North Coast Abalone Surveys in Harvested Areas, Spring 1978

P. A. Breen, A. P. Stefanson, and B. E. Adkins

Department of Fisheries and the Environment
Fisheries and Marine Service
Resource Services Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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ABSTRACT

Breen, P. A., A. P. Stefanson, and B. E. Adkins. 1978. North coast abalone surveys in harvested areas, spring 1978. Fish. Mar. Serv. MS Rep. 1480: 61 p.

Brief surveys were made of the abalone populations in 21 locations where harvesting had taken place in 1977. Ten sites were in the Queen Charlotte Islands and eleven sites were in the Banks Island area. Size frequencies, estimates of density and descriptions of each site are presented.

Key words: Abalone, Haliotis, population density, size frequency.

RÉSUMÉ

Breen, P. A., A. P. Stefanson, and B. E. Adkins. 1978. North coast abalone surveys in harvested areas, spring 1978. Fish. Mar. Serv. MS Rep. 1480: 61 p.

Nous avons visité dix stations de la côte est des îles Queen Charlotte, et aussi onze stations près de l'île Banks, ou l'ormeau avait récemment été l'objet d'une pêche commerciale en 1977. Nous y avons déterminé la densité de population et la répartition des tailles des populations d'ormeau.

Mots-clés: Ormeau, Haliotis, densité de population, répartition des tailles.

INTRODUCTION

Two surveys, described in this report, were made in early 1978 to examine harvested abalone populations on the north coast. Their purpose was to determine the present abundance of abalone in heavily fished areas, so as to estimate the relative impact of the fishery; and to examine population structure, in order to estimate the rate of production of abalone in these areas. Similar short surveys were conducted in 1976 (Adkins and Stefanson 1977; in 1977 (Adkins 1978); and in previous years (Stefanson, upublished data). This report presents our findings in rough form. Analysis and comparison of data here and in other reports will be presented elsewhere.

METHODS

The present surveys were made from the patrol vessel KITIMAT II.

Ten dives were made from April 18-22 on the lower east coast of the Queen Charlotte Islands, by Alf Stefanson, Bryan Allan, and Paul Breen. Eleven dives were made from May 9-12 around Banks Island by Alf Stefanson, Lanny Kalnin, and Bruce Adkins. The dive sites are shown in Fig. 1 and 4. On each dive, a visual estimate of abalone density was made, and notes were made concerning the substrate and the plant and animal communities present. A sample of abalone was collected for measuring, by simply collecting all the abalone seen until a sufficient number was obtained. In addition, searches were made under rocks and in crevices for the young. (Early year-classes tend to be found under rocks, adults out in the open.)

Because a much smaller area was searched for the hidden abalone, their proportion in the size structures shown here is under represented. Among the abalone collected from the open, there may be a bias toward the larger sizes, since larger abalone are more easily seen than smaller ones. Although this sampling method has some obvious deficiencies, it is very fast and the results are compatible with those from previous years.

All the depths presented here are in below chart datum; determined from a diver's depth gauge and corrected by subtracting tide height.

RESULTS

The abalone data are summarized in Table 1. The observations made at each site are presented below.

QUEEN CHARLOTTE ISLANDS

SITE 1. HAANS ISLET, CUMSHEWA INLET

This site was not, as far as we know, harvested before 1977, and it was surveyed in October 1976. At that time, average density was 5-6/m^2, and 65% of those found were above legal size. We know that fishing took place here during 1977. On this trip, we found abalone density to be variable, from 0-10/m^2. Under the Macrocystis integrifolia canopy, frequent patches of 5/m^2 were encountered; in the deeper sea urchin zone, density averaged near 0.5/m^2. Of 102 abalone measured, 51% were of legal size (Fig. 5). Although we looked in Macrocystis holdfasts and under many rocks, we could find no abalone less than 78 mm.

On the west wide of the islet, where the abalone were collected, the substrate was cobbles, fist-sized rocks, and boulders on sand and pebbles. The ground sloped very gently to 2.5 m (8 ft), where slope steepened and the substrate changed to fist-sized rocks only. On the shallow portion to 2.5 m, Macrocystis dominated: plants were from 0.5-1/m^2, extremely dense and formed a canopy at the surface much too thick to swim through. In the shade of this canopy, dense erect coralline algae (not identified) covered much of the solid rock surface, but there was little other undercanopy besides some scattered Laminaria saccharina. The rock itself was covered with both lithothamnion and Hildenbrandia: there was no Dodecaceria and no Balanophyllia.

At 2.5 m, the Macrocystis stopped, and Strongylocentrotus franciscanus began at 5/m^2. The rocks here were barren of macrophytes, but Agarum fimbriatum occurred where the sea urchins were less dense.

There was an abundance of other grazers: Tonicella lineata and Collisella ochracea were up to 50/m^2; Acmaea mitra and Amphissa columbiana were less abundant, and many Cryptochiton stelleri were seen during the dive. Less than 10 Astraea gibberosa were seen on the dive. Parastichopus californicus were about 1/m^2, and Cucumaria miniata tentacles formed 50% cover in the sea urchin zone.

SITE 2. FAIRBAIRN SHOALS, CHUMSHEWA INLET

We dove on the shoals to the northeast of the central rock. The level bottom, in approximately 3 m, was made up of boulders and smaller rocks on cobbles and sand, quite variable in relative composition. The Shoals were harvested in 1976 (9,500 kg) and even more heavily in 1977 (approximately 110,000 kg) until they were closed to commercial abalone fishing in the fall of 1977. In the 1976 survey, density from three parts of the Shoals were found to average 1.3/m^2, and 94% of the abalone collected were of legal size.

We estimated density of visible abalone to be 0.50-1/m^2, with a high variability. Roughly half the visible abalone collected for measuring were of legal size (Fig. 6). Juveniles, most of them probably at the end of their second year of growth, were easily found under rocks. No attempt was made to measure their density, because they were so highly aggregated.

The bottom was covered with small Nereocystis leutkeana, up to 2 m in height, which will form a dense canopy later. Under these was a dense undercanopy of Desmarestia ligulata var. ligulata (up to 20/m^2), also Cymathere triplicata, D. viridis, and large individuals (up to 0.8 m) of Delesseria decipiens. Beneath this cover was a rich layer of bladed reds such as Botryoglossum sp., Rhodymenia pertusa, and others; Odonthalia sp., and Dictyota binghamiae; under these were dense erect corallines; under those lithothamnion and Hildenbrandia.

The grazing fauna were the same as at Haans Islet, but none reached densities higher than 5/m^2. Under rocks were abundant Petrolisthes cinctipes, Cucumaria miniata and unidentified shrimps, sponges, and colonial ascidians. There were no sea urchins except scarce small S. doebachiensis in the corallines and under rocks.

SITE 3. FAIRBAIRN SHOALS, CHUMSHEWA INLET

Our second dive on the Shoals was at their outer edge across from Haans Islet. We found that abalone density was highly variable, and averaged less than 1/m^2 even when the juveniles under rocks were included. Of the 153 that were collected for measuring (Fig. 7), 59.5% were of legal size.

The bottom was level in 5-6 m, and composed of mixed rock sizes lying on a cobble floor. The dominant alga was Pterygophora californica at 1/m^2, heavily covered with large numbers of the grazer Tegula pulligo. Underneath was a light cover (up to 20%) of Nereocystis (up to 5/m^2, and up to 1 m high) and D. ligulata var. ligulata. The rock surface itself was covered mostly with lithothamnion, with an average of 10% cover of Dodecaceria. This area seemed to be under-grazed in comparison with similar areas elsewhere: there were numerous colonial diatoms, small brown blades too small to identify, Enteromorpha, etc. These formed a light film on rocks and on the shells of grazers.

The Pterygophora forest was interrupted by large areas dominated by green sea urchins (S. droebachiensis) at densities up to 50/m^2, probably averaging 5/m^2. In these areas there were no macrophytes. The sea urchins were nearly all greater than 60-mm test diameter, an indication that they were at least 5 yr old.

The most abundant grazer (apart from S. droebachiensis) was A. mitra; also present were C. ochracea, T. lineata, and Calliostoma spp. None of these were present at more than 5/m^2. S. franciscanus appeared as we moved east over the shoals, and reached 5/m^2 in the most dense aggregation. In that area, Pterygophora was the only macrophyte.

SITE 4. GIRARD POINT, CUMSHEWA INLET

We dove just at the edge of the Shoals, southeast of Girard Point. The pattern of abalone distribution indicated that some harvesting had taken place, but there were areas that clearly had not been worked heavily. Density thus ranged from 0-10/m^2, and we estimated that it averaged 2-3/m^2 overall. Of 208 that were collected only 24.0% were of legal size. There were very few small juveniles here (Fig. 8).

The bottom was mostly mixed rocks, from pumpkin-size to fist-size, sloping at about 20°. Algae near datum were very dense: Laminaria setchellii was dominant, and beneath it were Alaria sp., Egregia menziesii, Pleurophycus gardneri, and Costaria costata. Very dense erect corallines covered the rock surface under these algae. From the intertidal zone to about 1 m, a variable cover of Macrocystis existed, alternating with Pterygophora 50% cover, with D. ligulata var. ligulata beneath it. At 1 m, S. franciscanus began at densities up to 10/m^2, but their distribution was not uniform and there was no clear boundary between the sea urchin and algal zones. Within the sea urchin-dominated areas there were patches densely covered with 1 m high Nereocystis plants.

Rocks within the sea urchin areas were heavily covered with lithothamnion, which had cemented small rocks together. There were also Dodecaceria at up to 20% cover, serpulid worms, and the same grazers as on the shoals, but again no Balanophyllia. Whereas fish had been rare on previous dives in Cumshewa Inlet, greenling were abundant at this site.

SITE 5. KINGSWAY ROCK, OFF SELWYN INLET

At this site, abalone averaged 1/m^2 in the shallow sea urchin zone. Of 100 sampled, none was of legal size (Fig. 9). Abalone were not abundant below the sublittoral fringe, but on a level plateau with fist-sized rocks in 15 m, we found juveniles (estimated to be 1 or 2 years old) at densites greater than 1/m^2.

The substrate was solid granite, sloping step-wise at an average 45°, interspersed with areas containing boulders and smaller rocks on level ground. The algal zone was restricted to a narrow band between the intertidal zone and 2 m depth. Laminaria ?setchellii dominated the upper portion, and Nereocystis the lower part; undercanopies were dominated by Costaria and D. ligulata. At 2 m, S. franciscanus began at 20/m^2, but were not consistent and tapered off quickly with depth. We noted that there were many 1 and 2 year olds in the sea urchin population. Green sea urchins were present in irregular, dense patches such as those described at site 3.

