 lb of abalone in 1977 and up to 7,000 lb in 1978. However, this site did not appear to be a habitat that produces legal abalone.

## STATION 59. Agglomerate Island (JUAN PEREZ SOUND)

52 37 45 N; 131 25 12 W

The MEAN DENSITY was 8.13/$m^2$; but distribution was patchy (variance 33.45). We estimated up to 15% of the abalone to be legal sized; the LEGAL DENSITY was 1.22/$m^2$. Juveniles were abundant and many near 10 mm were noted. All were on the exposed surface of the substrate.

The SUBSTRATE was smooth bedrock with a 40° slope. At 4 m, the substrate changed to cobbles and boulders and the slope to 5°. A light (5%) CANOPY of Nereocystis formed a narrow band along the east side of the island, extending from near datum to 1 m. Laminaria, Costaria, Lessoniopsis, and Hedophyllum produced a 15% cover from just above datum to the bottom edge of the Nereocystis canopy. Erect corallines and polysiphonous reds occurred beneath the kelps. Lithothamnion, Hildenbrandia, and Ralfsia encrusted all the exposed rock at this site. SEA URCHINS began at 1 m; density was 15/$m^2$. Green sea urchins were noted in patches along the kelp-sea urchin interface, their density was up to 20/$m^2$. Also noted were Acmaea mitra and Balanophyllia, both in the sea urchin zone.

COMMENTS

This site is in the Juan Perez Sound closure. We found both a good commercial density and moderate numbers of juveniles here. The legal sized abalone were found near datum; the juveniles appeared to be restricted to the sea urchin zone in deeper water.

## STATION 60. Near Newberry Point (WERNER BAY)

52 27 55 N; 131 25 18 W

The MEAN DENSITY was 3.44/$m^2$ (variance 4.66). We estimated 10% of these to be legal, so LEGAL DENSITY was 0.34/$m^2$. Juveniles around 30 mm were common in the area surveyed.

The SUBSTRATE was solid bedrock carved into smooth, flat areas separated by steep-walled canyons. There was no upper CANOPY, but Pterygophora formed a dense sub-surface canopy, with a very dense turf of erect corallines beneath it; and the rock was covered with lithothamnion.

Pterygophora ended at less than 1 m, and SEA URCHINS were found from there into deeper water on rock that supported only white lithothamnion.

COMMENTS

From Werner Bay, 31,000 lb were reported taken in 1977 and 21,000 lb in 1978. From the general area there were also large landings without specific locations: 26,000 lb in 1977. The site was typical of the Pterygophora/corallina community, and had abalone approaching commercial densities.

STATION 61. All Alone Stone (JUAN PEREZ SOUND)

52 29 03 N; 131 23 51 W

The MEAN DENSITY was 7.38/$m^2$ (variance 25.85). The high variance resulted from the pattern of distribution, with the largest number of abalone found in the uppermost quadrat of each series of four. Sizes are shown in Fig. 24. Only 2% were of legal size, for a negligible LEGAL DENSITY.

The SUBSTRATE was solid granite pavement blocks, descending at about 60°. The only ALGAE were Hedophyllum sessile and Gigartina spp. in the mid-intertidal zone, and a dense turf of erect corallines in the intertidal zone near datum, where SEA URCHINS began at 5/$m^2$. The subtidal zone was totally barren except for patches of white lithothamnion. The sea urchins decreased in both size and abundance with depth. Abalone were clearly most abundant in the bottom part of the corallina zone, reaching densities up to 23/$m^2$.

COMMENTS

No fishing has been reported from All Alone Stone, but all parts of the adjoining area have been surveyed and fished. This site did not have a commercial density of abalone.

STATION 62. Ramsay Rocks (JUAN PEREZ SOUND)

52 34 26 N; 131 20 37 W

Abalone were present at this site but density was too low for quadrat counts. Only 10% of the abalone seen were legal sized; these occurred near datum. Juveniles were present but not abundant. We found them on the exposed surfaces of the substrate between datum and 12 m.

The SUBSTRATE was smooth bedrock with a 15-25° slope. Boulders and large cobbles were found in the low spots. No CANOPY was present. The kelps Alaria, Hedophylum, and Costaria produced a 10% cover in a narrow band near datum. Erect corallines covered 20% of the substrate at the bottom edge of the kelp zone and lithothamnion encrusted all of the exposed substrate. SEA URCHINS began at 1 m and extended to below 12 m. We estimated their density at 10-20/$m^2$ near the kelp zone, but less below. The sea anemone Tealia crassicornis and the large medusa Cyanea were being eaten by Tealia at the time of these observations. A medusa fish, Icichthys lochingtoni, was seen on the bell of one of the Cyanea.

COMMENTS

This site lies within the Juan Perez Sound closure. We did not find commercial densities here.

STATION 63. Just southwest of Werner Point (WERNER BAY)

52 29 25 N; 131 28 34 W

The MEAN DENSITY was 0.94/$m^2$ (variance 2.06). All the abalone were collected from quadrats, and the sizes are shown in Fig. 25. Half were legal size, so LEGAL DENSITY approaches 0.50/$m^2$.

The SUBSTRATE was head-size boulders on sand, giving way to sand at just below datum. The CANOPY was a small bed of Macrocystis not more than 5 m wide, forming 80% cover at the surface, with Laminaria beneath it at 50% cover, a rich turf of erect corallines under that, and both Hildenbrandia and pink lithothamnion on the rocks. Astraea were present 1-2/$m^2$ within the Macrocystis forest. There were no SEA URCHINS on the shore where this small kelp bed was found, but further toward Werner Point, sea urchins were found and the kelp bed did not exist. Quadrats were confined to the area beneath the kelp.

COMMENTS

For fishing pressure see Station 60. We were surprised to find Macrocystis in this location, since the site faces Hecate Strait almost directly to the east southeast. Werner Bay has been heavily fished, but this site had a commercial density of abalone. However, the total area containing legal abalone was small.

STATION 64. Ramsay Point (JUAN PEREZ SOUND)

52 33 50 W; 131 26 17 N

The MEAN DENSITY was 3.63/$m^2$; distribution was even (variance 5.18). Of the abalone collected from the quadrats, 15% were legal sized (Fig. 26), and there was a healthy population of sub-legals; the LEGAL DENSITY was 0.54/$m^2$. The quadrat measurements were taken in both the kelp and sea urchin zones, between datum and 2 m. Juveniles were present on the exposed surface of the substrate.

The SUBSTRATE was solid bedrock with shallow, wide crevices. The slope varied between 5° and 10° from datum to 2 m, where the substrate changed to mud and the slope became almost 0°. A CANOPY of Macrocystis and Nereocystis formed 15% cover in a narrow band 5 m wide along the shore, extending from near datum to 2.0 m. Ulvoids, Gigartina spp. and Laminaria produced up to 60% cover under the canopy. Erect corallines were abundant, covering 80% of the surface beneath the kelps and almost all of the exposed substrate was encrusted with lithothamnion, Hildenbrandia and Ralfsia. Zostera sp. occurred in the mud at the bottom of the rock slope. SEA URCHINS occurred between 1.5 m and 2.5 m; density was up to 20/$m^2$. We also noted: S. droebachiensis, Patiria, Tealia, Crassicornis, Pycnopodia, Parastichopus, Ceratastoma, and Serpula sp. in the sea urchin zone and on the mud substrate below.

COMMENTS

This site is on the southern boundary of the Juan Perez Sound closure; it is less than 20 m southwest from the location of site 5 of Adkins 1978. More than 1,900 lb of abalone were removed from the small area from Ramsay Point south, in 1978. In 1977, 6,000 lb of abalone were reported taken from Ramsay Island. There were also large landings from the area, with no maps given.

Only 9 of the 60 abalone we collected here were legal sized. This compares to 21 of the 38 abalone recorded from site 5 of Adkins 1978. This difference is significant ($\times^2$ = 17.84, df = 1, P = 0.05) and may be the result of an overlap of a harvested area with the closure area.

STATION 65. Northwest of Werner Point (JUAN PEREZ SOUND)

52 30 15 N; 131 28 16 W

The MEAN DENSITY was 2.44/$m^2$ (variance 4.66). Sizes are shown in Fig. 27; none were legal. We saw no juveniles even under rocks.

The SUBSTRATE was steep smooth bedrock in the intertidal zone, changing to chest-sized boulders and smaller rocks in the subtidal zone. Slope was about 20°. There were isolated patches of Nereocystis CANOPY,

50% cover at the surface, with Costaria beneath it. The greater part of the area was barren except for white lithothmnion. Red SEA URCHINS were only 1-2/$m^2$, but S. droebachiensis were consistently 50-100/$m^2$, all less than 25 mm in test diameter.

COMMENTS

This site lies within the Juan Perez Sound closure. From the type of community and the low modal size of abalone, this site appeared to be unsuitable habitat for legal abalone. "Outbreaks" of green sea urchins have been observed to change temporarily the community structure of shallow Georgia Strait, and perhaps this site shows a similar localized abundance of these animals.

STATION 66. Ramsay Island (JUAN PEREZ SOUND)

52 33 10 N; 131 25 48 W

The MEAN DENSITY was 2.94/$m^2$; distribution was patchy (variance 8.86). Only 11% of the abalone collected were of legal size (Fig. 28); the LEGAL DENSITY was 0.32/$m^2$. Juveniles were present both on the underside and exposed surface of the smaller boulders; however, their density was low. Most of the abalone were located near datum and all the quadrat counts were made under the canopy.

The SUBSTRATE was large to small boulders, the slope was 5°-10°. A CANOPY of Nereocystis and Macrocystis produced 35% cover in a 10-20 m wide band on the surface; it occurred at depths between 0.5 m and 2.0 m. The kelps Laminaria, Cymathere, and Costaria produced 60% cover beneath the canopy; erect corallines covered up to 20% of the rock surface beneath the kelps; and almost all the exposed substrate was encrusted with lithothamnion and Hildenbrandia. SEA URCHIN density was < 1/$m^2$, beginning at 2.0 m.

COMMENTS

For fishing history see Station 64. We found only a low commercial density at this site.

STATION 67. East side of Marco Rock (JUAN PEREZ SOUND)

52 31 10 N; 131 29 42 W

The MEAN DENSITY was 1.13/$m^2$ (variance 2.52). None were legal, and no juveniles were found. All abalone here were between 50 and 95 mm.

The SUBSTRATE was chest-size round boulders and smaller round rocks covered with white lithothamnion. There were no other macrophytes, and the area was dominated by SEA URCHINS at $2/m^2$, also by small green sea urchins at the same density. We noted the presence of S. purpuratus. Quadrats were made from near datum to about 3 m.

COMMENTS

This site lies within the Juan Perez Sound closure. The habitat does not appear suitable for legal abalone.

STATION 68. Bischof Islands (JUAN PEREZ SOUND)

52 34 35 N; 131 32 45 W

The MEAN DENSITY was $6.56/m^2$; however distribution was highly patchy (variance 32.93). None of the abalone collected at this site were of legal size. Juveniles were present on the exposed rock surfaces and in crevices. Most of the population were between 50 mm and 90 mm (Fig. 29). All the abalone were collected between 1 m above datum and 2 m; most were at the bottom edge of the kelp fringe.

The SUBSTRATE was broken bedrock and large boulders. The slope varied between 5° and 40°. A CANOPY of Nereocystis and Egregia occurred near datum, forming a fringe around the north side of the islet. A light understory of Laminaria sp., Alaria, and Pterygophora occurred beneath. Erect corallines covered 60% of the substrate beneath the kelps; lithothamnion and Dodecaceria encrusted the remaining substrate. SEA URCHINS at $10/m^2$ were found below the kelp fringe.

COMMENTS

This site lies within the Juan Perez Sound closure and is near the location of sites 9 and 10 of Adkins and Stefanson 1977. During that survey a mean density of $6.9/m^2$ was determined for these sites. This compares with the mean density of $6.56/m^2$ found during the present study. We noted no major changes in either the abalone population or the community structure at this site.

STATION 69. Rock south of Hutton Point (JUAN PEREZ SOUND)

52 31 22 N; 131 32 14 W

The MEAN DENSITY was $2.44/m^2$ (variance 3.06). We estimated 10% to be legal, so LEGAL DENSITY was $0.31/m^2$. There were no juveniles, and the maximum size observed was 125 mm.

The SUBSTRATE was the exposed edge of a tilted bed of sedimentary rock, and so it was a series of ledges with pockets of sand. Boulders appeared near 3 m, and sand-shell began within another 1 m of depth. The lower intertidal zone supported 80% cover of erect corallines; the rocks below were covered with both white and pink lithothamnion; but there were no other ALGAE. SEA URCHINS were present at $2/m^2$ from datum to deeper water, and the other grazers noted were Astraea to $10/m^2$ and Tonicella. Abalone were found in the upper subtidal zone.

COMMENTS

The site lies within the Juan Perez Sound closure. The density of abalone is close to being commercial.

STATION 70. Faraday Island (JUAN PEREZ SOUND)

52 35 55 N; 131 29 10 W

The MEAN DENSITY was $0.63/m^2$; (variance 0.65). We estimated at least 90% of the abalone to be legal sized; the LEGAL DENSITY was $0.57/m^2$. No juveniles were noted. All the quadrat counts were made in the kelp zone, down to 3 m. These quadrats were made in an area of high local abundance.

The SUBSTRATE was large boulders on a mud and shell bottom; boulders disappeared at 3 m. The slope was less than 5°. A dense CANOPY of Macrocystis extended in a 20 m wide band along the shore. An understory of bottom-form Macrocystis, Laminaria, Agarum, and Cymathere occurred beneath. Agarum and Laminaria continued below onto the mud substrate. SEA URCHINS were present in patches at densities up to $20/m^2$. They began at the bottom edge of the canopy and extended down to the beginning of the mud substrate. We noted Tegula, Astraea, and Cryptochiton in the kelp zone.

COMMENTS

This site lies within the Juan Perez Sound closure. We found a good commercial density here. This may reflect original densities in some of the protected Macrocystis sites that have been fished elsewhere.

STATION 71. Hoskins Islets: north islet, east side (JUAN PEREZ SOUND)

52 32 24 N; 131 32 50 W

The MEAN DENSITY in the upper part of the Pterygophora zone (near datum) was $28.00/m^2$ based on the number removed from 10 quadrats (variance

87.30 based on four counts). The sizes are shown in Fig. 30; none were legal. The MEAN DENSITY in the lower part of the Pterygophora forest (near 3 m) was 9.00/$m^2$ based on the number removed from 10 quadrats (no estimate of variance). None were legal; sizes are shown in Fig. 31. The MEAN DENSITY in deeper water beneath the Pterygophora zone (near 8 m) was 5.20/$m^2$ based on the number removed from 10 quadrats (variance 22.18, based on 10 quadrat counts). Sizes are shown in Fig. 32; none were legal.

The SUBSTRATE was entirely solid bedrock descending at 30-45° until 5 m, where chest-sized boulders began. From this point into deeper water, the slope decreased, the number of boulders lying on the bedrock increased, and the average boulder size decreased.

The ALGAE were Hedophyllum in the intertidal zone; Pterygophora/corallina to 3 m; then SEA URCHINS began at 2/$m^2$ and the Pterygophora stopped. Sea urchins quickly decreased in abundance with depth. The rocks themselves were covered with a mixture of Hildenbrandia and lithothamnion.

COMMENTS

This site lies within the Juan Perez Sound closure. It is clearly not habitat that produces legal abalone, probably because of the exposure. We sampled at three depths to measure the change in abalone size with depth, which can be seen clearly in Fig. 30 through 32.

STATION 72. Murchison Island (JUAN PEREZ SOUND)

52 35 45 N; 134 25 30 W

The MEAN DENSITY was 7.06/$m^2$; but distribution was highly patchy (variance 71.26). Sizes are shown in Fig. 33. None of the abalone collected were of legal size, so LEGAL DENSITY was 0.00/$m^2$. Juveniles were present but not abundant and all were on the exposed rock surface or in crevices. Quadrat counts were made both in the kelp zone and below, between 1 m and 7 m. Abalone were most abundant at the bottom edge of the kelp fringe.

The SUBSTRATE was solid rock; the slope was 45° down to a level cobble and boulder floor at 7 m. A light CANOPY of Nereocystis and Egregia occurred near datum with a thick understory of Alaria, Laminaria sp., Hedophyllum, Gigartina, and Phyllospadix beneath. The kelps were found between datum and 1 m. All the exposed substrate was encrusted with lithothamnion and Hildenbrandia. SEA URCHINS were abundant at this site, occurring at depths below 1 m; density varied between 20 and 30/$m^2$. The sea urchins S. droebachiensis and S. purpuratus were both noted, as were: Tegula, Tealia crassicornis, Acmaea mitra and Calliostoma ligatum.

COMMENTS

This site is in the Juan Perez Sound closure area and is at the same location as site 11 of Adkins and Stephanson 1977. No major changes in either the abalone population or the community structure were noted here during the present survey. Both surveys yielded a legal density of zero which result from the high exposure of this site.

STATION 73. Hoskins Islets (JUAN PEREZ SOUND)

The work described in under Station 71 required diving on 2 days, and this number was assigned to the same station. See Station 71.

STATION 74. Murchison Island, west side (JUAN PEREZ SOUND)

52 35 42 N; 131 27 40 W

The MEAN DENSITY was 0.75/$m^2$ (variance 1.13). Of these, 90% were estimated to be legal size, so LEGAL DENSITY was 0.67/$m^2$. No juveniles were found.

The SUBSTRATE was head-size rocks sloping at about 20-30°. The CANOPY was Macrocystis, forming only a 15% cover at the surface; with Agarum forming a light cover beneath it. Macrocystis ended at 2 m, and SEA URCHINS began at 5/$m^2$.

COMMENTS

This site lies within the Juan Perez Sound closure. It has a good commercial density of abalone.

STATION 75. Ramsay Island north side (JUAN PEREZ SOUND)

52 34 05 N; 131 24 22 W

The MEAN DENSITY was 1.81/$m^2$ (variance 3.10). The legal sizes were estimated to be 90% of the total, so LEGAL DENSITY was 1.63/$m^2$. No juveniles were found.

The SUBSTRATE was bedrock, nearly flat in the lower intertidal zone, then sloping at about 30°. The ALGAE were Egregia and Codium fragile in the lower intertidal zone, then a narrow band of Nereocystis with Laminaria beneath it in the upper subtidal zone. SEA URCHINS were found just below datum at 10/$m^2$, and the kelps stopped. Abalone were most

abundant under the kelps, but were also found in the upper sea urchin zone, and quadrats were made in both places.

COMMENTS

This site lies within the Juan Perez Sound closure, and has an excellent commercial density of abalone.

STATION 76. Ramsay Island Moorage (JUAN PEREZ SOUND)

52 34 28 N; 131 23 48 W

The MEAN DENSITY was estimated visually to be 0.5-1.0/$m^2$, with perhaps half these being legal.

The SUBSTRATE was bedrock sloping at 45° or more, with ledges on the way down. At 5 m the rock ended and a flat sand-shell floor began. ALGAE were some sparse Macrocystis near datum, a 20% cover of Laminaria in the upper subtidal, no turf, and a mixture of Hildenbrandia and pink lithothamnion on the rock itself. SEA URCHINS began at approximately 1 m, at 3/$m^2$. There were some large sea cucumbers here (Parastichopus californicus, not previously noted as being abundant); and a few large Astraea.

COMMENTS

This site lies within the Juan Perez Sound closure. It had a legal abalone density approaching a commercial value. These observations were made during a night dive.

STATION 77. Faraday Island, northwest corner (JUAN PEREZ SOUND)

52 36 34 N; 131 30 15 W

There were abalone at the location, but none were found in the first eight quadrats. None seen were legal, and most were near 80 mm.

The SUBSTRATE was rough bedrock, sloping at 30-60°. ALGAE were scattered patches of Macrocystis and Nereocystis, also scattered patches of Laminaria. SEA URCHINS dominated most of the bottom from near datum, at densities of up to 10/$m^2$. Astraea were abundant at 5/$m^2$. The cover on the rocks varied from 80% Hildenbrandia to 80% lithothamnion.

COMMENTS

This site lies within the Juan Perez Sond closure. It did not have legal abalone.

STATION 78. Bischof Islands (JUAN PEREZ SOUND)

52 34 12 N; 131 33 30 W

The MEAN DENSITY was 4.25/$m^2$ (variance 8.07). Most of the abalone collected were small; only 3% were legal sized (Fig. 34). The LEGAL DENSITY was 0.13/$m^2$. Some juveniles were present, all were on exposed substrate. Abalone were at depths between 1 m above datum and 3 m; but they were most abundant in the upper limits of the sea urchin zone.

The SUBSTRATE was smooth bedrock with a slope varying between 20 and 30°. There was no CANOPY at this site. Intertidally were Phyllospadix, Egregia, Laminaria, Gigartina, Codium setchelii and erect corallines. These stopped at 1 m above datum. Hildenbrandia and lithothamnion encrusted most of the exposed substrate. SEA URCHINS dominated this site, occurring from 1 m above datum to several meters below. Density was 5/$m^2$ near the upper limit, but decreased with depth.

COMMENTS

This site lies within the Juan Perez Sound closure. We did not find a commercial density here.

STATION 79. North side of Faraday Island (JUAN PEREZ SOUND)

52 36 45 N; 131 29 00 W

The MEAN DENSITY was 0.63/$m^2$ (variance 0.52). All the abalone in quadrats were collected and sizes are shown in Fig. 35; none were legal.

The SUBSTRATE was steep rough bedrock in the intertidal zone, changing to broken rock and gravel in the subtidal. Slope was very gradual. SEA URCHINS dominated the area below datum, at a density of 10/$m^2$ at the top of their distribution, but quickly decreasing in deeper water. The dominant alga in the intertidal zone was Codium. Astraea and Acmaea mitra were both large and at densities of 5/$m^2$. The rocks themselves were covered with 20% Hildenbrandia, 50% white lithothamnion; the rest being barren.

COMMENTS

This site lies within the Juan Perez Sound closure. It did not have any legal abalone.

STATION 80. Sivart Rock (JUAN PEREZ SOUND)

52 31 56 N; 131 36 06 W

The MEAN DENSITY was 1.00/$m^2$; distribution was fairly even (variance 0.93). We found no legals. Some juveniles near 25 mm were noted; these were either on the substrate surface or in shallow crevices. Abalone were at depths between datum and 4 m.

Smooth undulating bedrock with a 20° slope describes the SUBSTRATE at this site. There was no CANOPY. Alaria and Egregia formed a narrow fringe around the rock at 2.5 m above datum. Only erect corallines, lithothamnion and Hildenbrandia occurred below. SEA URCHINS began at 2 m above datum; their density was < 1/$m^2$ to below 4 m. We also noted: Dermasterias, Serpula, Acmaea mitra, S. droebachiensis, Pycnopodia, and Astraea.

COMMENTS

This site is within the Juan Perez Sound closure. It did not contain commercial densities. It appears to be unsuitable habitat for legal abalone.

STATION 81. Upper Sedgewick Bay (JUAN PEREZ SOUND)

52 37 42 N; 131 35 18 W

There were abalone at this site, but they were not nearly abundant enough to measure with the quadrat. All that we saw were legal size and up to 140 mm.

The SUBSTRATE was broken granite boulders and smaller rocks sloping at 30-45°. The ALGAE were bottom-form Macrocystis at 40% cover; Agarum at 40% cover, and a turf of Dictyota and erect corallines forming 10% cover; and a 25% cover of pink lithothamnion. This assemblage extended to at least 5 m. There were only a few SEA URCHINS, widely scattered at below 3 m. The intertidal zone contained Fucus above, sea mussels (Mytilus californianus) in the mid-zone, and Laminaria in the lower part.

COMMENTS

This was a unique site. The intertidal organisms were a mixture of sheltered and exposed forms. The subtidal flora were similar to that at sites 24 and 25, indicating a very sheltered site (as one would guess from the location). This site is within the Juan Perez Sound closure. It did not have enough abalone to be commercial.

STATION 82. De La Beche Island (JUAN PEREZ SOUND)

52 32 26 N; 131 38 02 W

The MEAN DENSITY was $0.25/m^2$ (variance 0.33). There were no legal sized abalone. Juveniles were present under the smaller boulders and cobbles. Their density was about the same as that of visual abalone. Abalone were found between 1 m above datum and 3 m.

The SUBSTRATE varied from large boulders to cobbles and had a slope of 10°. There was no CANOPY; only a light (1%) cover of Agarum was found. Some erect corallines were present; however, lithothamnion, Hildenbrandia and Ralfsia were the dominant cover. SEA URCHINS were present between datum and 4 m; density was $5/m^2$. We also noted Cucumaria miniata, Astraea, Acmaea mitra, and Tonicella lineata.

COMMENTS

This site lies within the Juan Perez Sound closure; it represents a very marginal abalone habitat. No legal abalone was noted here. We examined several spots around the island; however, this site was the only area where there was any kelp or enough abalone to measure. Everywhere the bottom was dominated by lithothamnion and sea urchins. Sea urchins were less dense elsewhere than here.

STATION 83. Rock off northeast corner of Wanderer Island (BURNABY STRAIT)

52 25 40 N; 131 23 54 W

No abalone were found at this site.

The SUBSTRATE was solid bedrock, sloping at 20° to meet a sand and cobble floor at 8.5 m. A very dense (90%) CANOPY of Macrocystis surrounded this rock producing a 15 m-wide patch on the surface. Beneath this was a thick understory of bottom form Macrocystis, Agarum, and Laminaria sp. Agarum continued below the canopy onto the sand and cobble substrate at 8.5 m. At datum, just above the upper limits of the kelps, were Corallina and Leathesia. Lithothamnion encrusted all the exposed rock surfaces. Parastichopus and Cucumaria miniata were noted; there were no SEA URCHINS here.

COMMENTS

Fishing intensity has been heavy in this general area. In 1977 16,000 lb of abalone were reported from Burnaby Strait. In 1978 2,000 lb were reported from the area around Wanderer Island. We found no abalone here during the present survey, but the very dense kelp cover hampered our searching. Because of the high density of kelp it is unlikely that harvesting has reduced the abalone population to the present level. This site probably has not been fished and represents an unsuitable habitat for abalone.

STATION 84. West side Wanderer Island (BURNABY STRAIT)

Surface observations were made at intervals from Station 83 to Station 85. Although there were Macrocystis plants, these invariably proved to be growing on clam shells lying on the sand, or on small stones. The whole area covered was unsuitable habitat for abalone.

STATION 85. Rock at the southwest corner of Wanderer Island (JUAN PEREZ SOUND)

52 24 50 N; 131 24 30 W

Abalone density was too low to conduct quadrat counts. Only 3 abalone were seen during the dive and all of them were legal sized.

The SUBSTRATE varied between the north and south side of the rock. On the north side were boulders on a 10° slope changing to a sand/shell floor at 3 m. On the south side was solid bedrock with overhanging ledges sloping at 70° to meet a sand/shell floor at 11 m. A CANOPY of Macrocystis occurred between datum and 3 m on the north side of the rock. A dense understory (almost impossible to swim through) of bottom form Macrocystis, Agarum, and Laminaria occurred beneath. On the sand/shell floor below were Agarum and Laminaria. On the south side, only Agarum occurred; on the sand/shell floor at 11 m. SEA URCHINS were not present. Numerous invertebrates were present at this site both under the Macrocystis canopy and on the steep bedrock wall. We noted Parastichopus, Astraea, Pododesmus, Tresus, Pisaster brevispinus, and several species of tunicates including Cnemadocarpa dura and Clavalina huntsmanii.

COMMENTS

See Station 83 for fishing history. This site was at the extreme sheltered end of the range of habitats that contain abalone.

STATION 86. Abraham Point (WERNER BAY)

52 27 58 N; 131 27 30 W

The MEAN DENSITY was 0.25/$m^2$ (variance 0.20). Abalone were evenly distributed in the area beneath the canopy and in the sea urchin zone. Of the few we observed, 75% were legal sized. The LEGAL DENSITY was 0.19/$m^2$. No juveniles were noted.

The SUBSTRATE was boulders sloping at 10° to meet a sand/mud floor at 3 m. A thick Macrocystis CANOPY occurred near datum producing 40% cover. A light understory of Agarum and Laminaria was beneath. Agarum continued down through the sea urchin zone onto the sand-mud substrate at datum. Erect corallines covered 10% of the rock surface; the remaining rock was encrusted with lithothamnion. SEA URCHINS were present; however their density was less than 1/$m^2$, occurring at depths near datum. We also noted: Cucumaria miniata, Astraea, Pagurus spp., Solaster stimpsonii, Tonicella lineata, Parastichopus, and Tegula.

COMMENTS

See Station 60 for fishing history. Commercial densities were not found at this site.

STATION 87. Central Point in Werner Bay (WERNER BAY)

52 28 55 N; 131 28 12 W

The MEAN DENSITY was 3.00/$m^2$ (variance 6.40). Eleven percent were legal (see Fig. 36 for sizes collected from the quadrats), and LEGAL DENSITY was 0.33/$m^2$. There were no juveniles seen under rocks.

The SUBSTRATE was rough bedrock descending at about 45°. ALGAE were Pterygophora, forming only a light canopy (in many cases the plants were only stipes); and a turf of erect corallines from 25-75% cover beneath that. The rock itself was covered with a varying mixture of red and green Hildenbrandia and pink lithothamnion. SEA URCHINS began at 2 m, and the rock was barren below that point. There were a very few red and green sea urchins in the Pterygophora forest. Other grazers were very scarce except for Tegula, which was very numerous (10-50/$m^2$).

COMMENTS

See Station 60 for fishing history. This site had a legal density that is probably too low to be commercial, especially considering the large number of sub-legals present. The habitat was a typical Pterygophora/corallina community.

STATION 88. Newberry Cove (WERNER BAY)

52 28 03 N; 131 26 54 W

The MEAN DENSITY was 16.56/$m^2$ (variance 185.06). Sizes of abalone collected from quadrats are shown in Fig. 37; legals were 5% of the total, for a LEGAL DENSITY of 0.83/$m^2$. Only a few juveniles were seen.

The SUBSTRATE was smooth rolling bedrock that sloped steeply to a boulder field in approximately 3 m. The ALGAE were Egregia at datum, then a very light cover of Nereocystis; with Pterygophora and Laminaria forming a 20% cover beneath it; and a 10% turf of erect corallines. Lithothamnion covered the rock at 80% cover. SEA URCHINS began at the lower edge of the kelp, at a density of 1/$m^2$. There were also patches of up to 20/$m^2$ S. droebachiensis within the kelp. Encrusting bryozoans and tunicates indicated a fairly exposed site. Abalone were present in both the kelp and sea urchin zones.

COMMENTS

See Station 60 for fishing pressure. This site appeared to be an excellent abalone producing habitat, and had commercial densities of abalone.

STATION 89. Marshall Inlet (WERNER BAY)

52 28 33 N; 131 28 58 W

Only two abalone were seen in a 15 min random search at this site. Both were large, to 140 mm.

The SUBSTRATE was hand and head-size rocks on gravel, with a shallow slope. The intertidal zone was bedrock. ALGAE were erect corallines in the intertidal zone, then a very dense cover of bottom-form Macrocystis, with sparse Agarum beneath it; a 20% cover of Gelidium and 20% erect corallines beneath that, and a mixture of Hildenbrandia and pink lithothamnion on the rocks. Macrocystis extended to 2 m, then ended and SEA URCHINS extended into deeper water.

COMMENTS

This site is too sheltered to produce legal abalone. See Station 60 for fishing pressure. This site did not have a commercial density of abalone.

STATION 90. East shore, HUXLEY ISLAND

52 27 15 N; 131 21 40 W

The MEAN DENSITY was 1.81/$m^2$ (variance 2.30). We estimated that 60% of these were legal, for a LEGAL DENSITY of 1.09/$m^2$. No juveniles were seen under rocks.

The SUBSTRATE was chest-sized and larger boulders lying on a gently sloping bottom. The CANOPY was a light cover of Macrocystis, forming only 10% cover at the surface; with Alaria and Cymathere forming a 10% understory; a sparse coralline turf and a mixture of Hildenbrandia and pink lithothamnion on the rocks. There was a sparse canopy of Pterygophora in a narrow band at the bottom edge of the Macrocystis, in 3 m. SEA URCHINS began at 3 m and continued deeper, but their density was less than 1/$m^2$. Abalone were found only under the Macrocystis. The dominant grazer was Cryptochiton on the barren rock.

COMMENTS

The whole of Huxley Island yielded at least 16,000 lb in 1977; in 1978 this side of Huxley Island yielded up to 3,000 lb. This site had a high commercial density of abalone.

STATION 91. Gottlob Point (WERNER BAY)

52 28 30 N; 131 27 46 W

The MEAN DENSITY was 9.38/$m^2$ (variance 34.12). We estimated that 5% were legal, so LEGAL DENSITY was 0.47/$m^2$. There were some juveniles as small as 20 mm.

The SUBSTRATE was bedrock, as described for Station 60. The ALGAE were dense Pterygophora, estimated to be 10 plants/$m^2$; a thick turf of erect corallines beneath it, and lithothamnion. This community extended to 2 m, where SEA URCHINS began at 1-2/$m^2$ and extended into deeper water. The other grazers noted were Tegula, especially on the Pterygophora plants, Acmaea mitra, and Calliostoma. S. droebachiensis reached 4/$m^2$ under the kelp. All quadrats were made in the Pterygophora zone.

COMMENTS

This site is within the area from which 66,000 lb were reported harvested in the past 2 yr. It had a low commercial density of abalone in a typical Pterygophora/corallina community. As at other sites like this one, we observed many abalone grazing on the Pterygophora blades. When disturbed, they showed a running response back to the substrate along the kelp stipe.

STATION 92. Section Cove (BURNABY STRAIT)

52 25 12 N; 131 22 00 W

Only two abalone, both legal, were seen during a 25 min search.

The SUBSTRATE was rough bedrock sloping at 30-45° to a sand-shell floor at 9 m. There was a CANOPY of Macrocystis, forming 20% cover at the surface; with a 20% cover of Agarum beneath it; erect corallines forming a 20% turf; and a covering on the rocks of 80% Hildenbrandia and 20% pink lithothamnion. Macrocystis ended at 2 m, but Agarum continued to the bottom of the rock slope. SEA URCHINS were present in the Agarum zone, but were less than $1/m^2$. We noted Parastichopus at this site, and there were Cucumaria miniata in the crevices.

COMMENTS

The area around Section Cove was heavily harvested in 1977, with many landings reported without specific location; in 1978 at least 4,500 lb were taken from the cove itself. The high proportion of Hildenbrandia and the presence of Agarum indicate a sheltered habitat.

STATION 93. Moresby Island across from Huxley Island (BURNABY STRAIT)

52 27 03 N; 131 24 55 W

The MEAN DENSITY was $1.50/m^2$ (variance 1.33). We estimated that legal sizes were 25% of the total, so LEGAL DENSITY was $0.38/m^2$. No juveniles were found in this area.

The SUBSTRATE was bedrock in the intertidal zone, changing to boulders and rocks of all sizes sitting on gravel; the gravel forming 30-50% of the bottom. ALGAE were Prionitis in the intertidal zone; scattered Pterygophora forming an unimportant cover in the subtidal zone, a variable turf of erect corallines up to 20% cover, and a variable mixture of red and green Hildenbrandia and white and pink lithothamnion. Abalone were evenly distributed in the area that we surveyed: from datum to 2 m. SEA URCHINS were also throughout this area at $2/m^2$.

COMMENTS

This part of Burnaby Strait was reported to be fished in 1977 but not in 1978; the landings are included in the Werner Bay landings. Although this appeared to be a sea urchin dominated area, it still had a commercial density of abalone. We observed the remnants of Macrocystis stipes at this site, indicating that once there was a kelp bed here, probably within the past year.

STATION 93a. Rock south of Dolomite Narrows

52 20 14 N; 131 20 07 W

We made observations on this site from the surface. The bottom was sand with many Pisaster brevispinus and clam shells. There were small rocks that supported Macrocystis, but no expanses of solid substrate for abalone. There were no sea urchins, either. The presence of the white sea anemone Metridium senile indicated the effect of current.

STATION 94. Deluge Point (SKINCUTTLE INLET)

52 19 42 N; 131 14 45 W

The MEAN DENSITY was 1.63/$m^2$ (variance 3.18); none were legal. Most of the abalone seen were from 40-60 mm.

The SUBSTRATE was smooth rolling bedrock, sloping at an average of 30°. There was a band of Pterygophora from near datum to approximately 1 m; then patches of Nereocystis, forming 20% cover at the surface, located on the higher parts of the rolling substrate. Beneath it were Botryoglossum, polysiphonous reds and erect corallines forming a turf covering 15% of the rock, and lithothamnion completely covering the exposed rock. SEA URCHINS were present in the low parts of the rock surface, and from 5 m to deeper water. Abalone were found both under the kelps and among the sea urchins. These quadrats were made from datum to 6 m.

COMMENTS

In 1977, at least 13,000 lb were taken from this shore of Skincuttle Inlet, plus landings reported without specific location. In 1978, 16,000 lb came from the whole of Skincuttle Inlet. This site appeared to be too exposed to produce legal abalone.

STATION 95. Rock northeast of Smithe Point (SKINCUTTLE INLET)

52 19 44 N; 131 18 24 W

The MEAN DENSITY was 0.63/$m^2$ (variance 0.65). We collected all the abalone from the quadrats, and their sizes are shown in Fig. 38. Legals were estimated to be 30% of the population (although fewer were actually found within the quadrat), so LEGAL DENSITY was 0.19/$m^2$. The smallest abalone seen was 70 mm.

The SUBSTRATE was jagged bedrock in rolling formations not far beneath the surface. We surveyed from datum to 1 m. The CANOPY was very sparse Macrocystis, present in the area but not important; Agarum forming 100% cover from 1 m to deeper water; only very scattered erect corallines, and white lithothamnion. SEA URCHINS were present only in the area from datum to 1 m, above the kelp. Their density was only $0.5/m^2$, but the individuals were very large. The abalone were most abundant in the sea urchin zone. The dominant grazer was Tonicella lineata; many large Astraea were also present.

COMMENTS

In 1977, 42,000 lb were removed from Skincuttle Inlet; 10,500 lb were taken from this shore. In 1978, 16,000 lb were taken from the whole inlet, so the whole general area has been well harvested. Local residents came out to us in a canoe and told us that they saw this site and Station 97 being harvested in the 1978 season. On this site there was not a commercial density of abalone.

## STATION 96. Between Harriet Harbour and Deluge Point (SKINCUTTLE INLET)

52 18 55 N; 131 12 00 W

The MEAN DENSITY was $1.13/m^2$ (variance 0.78). We estimated 10% of the abalone to be of legal size; the LEGAL DENSITY was $0.11/m^2$. Most of the abalone were between 40 mm and 60 mm; occurring in both the kelp and sea urchin zones.

Bedrock and large boulders formed the SUBSTRATE; sloping at 10-20°. Macrocystis formed a CANOPY covering 15% of the surface over a light understory of Pterygophora and Laminaria sp. These occurred from datum to 2 m. A thick turf of Codium setchellii and erect corallines occurred near datum and pink lithothamnion encrusted the exposed rock. SEA URCHINS were present, but density was less than $1/m^2$. They began at 1 m and continued downward. Dodecaceria, Serpula, tunicates bryozoans, and Balanophyllia were all abundant at this site.

COMMENTS

For fishing pressure, see Station 94. There was not a commercial density of abalone at this site.

## STATION 97. Low rocks east of Swan Islands (SKINCUTTLE INLET)

52 20 04 N; 131 17 12 W

There were abalone present at this site, but none occurred in the first eight quadrats. The ones we saw were 80% legal to 115 mm, and were

usually present in little groups of 2 or 3. There were no juveniles.

The SUBSTRATE was solid, smooth pavement bedrock sloping at 30°. ALGAE were present only as Egregia in the intertidal zone, a few Agarum plants in deeper water; and some scattered patches of Ulva. The rock itself was 80% barren granite; the rest white lithothamnion. SEA URCHINS were present from datum to deeper water; at $10/m^2$ at datum and decreasing deeper. Astraea was the dominant grazer, present at $2-3/m^2$ as large (75-100 mm) individuals.

COMMENTS

For fishing history see Station 95. The local residents' story, that this site had good populations of abalone and was repeatedly harvested this year, is credible. The substrate is totally smooth, and so it would be possible to remove a high proportion of the abalone population. The observation that many of the remaining abalone are in small groups is consistent with heavy harvesting, in which a few were overlooked. The presence of Ulva also indicates a release of grazing pressure. There was not a high enough density to measure.

STATION 98. Island near Bush Rock (SKINCUTTLE INLET)

52 18 04 N; 131 16 22 W

The MEAN DENSITY was $2.25/m^2$ (variance 6.20). We estimated that less than 5% of the abalone were legal sized; the LEGAL DENSITY was less than $0.11/m^2$. Several juveniles were present,30-50 mm long. Quadrat measurements were made in the kelp zone between 1 m and 3 m.

Bedrock covered with large boulders formed the SUBSTRATE. The slope varied from 5° near datum to 20° at 3 m and below. Macrocystis formed a CANOPY producing a 30% cover over an understory of Laminaria sp. Macrocystis stopped at 2 m, but Laminaria continued deeper. Near datum was a light turf of Codium setchellii, Phyllospadix, and erect corallines. Lithothamnion covered almost all of the exposed substrate. SEA URCHINS occurred in patches with a density of $5/m^2$, in the Laminaria zone at 3 m and below. Astraea was the dominant grazer at this site.

COMMENTS

See Station 94. This exact site was reported fished both in 1977 and 1978. There was not a commercial density of abalone here.

STATION 99. Rocks between Pelican Point and Rock Islet (SKINCUTTLE INLET)

52 20 38 N; 131 14 54 W

The MEAN DENSITY was 3.06/$m^2$ (variance 9.93). Abalone were collected from the quadrats and their sizes are shown in Fig. 39; 2% were legal for a negligible LEGAL DENSITY.

The SUBSTRATE was smooth bedrock sloping at 60° or more, with some relief. The ALGAE were intertidal Egregia, then a narrow Pterygophora/corallina community that ended near datum. SEA URCHINS began near datum, and were 30/$m^2$ or more - packed as tightly as they could be - although this density did not continue deeper. Metridium were up to 50% cover of the rock surface on steep faces. S. purpuratus was present right at the top of the red sea urchin zone, and we noted the presence of the horse barnacle Balanus nubilus. The dominant grazers after sea urchins were Astraea and Tonicella. We surveyed the upper 5 m of the sea urchin zone.

COMMENTS

No log sheets showed fishing on this exact site, but the general area was moderately fished (see Station 95) and there are considerable landings with no exact site given in 1977. From the type of habitat, the abalone size frequency and the appearance of the abalone, this did not appear to be a suitable habitat for legal abalone, despite the presence of one legal individual in our quadrats.

STATION 100. Harriet Island northeast corner (SKINCUTTLE INLET)

52 18 20 N; 131 14 40 W

The MEAN DENSITY was 0.75/$m^2$ (variance 0.73). The sizes of abalone collected from the quadrats are shown in Fig. 40; half were legal and LEGAL DENSITY was 0.37/$m^2$. The smallest animal seen under rocks was 50 mm.

The SUBSTRATE was bedrock sloping at about 30° to head-sized rocks at approximately 3 m, and then to cobbles on sand-shell in deeper water. The ALGAE were isolated individuals of Macrocystis, sparse erect corallines, and lithothamnion covering 10% of the rock surface; with red and green Hildenbrandia covering 60% of the rest. SEA URCHINS were present at 1/$m^2$ from near datum to about 2 m, where their distribution faded. Patiria were present. Astraea was the dominant grazer after sea urchins.

COMMENTS

The 1977 landings for Harriet Harbour were 3,500 lb. This station was surveyed at the exact location of site 1 in Adkins 1978. In July 1977, there was a Nereocystis canopy extending to 3 m below datum, where it ended and sea urchins began at densities of 5/$m^2$. Beneath the bull kelp were Laminaria and D. ligulata. The sea urchins extended to 10 m depth. There has been a striking change to this year: the Nereocystis and other kelps have gone, the sea urchin distribution has moved upwards, and sea urchin density has decreased. In 1978 the reported landings from Harriet Harbour were 2,700 lb. Between the 1977 and 1978 surveys, the abalone abundance decreased from 1.71/$m^2$ to 0.75/$m^2$, a difference which is statistically significant ($t = 2.41$; d.f. = 43; $P = 0.05$). At the time of this survey, this site still had a low commercial density of abalone.

STATION 101. Head of Swan Bay (SKINCUTTLE INLET)

52 20 58 N; 131 19 12 W

Only one abalone was seen in the first eight quadrats; it was 140 mm.

The SUBSTRATE was shallow-sloping bedrock, with small depressions. The ALGAE were bottom-form Macrocystis forming 100% cover on the rock; an additional 10% cover of Agarum beneath that; with a 50% cover of erect corallines and then pink lithothamnion. There were no SEA URCHINS and no starfish. The dominant grazers were large Astraea at about 3/$m^2$.

COMMENTS

For fishing history see Station 95. This site appears too sheltered to produce commercial abalone populations.

STATION 102. North of Howay Island (POOLE INLET)

52 25 02 N; 131 15 18 W

The MEAN DENSITY was 5.75/$m^2$ (variance 43.67). All abalone found in quadrats were collected and their sizes are shown in Fig. 41; 6% were legal, for a LEGAL DENSITY of 0.35/$m^2$. No juveniles were found other than those represented in the quadrats.

The SUBSTRATE was bedrock overlain with chest-size boulders, sloping at 5°. The ALGAE were Nereocystis, forming a canopy of 10% cover at the surface; Pterygophora beneath it; Costaria, Pleurophycus and

similar algae forming a 30% cover on the bottom; a turf of corallines and red algae under that; and a mixture of lithothamnion (30%) and Hildenbrandia (60%) on the rocks. SEA URCHINS were present at low density in isolated patches beneath the kelp zone, in 5 m. The intertidal zone supported Phyllospadix and Codium fragile. These quadrats were made from datum to 5 m, in the kelp.

COMMENTS

In 1977, 4,500 lb were reported taken from this shore of Poole Inlet; in 1978, 6,000 lb were taken from the whole of Poole Inlet. In this exposed Nereocystis forest, there was a dense population with all sizes represented, but not a commercial density of abalone.

STATION 103. East of Kingfisher Cove (SKINCUTTLE INLET)

52 20 40 N; 131 15 50 W

The MEAN DENSITY was $0.56/m^2$ (variance 0.93). We considered that 80% of those that we saw were legal, with many of them being large to 140 mm. The sizes of abalone collected are shown in Fig. 42. The LEGAL DENSITY was $0.45/m^2$. No juveniles were seen.

The SUBSTRATE was smooth bedrock, sloping gently at first and then at about 30° to a sand-shell floor at 4.5 m. ALGAE were Fucus in the intertidal zone; an extremely dense Macrocystis forest, extending for about 10 m to a depth of 1 m; and some Agarum from 3 to 4.5 m. Under the Macrocystis canopy there was no understory, but erect corallines formed a dense turf at 50% cover. Pink lithothamnion covered the rocks. There was a SEA URCHIN zone from just below the kelp to 3 m; their density was variable up to $10/m^2$. The dominant grazers were large Astraea at $2-3/m^2$, Acmaea and Tonicella in the sea urchin zone, and Tegula in the Macrocystis forest. Abalone were present in both the kelp and sea urchin zones; these quadrats were made in the sea urchin zone.

COMMENTS

For fishing pressure see Station 95. This site still had a commercial density of abalone. As in many Macrocystis communities, nearly all the abalone are old and large, with no juveniles.

STATION 104. Burnaby Island west of Howay Island (POOLE INLET)

52 23 54 N; 131 16 50 W

The MEAN DENSITY was $1.75/m^2$ (variance 3.27). The average size was around 80 mm, and less than 5% were estimated to be of legal size, for a negligible LEGAL DENSITY.

The SUBSTRATE was bedrock with a very rough relief, with boulders lying in the low places. The ALGAE were Nereocystis, forming a light (20%) canopy at the surface; Pterygophora beneath it; a 40% cover of Laminaria, Costaria and other kelps on the bottom; and a 20% turf of erect corallines. The rocks were 90% covered with lithothamnion and Hildenbrandia. The intertidal zone supported Codium and Leathesia. SEA URCHINS began at 3 m, where the kelp ended, and continued deeper at 5/$m^2$. Green sea urchins were scattered at low density throughout the kelp. The abalone were in both the kelp and sea urchin zones.

COMMENTS

For fishing history see Station 102. This site did not have a commercial density of abalone.

STATION 105. East Copper Island, northwest corner (SKINCUTTLE INLET)

52 21 39 N; 131 10 55 W

The MEAN DENSITY was 3.31/$m^2$ (variance 91.83). The huge variance resulted from there being 39 in one quadrat, while the next highest was 3. There were no legals, and the smallest was 20 mm.

The SUBSTRATE was granite descending in large steps. The ALGAE were intertidal Lessoniopsis, Phyllospadix, and erect corallines. These all ended at datum, and the rocks below were covered with a mixture of lithothamnion and Hildenbrandia, with 25% Dodecaceria. SEA URCHINS were from 20-30/$m^2$ at datum, decreasing deeper. The dominant grazer after sea urchins was Tonicella. Abalone were concentrated in a very narrow band within the erect coralline turf at datum.

COMMENTS

This site is obviously exposed and unsuitable for commercial abalone. The high variance was again caused by the unequal distribution of abalone within the area being surveyed, just as at Stations 45 and 61.

STATION 106. Howay Island, west side (POOLE INLET)

52 23 31 N; 131 15 41 W

The MEAN DENSITY was 0.31/$m^2$ (variance 0.23). There were no juveniles, and there were less than 10% legals.

The SUBSTRATE was boulders and sand-shell and pebbles, sloping at 10°, with the rock size decreasing with depth. The CANOPY was a mixture of Macrocystis and Nereocystis, forming a 15% cover at the surface; a 10%

cover of Laminaria and Cymathere beneath that; a sparse turf of erect corallines and then 20% lithothamnion and 20% Hildenbrandia (both red and green) on the rocks. The SEA URCHIN zone began at approximately 3 m, where the kelps ended. They were also present at very low density among the kelps. The dominant grazers were Tegula and Acmaea mitra.

COMMENTS

Landings of 1,700 lb and 700 lb were reported taken from all of Howay Island in 1977 and 1978 respectively. This site did not have a commercial density of abalone.

STATION 107. West of George Island (SKINCUTTLE INLET)

52 21 00 N; 131 13 06 W

The MEAN DENSITY was 0.94/$m^2$ (variance 1.00). No juveniles were seen, most of the abalone were near 80 mm, and none were legal.

The SUBSTRATE was craggy bedrock, full of fissures and overhangs, in the form of a submerged rock rising to 2 m below datum. It had the appearance of suddenly cooled valcanic rock. We surveyed to 4 m and noted that abalone were most numerous above 3 m. There was a sparse thin CANOPY of Nereocystis, forming not more than 10% cover at the surface; with Ulva and polysiphonous reds forming a 40% turf. The rock was covered with 50% Dodecaceria and 50% lithothamnion. SEA URCHINS were 1-3/$m^2$, among the Nereocystis as well as deeper. Tegula was the most abundant grazer after sea urchins. We noted that the anemone Tealia sp. was present at 2/$m^2$, several times any previously noted abundance.

COMMENTS

The Copper Islands were reported to have been only lightly fished in 1977 and not at all in 1978. This does not appear to be a suitable site for commercial abalone, but the presence of Ulva and polysiphonous red algae indicate some kind of grazing disturbance.

STATION 108. Central part of POOLE INLET

From: 52 22 04 N; 131 17 25 W
To: 52 21 58 N; 131 17 42 W

We made surface observations in the area listed. We saw no suitable habitat; instead we found sand, sand-shell, gravel, small stones, and clamshells supporting Agarum and bottom-form Macrocystis. Some residents in the area told us that they had found no abalone from here to Rebecca Point.

COMMENTS

This area is obviously not suitable habitat, yet the area is shown on log sheets as having been fished.

STATION 109. Southwest of Poole Point (SKINCUTTLE INLET)

52 22 10 N; 131 14 55 W

The MEAN DENSITY was 3.00/$m^2$ (variance 10.93). Fig. 43 shows the sizes of abalone found in quadrats; 30% were legal. LEGAL DENSITY was 0.90/$m^2$. Some juveniles in the range 20-30 mm were found under rocks.

The SUBSTRATE was bedrock heavily overlain with round boulders of mixed sizes, sloping at 20°. There was a CANOPY of Nereocystis, forming 25% cover at the surface; a 50% cover of Pterygophora and 50% of Laminaria, Cymathere, and Costaria in the understory; a thick turf of erect corallines at 75% cover; and lithothamnion and bryozoans on the rocks themselves. All these algae continued from near datum to 1 m, where SEA URCHINS began at a density of 3/$m^2$ and continued to deeper water. The rocks in the sea urchin zone were covered with 50-80% white lithothamnion. These quadrats were made in the kelp zone.