In the sea urchin zone, the rock was covered with thick lithothamnion, and Dodecaceria up to 50% cover. Anemones (unidentified) and Serpula were abundant, and Balanophyllia was present here at densities up to 100/m^2. The grazers A. mitra and T. lineata were at 20-50/m^2, and Cryptochiton stelleri was unusually common at 0.1/m^2. We noted many dens made by Octopus dofleini. The most notable fish were Sebastes melanops, in a large school in the water around us throughout the dive.

SITE 6. HEATER HARBOUR, NORTH MOUTH

The Heater Harbour area was heavily fished (23,000 kg) during 1977. At this site we found that abalone were still present at 1-2/m^2, reaching 5/m^2 in patches. There were no juveniles smaller than 72 mm, except three that were found in the lower intertidal zone; and of 179 abalone collected for measuring, 24.6% were legal-sized (Fig. 10).

The substrate was solid bedrock from the intertidal zone to approximately 1-2 m depth, where boulders and head-sized rocks began. These sloped gradually (10° slope) as far as we swam (to 10 m). The intertidal zone was dominated by sea mussels (Mytilus californianus) and the barnacle Balanus cariosus in the mid-part, and by Hedophyllum sessile, Laminaria ?setchellii, and Phyllospadix scouleri to 1 m. From 1 to 2 m there was a light Pterygophora forest, above dense corallines (resembling Corallina vancouveriensis, but not identified) and Iridaea sp. S. franciscanus began at 2 m depth, at densities around 5/m^2 that were quite consistent and remained constant with depth.

The sea urchin zone was lacking in large macrophytes, but was covered in a light film of diatoms, Enteromorpha and other small ulvoids, small sparse Nereocystis and Cymathere, D. viridis and clumps of polysiphonous red algae. There was no Agarum. Abalone were distributed throughout the sea urchin zone, and were still abundant at 10 m. They were most abundant in a small patch that lacked S. franciscanus, and here there were very dense ulvoids. The rock surface was covered by lithothamnion (80%) and Dodecaceria (20%). There was no Balanophyllia.

The same grazers as described for site 3 were present here, at densities around 10/m^2. Also present at 1/m^2 were Astraea gibberosa. Cucumaria miniata were numerous (10/m^2) in the deeper water.

SITE 7. HEATER HARBOUR, SOUTH MOUTH

This site was directly across the harbour from site 6. Abalone abundance was very low (less than 0.1/m^2), but the abalone were mostly large (up to 140 mm).

The substrate varied from tumbled boulders to cobbles on sand, and in slope from 0-20°. Lower intertidal zone supported Egregia and dense ulvoids, below this was a dense Macrocystis canopy above a 100% understory of Laminaria saccharina and L. spp., Costaria and Cymathere. Below 2 m, there were patches of S. franciscanus and barren rock, and Agarum fimbriatum occurred at the lower edge of this zone. Where sea urchins were not present, the Macrocystis association continued into deeper water. Dodecaceria was 80% of the rock surface cover in this area, and Ceratostoma foliata was seen for the first time on this trip. Two Octopus were seen during the dive.

SITE 8. RAINY ISLAND ROCKS

We dove between the two larger islets. We found abalone present ranging from 1-10/m^2, averaging approximately 2/m^2 when juveniles under rocks were included. Of 264 collected for measuring, 10.2% were legal-sized (Fig. 11).

The substrate was bedrock in variable configurations, with boulders and rocks lying on places with shallow slope. There was a narrow band of Alaria sp. and Hedophyllum in the intertidal zone, then S. franciscanus beginning near datum at 20/m^2. There were thus no macrophytes below datum, except in surge channels where Alaria sp., Laminaria spp., and Costaria formed dense beds. The rock itself was covered with thick lithothamnion: there was no Dodecaceria and no Balanophyllia.

Abalone were abundant to 10 m. Juveniles were common under rocks, and as usual were highly aggregated. Abalone were most abundant (up to 10/m^2) in a patch which contained no sea urchins and had thick coating of colonial diatoms.

SITE 9. CARPENTER BAY, HEAD

Carpenter Bay was also heavily fished in 1977 (20,000 kg). We dove on the shoal due west of Samuel Rock near the head of the bay. We found an estimated density of 0.2-0.5/m^2 at this site. Of 60 abalone collected for measuring, 61.6% were legal-sized (Fig. 12).

The substrate was solid bedrock, mixed with large boulders on cobble. Where we examined it, the bottom was from 6-9 m below datum, and supported a Macrocystis forest, with plants at about 0.25/m^2. The understory was 50-75% cover of Agarum fimbriatum, plus a few Laminaria sp. The rock surface itself was covered with lithothamnion (25%) and Hildenbrandia (75%). While Macrocystis was not found below 9 m, Agarum continued.

The abalone were unevenly distributed, and many were in crevices and on the undersides of boulders, in places where they might have been left behind by harvesters. They did not continue deeper than the Macrocystis forest.

The only other fauna noted were abundant Tegula pulligo on the plants, Astraea at 2/m^2, and a few Hinnites giganteus. When we swam above the Macrocystis forest, we found a barren zone dominated by S. franciscanus at 2/m^2, and the rocks covered entirely with lithothamnion.

SITE 10. BAY ON SOUTH SIDE OF CARPENTER BAY

We dove on the point that forms the east end of the bay. Abalone were abundant, from 5-10/m^2 under a Pterygophora forest or Laminaria setchellii. Of 123 collected, only 9.8% were of legal size (Fig. 13).

The substrate was bedrock sloping in sharp irregular formations to 4 m, then changing to large boulders and smaller rocks sloping at about 30°. The intertidal indicated an exposed site: the mid-part was dominated by B. cariosus, and Mytilus californianus was seen in surge channels. The lower intertidal zone was dominated by Phyllospadix and Laminaria setchellii, with Anthopleura xanthogrammica. From near datum to 3-4 m, there were two different communities. The first contained Pterygophora at 2/m^2, forming a very dense sub-surface canopy, with dense erect corallines covering the rock below. The other contained very dense L. setchellii with the same corallines beneath. Both were most common on the many flat shelves present here.

Below 4 m, S. franciscanus was present, beginning at 5-10/m^2. The rocks in this zone were covered with Dodecaceria (75%), and supported abundant limpet and chiton grazers at about 25/m^2. There were again no Balanophyllia. When we went to 7.5 m, we found fewer sea urchins and abundant Cucumaria miniata.

The abalone were most abundant under the Pterygophora forest, (where in fact many were climbing the plants and eating the blades) and did not extend

in numbers into the sea urchin zone. However, there were some 2-3 yr olds on a wall near the top of the sea urchin zone; the only juveniles seen on this dive.

PRINCE RUPERT

I. SOUTH END OF THE ESTEVAN GROUP

Three sites were examined in this area (Fig. 3). All are exposed to ocean swells coming from the southeast out of Caamano Sound. The substrates are similar in each with solid bedrock sloping steeply from the surface to a level or slightly sloping cobble and pebble bottom between 3 and 6 m. Strong tidal current was present at all three sites examined.

A commercial abalone boat was working this general area and several had recently left.

SITE 11. SOUTH END OF LOTBINIERE ISLAND

Abalone were abundant but distribution was patchy. They occurred at depths between 0 and 7 m. Density was as high as $3/m^2$ in some spots but averaged $<1/m^2$ over the entire site. Both legal and sub-legal sized abalone were present; 65% were of legal size. A few 0 and 1st year-class abalone were found on the under side of large cobbles but they were not abundant. We found up to two under every ten rocks we overturned. Sizes are shown in Fig. 14.

A narrow band of Nereocystis luetkeana ended at datum. The kelps Cymathere triplicata, Costaria, Desmarestia spp., and new growth Nereocystis produced the light understory. At the bottom edge of this band were patches of Delesseria decipiens and Plocamium coccinium var. pacificum.

Sea urchins (S. franciscanus) began at datum and continued down onto the cobble/boulder floor at 7 m. Sea urchins were present in a number of year-classes; many of them were young. Density was as high as $10/m^2$ in the upper parts of this zone. New growth Cymathere, D. ligulata var. ligulata, D. viridis, and Nereocystis were present in small patches among the sea urchins. At 6 m, Laminaria spp. dominated the bottom cover. Agarum cribrosum was sparsely scattered among these plants.

All over the area were S. droebachiensis, Parastichopus californicus, Cucumaria miniata, Tegula pulligo, Astraea gibberosa, and Cryptochiton stelleri.

SITE 12. ROCKS ON THE WEST SIDE OF HICKEY ISLAND

Abalone were smaller at this site than at site 1. Of 106 measured, 33% were above legal size (Fig. 15). Density was highest ($4/m^2$) near the kelp zone, but averaged about $1/m^2$ over the entire site. Some very small year-class abalone were present: we found about two on the underside of every eight to ten rocks we overturned.

From the intertidal zone to 1.6 m were the kelps Cymathere, Nereocystis, Costaria, and Desmarestia spp. Erect corallines, lithothamnion and Hildenbrandia occurred on the rock surface beneath the kelps.

S. franciscanus began at 1.6 m and continued down the rock slope onto the cobble/boulder bottom at 8 m. Several early year-classes were present. Density of sea urchins was low at this site, averaging 2/m^2. Desmarestia viridis and new growth Nereocystis occurred in patches among the sea urchins at depths between 3.3 and 7.0 m.

SITE 13. SOUTH END OF LOTBINIERE ISLAND

Abalone were abundant at this site, averaging 2/m^2. Density was greatest on the cobble and boulder substrate at depths above 7 m. Most of the abalone seen were large; however there were some early year-classes present. Of 111 abalone measured, 75% were of legal size (Fig. 16). No 0 or 1st year-class abalone were seen under any of the rocks we overturned.

Macrocystis and Nereocystis formed a thick canopy, extending from the intertidal to 0.3 m. Laminaria spp., Desmarestia spp., Costaria, and Cymathere produced the understory which covered about 80% of bottom beneath the canopy. Abalone were present but not abundant under the kelp cover.

S. franciscanus began at a depth of 0.3 m and continued onto a cobble/boulder floor at 7 m. Ulvoids and diatoms covered this area to 7 m, where Agarum cribrosum began. Patches of Desmarestia veridis, Plocamium coccineum var. pacificum and polysiphonous reds occurred among the sea urchins. On the cobble/boulder floor were Parastichopus californicus, Cucumaria miniata, Calliostoma ligatum, Tonicella lineata, and Acmaea sp.

II. WEST SIDE OF THE ESTEVAN GROUP

Three sites on the west coast of the Estevan Group were examined (Fig. 3). All were exposed to ocean swells coming from the northwest out of Hecate Strait. Solid rock and cobble substrate were found at two of the sites while the third had only solid substrate.

One commercial abalone boat was working the area at the time of our observations and several other boats had recently been in the area.

SITE 14. MURRAY ANCHORAGE

Abalone density varied from 4/m^2 in some areas in the sea urchin zone to 1/m^2 under the kelp canopy, but was greatest along the kelp/sea urchin zone interface. These abalone were small (Fig. 17). Of 152 abalone measured, 11% were of legal size.

Nereocystis formed a canopy to 1 m. Laminaria spp. were underneath with erect corallines and lithothamnion on the rock surfaces beneath them. S. franciscanus began at 1 m with a density of 5/m^2. Several year-classes were present; however early year-classes were most abundant. Lithothamnion,

Hildenbrandia, Dodecaceria, and a thick growth of colonial diatoms covered the rock surface in the sea urchin zone. Agarum cribrosum and Fauchea sp. occurred throughout this zone to 8 m.

On the rock surface among the sea urchins were Pycnopodia, Cucumaria miniata, Pagurus spp., Tonicella lineata, Serpula sp., and Acmaea spp.

SITE 15. ROCK SOUTH OF FINNERY POINT

Abalone were large and abundant in this area (Fig. 18). Distribution was patchy with density averaging $2/m^2$. Size and density of abalone were greater (to $5/m^2$) on the protected side of this site. Of 164 abalone measured, 38% were of legal size (Fig. 18).

Laminaria spp. formed a canopy to 3 m on the protected side of the rock. On the exposed side of the rock, were also found Lessoniopsis, Nereocystis, Desmarestia spp., and Costaria. Erect corallines, lithothamnion, Porphyra sp., Constantinia simplex, and Codium setchellii were found in the understory.

Compound ascidians, Tealia crossicornis, Anthopleura xanthogrammica, and Katherina tunicata were all present in the kelp zone on the exposed side of the islet. Sea urchins (S. franciscanus) began at 3 m and continued onto the cobble/boulder floor at 7 m. Their density was $10/m^2$. S. drocbachiensis, Pycnopodia, Epiactis prolifera, Fauchea sp., and polysiphonous reds occurred in the sea urchin zone.

SITE 16. NORTHWEST END OF NICHOL ISLAND

Abalone were abundant but small at this site, occurring between 0 and 7 m. Density varied from $5-8/m^2$, but was highest at the shallower depths. Of 141 abalone measured, 15% were of legal size (Fig. 19). We saw no 0 or 1st year-class abalone under any of the rocks we overturned.

The kelps Laminaria spp., Alaria nana, and Nereocystis formed a canopy extending from the intertidal to 3 m. Lithothamnion, Dodecareria, erect corallines, and patches of Phyllospadix occurred on the gently sloping rock surface beneath the canopy.

At 3 m, S. franciscanus began, continuing down the rock slope onto a level area of large cobbles at 7 m. Their density was $20/m^2$ on this shoal. Many young were present. Lithothamnion and Dodecaceria sp. covered most of the rock surface in the sea urchin zone. Balanophyllia and Cucumaria miniata were abundant in this zone.

III. WEST SIDE OF BANKS ISLAND

We examined four sites moderately exposed to Hecate Strait, on the west coast of Banks Island (Fig. 4).

Abalone harvesting had recently taken place all along this area, but we saw no active commercial vessels.

SITE 17. WRECK ISLANDS

Abalone were present from 0 to 5 m. Density ranged from $2/m^2$ in the shallower depths to $1/m^2$ at 5 m. Size of the abalone at this site was small (Fig. 20). Only 11% of 114 abalone measured were of legal size. On the exposed side of this site, some juveniles were found on the cobble floor at a depth of 3 m. About three 0 and 1st year-class abalone were seen under every five rocks we overturned.

A narrow band of Nereocystis, Alaria nana, and Costaria occurred to datum on steeply sloping solid rock. Hildenbrandia sp. and erect corallines grew on the rock surface beneath the kelps. A band of ulvoids occurred at the bottom edge of the kelp zone.

Sea urchins (S. franciscanus) began at datum and continued down the slope to 12 m. Density averaged $5/m^2$. Lithothamnion and Dodecareria sp. covered the rock surface in the sea urchin zone. S. droebachiensis, Tonicella lineata, Cucumaria miniata, Balanophyllia, Metridium, Serpula, and Acmaea spp. occurred throughout the sea urchin zone.

SITE 18. ANTLE ISLAND

Abalone were large and abundant but highly patchy at this site. Density reached $10/m^2$ in some areas under the kelps. Of 92 abalone measured, 11% were of legal size (Fig. 21). We saw only two 0 year-class abalone at this site.

Nereocystis, Laminaria sp., Alaria nana, Phyllospadix, Codium setchellii, and erect corallines extended from the intertidal to 2 m. S. franciscanus began at this depth, occurring in dense patches over the flat cobble-strewn area. Many year-classes of sea urchins were present. Lithothamnion and Dodecaceria sp. covered most of the substrate in this zone. Diatoms, ulvoids, and small patches of Nereocystis, Desmarestia spp., Porphyra sp., Gigartina sp., and Zostera sp. were present among the sea urchins. S. droebachinesis, Cucumaria miniata, Pycnopodia, Cryptochiton, Mediaster aequalis, and Polynices lewisii occurred throughout this zone. A strong tidal current was present at this site.

SITE 19. GRIFFITH HARBOUR

Abalone distribution was patchy at this site. Density was as high as $4/m^2$ in some crevices in the rock but averaged about $1/m^2$. The abalone at this site were large (Fig. 22). Of 88 abalone measured, 57% were of legal size.

A canopy of Nereocystis occurred to 1 m. Desmarestia spp., Costaria, and Laminaria spp. formed the understory. S. franciscanus were present between 1 and 4 m at a density of $<1/m^2$. Ulvoids and diatoms were the major cover on the cobbles and boulders in the sea urchin zone.

On a sand/shell floor beginning at 4 m were large patches of Desmarestia spp., Nereocystis, and Costaria.

SITE 20. BORROWMAN GROUP

Abalone were present on both the protected and exposed sides of this site. Density varied from $<1/m^2$ on the protected side to $3/m^2$ on the exposed side. Distribution was patchy on both sides. Early year-classes of abalone were present but were not abundant (Fig. 23). We found one 0 or 1st year-class abalone under every 10 rocks we overtuned. Of 144 abalone, 35% measured were of legal size.

Nereocystis and Macrocystis formed a dense canopy along the edge of the protected side of the islet. Laminaria sp., Desmarestia spp., Costaria, and Agarum cribrosum occurred beneath the canopy. Both the kelps and the rock substrate were covered with a thick diatom growth. On a mud and sand floor a 5 m was a large bed of Zostera sp.

On the exposed side of the islet Nereocystis formed a light canopy. Laminaria spp. formed the light understory. Codium setchellii, lithothamnion, and erect corallines attached to the rock substrate beneath.

S. franciscanus began at the bottom edge of the kelp zone on the cobbles and boulders at 1.6 m. Density was as high as $15/m^2$ in some patches. Lithothamnion and Dodecaceria sp. formed the major cover in the sea urchin zone.

IV. NORTH END OF BANKS ISLAND

SITE 21. SHOAL NEAR DEADMAN ISLET

Only one site was examined here (Fig. 4), on a large level shoal. Cobbles and boulders covered the bottom at 8 m. This area is partially exposed to ocean swells coming from the northwest out of Hecate Strait. A strong tidal current was present at the time of these observations. Recent harvesting had taken place here. Large abalone (Fig. 24) were present over most of this site, with density averaging $1/m^2$. Juvenile abalone were seen both on the surface and on the underside of some of the larger cobbles we overturned. Of 145 abalone measured, 48% were of legal size.

Macrocystis and Nereocystis formed a canopy covering most of this site. Desmarestia spp., Laminaria spp., Costaria, and Agarum cribrosum formed a light understory beneath. Long blades of Porphyra nereocystis hung from the Nereocystis stipes. S. franciscanus was present at this site, but their density was $<1/m^2$.

On the cobble/boulder bottom beneath the kelps were Cucumaria miniata, Pycnopodia, Tonicella lineata, Tegula pulligo, Acmaea spp., Cryptochiton, and Solaster stimpsoni. We saw a large number of salps drifting in the water.

REFERENCES

Adkins, B. E. 1978. An examination of some commercially harvested abalone populations in the Moresby Island area. Fish. Mar. Serv. MS Rep. 1455 19 p.

Adkins, B. E., and A. P. Stefanson. 1977. An examination of harvested and unharvested abalone populations in the Moresby Island area. Fish. Mar. Serv. MS Rep. 1435: 23 p.

Table 1. Approximate density and percentage of legal size in abalone populations observed during this survey.

Site #	Location	Approx. density	No. measured	% legal size
		Queen Charlottes		
1	Haans It.	0-10/m^2	102	51
2	Fairbairn Shoals	0.5-1.0/m^2		
3	Fairbairn Shoals	< 1.0/m^2	153	59
4	Girard Point	2-3/m^2	208	24
5	Kingsway Rock	1/m^2	100	0
6	Heater Harbour N. Mouth	1-2/m^2	179	25
7	Heater Harbour S. Mouth	< 0.1/m^2	-	All
8	Rainy Island Rocks	2/m^2	264	10
9	Head of Carpenter Bay	0.2-0.5/m^2	60	62
10	Bay on south side of Carpenter Bay	5-10/m^2	123	10
		Banks Island		
11	S. end Lotbinière I.	< 1/m^2	110	65
12	W. side Hickey I.	1/m^2	106	33
13	S. end Lotbinière I.	2/m^2	111	75
14	Murray Anchorage	1-4/m^2	152	11
15	Rock off Finnerty Pt.	2/m^2	164	38
16	NW end Nichol I.	5-8/m^2	141	15
17	Wreck Islands	1-2/m^2	114	11
18	Antle Island	5-10/m^2	92	11
19	Griffith Harbour	1/m^2	88	57
20	Borrowman Group	1-3/m^2	144	35
21	N. end Banks Island	1/m^2	145	48