COMMENTS

The fishing pressure in the Skincuttle Inlet area is given in Station 95. This site is included in an area that yielded 6,000 lb in 1978, but this exact place may or may not have been harvested. There was a commercial density here, in an exposed Nereocystis community with a robust population.

STATION 110. Rebecca Point (POOLE INLET)

52 22 45 N; 131 17 43 W

The MEAN DENSITY was 0.19/$m^2$ (variance 0.16). All were sublegal, down to 40 mm.

The SUBSTRATE was solid, smooth pavement bedrock sloping at about 20°. The ALGAE were Laminaria, Hedophyllum, and Egregia in the intertidal zone, with a 20% turf of erect corallines; then SEA URCHINS began at 5/$m^2$ near datum and the rock was barren except for white lithothamnion (30%), green Hildenbrandia (50%), and Dodecaceria. We noted Tegula, Calliostoma, serpulids, Patiria and Dermasterias on the rock. We also noted Pisaster brevispinus, which is normally not found on solid substrate.

COMMENTS

In 1977, 4,000 lb were taken from this point and east in Poole Inlet; in 1978 6,000 lb were taken from the whole of Poole Inlet. This site did not have legal abalone, and appeared to be totally dominated by sea urchins and Patiria.

STATION 111. Southern edge of Francis Bay (POOLE INLET)

52 22 09 N; 131 15 50 W

The MEAN DENSITY was 6.13/$m^2$ (variance 13.32). The sizes of those collected in the quadrats are shown in Fig. 44; 3% were legal, for a LEGAL DENSITY of 0.18/$m^2$. No juveniles were found except those seen in the open.

The SUBSTRATE was bedrock with chest-sized and smaller boulders, sloping at 10°. The CANOPY was a very sparse Nereocystis cover, with a 40% mixture of Laminaria and Cymathere beneath it, and a 60% turf of erect corallines. All this ended at 1.5 m, where SEA URCHINS began at 1/$m^2$. Dodecaceria formed a 50% cover in the sea urchin zone; the rest of the rock surface being barren. These quadrats were made below the kelp zone.

COMMENTS

Reported landings from Poole Inlet were 10,400 lb in 1977 and 6,000 lb in 1978. Along this part of Francis Bay, 4,000 lb were taken in 1977. From the algae and abalone size frequency this appears to be a suitable habitat, but this site did not have a commercial density of abalone.

STATION 112. North side of largest Bolkus Island (SKINCUTTLE INLET)

52 19 34 N; 131 16 58 W

Only one abalone, a legal one, was seen during a 10 min random search.

The SUBSTRATE was bedrock sloping at 10° to a sand-shell floor at about 1 m. ALGAE were some Gigartina and Iridaea in the intertidal zone, and some isolated Macrocystis plants growing on rocks and outcroppings on the sand-shell. On the intervening bedrock, there were Patiria at 10/$m^2$ and some unidentified worm tubes. No algae grew there, and it appeared that the bat stars were keeping the surface barren. SEA URCHINS were present only on rock outcroppings in deeper water. As well as abalone, other grazers were conspicuously absent from the bedrock.

COMMENTS

There were reported landings of 2,000 lb from these islands in 1977; none in 1978. This exact site appeared to be unsuitable abalone habitat for commercial abalone.

STATION 113. West side of largest Rankine Island (CARPENTER BAY)

52 15 27 N; 131 03 55 W

The MEAN DENSITY was 1.00/$m^2$, with a variance of 6.40. All were sub-legal, and we saw juveniles around 20 mm under broken rock in 4 m.

The SUBSTRATE was broken granite descending at 45° in almost regular steps, with broken rock beginning at 4 m. The ALGAE were Egregia, Laminaria, Phyllospadix, and a dense coralline turf in the intertidal zone, all ending at datum where dense SEA URCHINS began (10-15/$m^2$). Abalone were concentrated in groups in the bottom of the coralline turf, hence the high variance. Other grazers seemed very abundant: we noted Astraea at 5/$m^2$, Tegula and Acmaea mitra both at 10/$m^2$; a few Tonicella and green sea urchins; and a few purple sea urchins in the lower intertidal zone.

COMMENTS

No landings were reported from this general area in 1977, but 3,000 lb were reported taken from the Rankine Islands and the opposing shore in 1978. This site did not appear to be suitable for producing legal abalone.

STATION 114. Ingraham Point (CARPENTER BAY)

52 14 00 N; 131 01 45 W

The MEAN DENSITY was 2.31/$m^2$ (variance 4.63). We estimated that 40% were legal, for a LEGAL DENSITY of 0.93/$m^2$. The smallest abalone seen was about 40 mm.

The SUBSTRATE was boulders 1 m in diameter on sand, cobbles and pebbles, sloping at about 20°. There was a CANOPY of Macrocystis and Nereocystis forming a 15% cover at the surface; an understory of Pterygophora, Laminaria, and Costaria at 30% cover; a thick dense turf of erect corallines and red algae at 80% cover; and a mixture of lithothamnion and red and green Hildenbrandia. SEA URCHINS began at 2 m, where the rocks became barren, at 10/$m^2$. Some green sea urchins were also scattered at low density through the kelp.

COMMENTS

There was no fishing reported from here in 1977. In 1978 fishing was reported for this exact site, but the landings are included in the total for Carpenter Bay, 23,000 lb. This station had a good commercial density of abalone at this survey.

STATION 115. Moresby Island opposite Rankine Islands (CARPENTER BAY)

52 15 45 N; 131 05 12 W

The MEAN DENSITY was $1.44/m^2$ (variance 2.53). The sizes of abalone collected in quadrats are shown in Fig. 45; 26% were legal sized for a LEGAL DENSITY of $0.37/m^2$. No juveniles were found, but not long was spent looking for them.

The SUBSTATE was solid bedrock sloping steeply from the intertidal zone, then sloping more gradually with increasing depth to 3 m, where chest-sized and larger boulders began on a 20°slope. The CANOPY was a mixture of 90% Nereocystis with 10% Macrocystis, forming a 25% cover at the surface. This extended from 1-4 m. Beneath it were Pterygophora and Laminaria at 50% cover, an 80% cover of erect corallines and small red algae (especially Fauchea), and lithothamnion. At 4 m, SEA URCHINS began at $2/m^2$ and continued into deeper water. The kelp forest stopped at 4 m, but Pterygophora stipes continued for a short distance.

COMMENTS

This shore and the Rankine Islands yielded reported landings of 3,000 lb in 1978, but were not reported fished in 1977. This site had an abalone density close to commercial levels. We found an Octopus in a den with abalone living on the rocks immediately adjacent, and yet there was also a newly-dead abalone shell within the den.

STATION 116. South shore of CARPENTER BAY

52 13 33 N; 131 02 25 W

Only two abalone, neither legal, were found in 16 quadrats.

The SUBSTRATE was bedrock sloping at 10° with boulders in low spots and in deeper water. There was a light CANOPY of Macrocystis and Nereocystis, above a 20% cover of Laminaria, Alaria, Cymathere and other algae; with a sparse turf of corallines beneath that; and a complete cover of red and green Hildenbrandia and lithothamnion. The intertidal zone had Phyllospadix and Gigartina. SEA URCHINS began at 2 m and deeper, but were patchy. There were scores of hermit crabs in Tegula shells in each

quadrat. The other important grazers after sea urchins were Astraea, Tonicella and Acmaea.

COMMENTS

In 1977, this exact site was not reported to have been fished. In 1978, less than 4,000 lb were taken between Station 124 and Benjamin Point. This site did not have any legal abalone at this survey, and might be unsuitable habitat.

STATION 117. Just west of Iron Point (CARPENTER BAY)

52 14 42 N; 131 05 39 W

There were abalone present at this site, but not enough to count formally. The size range was from 20 mm to legal; the 20-30 mm individuals present under stones.

The SUBSTRATE varied from smooth bedrock, to round head and hand-sized rocks, to gravel; all having a very shallow slope. The ALGAE were patches of Macrocystis forming up to 20% cover at the surface, and scattered Cymathere. There was no turf, and the rocks themselves were covered with 80% green and 20% red Hildenbrandia. We found some Macrosystis stipes on the otherwise barren substrate. SEA URCHINS were not evenly distributed, and they varied from being absent to reaching $5/m^2$. The most abundant grazer was Tegula.

COMMENTS

In 1977, 2,400 lb were reported taken from the north shore of Carpenter Bay. In 1978, 23,500 lb were listed as coming from the whole bay. This site did not have commercial quantities of abalone. It was an unusual site: Macrocystis were present, but the community was not a typical Macrocystis forest; and the presence of stipes in barren areas indicated that recent changes had occurred.

STATION 118. South shore of CARPENTER BAY

52 13 19 N; 131 03 33 W

The MEAN DENSITY was $2.56/m^2$ (variance 10.00). About 2% were legal, for only a trifling LEGAL DENSTIY. The sizes of abalone collected from quadrats are shown in Fig. 46.

The SUBSTRATE was the same as at Station 116. The ALGAE were Pterygophora and D. ligulata, a 20% turf of erect corallines and polysiphonous reds, and a complete cover of lithothamnion and

Hildenbrandia. SEA URCHINS began at 3 m, where the kelp ended, and continued deeper at 5/$m^2$. Again there were many hermit crabs in Tegula shells.

COMMENTS

From this shore of Carpenter Bay landings of 20,000 lb were reported in 1977, and the whole bay yielded 23,500 lb in 1978. This site was within an area where reported landings were concentrated, and did not have a commercial density of abalone at the time of this survey.

STATION 119. South Cove (CARPENTER BAY)

52 13 19 N; 131 06 12 W

The MEAN DENSITY was 1.06/$m^2$ (variance 1.00). The sizes of abalone collected are shown in Fig. 47. Only one legal abalone was found in the quadrats, but both divers thought a higher proportion was present in the population. LEGAL DENSITY was 0.01/$m^2$ or less.

The SUBSTRATE was round chest-sized boulders and smaller rocks on a very shallow slope. The only ALGAE present were white lithothamnion, mixed with a 50% cover of Dodecaceria, and some colonial diatoms giving the rocks a furry appearance. SEA URCHINS were present at densities of less than 3/$m^2$ throughout. These quadrats were made from 1-2 m.

COMMENTS

In 1978, all of Carpenter Bay yielded 23,500 lb; in 1977 the south shore yielded 20,000 lb. This exact site was shown on log sheets as having been fished several times. It did not have a commercial density of abalone at the time of this survey, and the presence of a colonial diatom film on the rocks might indicate a recent release from grazing pressure. Juvenile density was low.

STATION 120. South shore (CARPENTER BAY)

52 13 15 N; 131 03 45 W

In a 25 min random search, only three abalone, all near 50 mm, were seen.

The SUBSTRATE was solid bedrock sloping at about 10°. The only algae were lithothamnion and green Hildenbrandia forming a 20% and 80% cover respectively. SEA URCHINS were present at low (1/$m^2$) density, and the next abundant grazer was Astraea.

COMMENTS

The fishing history of this area is described under Station 118. Although this exact location was included in the area shown on log sheets have been fished repeatedly, there were no legal sized abalone.

STATION 121. East of Samuel Rock (CARPENTER BAY)

52 14 39 N; 131 06 42 W

There were abalone present at less than $0.1/m^2$, but they were not abundant enough to count within quadrats. All those we saw were 125-140 mm, and there were no juveniles.

The SUBSTRATE was head-sized rocks on gravel, on a nearly level bottom in 3 m. The CANOPY was very dense Macrocystis, forming an 80% cover at the surface. Beneath it were Agarum and a bit of Laminaria at 50% cover; a 25-50% turf of erect corallines; and bright pink lithothamnion on the rocks themselves. The bedrock on the shore inside the kelp forest supported SEA URCHINS at $5/m^2$ and smaller abalone at the same low density as the kelp forest.

COMMENTS

For fishing history of this shore see Station 117. This site was a typical sheltered Macrocystis forest, and did not have a commercial quantity of abalone.

STATION 122. Kiju Point (CARPENTER BAY)

52 13 30 N; 131 05 24 W

The MEAN DENSITY was $0.19/m^2$. None of the abalone seen were legal sized.

The SUBSTRATE was bedrock and very large (car-sized) boulders sloping at 5-20°. There was a narrow band of Pterygophora and a coralline turf in the upper subtidal zone, then only a mixture of 20% lithothamnion and 80% green Hildenbrandia. SEA URCHINS were present, but their density was less than $1/m^2$.

COMMENTS

For the fishing history of this shore, see Station 118. This site had no legal abalone, and we thought that it might not have been suitable habitat. The high percentage cover of green Hildenbrandia and low abalone density was very similar to Station 120.

STATION 123. West of South Cove (CARPENTER BAY)

52 13 48 N; 131 07 36 W

Only two abalone were found in 16 quadrats, both legal to 140 mm. Others were seen in the area, but their abundance was as low as the quadrat results suggest. There were no juveniles, and we estimated that 80% were legal.

The SUBSTRATE was steep intertidal bedrock to approximately 1-2 m (not surveyed carefully because of surge), changing to nearly level head-sized rocks on gravel. The CANOPY was Macrocystis forming 75% cover at the surface; a mixture of Agarum and Laminaria beneath it forming 25% cover; a 50% turf of erect corallines; and a covering of pink lithothamnion on the rocks. Large Astraea were the dominant grazer under the kelp. There were no SEA URCHINS present under the canopy, but we noted them on the shallow bedrock at a density of $3/m^2$. The rocks there were covered mostly with green Hildenbrandia.

COMMENTS

For fishing history of this shore of Carpenter Bay, see Station 118. This site is a typical Macrocystis forest, but did not have a commercial denstiy of abalone.

STATION 124. South shore of CARPENTER BAY

52 13 25 N; 131 03 13 W

The MEAN DENSITY was $3.38/m^2$ (variance 21.18). The sizes of abalone collected from quadrats are shown in Fig. 48. Approximately 2-5% were legal, for a LEGAL DENSITY of less than $0.20/m^2$.

The SUBSTRATE was smooth bedrock in irregular formations that included large areas of level, smooth bottom in 1-2 m, as well as canyons and gullies with steep walls. Boulders and smaller rocks on sand began in about 4 m. The ALGAE were Pterygophora and L. setchellii, forming dense sub-surface canopies with a 90% cover of erect coralline turf beneath them, and pink lithothamnion under that. SEA URCHINS were found in the deeper gullies and crevices, and at the bottom edge of the kelps in about 2 m. There was an abundance of Tegula, Tonicella, A. mitra, and Calliostoma ligatum in this area. Abalone were concentrated in the Pterygophora and Laminaria forests, where these quadrats were made.

COMMENTS

For the fishing history of this shore, see Station 118. This site was surveyed at site 10 in Breen, Stefanson, and Adkins 1978. Between the April and August surveys, there was an apparent decrease in

the percentage of legal sizes, but this may have been caused both by the April sampling and the difference in sampling methods. At any rate, there was not a commercial quantity of legal abalone at the time of this survey.

## STATION 125. Inside Marion Rock (COLLISON BAY)

52 17 23 N; 131 06 30 W

The MEAN DENSITY was 0.94/$m^2$ (variance 2.26); of these 20% were estimated to be of legal size, for a LEGAL DENSITY of 0.19/$m^2$. The legal abalone were just at or over legal size, and we noted that the 25 mm individuals we found in the coralline turf appeared to be old.

The SUBSTRATE was bedrock sloping at 45° in the intertidal and upper subtidal zones, changing to mized sizes of round rocks lying on gravel, with a shallow slope, in 1-2 m. ALGAE were limited to Pterygophora and dense corallines forming a narrow band on the shallow bedrock. SEA URCHINS were present, up to a density of 10/$m^2$, but were very localized. Abalone were present in both zones. The other grazers noted were A. mitra and C. ochracea. Tonicella was present but not important. Abalone were concentrated at the lower end of the coralline turf, but were also present on the mixed rock and gravel bottom. Quadrats were made in both areas.

### COMMENTS

Collison Bay was reported harvested in both 1977 (3,000 lb) and 1978 (8,500 lb). This site did not have commercial quantities of abalone.

## STATION 126. Iron Point (CARPENTER BAY)

52 15 02 N; 131 05 05 W

The MEAN DENSITY was 1.19/$m^2$ (variance 1.10). Less than 5% were legal, and 80-90 mm was the modal size. No juveniles were found.

The SUBSTRATE was bedrock sloping at 30°. The ALGAE were intertidal Phyllospadix, Egregia, Hedophyllum, and Laminaria, with a 90% coralline turf; all ending just below datum, where SEA URCHINS began at a density of less than 1/$m^2$; and the rock was covered only with lithothamnion. The other grazers were noted were A. mitra, a few Tegula and green sea urchins, Tonicella and Patiria.

COMMENTS

For the fishing history of this part of Carpenter Bay, see Stations 115 and 117. There was not a commercial density of abalone at this site.

STATION 127. West side of Gona Point (COLLISON BAY)

52 17 06 N; 131 06 32 W

The MEAN DENSITY was 1.13/$m^2$ (variance 1.32); the sizes of abalone collected from the quadrats are shown in Fig. 49. None were legal size, and no juveniles were found.

The SUBSTRATE was steep (70°) smooth bedrock, changing to boulders on bedrock in 4 m. There were no ALGAE except intertidal Codium and Egregia ending above datum; and white lithothamnion and green Hildenbrandia mixed with Dodecaceria in deeper water. Much of the rock surface was barren. SEA URCHINS began just above datum, at 3/$m^2$ density, decreasing rapidly with depth. The other important grazers were large Astraea at 1/$m^2$.

COMMENTS

For the fishing history of this area see Station 125. This site did not have any legal abalone.

STATION 128. Southwest of Ingraham Point (CARPENTER BAY)

52 13 42 N; 131 00 53 W

The MEAN DENSITY was 2.31/$m^2$ (variance 9.56); there were no legals, but many juveniles of the first year-class were found (Fig. 50).

The SUBSTRATE was flat smooth bedrock in 3-4 m. The CANOPY was Nereocystis, forming 30-40% cover at the surface. Under the outer part of this canopy was an undercanopy of Pterygophora. Corallines, bladed and polysiphonous reds (especially Botryoglossum) formed a 15% turf; and the rock itself was covered with lithothamnion at 80% cover. SEA URCHINS were present in patches under the canopy with a density of up to 10/$m^2$; they were also found on barren bedrock in 5 m and deeper. The other important grazers were Tegula, a few S. droebachiensis and Cryptochiton. Acmaea mitra, Astraea, and Calliostoma were present but not abundant.

COMMENTS

This site resembled Station 52. It was a habitat probably too exposed to produce legal abalone, and had relatively high numbers of exposed juvenile abalone.

STATION 129. West side of largest Nest Islet (COLLISON BAY)

52 17 35 N; 131 07 33 W

Only three abalone were found in 16 quadrats, all sub-legal. Two abalone near 25 mm were seen outside quadrats.

The SUBSTRATE was smooth granite bedrock descending at an average slope of 20° or less. The ALGAE were intertidal Pterygophora and coralline turf, which both ended sharply at datum, where SEA URCHINS began and the rock was barren. In the upper subtidal zone, sea urchin density could not physically have been higher, and we estimated it to be in excess of $30/m^2$. The most abundant grazer after sea urchins was A. mitra.

COMMENTS

For the fishing history of this area see Station 125. This site had the appearance of a habitat too exposed to produce legal abalones.

B. ANALYSIS BY HABITAT

As the preceding descriptions show, we found abalone in almost every place where suitable substrate existed: from very exposed to very sheltered situations, and in plant communities featuring several different large kelps. While we were carrying out the survey we noticed some consistent relationships between the habitat type and the size and number of abalone. These relationships are very important to understand, because the focus of this survey was on size and abundance of abalone in different places. It would not be possible to understand the results without first understanding how abalone populations vary among different habitats.

The kind of plant community that we observed at a particular place could be influenced by many factors: a few of the most important ones might be exposure to surge, the amount of light falling on the water surface, the substrate type and slope, the abundance of grazers, and the immediate past history or successional stage of the site. Some of these might affect abalone abundance as well; and this would explain why there were predictable associations between abalone and kelp. It was well beyond the scope of this survey to relate the existence of particular plant communities to these other factors. Instead we simply tried to

relate the plant community, as defined by the plants present, to the abalone populations. We grouped stations by using the most abundant kelps (measured as percent cover) in the canopy and upper stories.

Results are shown in Table 1. Of the sites with abalone present, 107 fell into the eight groups shown. Abalone were least abundant in Macrocystis forests; (in places with bottom-form Macrocystis they were always either absent or too scarce to count). However, the proportion of legal abalone was always high in the surface Macrocystis communities, and many of the sites were commercial.

In the Nereocystis communities, abalone were about twice as abundant, but the proportion of legal sizes was always much lower than in Macrocystis forests, so legal density varied. The least abundance of legal abalone was found where annual kelps dominated the understory. The annuals are perhaps indicative of regular disturbance, eg., by grazers or the effects of storms, that prevents the establishment of perenniel kelps. One would thus expect such places to be poor for abalone growth. The highest density of legal abalone beneath Nereocystis canopies was found where there was Pterygophora, indicative of stable substrate with considerable exposure.

The highest average density of legal abalone was found in Laminaria forests without a canopy. We encountered only four such sites on this survey.

The highest abalone density was observed in forests of Pterygophora without an overcanopy. Density of all sizes averaged $28/m^2$ at site 71. However, legal sizes averaged 3%, so the average legal density was lower than in Nereocystis forests.

In communities dominated by sea urchins, abalone density was around Nereocystis forest levels, but again only 3% were legal, and average legal density was very low. This is somewhat misleading: of 27 sites, 20 had either no legals or too few to count, and four of the remainder had legal densities greater than $0.30/m^2$.

Size frequencies observed in the Macrocystis, Nereocystis, Pterygophora, and sea urchin communities are shown in Fig. 51 through 54. In all these figures, the proportion of small individuals appears to be under-represented. This results first, from our sampling technique: we collected only those abalone which were visible without turning over rocks (except on the Fairbairn shoals). Second, the vertically stratified sampling at site 71 shows that juveniles tend to be found in deeper water and adults in more shallow water. All the sampling was done in the shallow adult habitat.

It is clear that the maximum size obtained by abalone varies among these communities, being largest in Macrocystis beds and least in sea urchin dominated areas. On this admittedly rough analysis, it appears that final size is related to the biomass of kelp production in the community, which decreases along the series Macrocystis > Nereocystis > Pterygophora > sea urchin communities. This series is also, roughly, one of increasing exposure to wave action. It is not possible to say definitely whether the differences in final size result from slower growth

Table 1. Abalone abundance in eight major community types.

| Community | # sites | # sites with too few abalone to count | # sites remaining | $\bar{x}$ abalone density #/$m^2$ | % legal | $\bar{x}$ legal density |
|---|---|---|---|---|---|---|
| Bottom-form Macrocystis | 6 | 6 | 0 | - | - | - |
| Surface-form Macrocystis | 23 | 3 | 20 | 1.14 | 46 | 0.52 |
| Nereocystis/Laminaria | 8 | - | 8 | 1.80 | 24 | 0.43 |
| Nereocystis/annuals | 11 | - | 11 | 2.26 | 16 | 0.36 |
| Nereocystis/Pterygophora | 16 | - | 16 | 2.29 | 29 | 0.65 |
| Nereocystis/Laminaria | 5 | 1 | 4 | 3.75 | 20 | 0.76 |
| Pterygophora | 8 | 1 | 7 | 9.47 | 3 | 0.32 |
| No kelps; sea urchins | 30 | 3 | 27 | 2.26 | 3 | 0.08 |
| | Σ 107 | 14 | 93 | $\bar{x}$ 2.59[a] | 15 | 0.38 |

[a]Overall means.

or higher natural mortality, or both, in the sea urchin and Pterygophora communities. There is no way to determine the age of an abalone from rings or other annual depositions. Age can be guessed at from size, knowing the growth rate. Growth rate has been measured only within Nereocystis communities. The appearance of abalone shells from different habitats suggests that growth rates are not the same in each community: for instance, 50 mm shells from Nereocystis communities are usually quite clean, low, and thin and brittle at the leading edge. The same size shell from a Pterygophora or sea urchin habitat may be heavily encrusted (or alternatively eroded so that the nacre can be seen around the apex), the height is often great, and the leading edge may be thick and smooth. This suggests that the same size shells are very different ages in the two different habitats, hence that growth rates are very different. In turn, this would indicate that differences in final size are accounted for by differences in the pattern of growth, rather than resulting from higher natural mortality rates in the sea urchin and Pterygophora habitats.

Whatever the cause of the differences seen in Fig. 51 through 54, there are obvious differences in the ability of each site to produce abalone. In the sea urchin and Pterygophora habitats, few abalone reach legal size. The sea urchin habitat has only low total densities as well, and so these areas will never be important for abalone production. If, as the Australians and Californians believe, abalone fishing releases a competitive pressure on sea urchins, allowing them to take over the habitat, this could be a serious limitation to sustained production. Some of the sites now dominated by sea urchins may once have been productive kelp communities. In Pterygophora forests also, few abalone reach legal size. The high density usually found in this habitat may influence growth; and obvious next steps are to measure growth rates in Pterygophora beds, and to measure the effect of thinning out the beds on the remaining population.

In Macrocystis beds, the low abalone density, lack of juveniles, and the very large size of legal abalone all suggest that the existing populations have accumulated over a long period of time and that annual production is low. Macrocystis beds may be the prime place to harvest abalone in the initial fishery, but later production will probably be only a small fraction of the initial yields. The Nereocystis forests are the best abalone-producing habitat. Because growth rates were measured in this community, some estimates of production can be made.

## C. ANALYSIS BY AREA

Stations were grouped into major areas, as shown in Table 2. Of 131 stations occuppied, 124 fell into one of the twelve groups, and the rest were isolated or duplicate stations. Mean abalone density was calculated only from the stations that remained after dimination of those with no measurable abundance of abalone or no legal abalone. In some instances, this procedure may have eliminated sites that had actually been harvested and consequently had abalone densities too low to measure. For

instance we are reasonably certain that Station 97 was heavily harvested, and the fishery was able to remove nearly all the legal abalone from the flat smooth substrate. However, such cases were probably rare. If there is error in this procedure, it produces an estimate of average abundance that is too high.

In Table 2 it can be seen that mean abalone density varied from about $1/m^2$ in Rockfish Harbour to $5.31/m^2$ at Werner Bay. There was a strong influence of habitat type contributing to these figures: in Werner Bay, four of the seven sites were Pterygophora communities, hence the high densities. In the Cumshewa and Selwyn Inlet groups, the greater number of sites were Macrocystis forests, reflected in the low abalone densities and high percentage of legal sizes.

Among the areas, legal density varied much less than total density. The range was only from $0.17/m^2$ at Poole Inlet to $0.84/m^2$ at Kunga Island.

The closed area in Juan Perez Sound had the highest density of legal sizes after Kunga Island. This was expected, considering that the closure was enacted in 1973.

There were poor abalone stocks in the three southernmost areas: Skincuttle Inlet, Poole Inlet, and Carpenter/Collison bays. Each of these areas was fished moderately heavily in 1977 and 1978, and each showed lower landings in 1978 than in 1977. In each area, few sites had commercial quantities of legal abalone remaining, and the average legal densities were low. In these places, most of the accumulated stock has been removed.

## D. RECENT CHANGES IN ABALONE STOCKS

Several of our sites re-occuppied the stations of previous surveys. Table 3 shows the equivalence of stations between this survey and those of Adkins and Stefanson (1977), Adkins (1978), and Breen et al. (1978).

At Haans Islet, we may have been a couple of hundred meters from the previous stations. The size frequency of abalone and the community type that we observed were very different from two previous surveys. Between 1976 and April 1978, however, legal density decreased from more than $3.5/m^2$ to about $1/m^2$. The size frequencies show a decline in the proportion of legal sizes.

Between 1976 and 1978, density on the Fairbairn Shoals decreased by a factor of at least 2 when the differences in methods among surveys are taken into account. Size frequencies show that the proportion of legal sizes has also been greatly diminished. (Fig. 55 shows the three samples taken on the shoals in this survey.)

Table 2. Abalone abundance in each major area surveyed.

| Area | Total # sites | Sites without measurable abalone[a] | Sites without legals | Remaining sites | $\bar{x}$ density #/$m^2$ | % legal | $\bar{x}$ legal density #/$m^2$ | # legal sites[b] |
|---|---|---|---|---|---|---|---|---|
| [c]Cumshewa Inlet | 20 | 8 | - | 12 | 1.30 | 40 | 0.52 | 7 |
| [d]Limestone | 10 | 1 | 1 | 8 | 2.15 | 23 | 0.50 | 6 |
| Selwyn Inlet | 5 | 2 | - | 3 | .94 | 36 | 0.33 | 2 |
| [e]Atli Inlet | 9 | 2 | 1 | 6 | 1.49 | 51 | 0.76 | 5 |
| Kunga Is. | 5 | - | 2 | 3 | 2.75 | 31 | 0.84 | 3 |
| [f]Juan Perez Sound | 22 | 3 | 8 | 11 | 3.42 | 24 | 0.81 | 7 |
| Outside Ramsay Is. | 3 | - | 3 | 0 | - | - | - | 0 |
| Werner Bay | 8 | 1 | - | 7 | 5.31 | 9 | 0.46 | 6 |
| Burnaby Strait/ Huxley Is. | 7 | 4 | 1 | 2 | 1.66 | 44 | 0.74 | 2 |
| Skincuttle Inlet | 13 | 3 | 3 | 7 | 1.63 | 19 | 0.31 | 3 |
| Poole Inlet | 6 | 1 | 1 | 4 | 3.49 | 5 | 0.17 | 1 |
| Carpenter/Collison Bays | 17 | 5 | 5 | 7 | 1.84 | 14 | 0.26 | 2 |
| Total | 125 | 30 | 25 | 70 | $\bar{x}$ 2.43[g] | 22[g] | 0.52[g] | 44 |

[a]Less than 0.1/$m^2$.

[b]Legal density > 0.30/$m^2$.

[c]To Skedans Point.

[d]Skedans Point to Haswell Is.

[e]Includes Tanu.

[f]Closed Area.

[g]Overall means. These are higher than means in Table 1 because sites without legal abalone were eliminated.

Table 3. Comparisons between surveys at the same sites.

| Place | Station | Adkins & Stefanson 1977 | Adkins 1978 | Breen et al. 1978 | Survey 1 | | Survey 2 | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Abalone density #/$m^2$ | % legal | Abalone density #/$m^2$ | % legal |
| Haans Islet | 3<br>Fig. 5 | Site 4<br>Fig. 7 | | Site 1<br>Fig. 5 | 5.7 | 65 | 2 | 51[a] |
| Fairbairn Shoals | 8, 9, 10<br>Fig. 55 | Sites 1, 2, 3<br>Fig. 6 | | Sites 2, 3<br>Fig. 6, 7 | 1.3 | 94 | 0.7 | 55[a] |
| Tar Islands | 51<br>Fig. 21 | Site 8<br>Fig. 8 | | | 4.4 | 15 | 3.38 | 3 |
| Ramsay Island | 64<br>Fig. 26 | | Site 5<br>Fig. 6 | | 4.4 | 55 | 3.63 | 15 |
| Bischof Island | 68<br>Fig. 29 | Site 9<br>Fig. 9 | | | 6.9 | 11 | 6.56 | 5 |
| Murchison Island | 72<br>Fig. 33 | Site 11<br>Fig. 10 | | | 10 | 0 | 7.06 | 0 |
| Harriet Island | 100<br>Fig. 40 | | Site 1<br>Fig. 2 | | 1.7 | 57 | 0.75 | 50 |
| Carpenter Bay | 124<br>Fig. 48 | | | Site 10<br>Fig. 13 | 5-10 | 10 | 3.38 | < 5 |

[a]Comparison between October 1976 and April 1978.

In the Tar Islands, within the Juan Perez Sound closure, density and size did not change between 1976 and 1978. In the Bischof Islands and at Murchison Island, also within the closure, density and size similarly did not change.

At the corner of Ramsay Island, where the closure line meets the shore, there was a significant decrease in legal abalone from July 1977 to August 1978.

At Harriet Island, there was a significant decrease in abalone density, from July 1977 to August 1978 from 1.7 to 0.75/$m^2$; and the legal density decreased from 0.97 to 0.38/$m^2$. In addition, there was a striking change in the community type, from a Nereocystis forest to a community dominated by sea urchins. The two surveys at this site were carried out in precisely the same spot.

At a site in Carpenter Bay, there was little change from April to August 1978. The change that was observed reflects differences in survey technique.

## E. OTHER CHANGES

As well as the change in community type that we observed at Station 100, and the possible change at Station 3, we found evidence of recent change at two other sites. At Station 93, in the upper end of Burnaby Strait, there were old Macrocystis holdfasts on a bottom dominated by sea urchins. The same observation was made at Station 117 in Carpenter Bay. Both areas had been moderately fished, and these observations lend support to the conjecture that sea urchins may invade abalone habitat in the wake of harvesting.

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We also thank Gaye Clowes, Sandra Poole, and Gloria Melluish for producing this report in time for the meeting.

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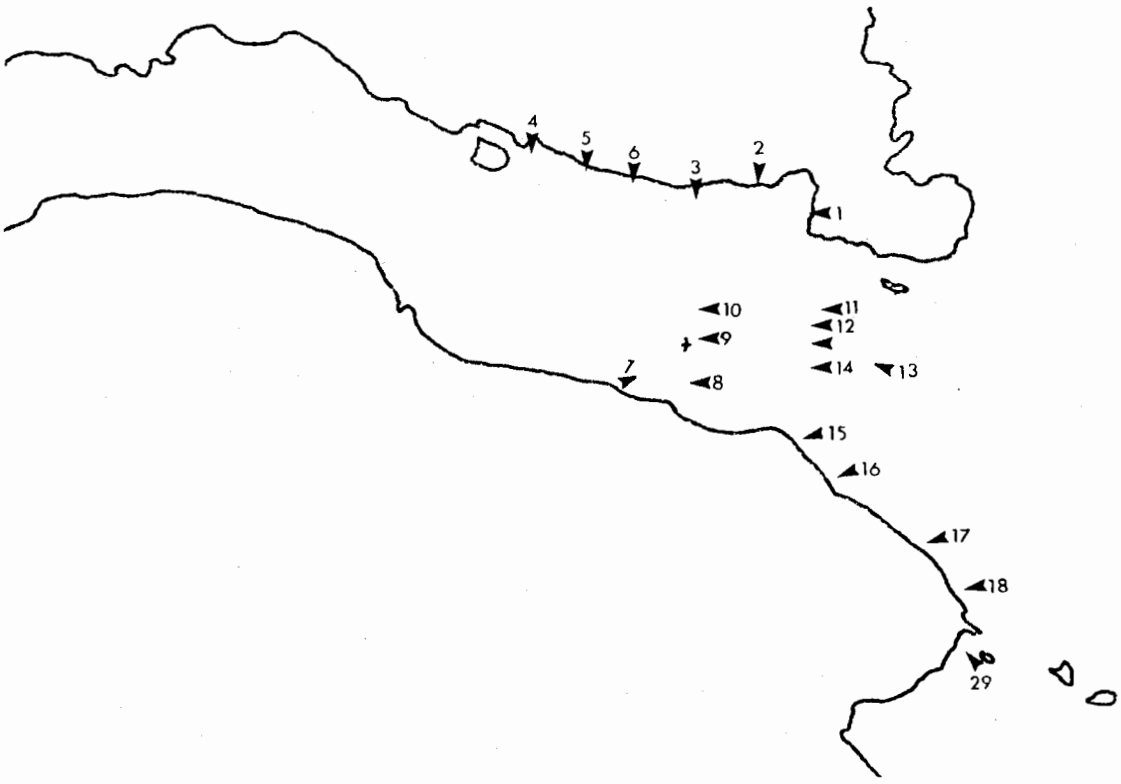



Fig. 1. Dive sites in the area from Cumshewa Head to Skedans Point.

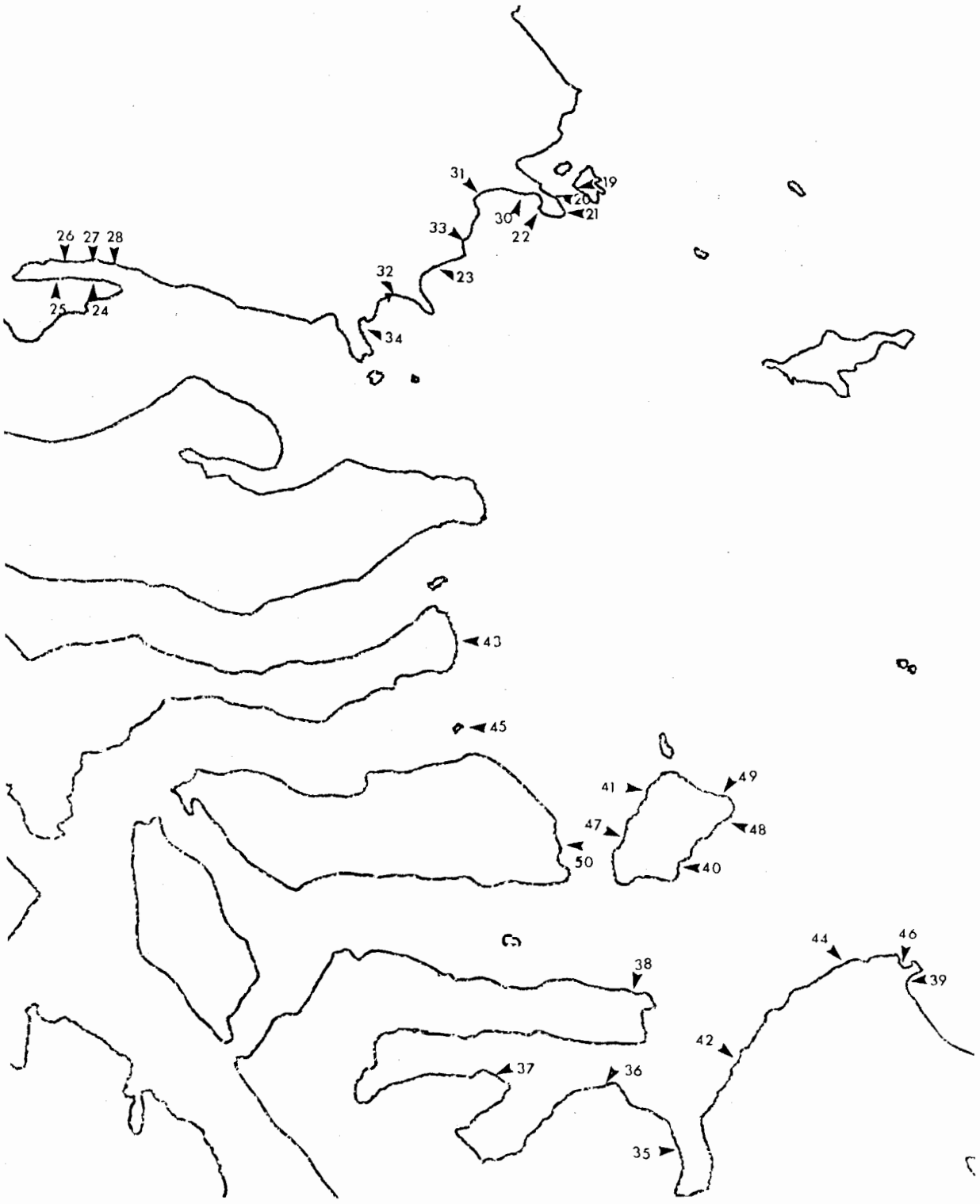



Fig. 2. Dive sites in the area from Limestone Islands to Dodge Point.

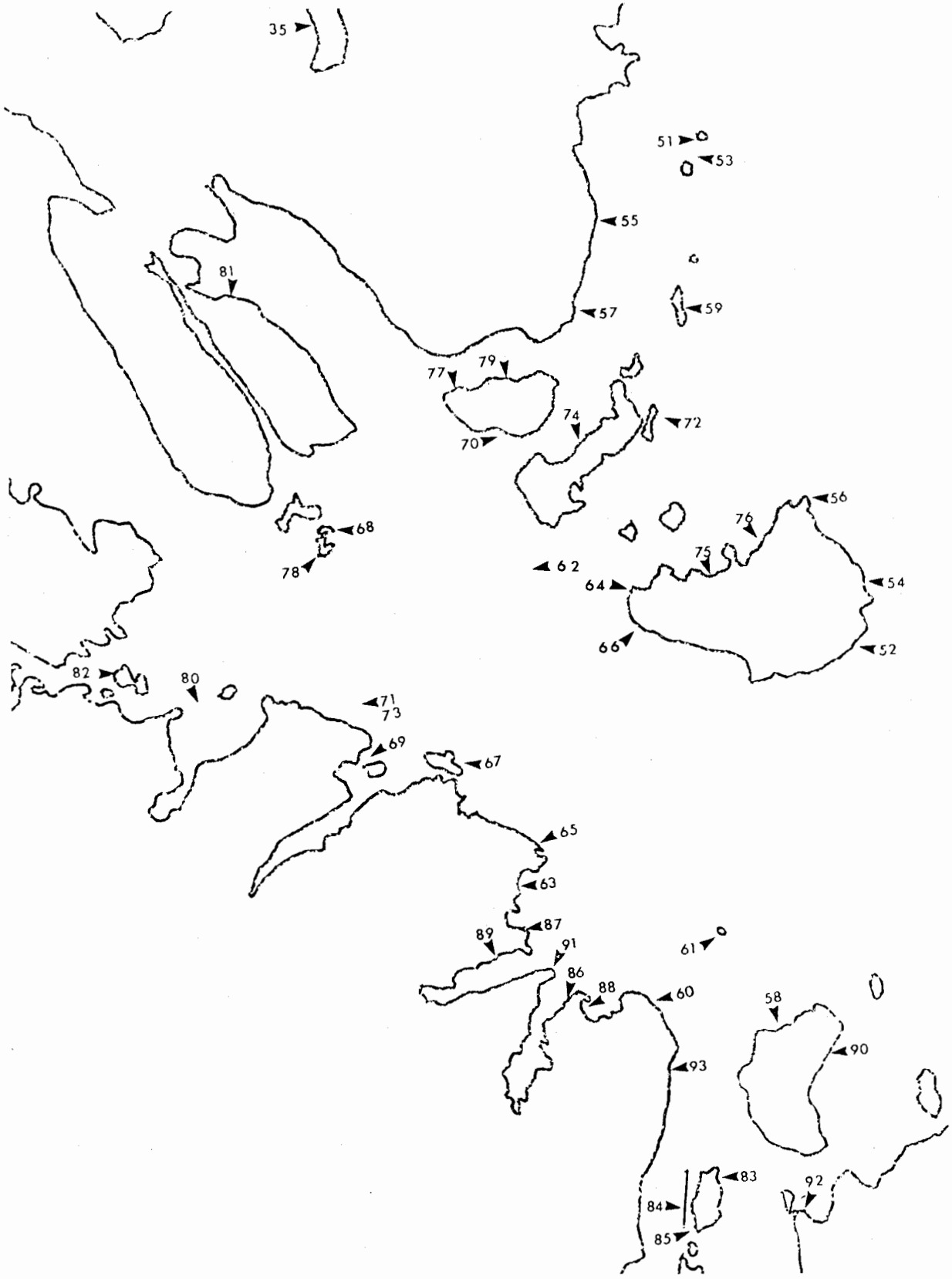


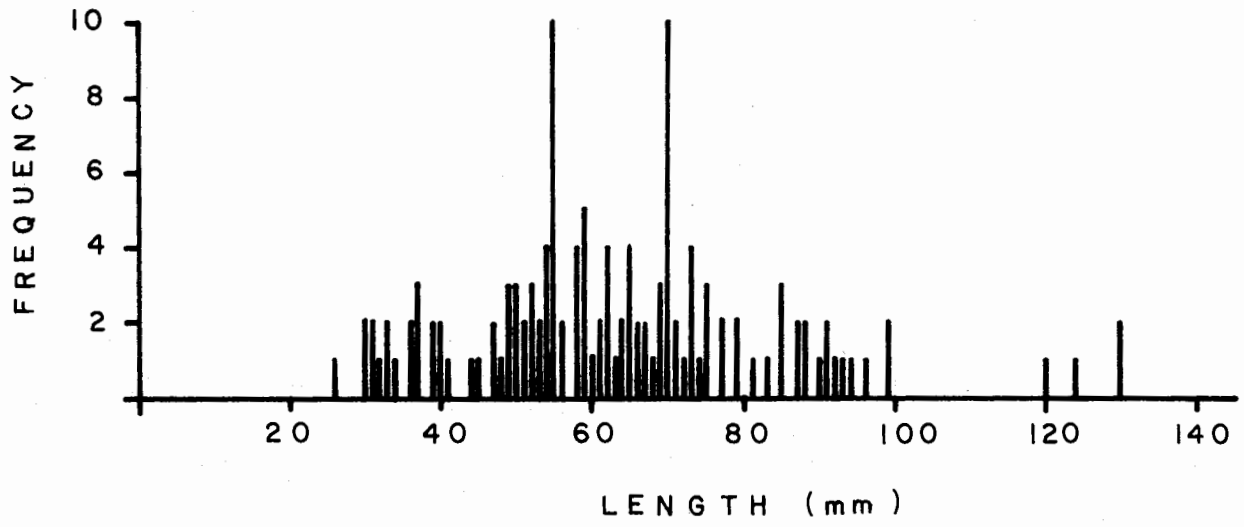

Fig. 3. Dive sites in the area from the Tar Islands to Burnaby Island.


Fig. 4. Dive sites in the area from Scudder Point to Ingraham Point.

Fig. 5. Abalone population structure at Haans Islet.

Fig. 6. Abalone population structure at a site on the Fairbairn Shoals.

Fig. 7. Abalone population structure at a site on the Fairbairn Shoals.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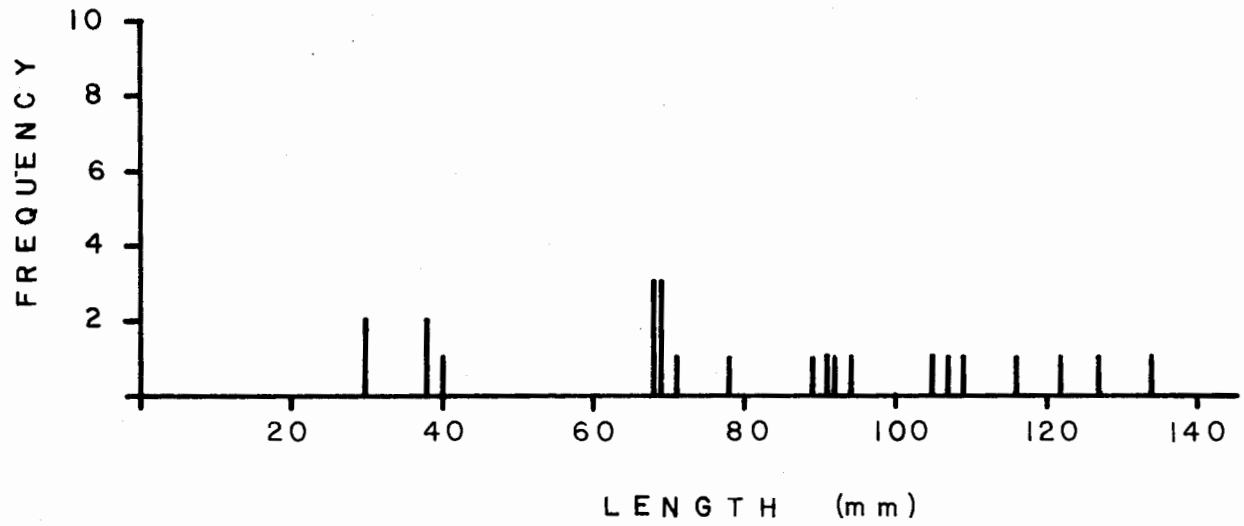
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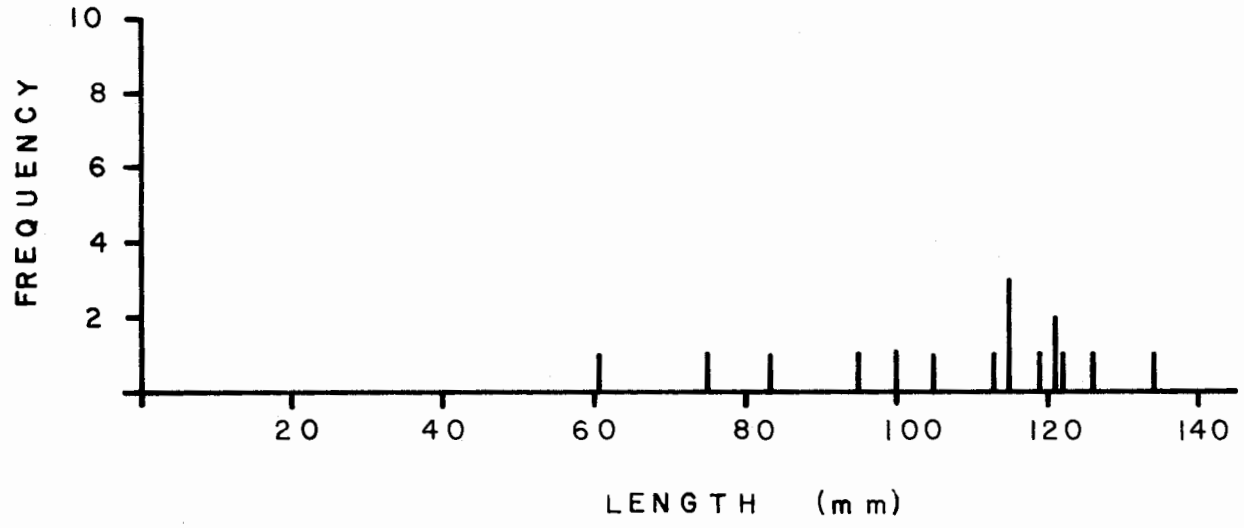
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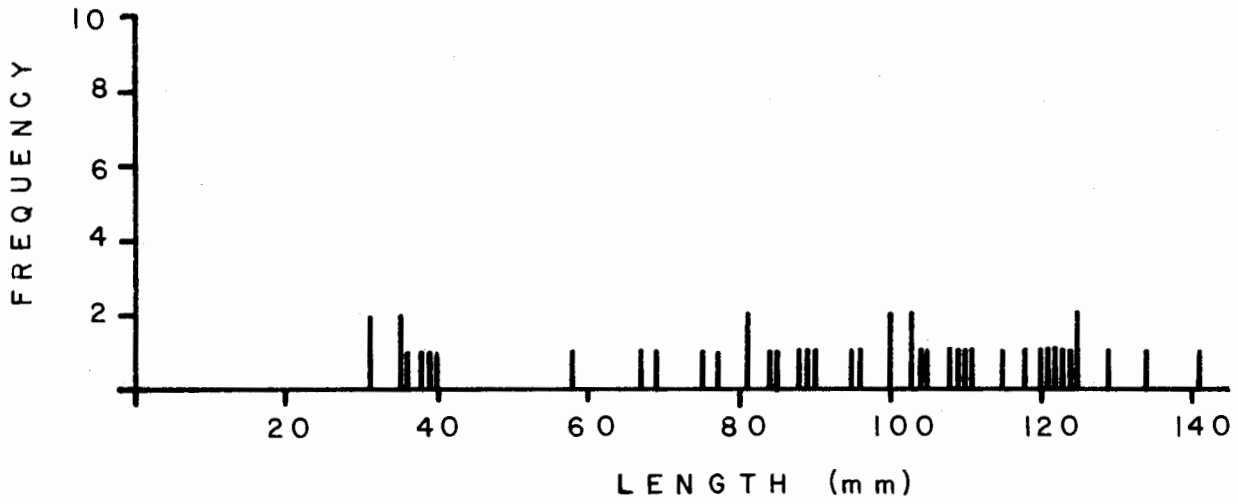
Fig. 8. Abalone population structure at a site on the Fairbairn Shoals.

Fig. 9. Abalone population structure at Girard Point.