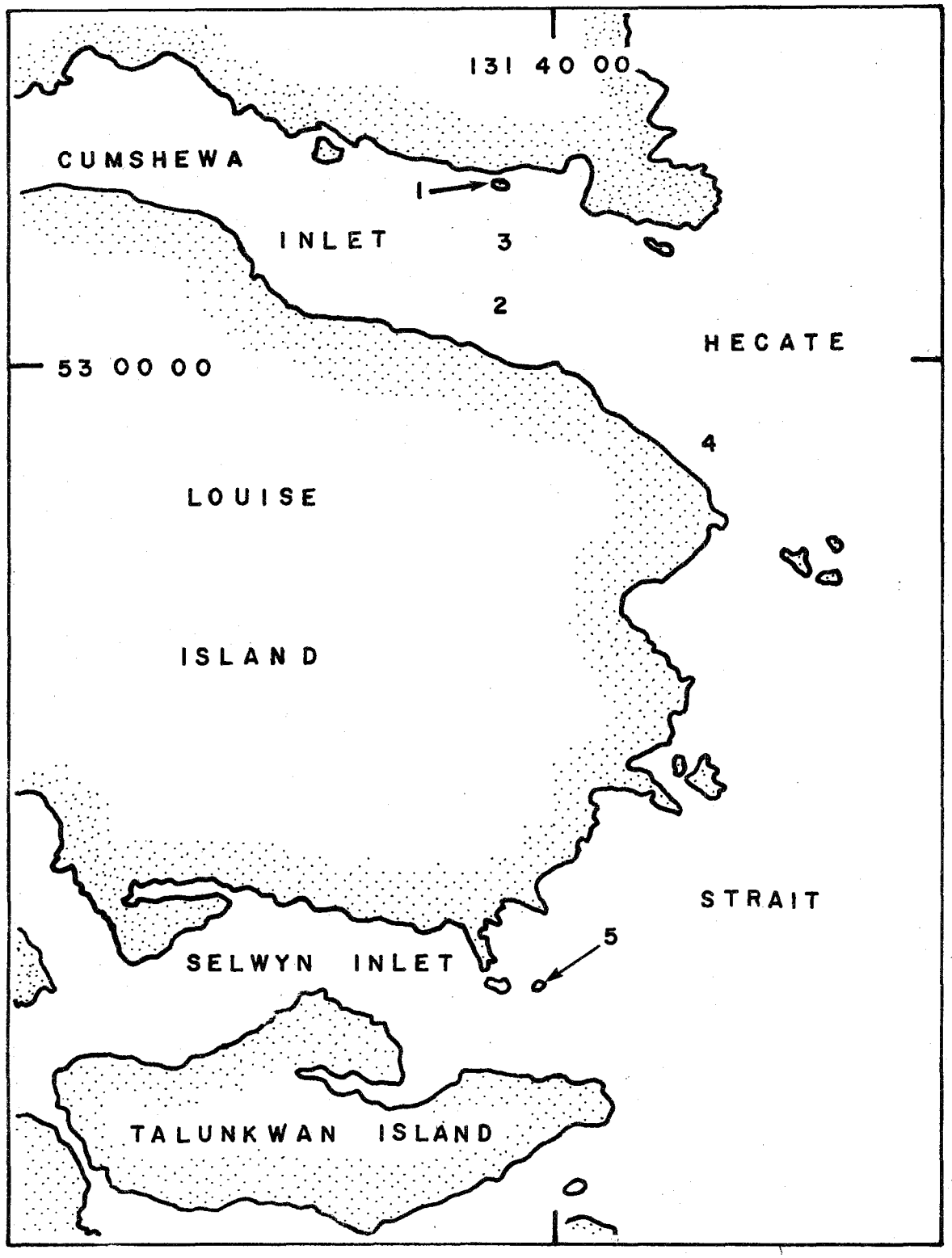


Fig. 1. Dive sites 1-5. Queen Charlotte Islands.

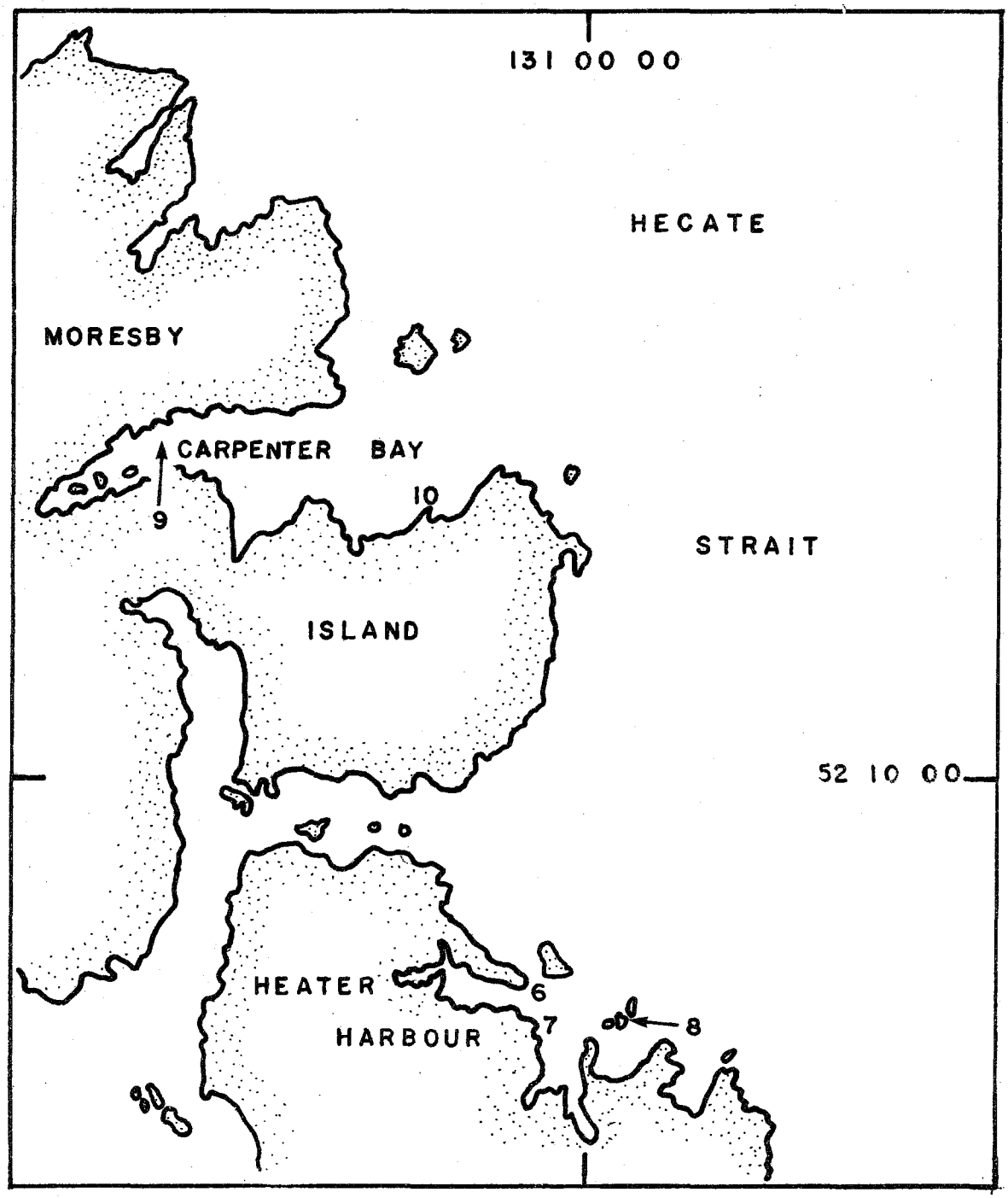


Fig. 2. Dive sites 5-10. Queen Charlotte Islands.

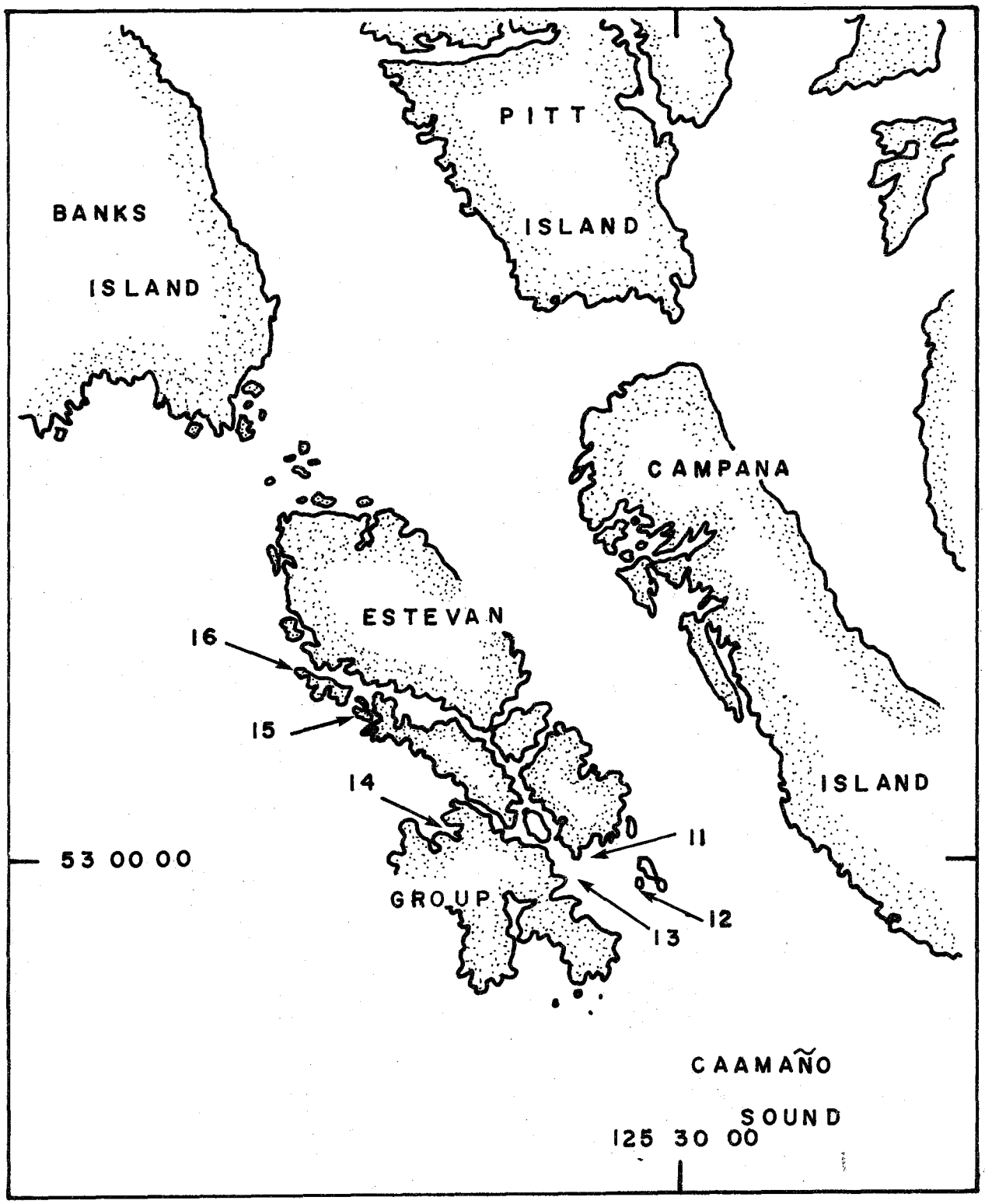


Fig. 3. Dive sites 11-16. Estevan Group.