Fig. 10. Abalone population structure east of Girard Point.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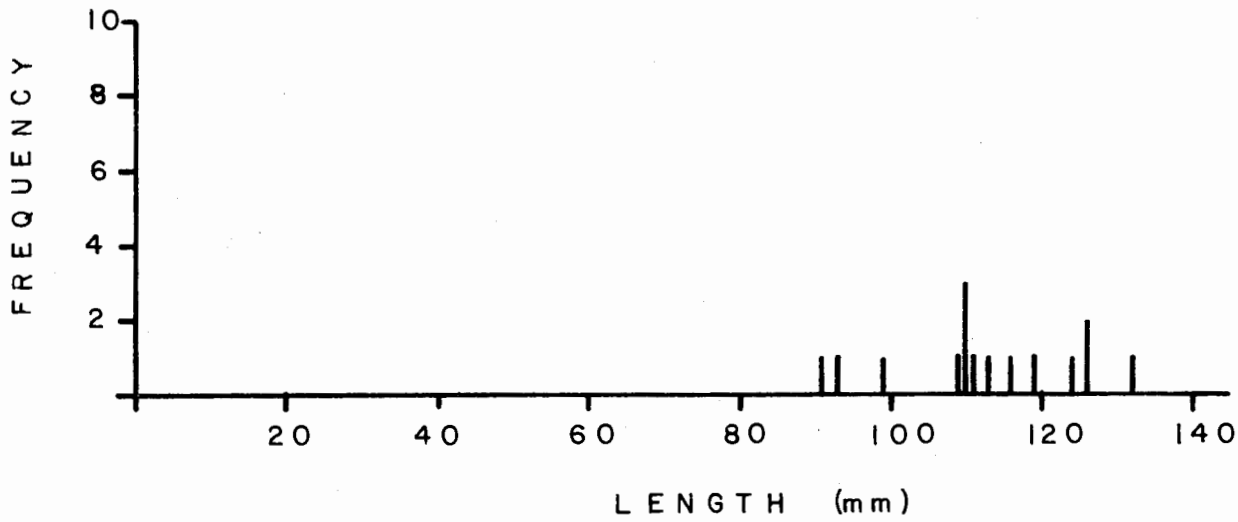
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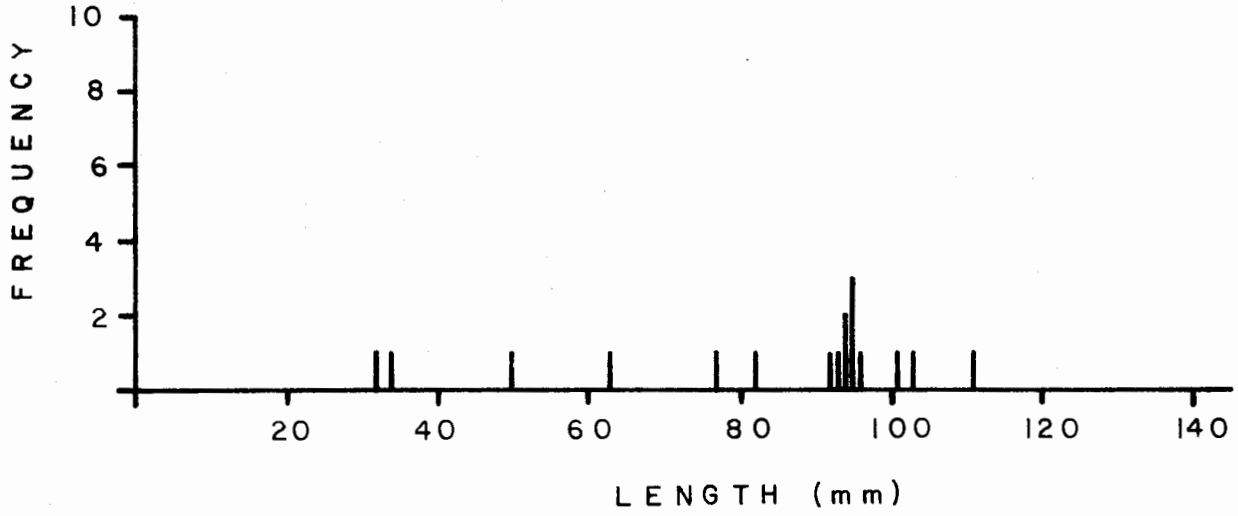
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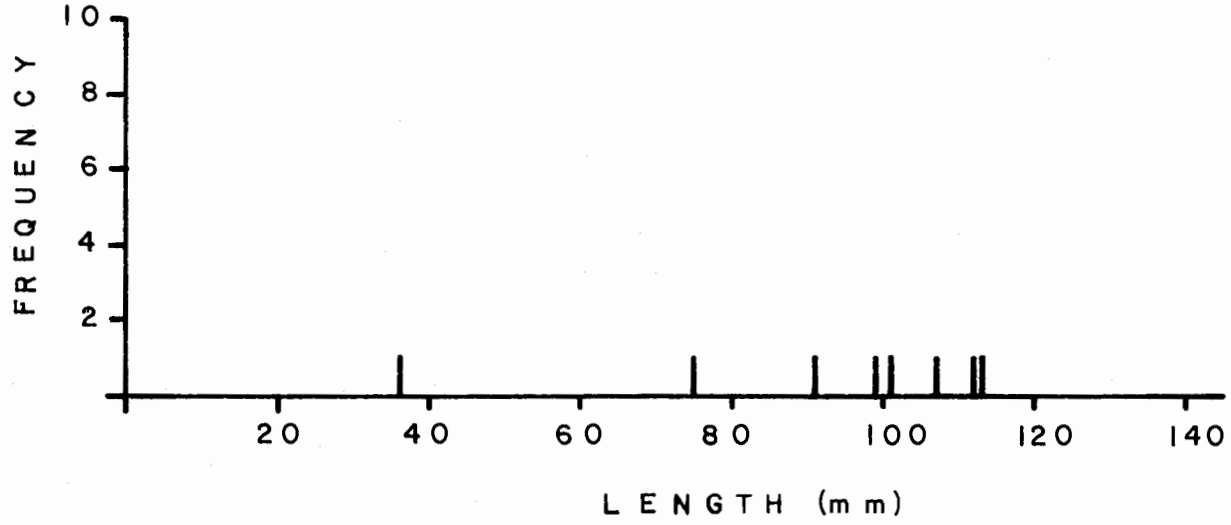
Fig. 11. Abalone population structure near False Point.

Fig. 12. Abalone population structure at False Point.

Fig. 13. Abalone population structure at Vertical Point.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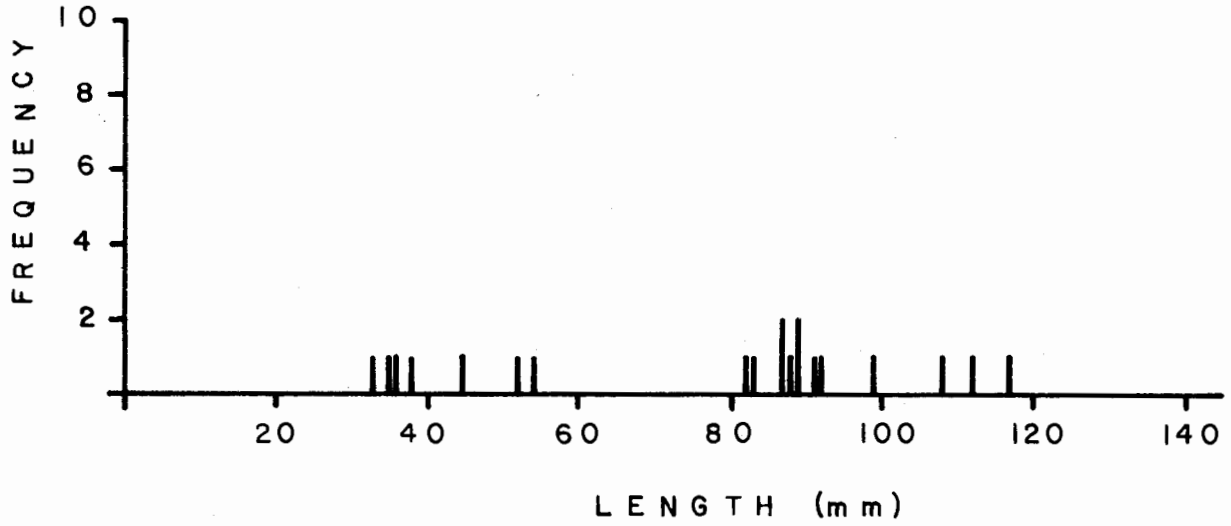
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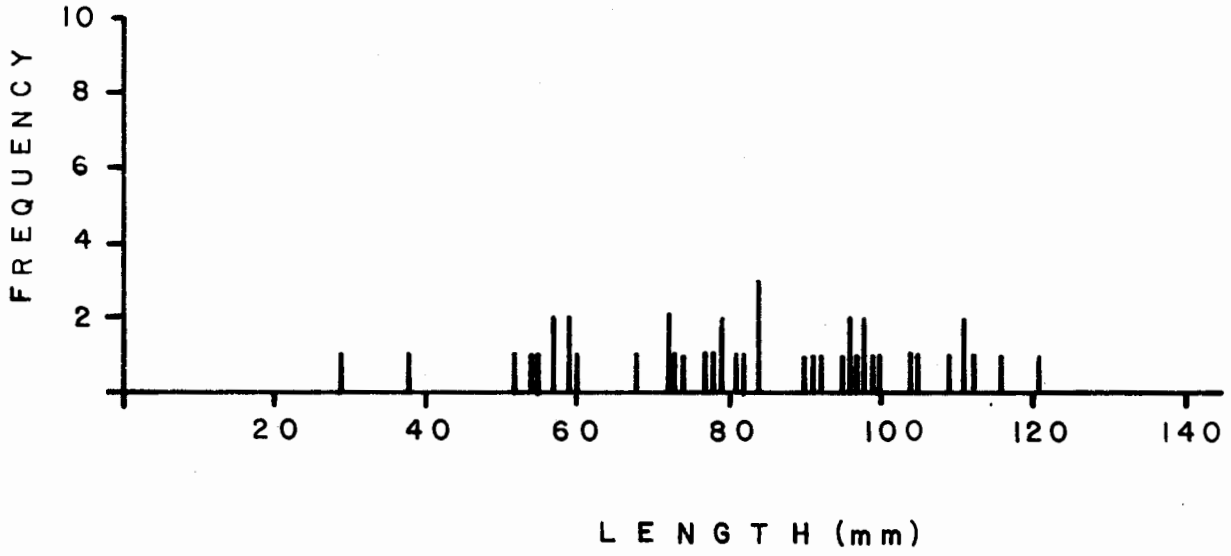
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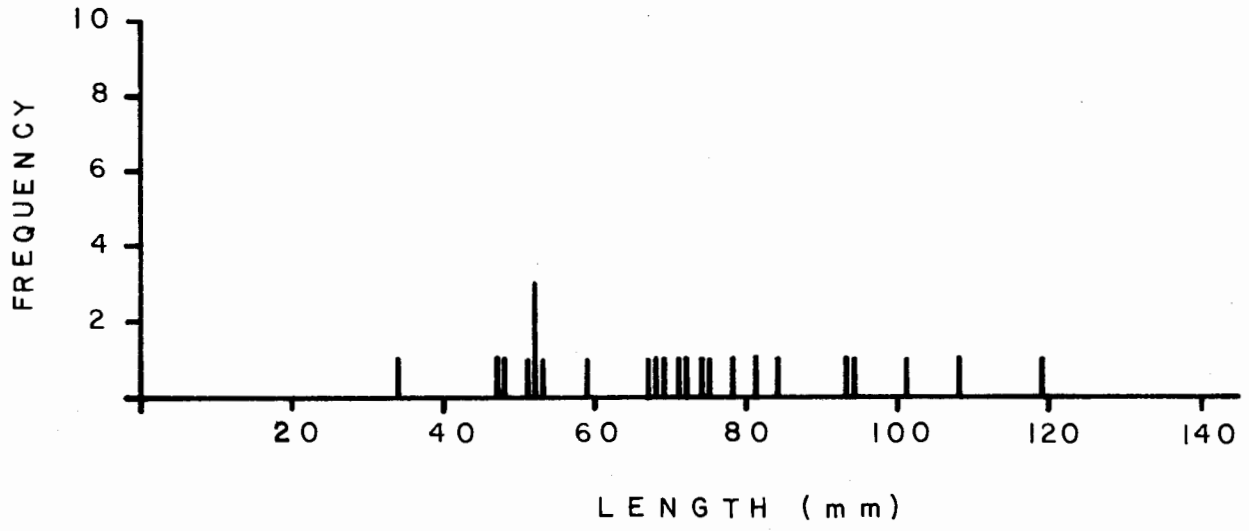
Fig. 14. Abalone population structure at a site on the north shore of Rockfish Harbour.

Fig. 15. Abalone population structure near Skedans Point.

Fig. 16. Abalone population structure at a site in Breaker Bay.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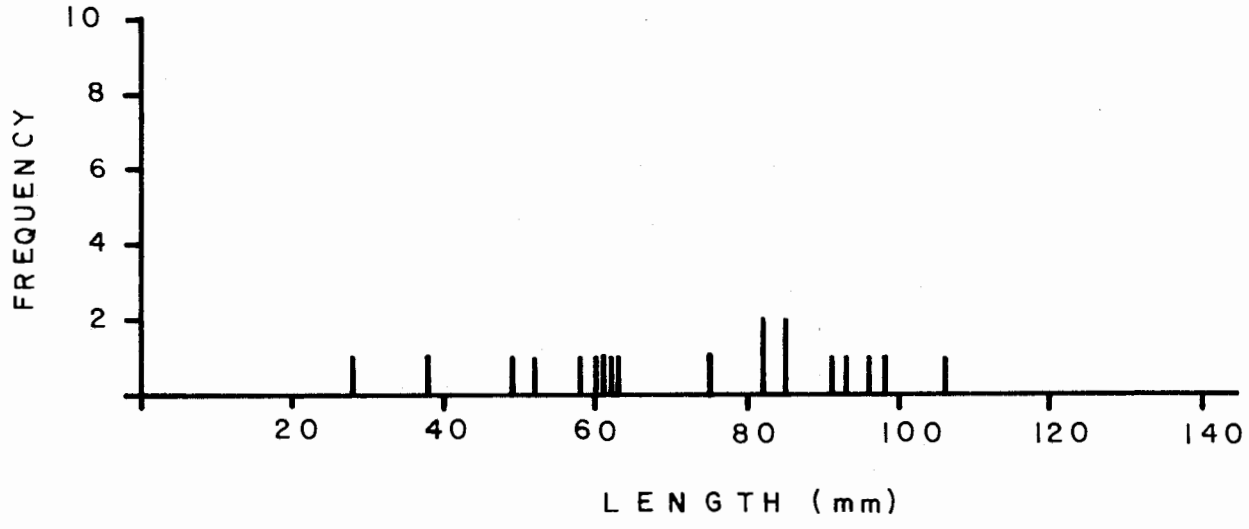
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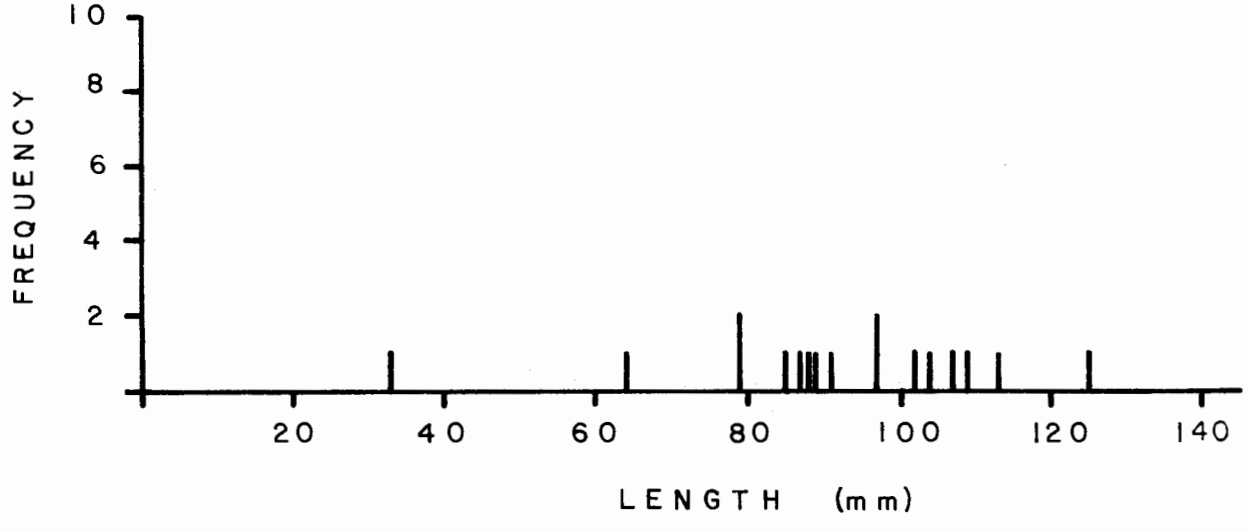
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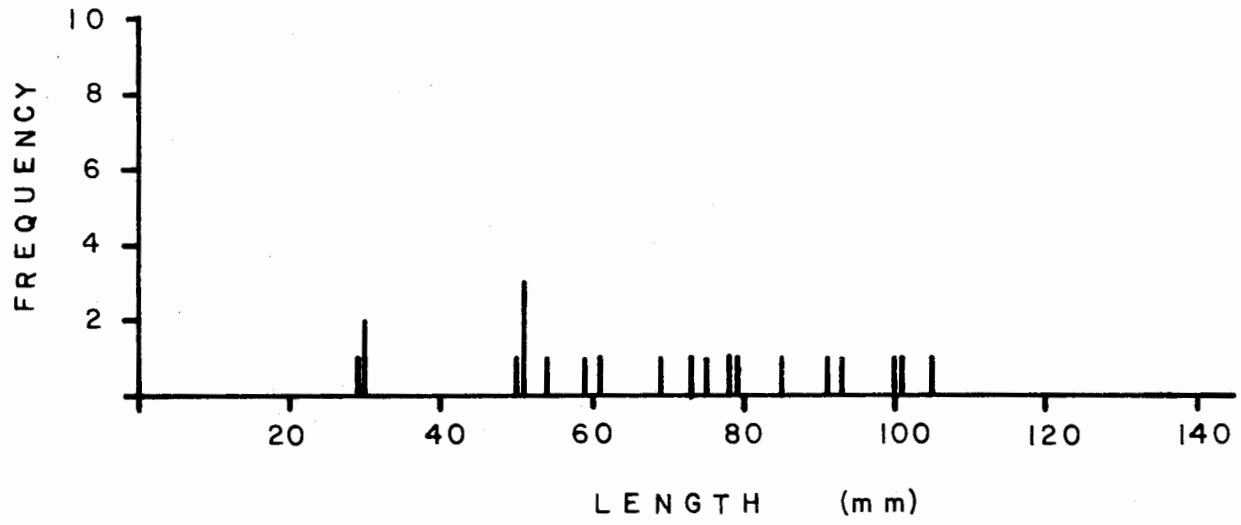
Fig. 17. Abalone population structure at a site west of Tsinga Point.

Fig. 18. Abalone population structure at a site on the northwest end of Kunga Island.

Fig. 19. Abalone population structure at a site in Atli Inlet.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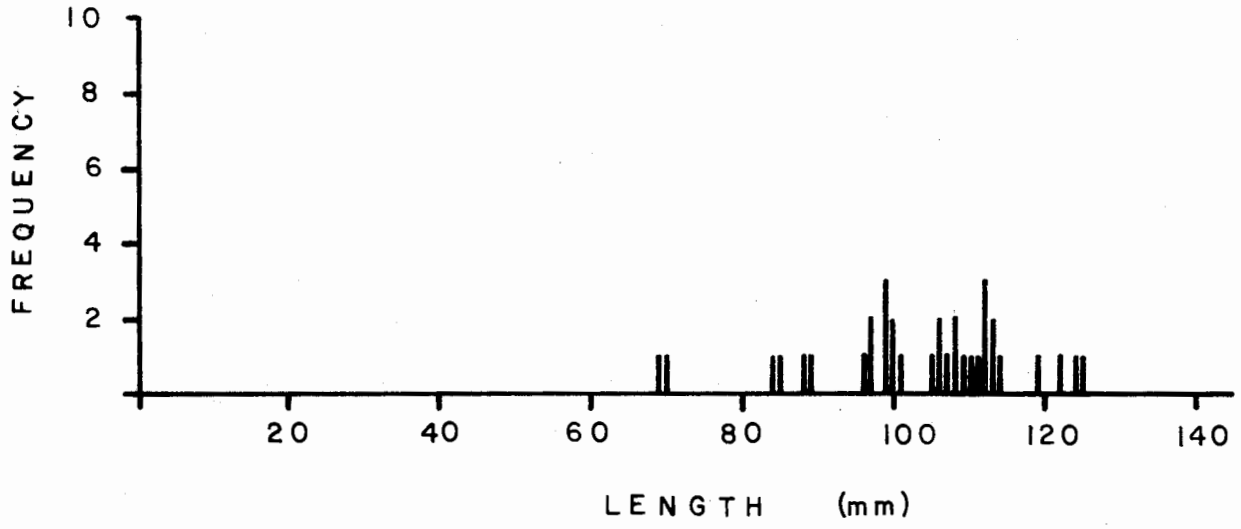
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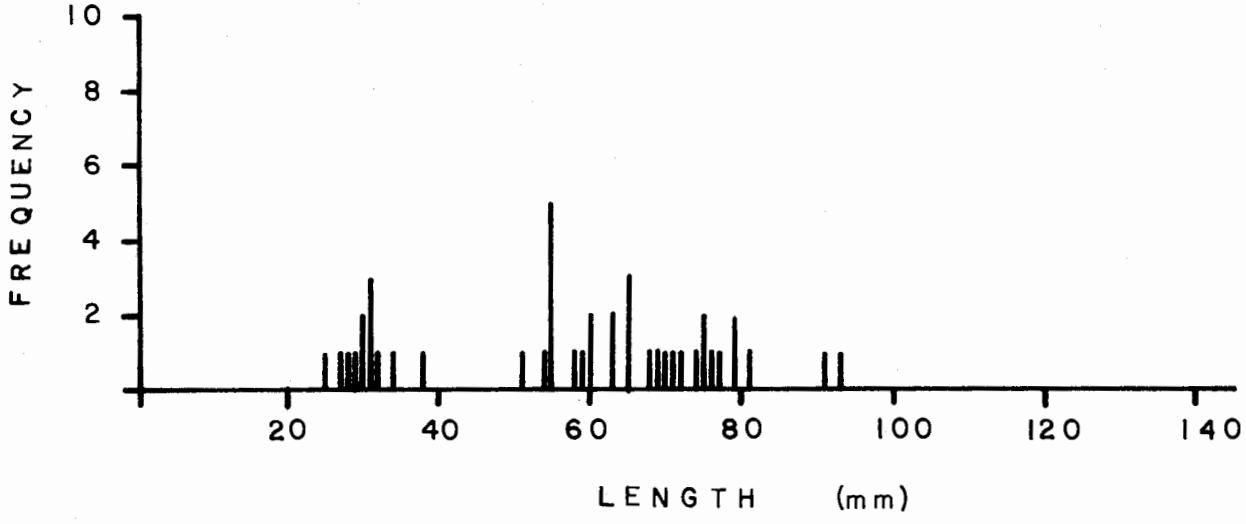
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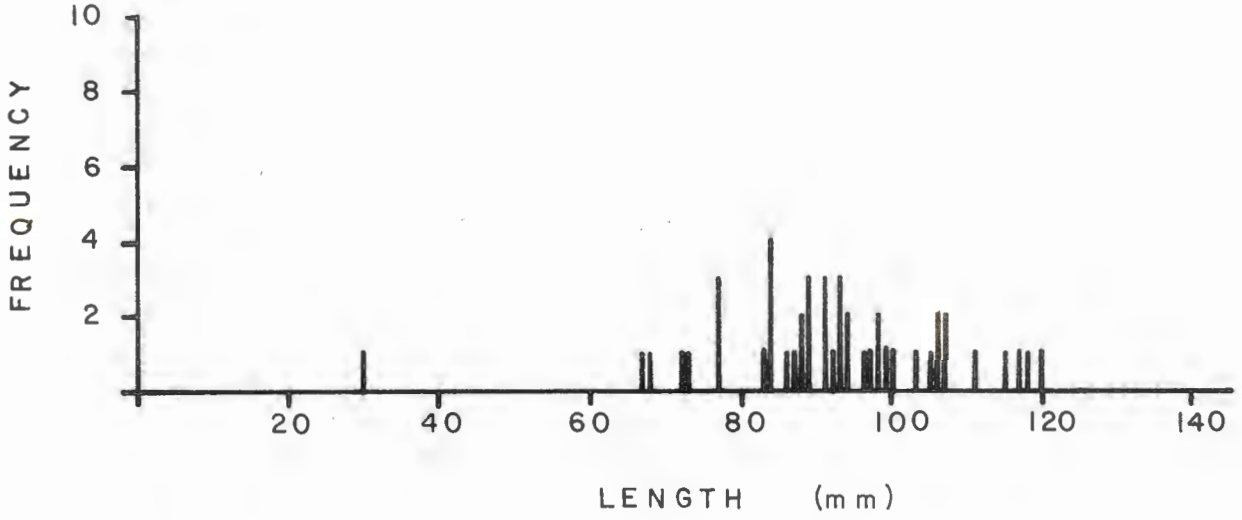
Fig. 20. Abalone population structure at Tanu.

Fig. 21. Abalone population structure at a site on the north side of the Tar Islands.