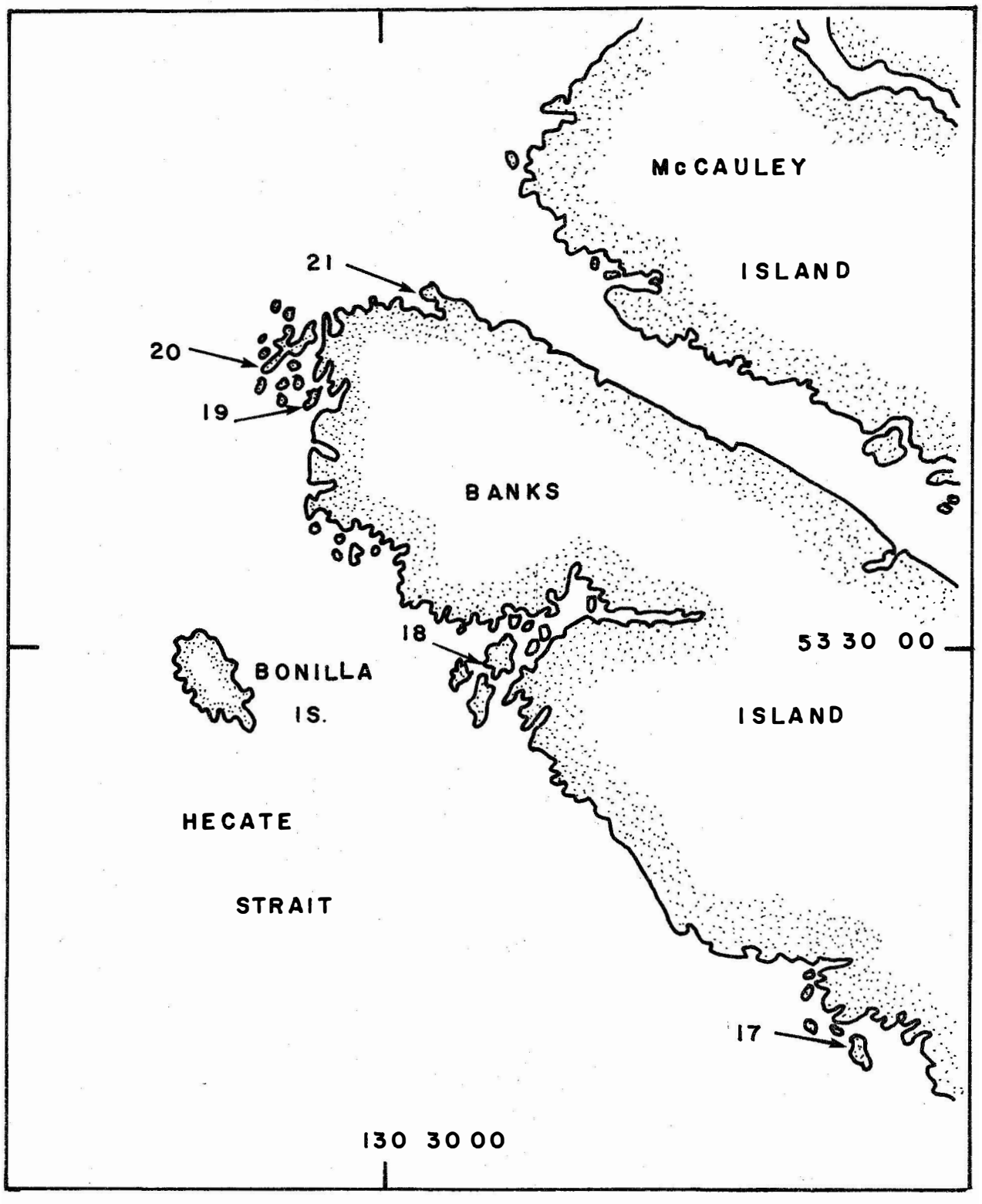


Fig. 4. Dive sites 17-21. Banks Island.

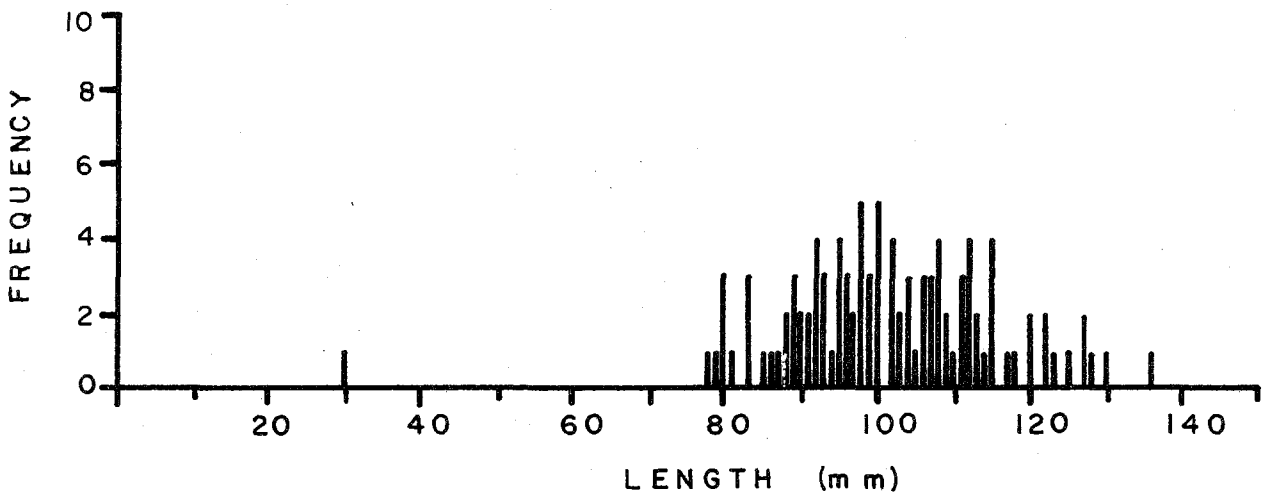


Fig. 5. Abalone population structure at site 1.

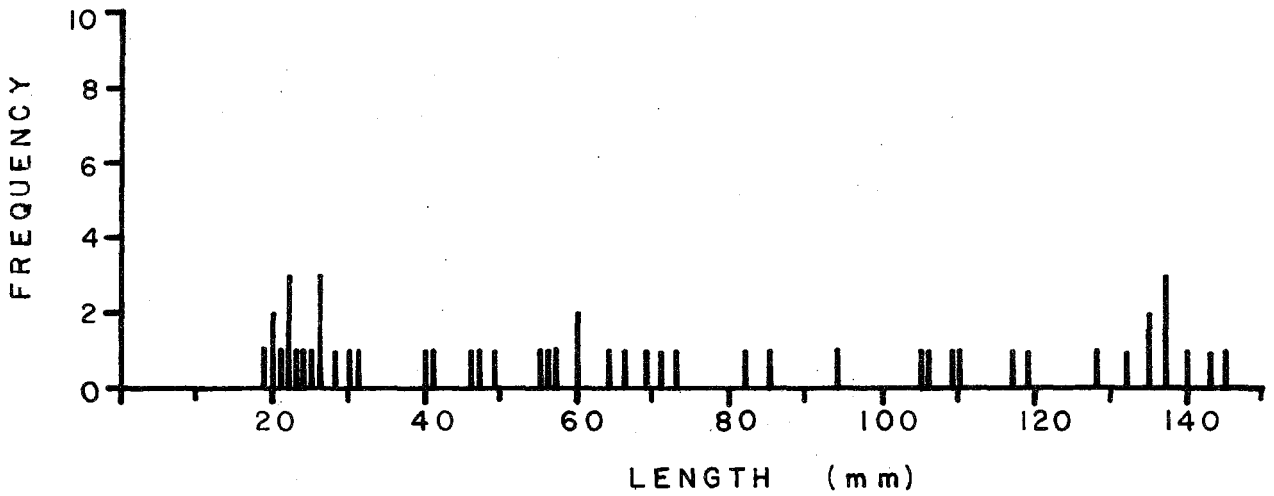


Fig. 6. Abalone population structure at site 2.

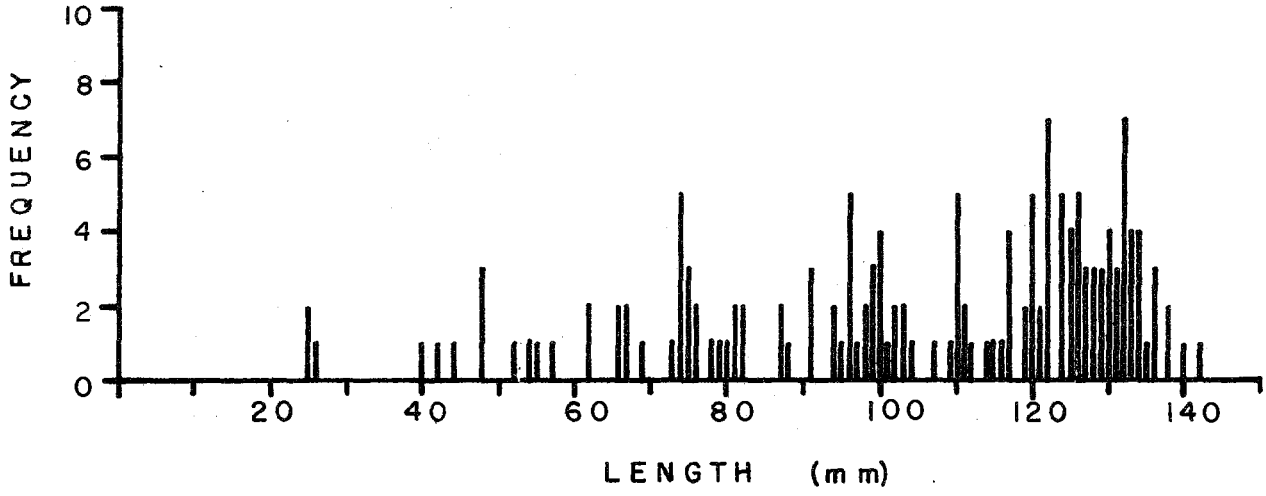


Fig. 7. Abalone population structure at site 3.