Fig. 22. Abalone population structure at Kloo Rock.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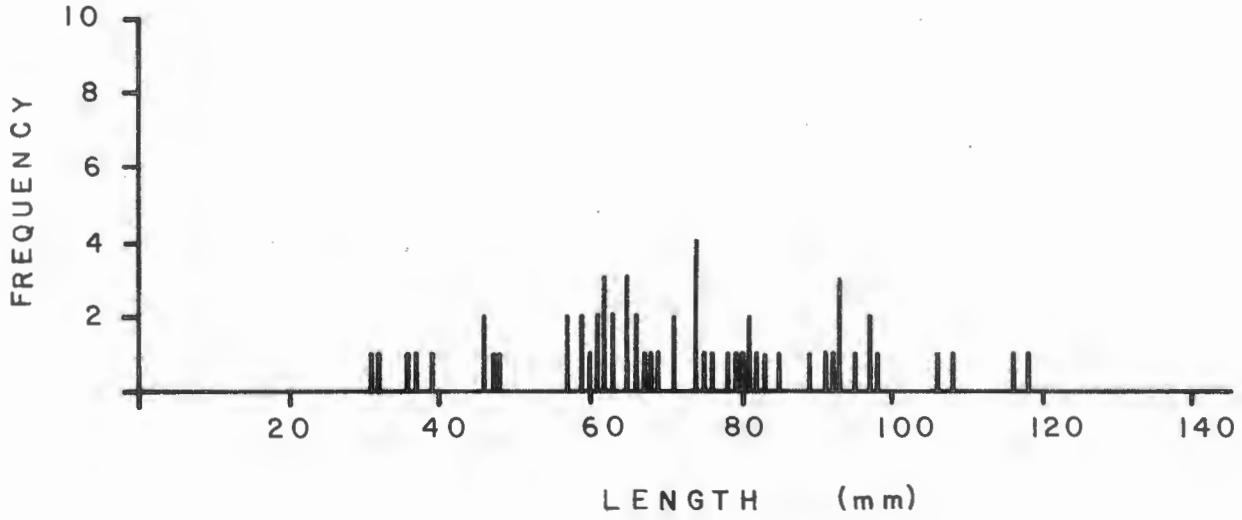
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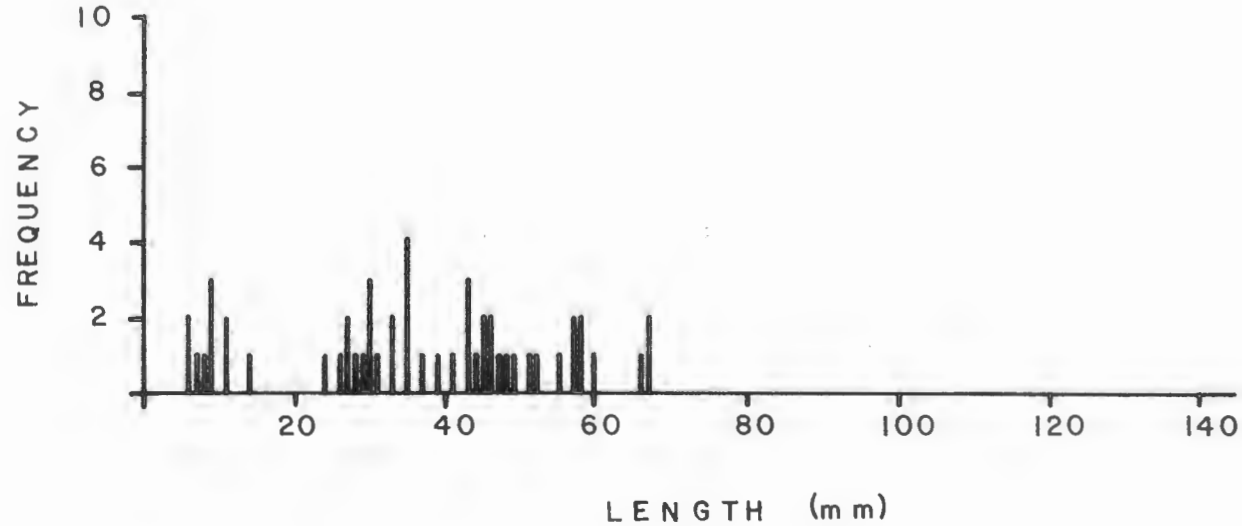
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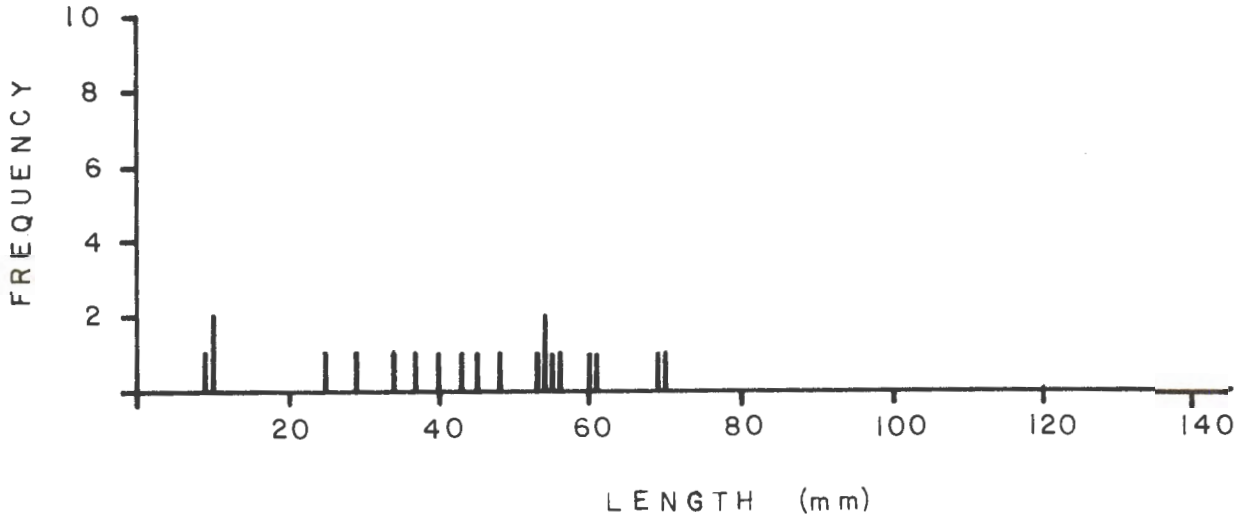
Fig. 23. Abalone population structure at a site on the north end of Huxley Island.

Fig. 24. Abalone population structure at All Alone Stone.

Fig. 25. Abalone population structure at a site near Werner Point.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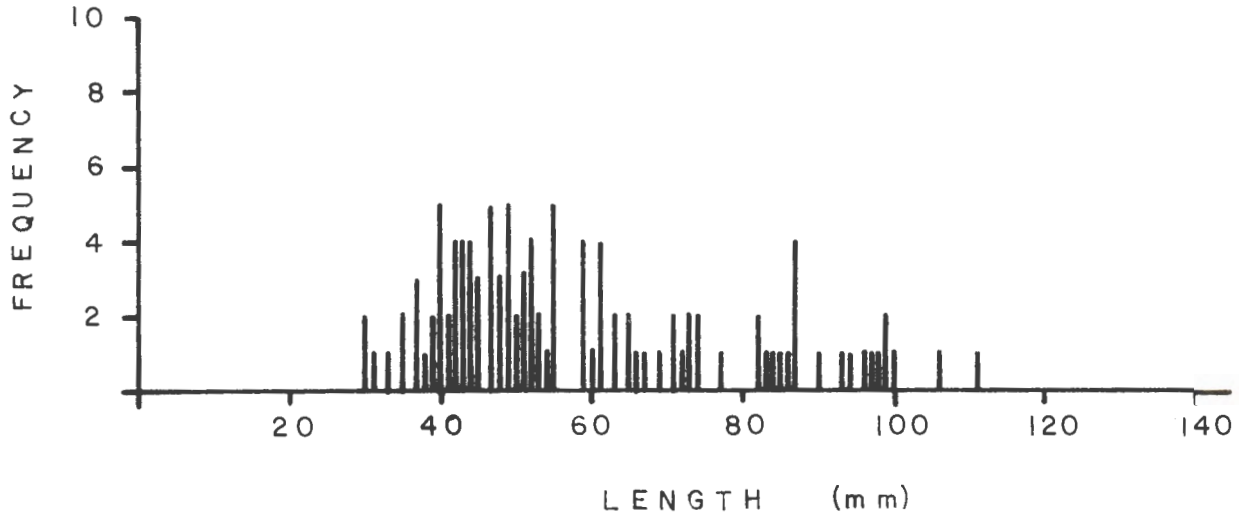
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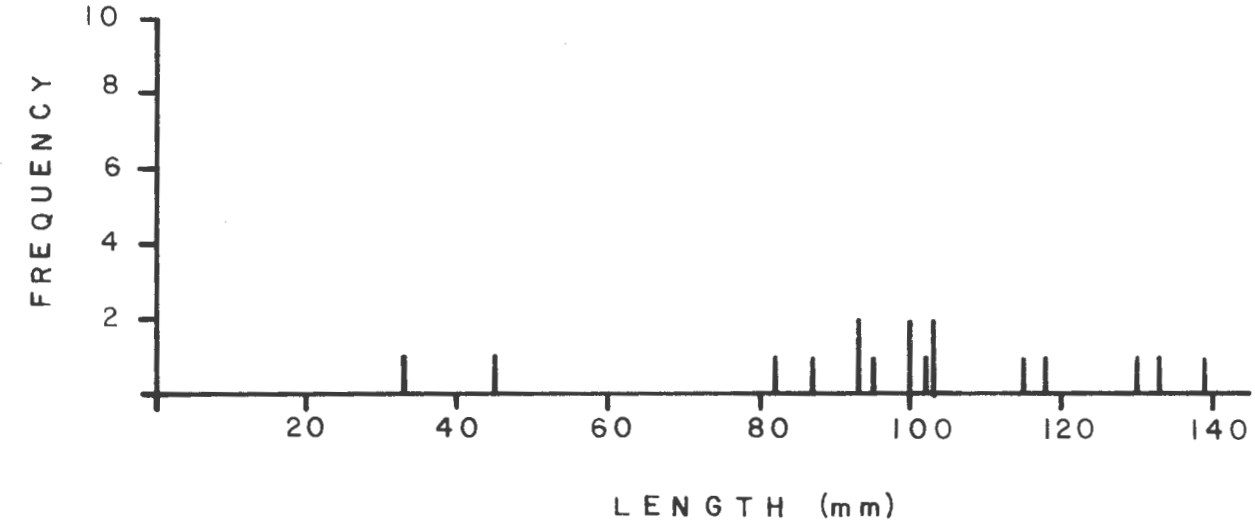
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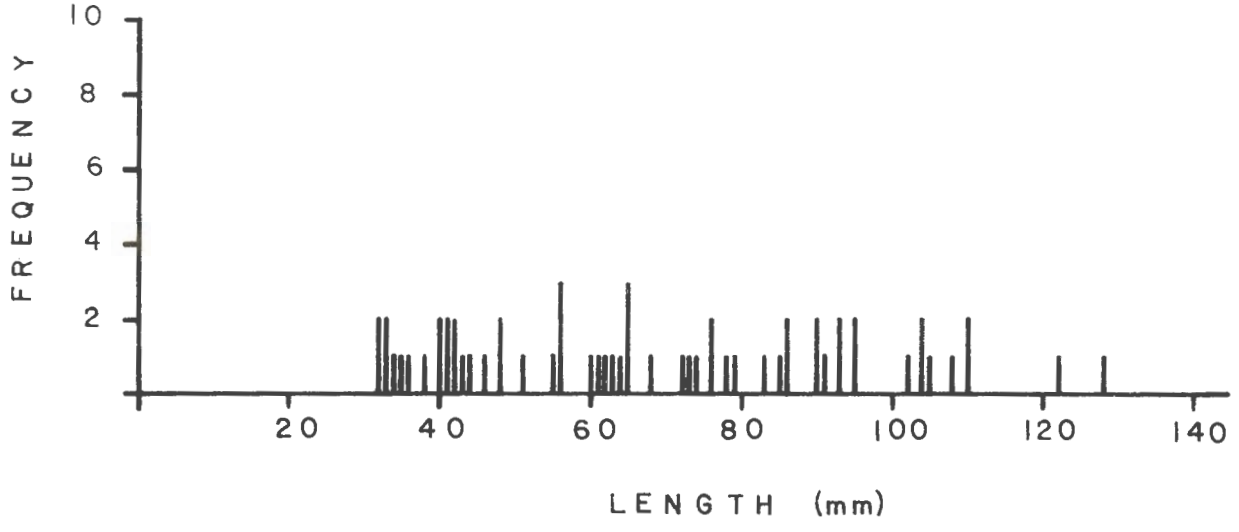
Fig. 26. Abalone population structure at Ramsay Point.

Fig. 27. Abalone population structure at a site in Werner Bay.

Fig. 28. Abalone population structure at a site on the west side of Ramsay Island.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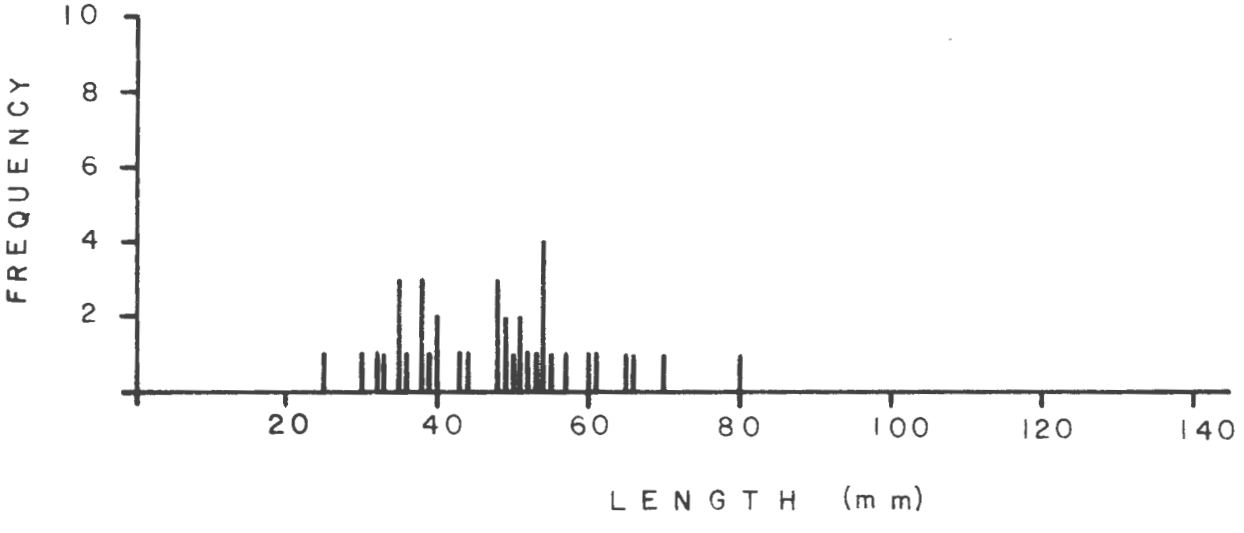
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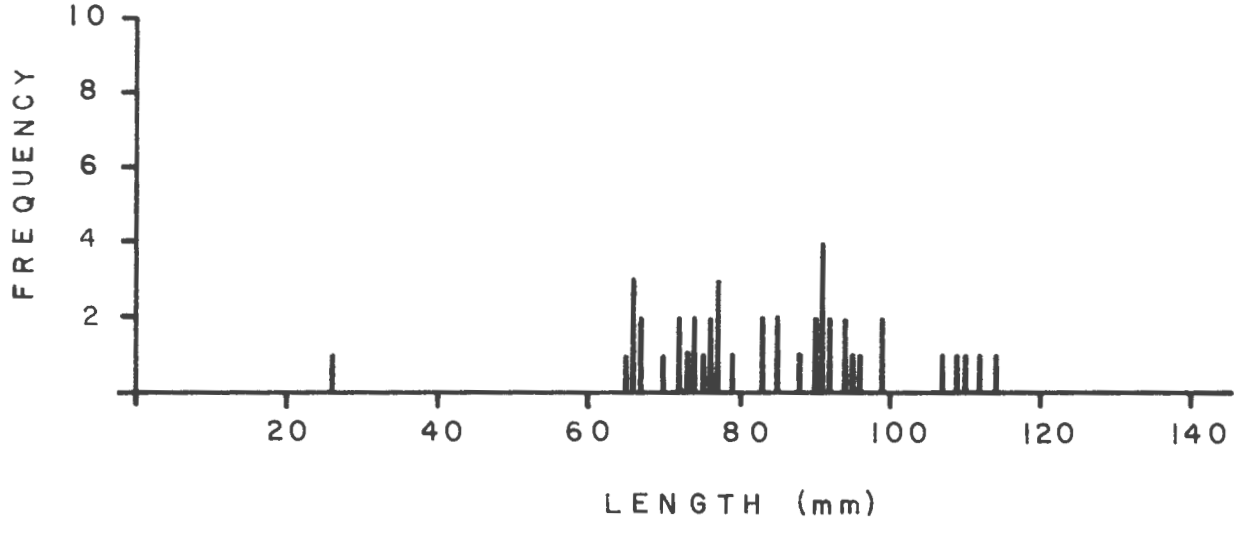
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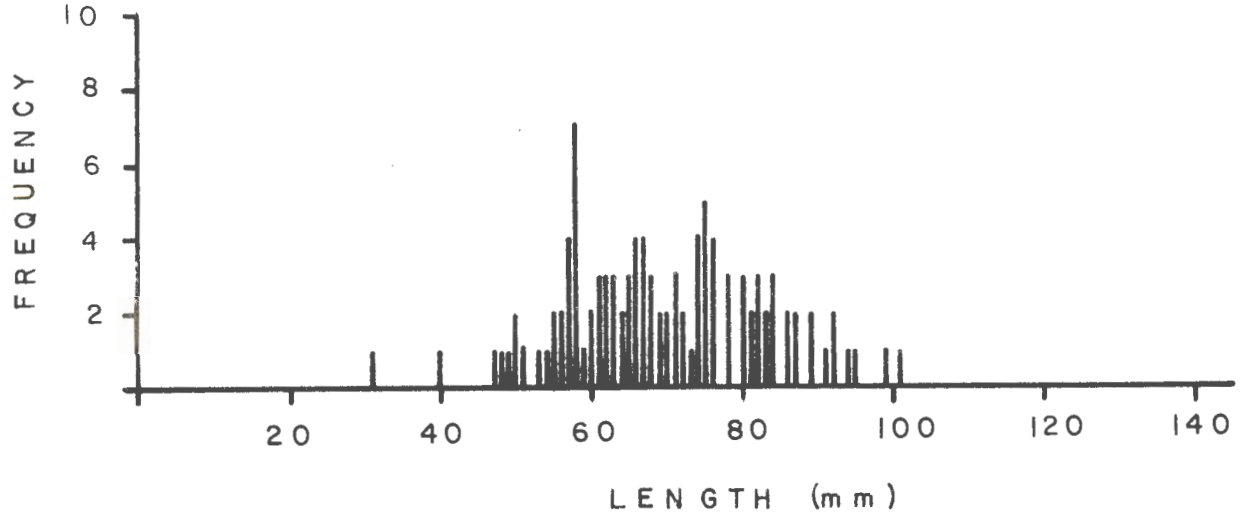
Fig. 29. Abalone population structure at a site on the Bischof Islands.

Fig. 30. Abalone population structure at Hoskins Islets; at the top of the Pterygophora zone.

Fig. 31. Abalone population structure at Hoskins Islets; at the bottom of the Pterygophora zone.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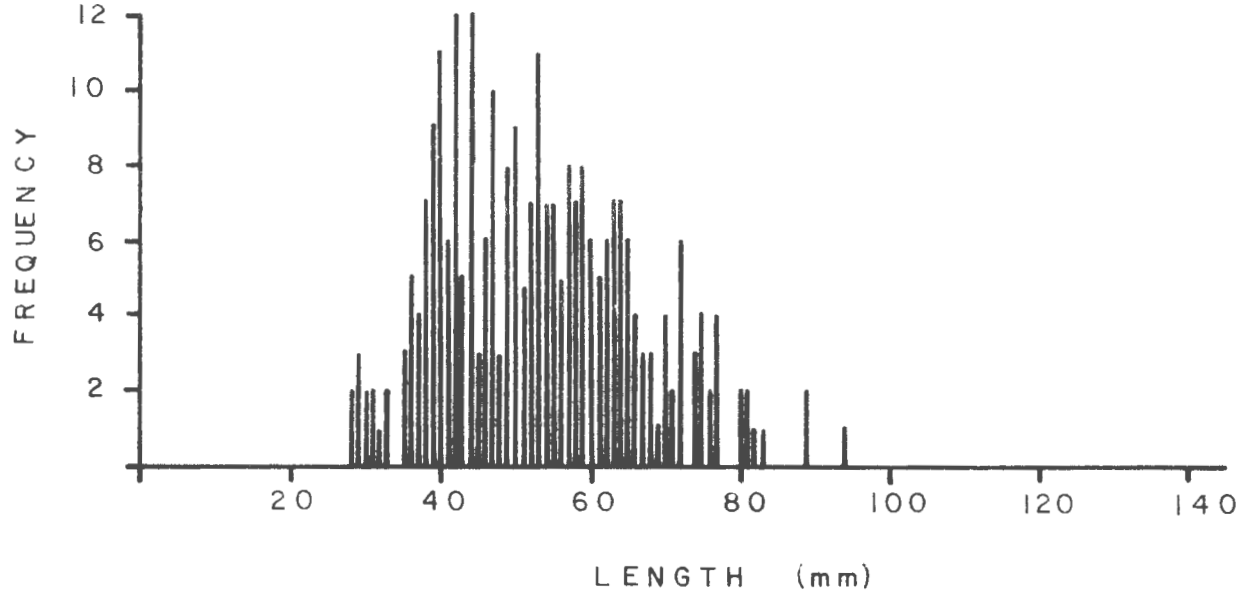
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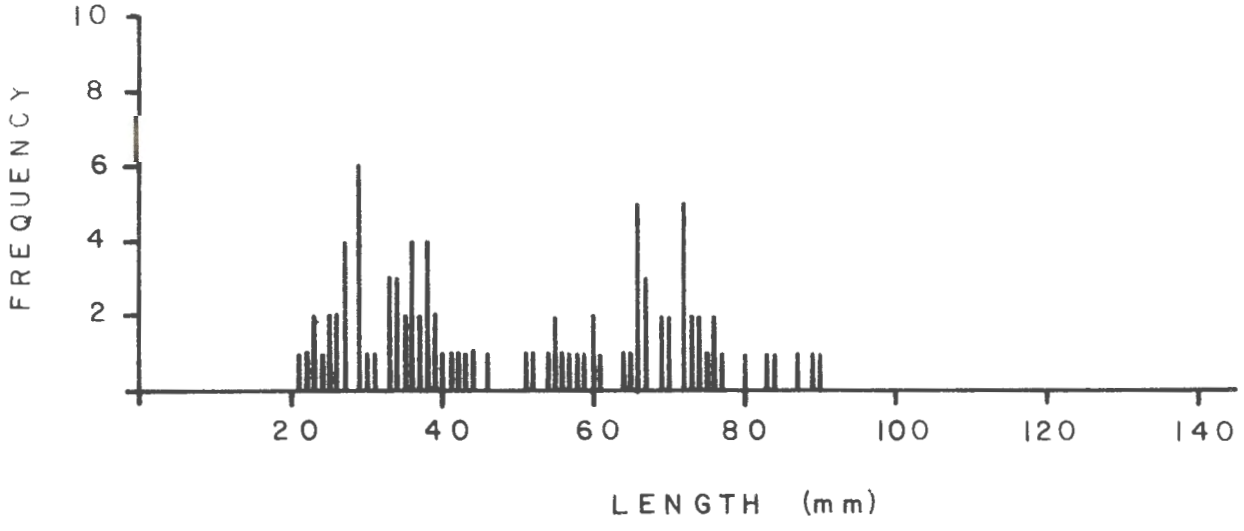
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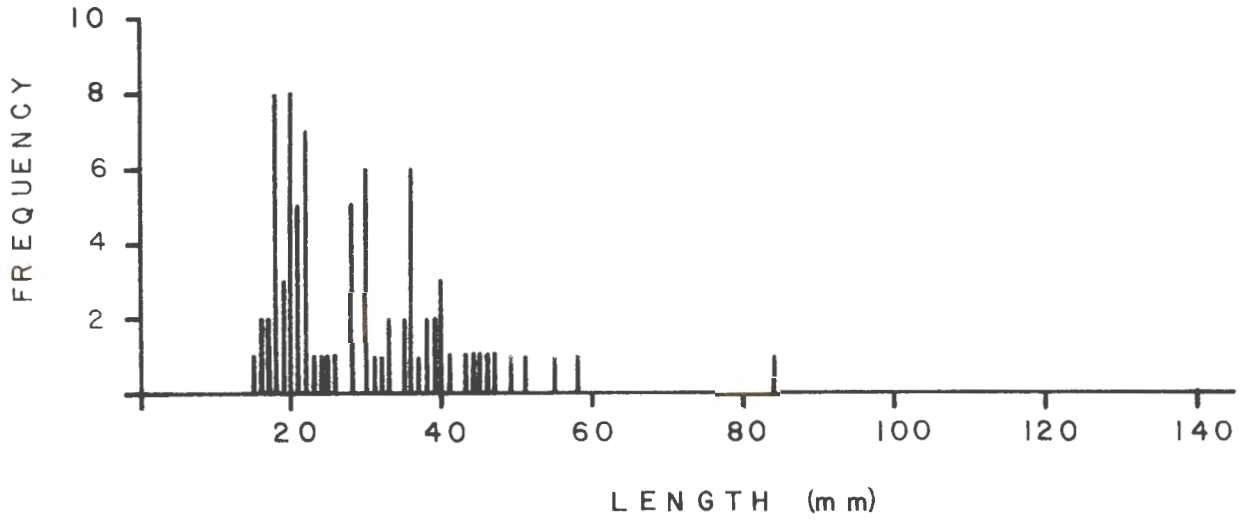
Fig. 32. Abalone population structure at Hoskins Islets; at a depth of 16 m.

Fig. 33. Abalone population structure on a rock at the north end of Murchison Island.