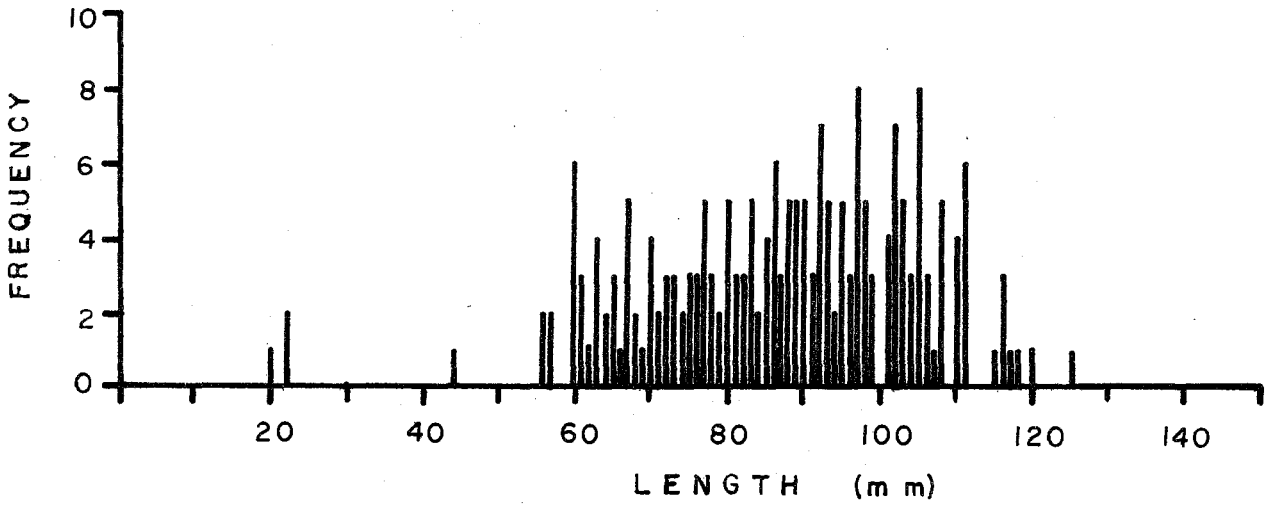


Fig. 8. Abalone population structure at site 4.

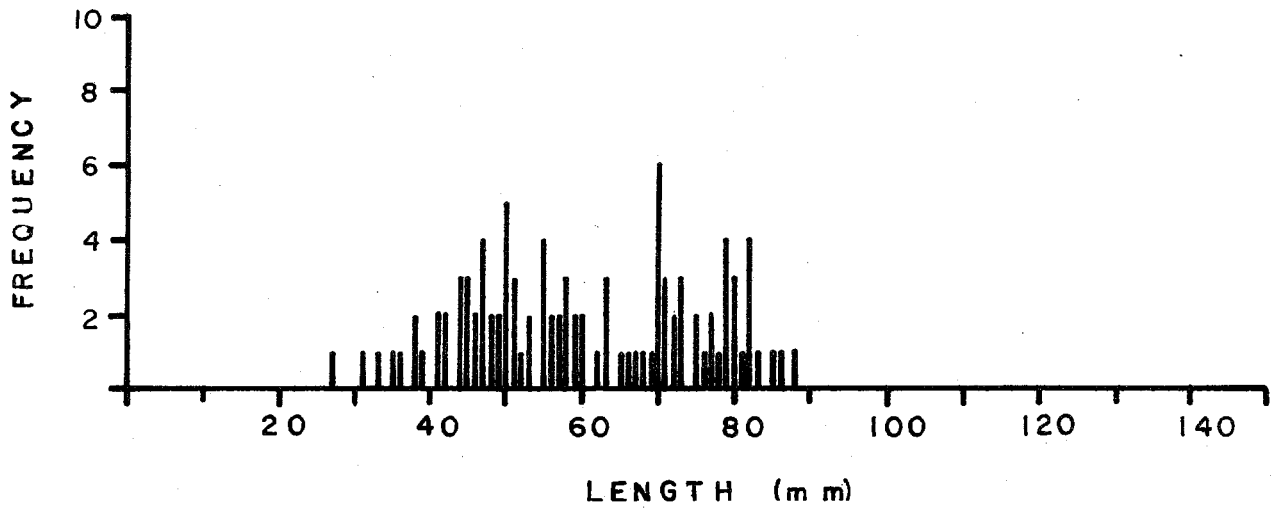


Fig. 9. Abalone population structure at site 5.

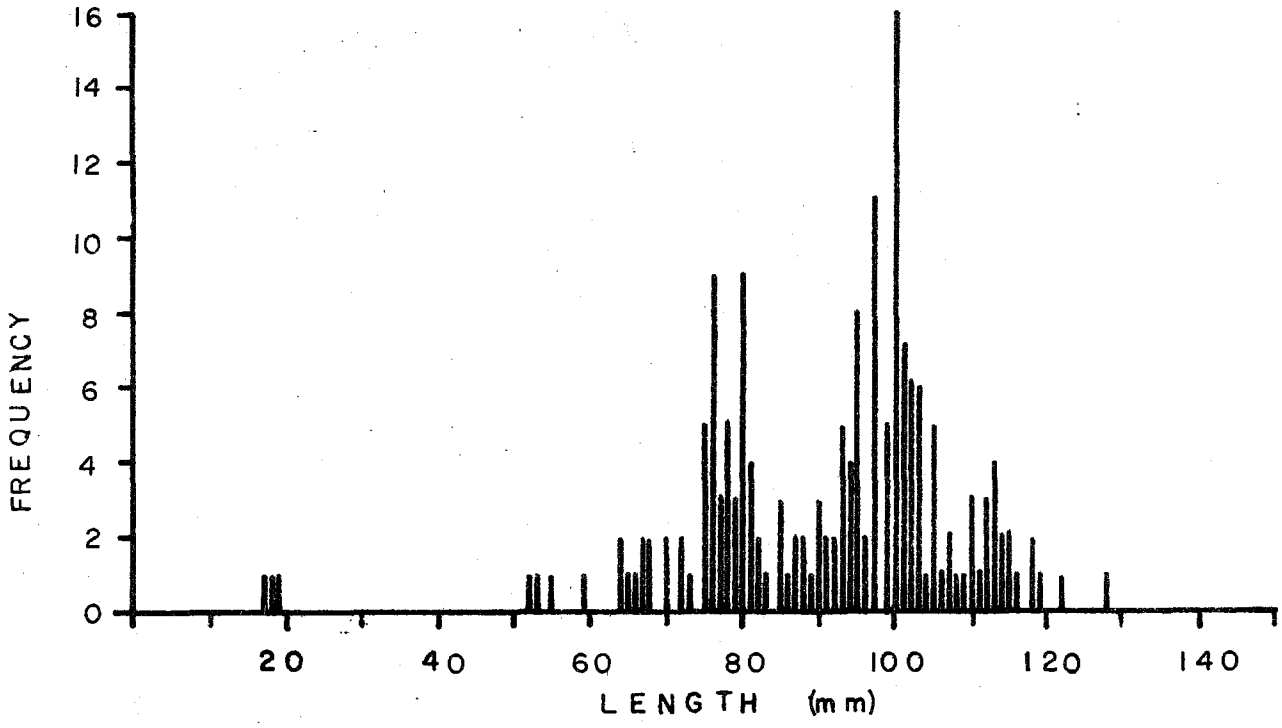


Fig. 10. Abalone population structure at site 6.

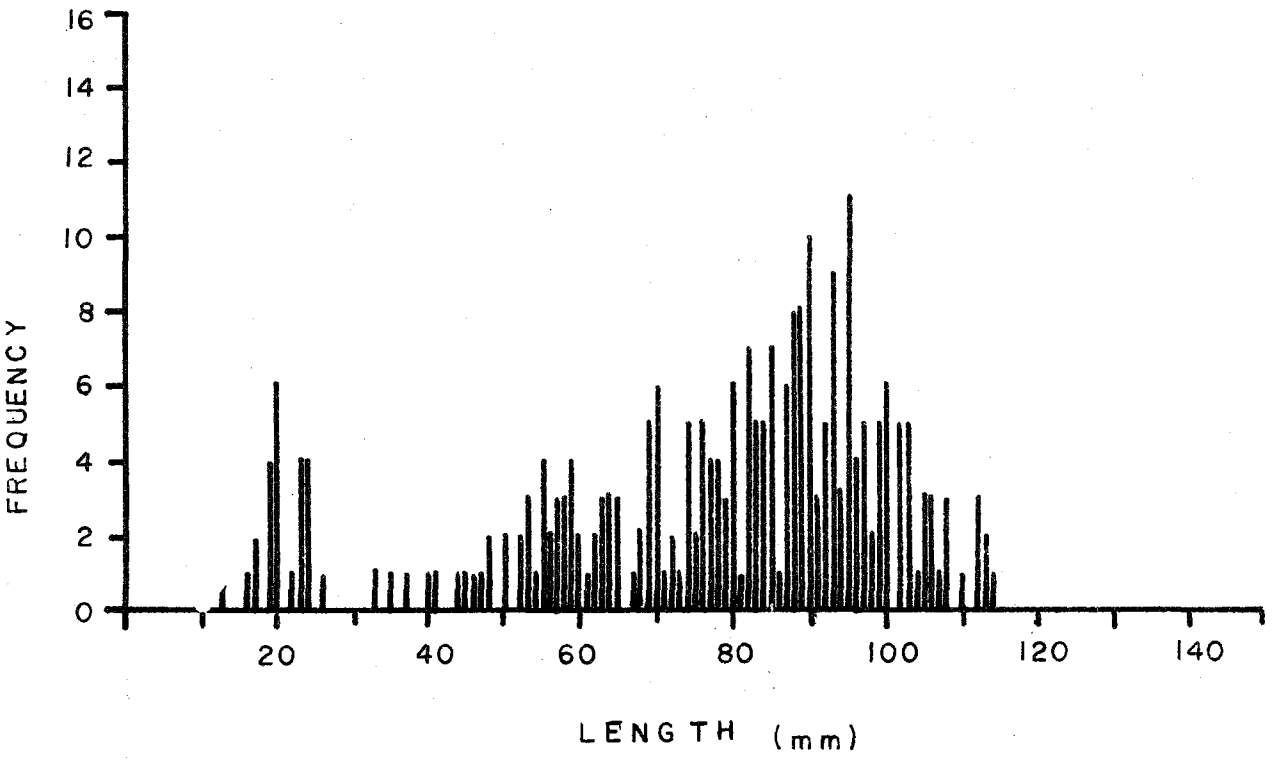


Fig. 11. Abalone population structure at site 8.

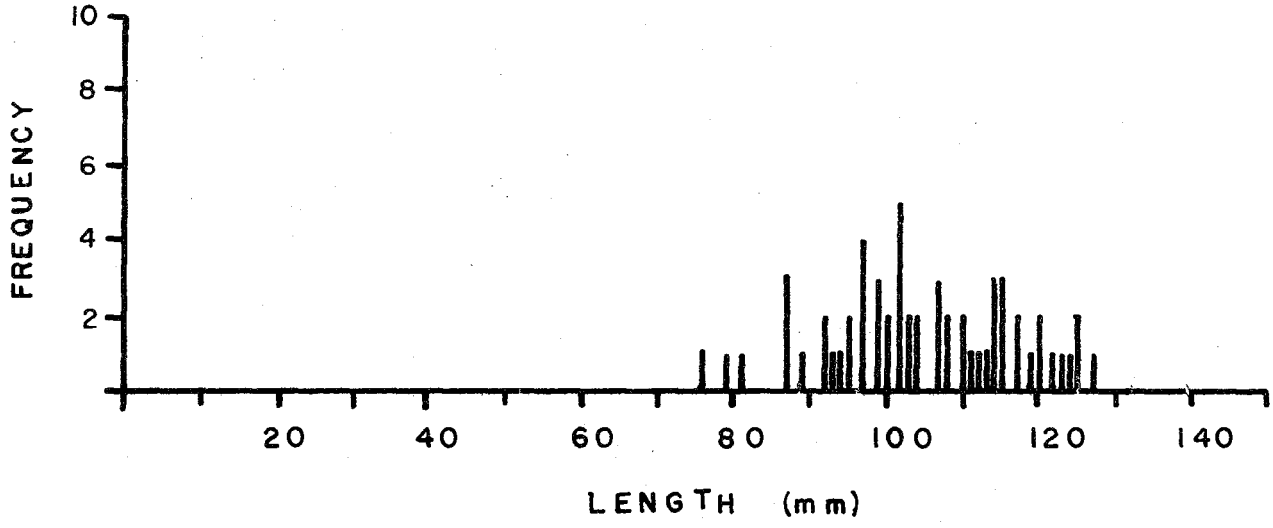


Fig. 12. Abalone population structure at site 9.

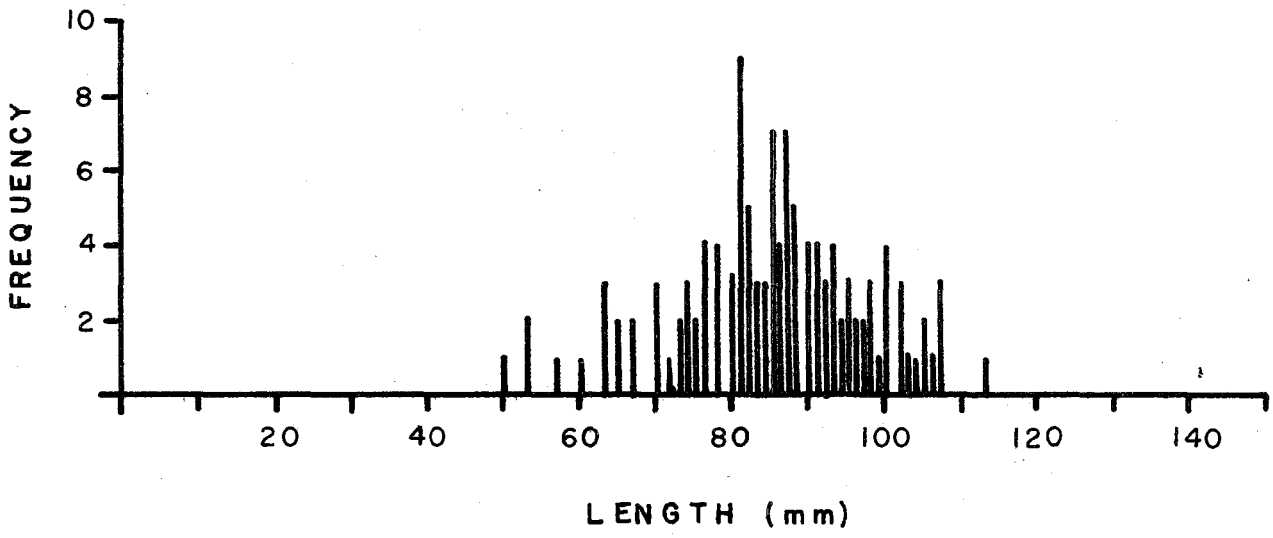


Fig. 13. Abalone population structure at site 10.

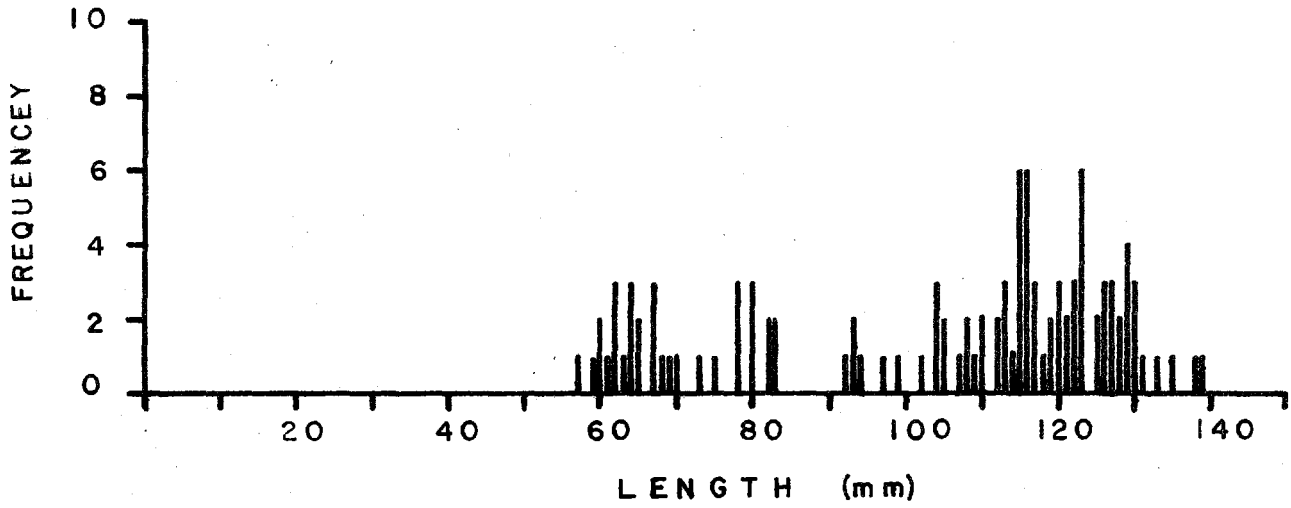


Fig. 14. Abalone population structure at site 11.

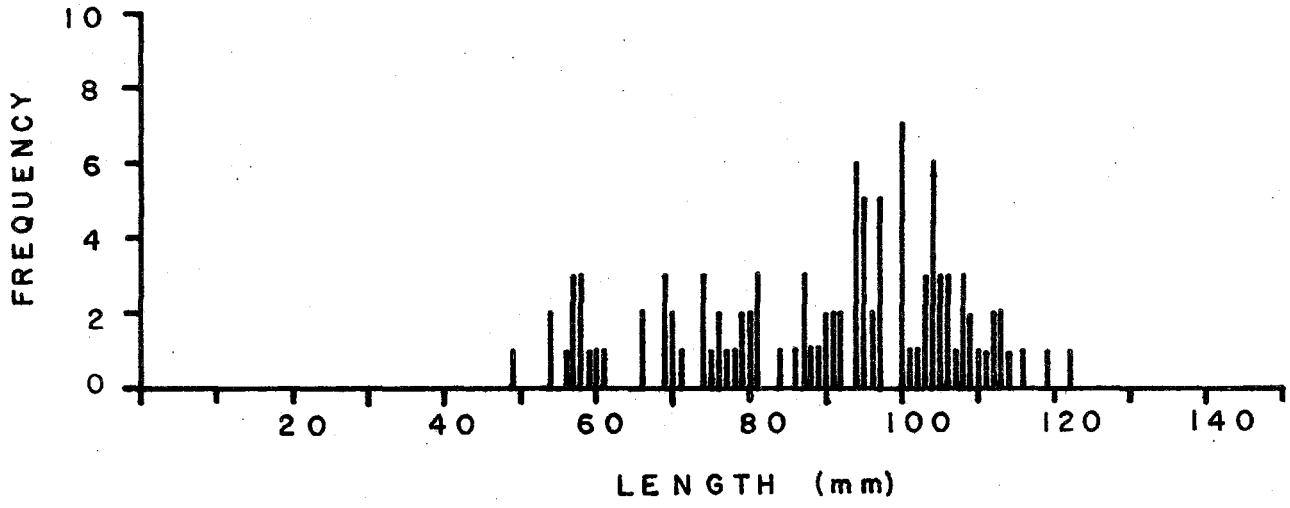


Fig. 15. Abalone population structure at site 12.