Fig. 34. Abalone population structure at a site on the Bischof Islands.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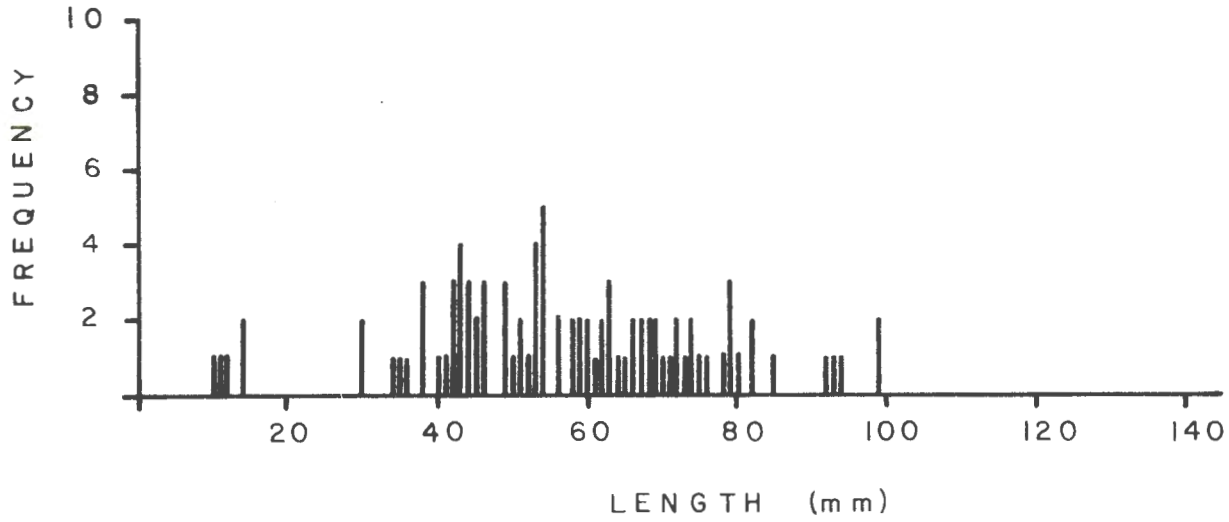
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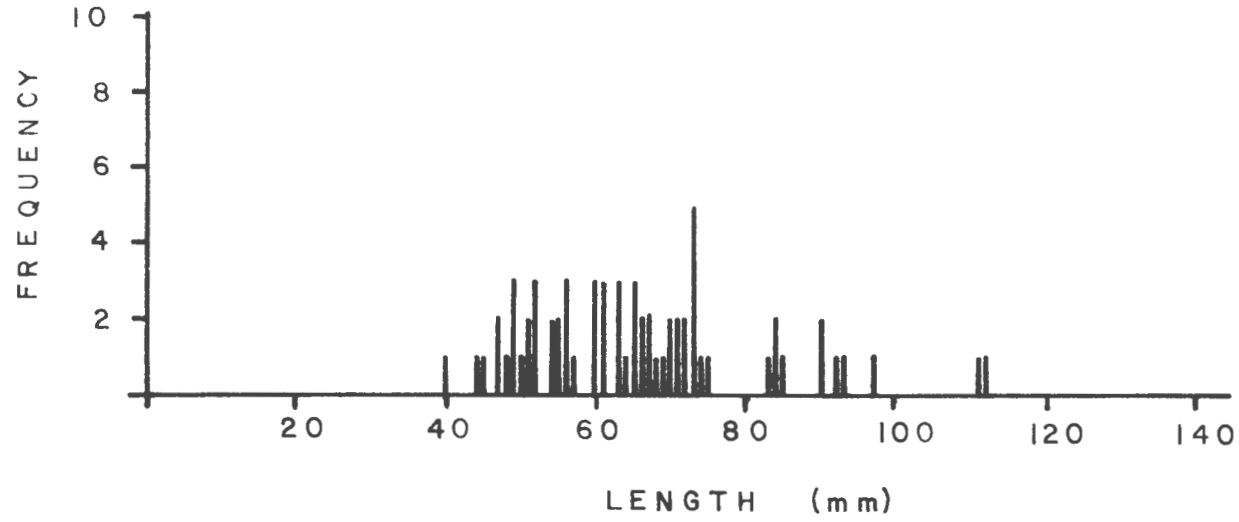
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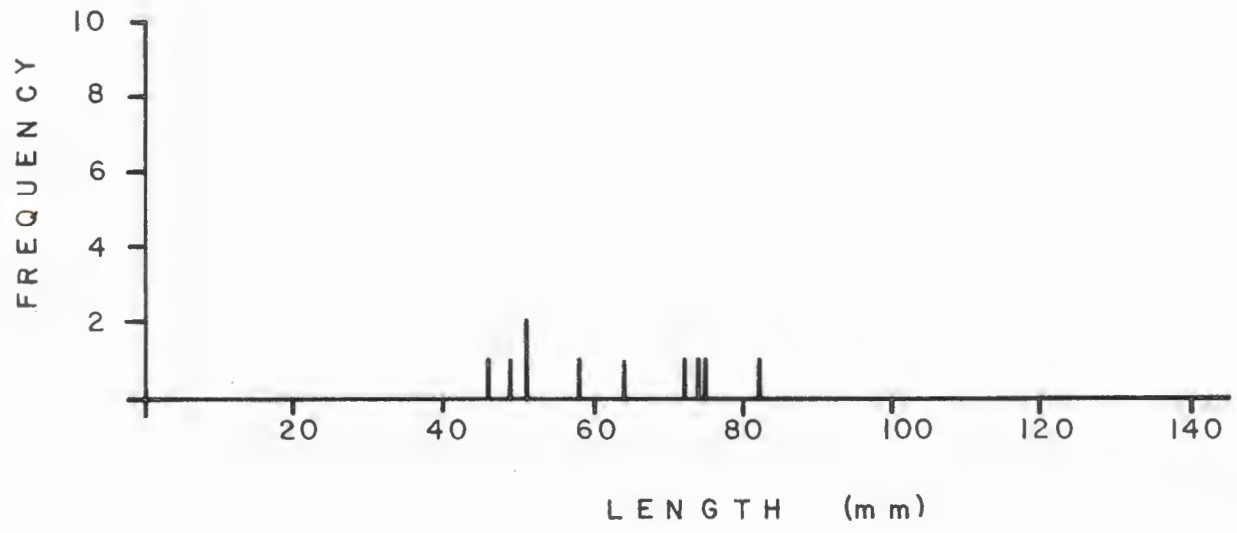
Fig. 35. Abalone population structures at a site on the north side of Faraday Island.

Fig. 36. Abalone population structures at a site in Werner Bay.

Fig. 37. Abalone population structures near Newberry Point.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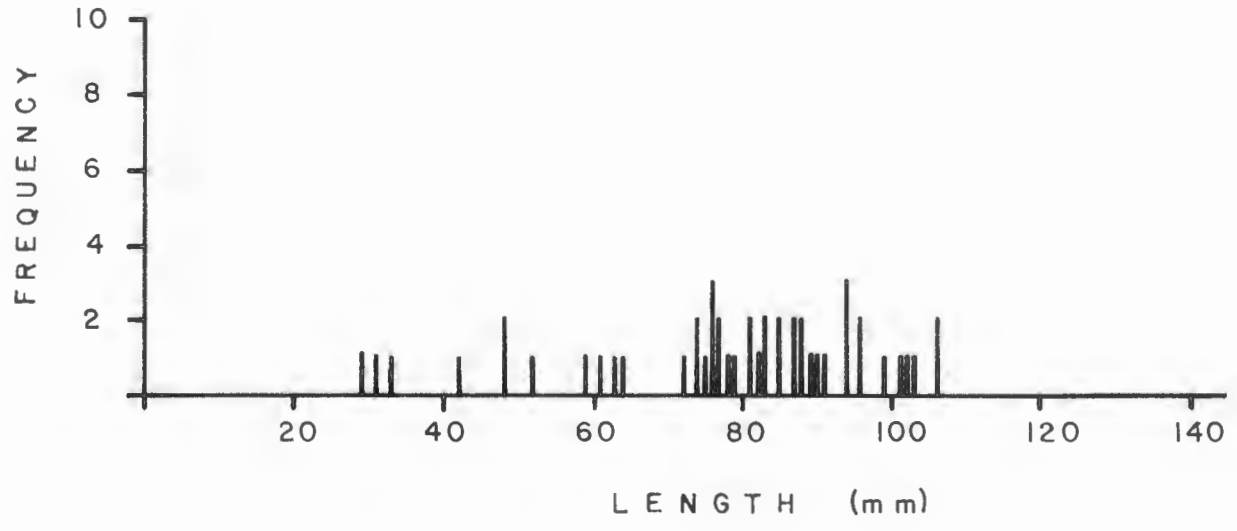
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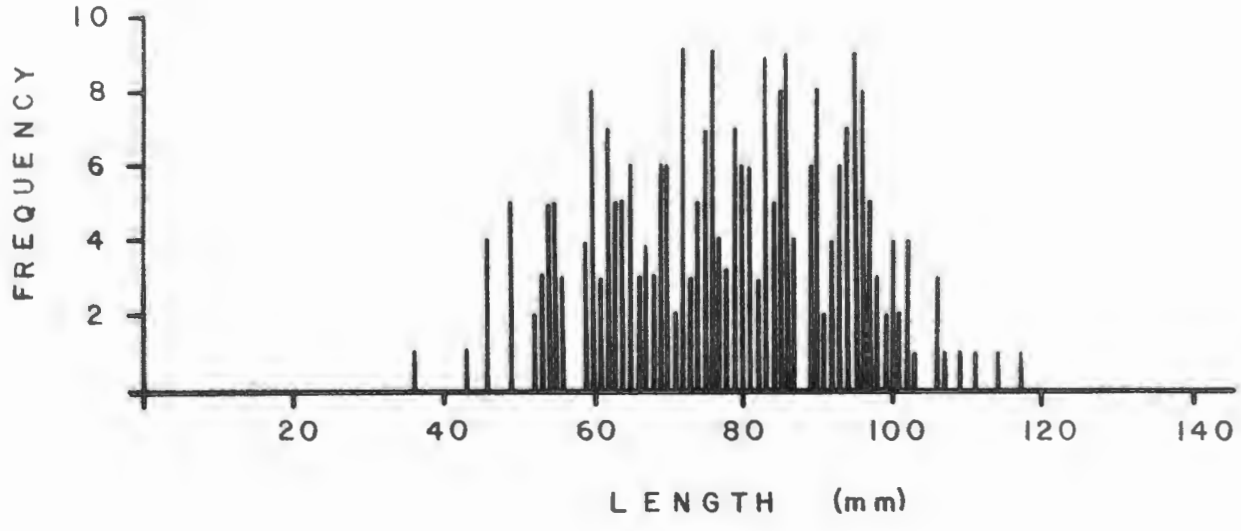
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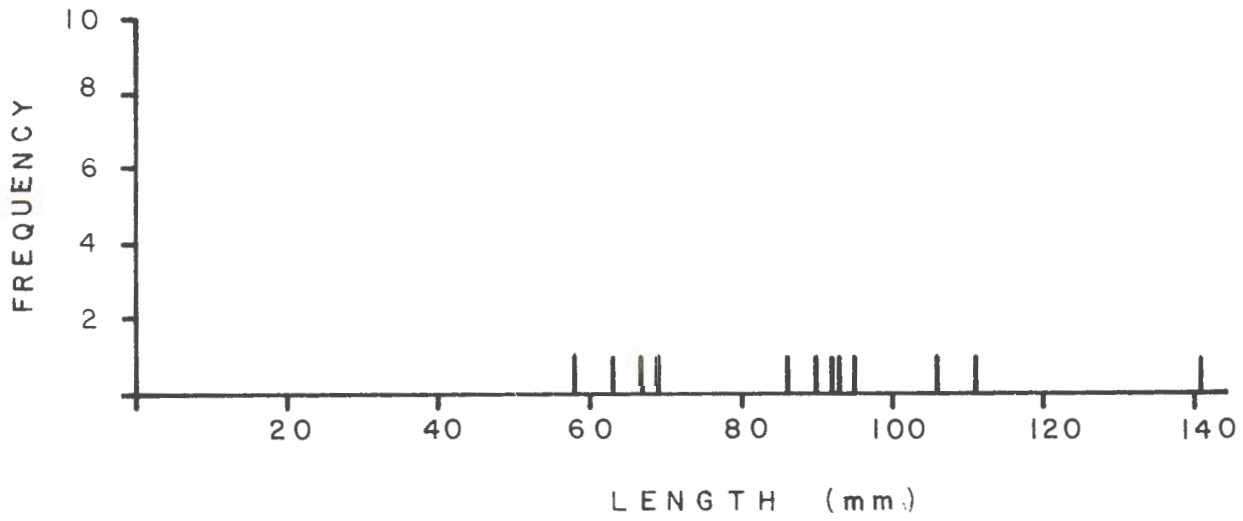
Fig. 38. Abalone population structure at a site on the Swan Islands.

Fig. 39. Abalone population structure near Pelican Point.

Fig. 40. Abalone population structure at Harriet Island.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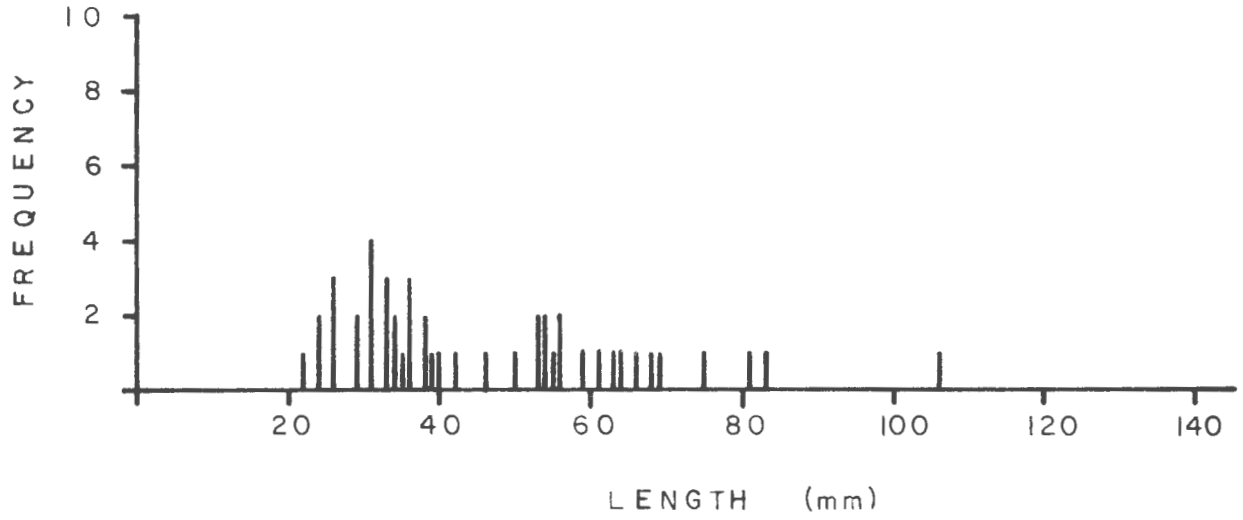
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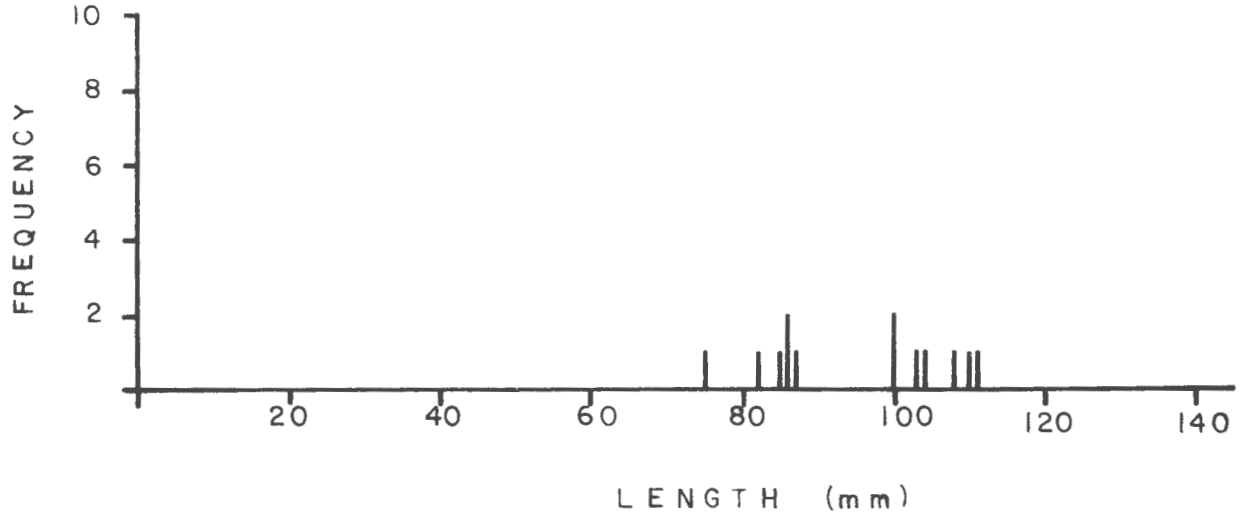
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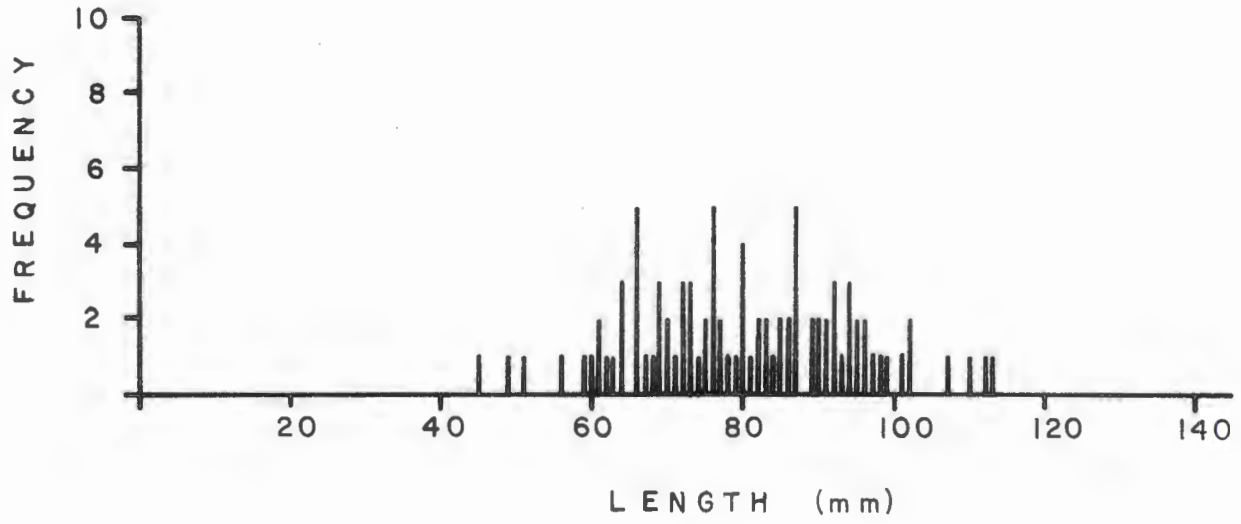
Fig. 41. Abalone population structure at a site on the southeast side of Burnaby Island.

Fig. 42. Abalone population structure at a site near Pelican Point.

Fig. 43. Abalone population structure at a site near Poole Point.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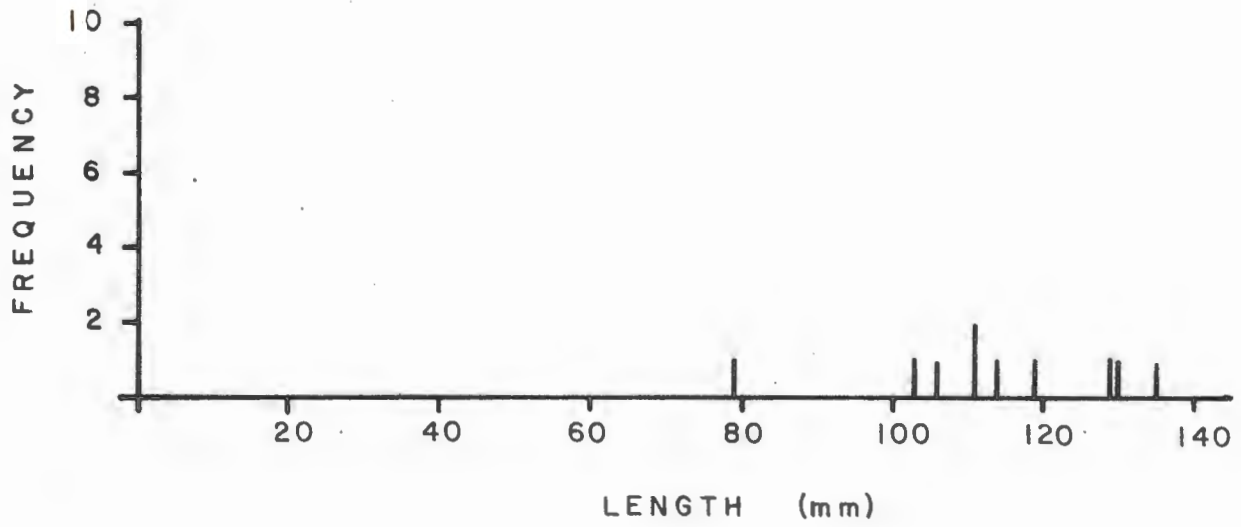
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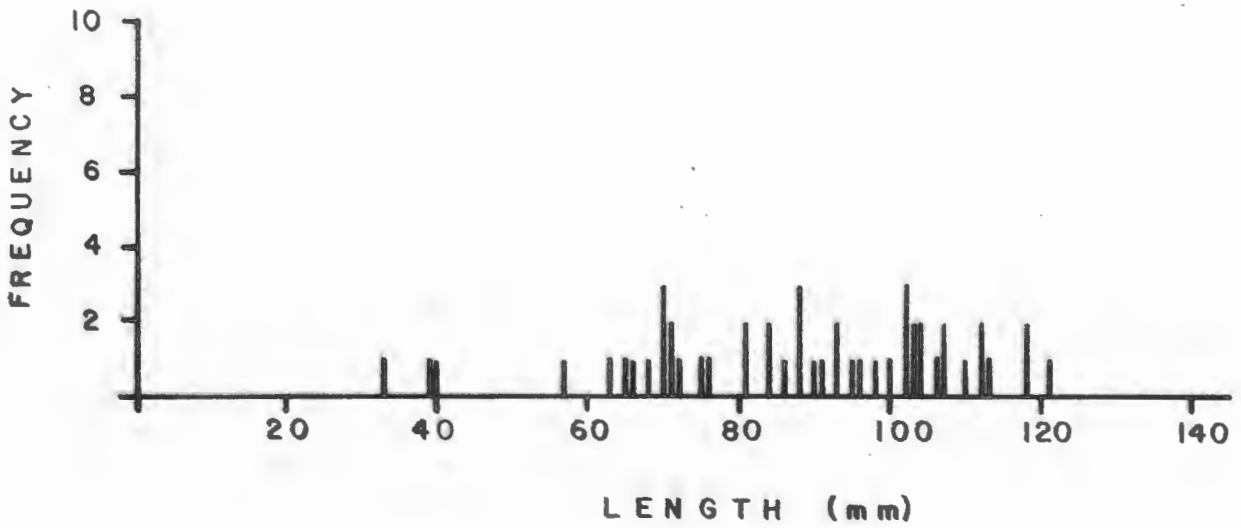
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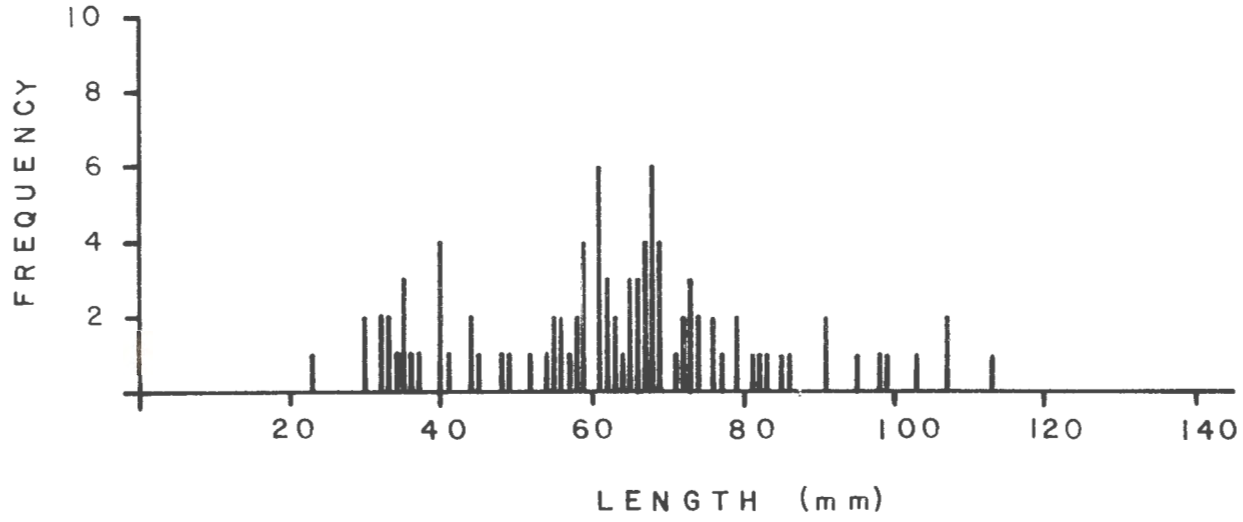
Fig. 44. Abalone population structure at a site in Francis Bay.

Fig. 45. Abalone population structure at a site on the north side of Iron Point.

Fig. 46. Abalone population structure at a site on the south shore of Carpenter Bay.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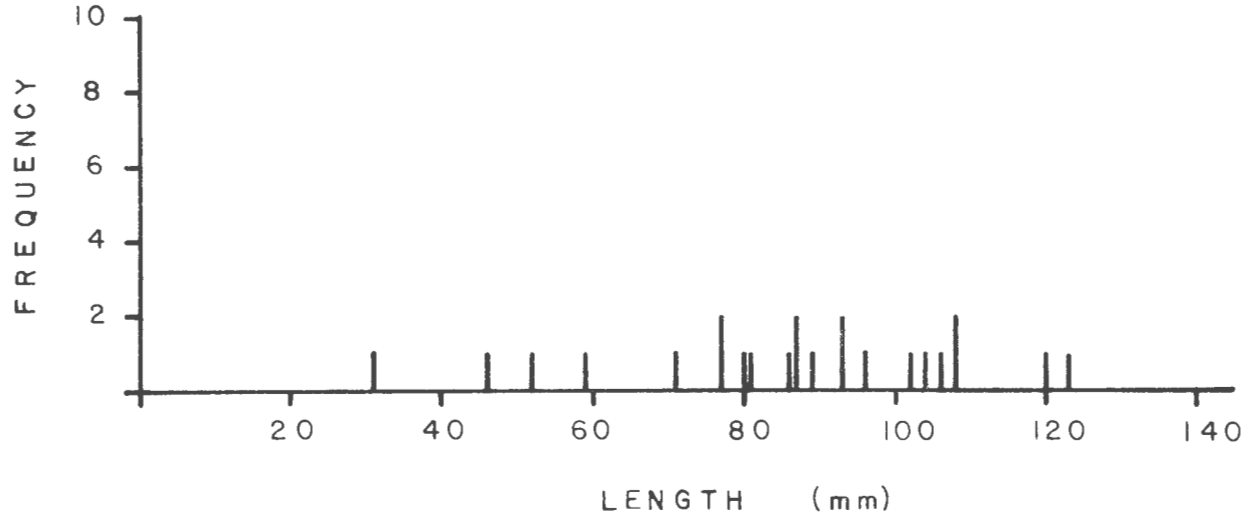
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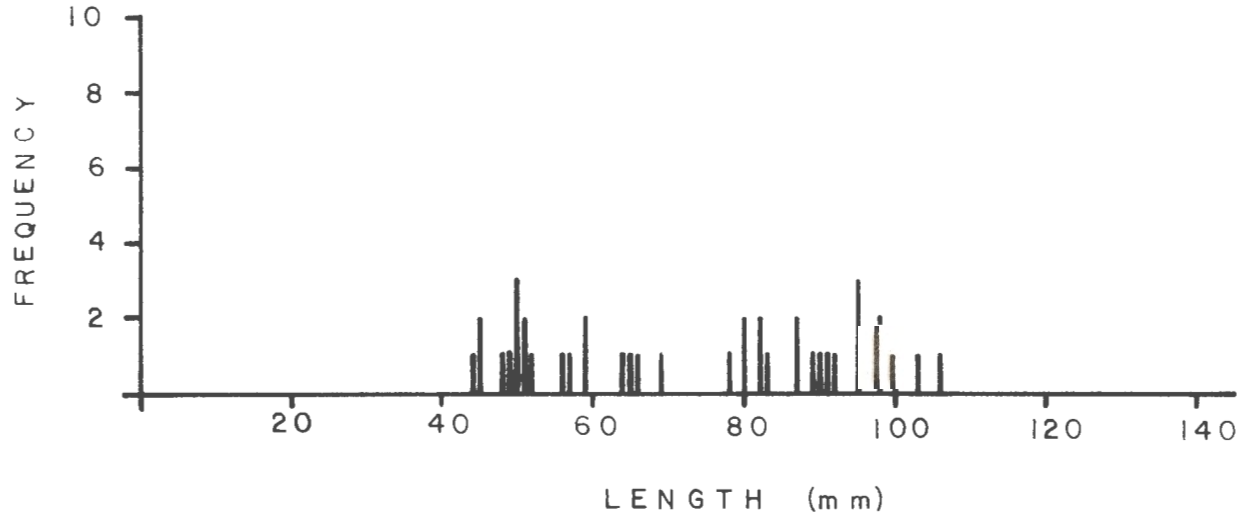
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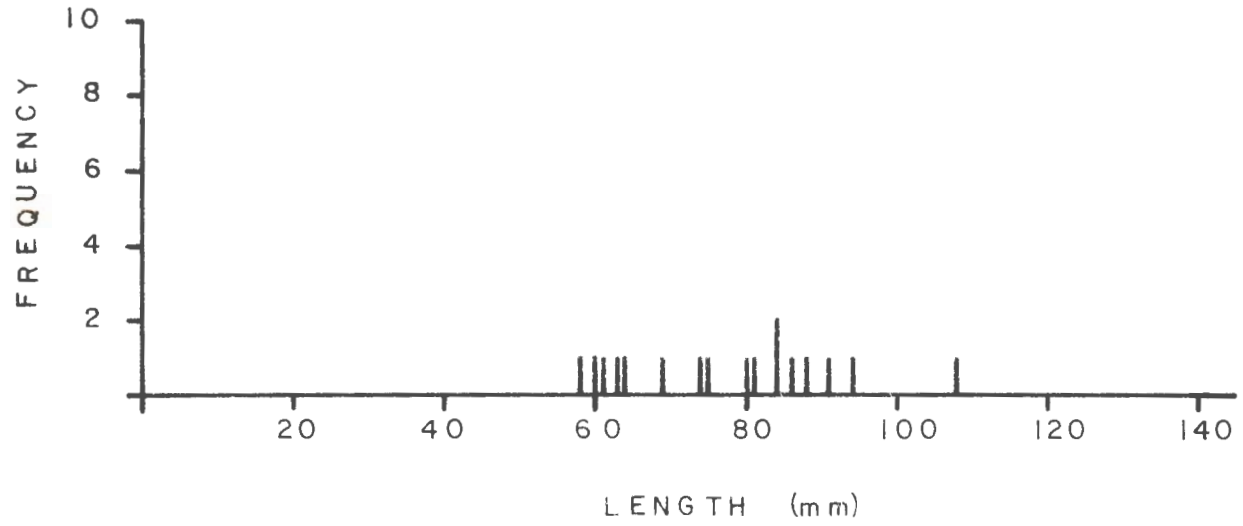
Fig. 47. Abalone population structure at South Cove.

Fig. 48. Abalone population structure at a site on the south shore of Carpenter Bay.

Fig. 49. Abalone population structure at Gona Point.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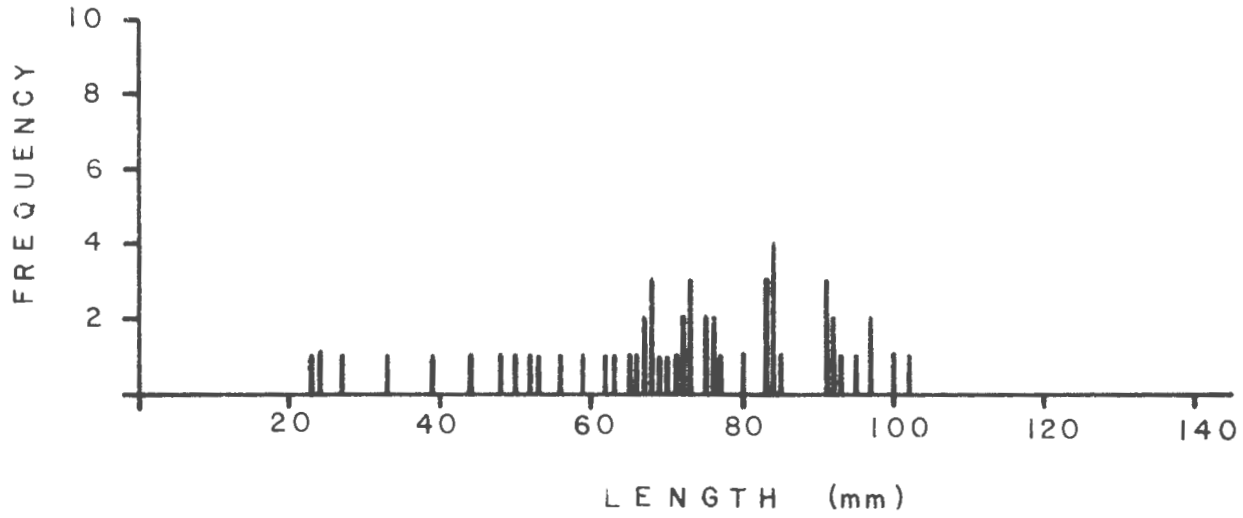
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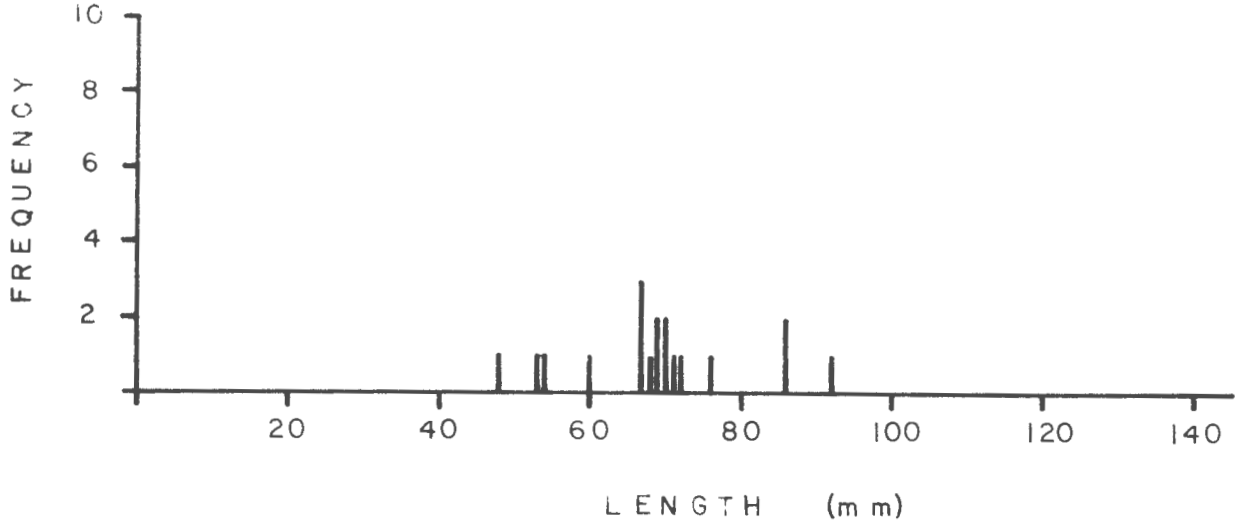
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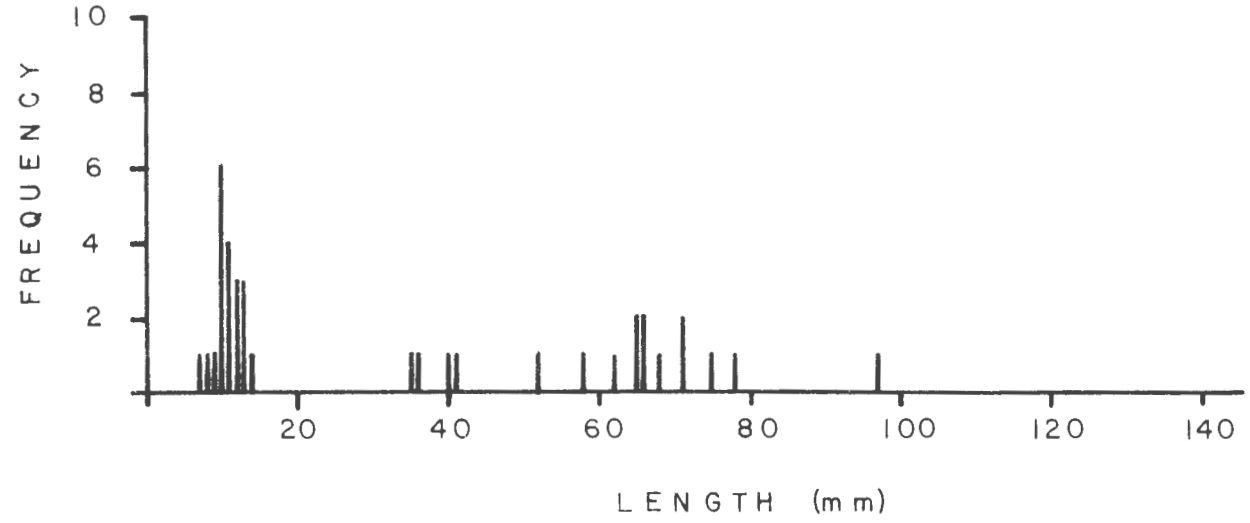
Fig. 50. Abalone population structure at a site south of Ingraham Point.

Fig. 51. A composite diagram of abalone population structure in Pterygophora communities.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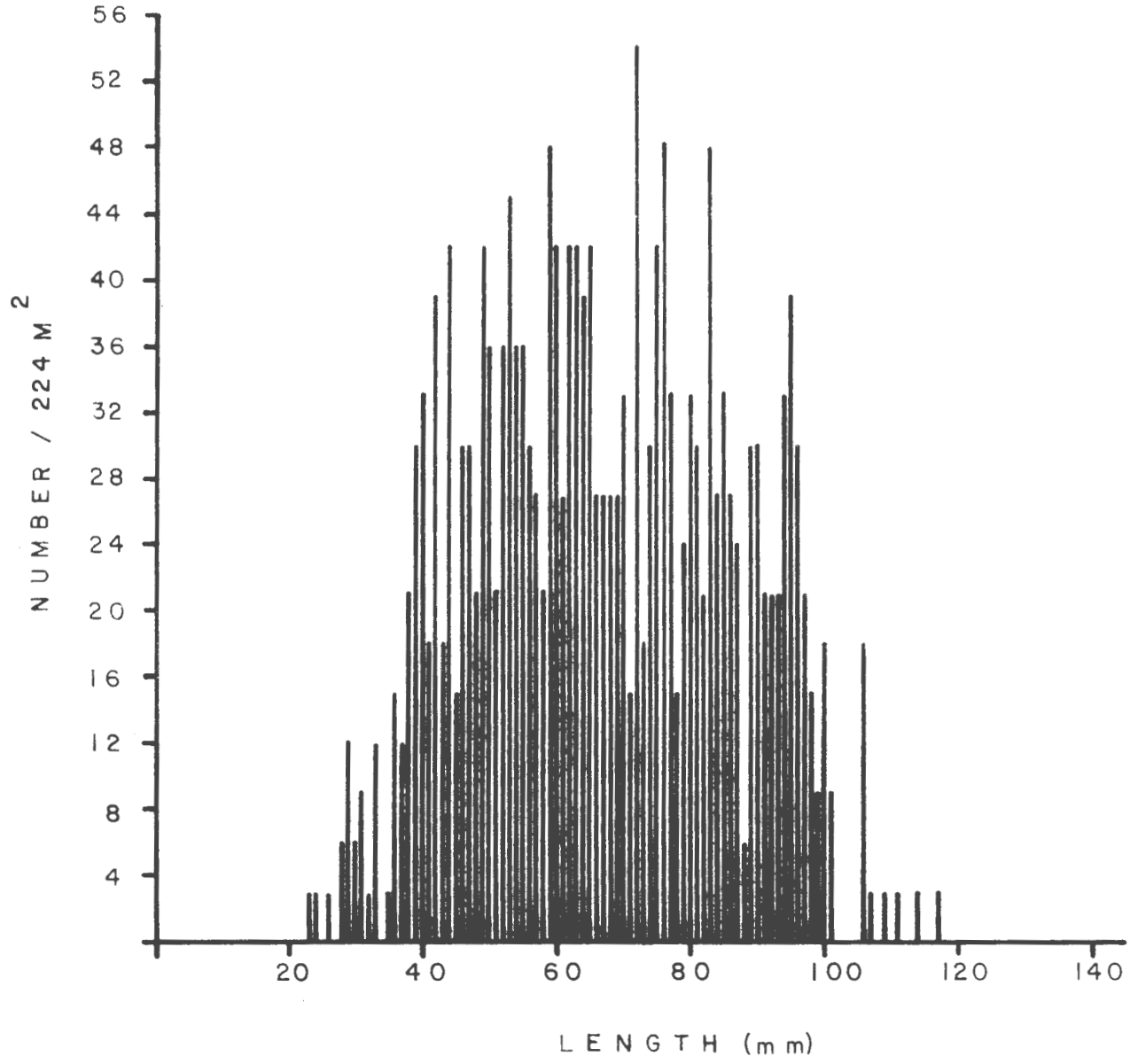
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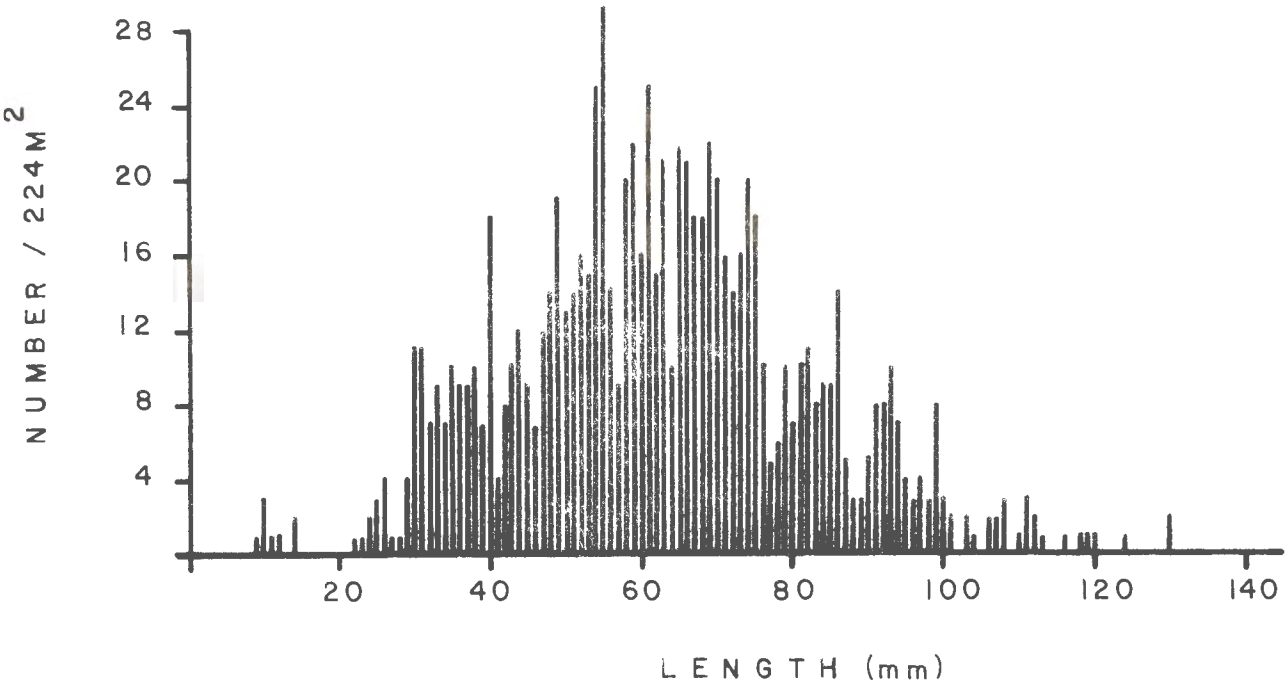
Fig. 52. A composite diagram of abalone population structure in sea urchin communities.

Fig. 53. A composite diagram of abalone population structure in Macrocystis communities.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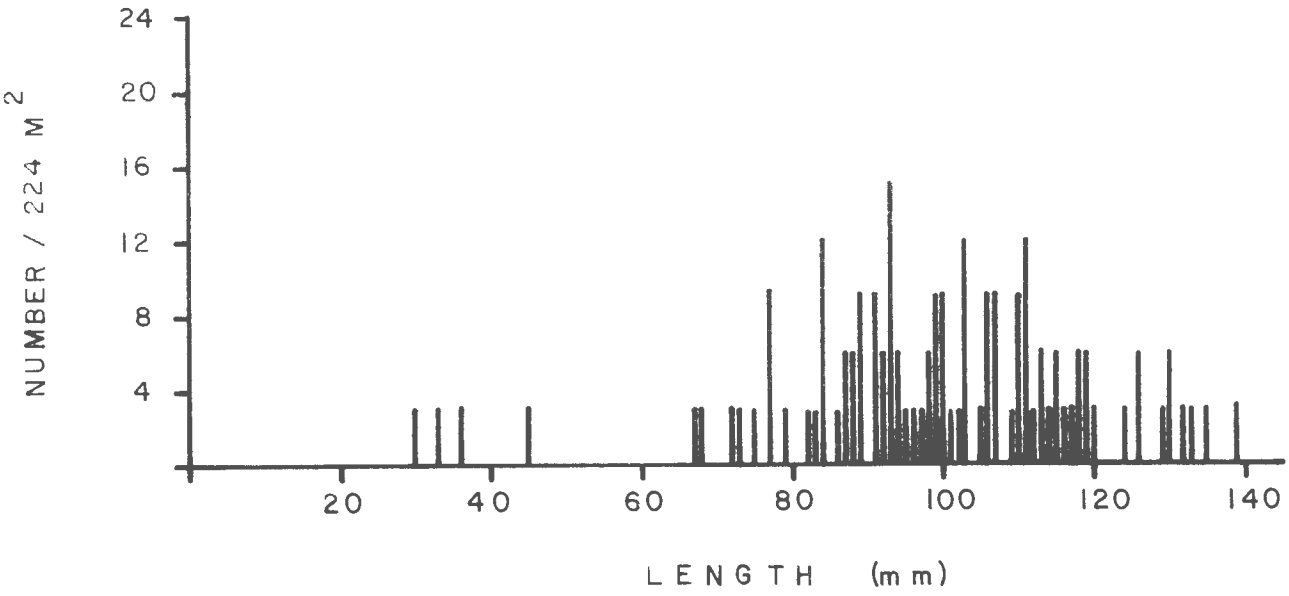
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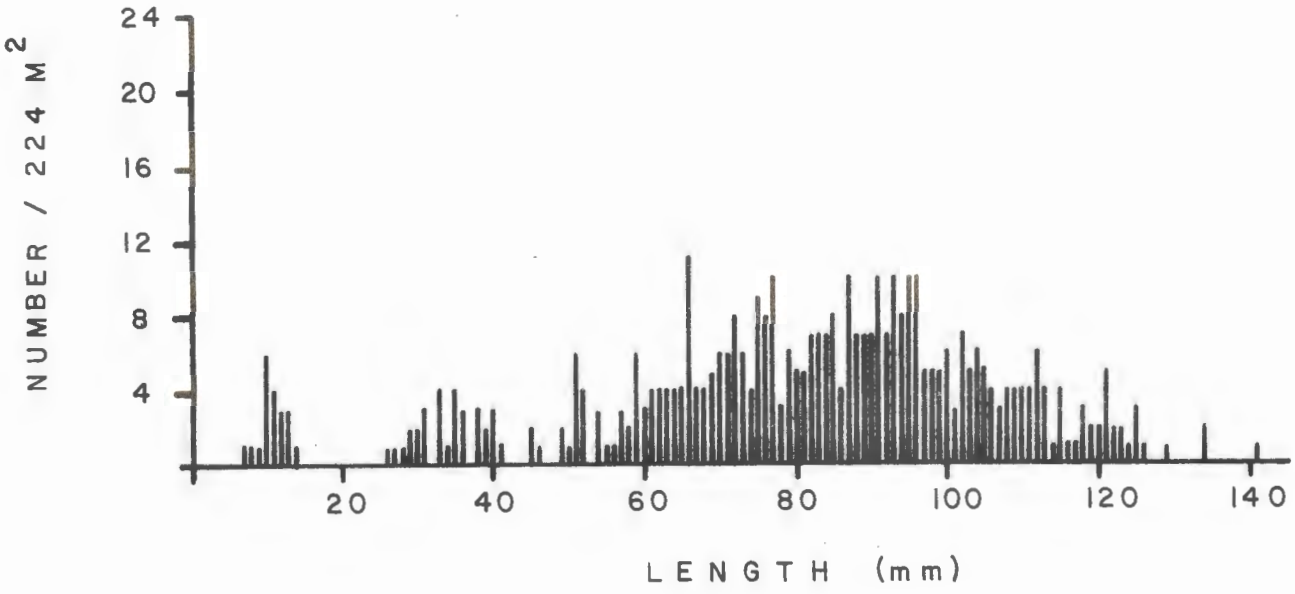
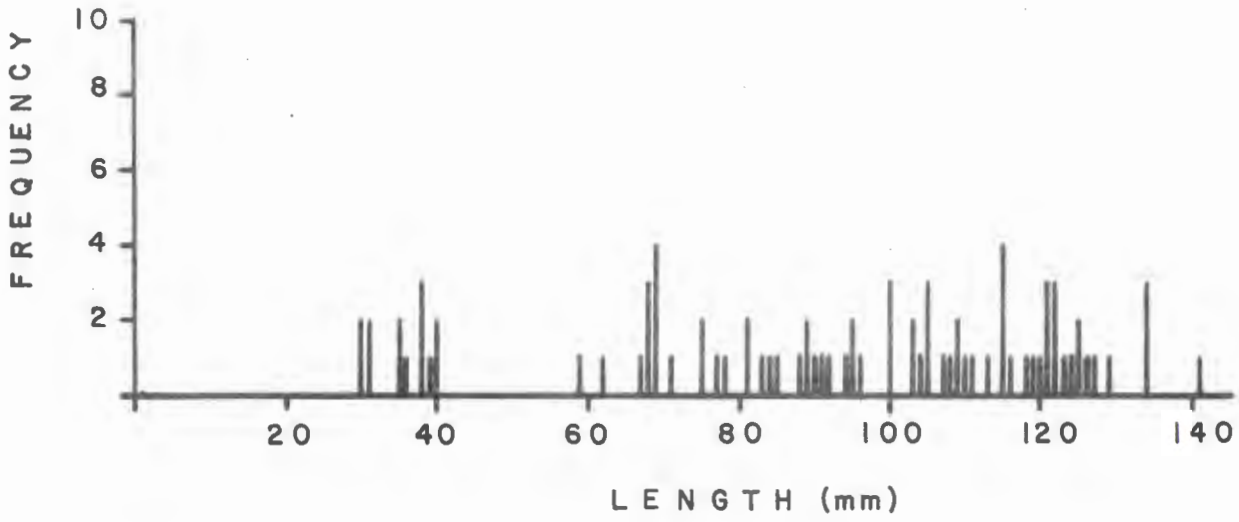
Fig. 54. A composite diagram of abalone population structure in Nereocystis communities.

Fig. 55. A composite diagram of abalone population structure in the Fairbairn Shoals.


NUMBER / 224 M2
24
20
16
12
8
4
20
40
60
80
100
120
140
LENGTH (mm)


FREQUENCY
10
8
6
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2
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100
120
140
LENGTH (mm)

APPENDIX 1. Station sheet filled out by divers.

QUEEN CHARLOTTE ISLANDS ABALONE SURVEY 1978

STATION 21 LAT 52 54 09 LONG 131 37 07 DATE 10 AUG

PLACE: N.E. POINT OF VERTICAL PT

DIVERS: PAB RH TENDING: JC

IN: 1000 OUT: 1025 DURATION: 25 MAX DEPTH: 25 TIDE: 6

ABALONE:

just below kelp → 0 1 6 4 1 0 0 1 x 2.69

in kelp → 2 6 6 3 8 4 0 1 $s^2$ 7.03

SIZE: all coll. SEEOVER 19%

DEPTH OF QUADRATS: see below

JUVENILES: none seen under few rocks turned

3.75/m² in kelp
$s^2$ = 7.64

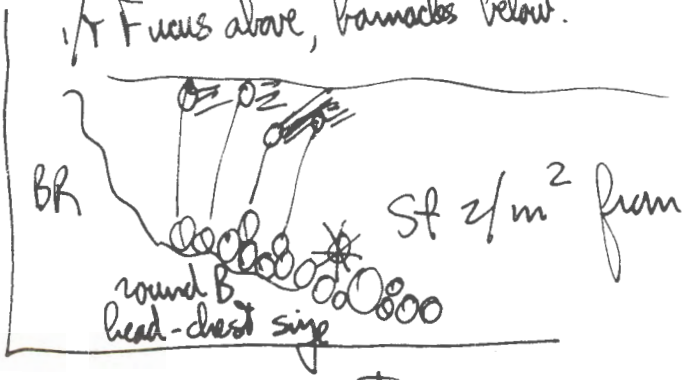
ALGAL COVER:

| | | |
|---|---|---|
| Canopy | NEREO | 50 % |
| Bottom | Laminaria | 80 % |
| Turf | none | % |
| Rocks | pink Litho under kelp | → 100 % |

fairly abundant Codium setchelli

draw a depth profile on the back ↓

INVERTEBRATES & COMMENTS AND COMPLAINTS:




Nereo was extensive in corner, did not extend outside. Dodecaceria in St zone. Other grazers Collisella Tarsicella, neither important. Abalone were highly conc. in lower part of kelp