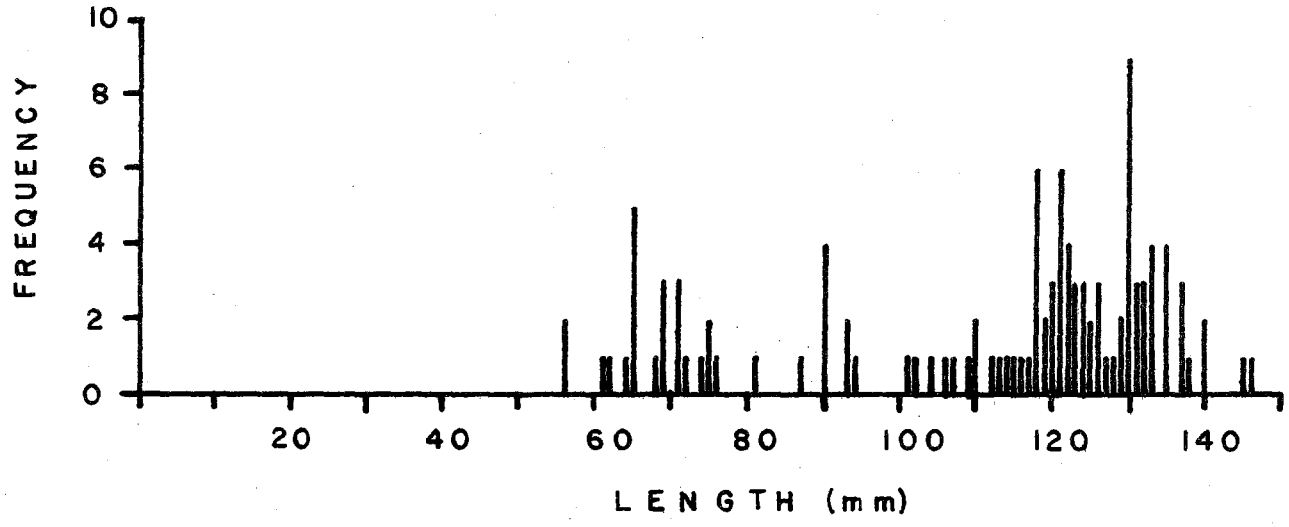


Fig. 16. Abalone population structure at site 13.

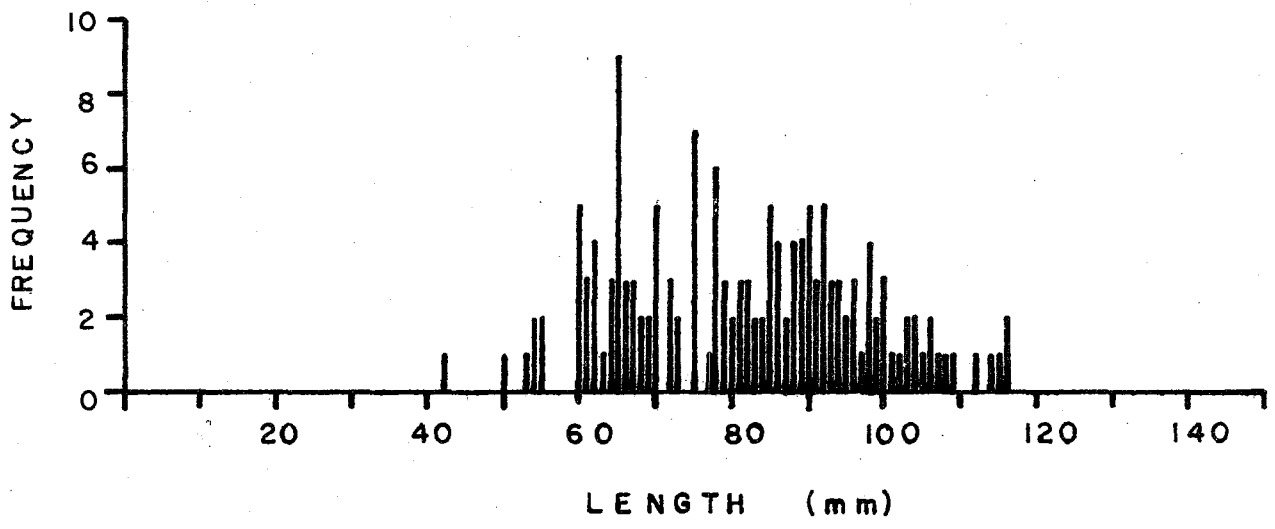


Fig. 17. Abalone population structure at site 14.

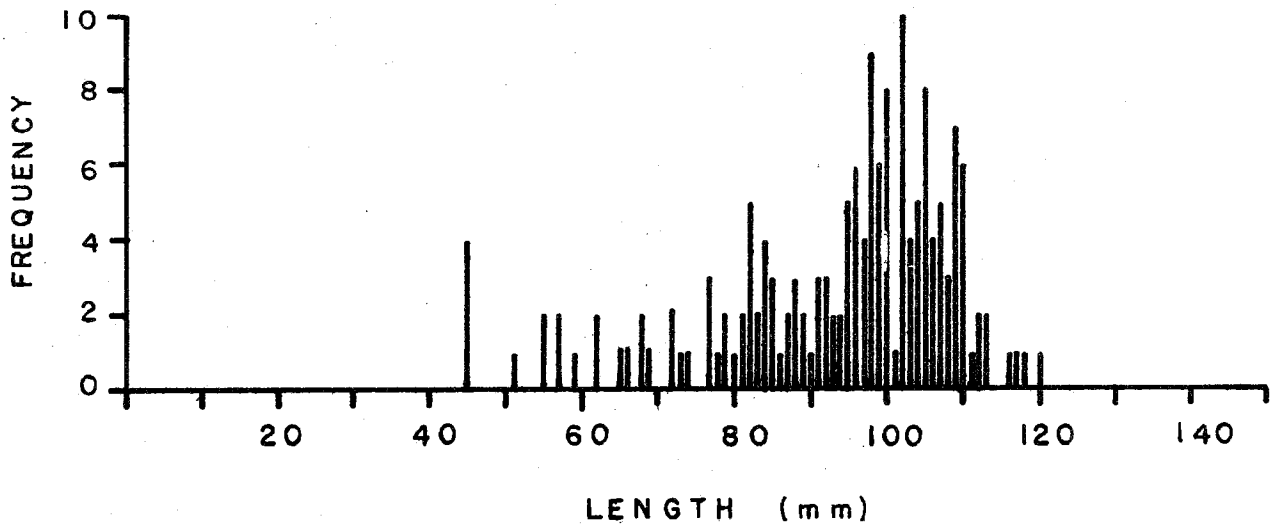


Fig. 18. Abalone population structure at site 15.

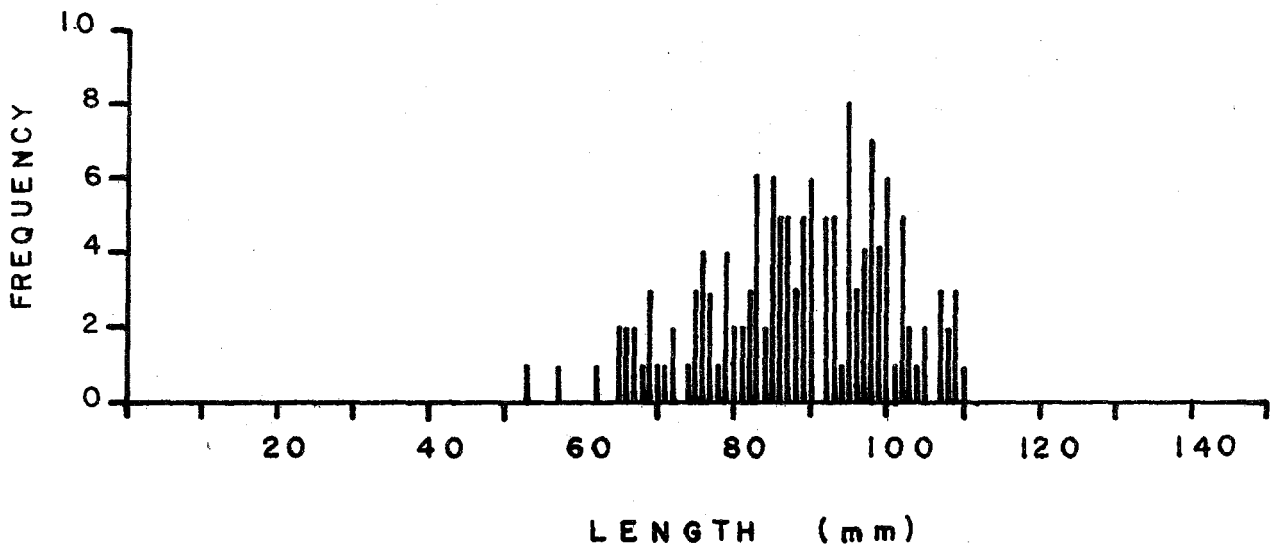
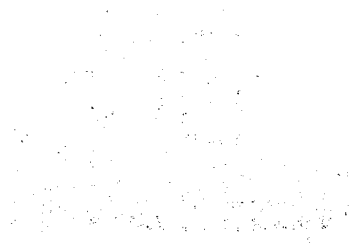


Fig. 19. Abalone population structure at site 16.



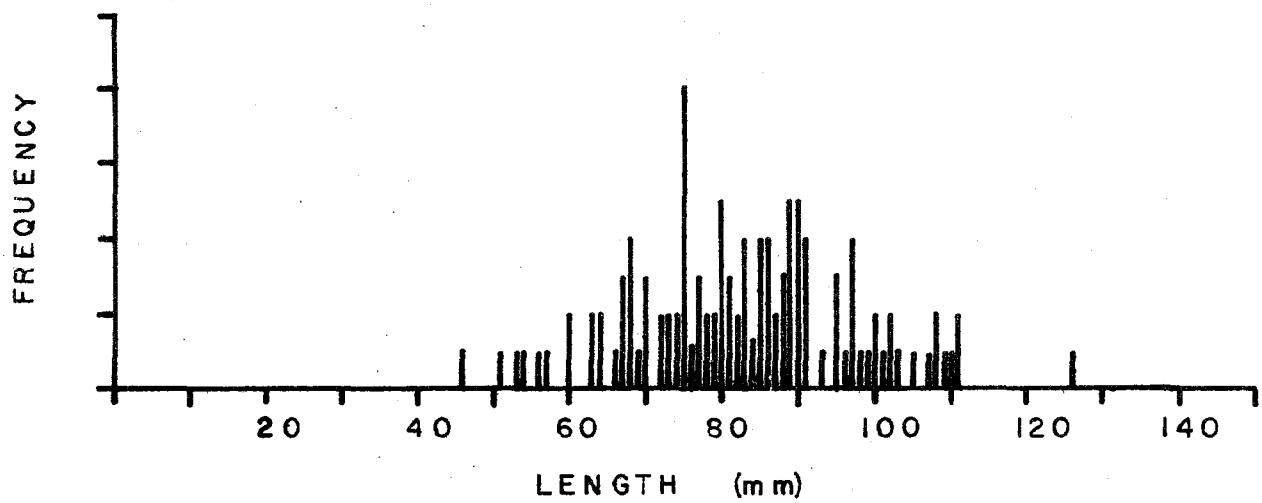


Fig. 20. Abalone population structure at site 17.

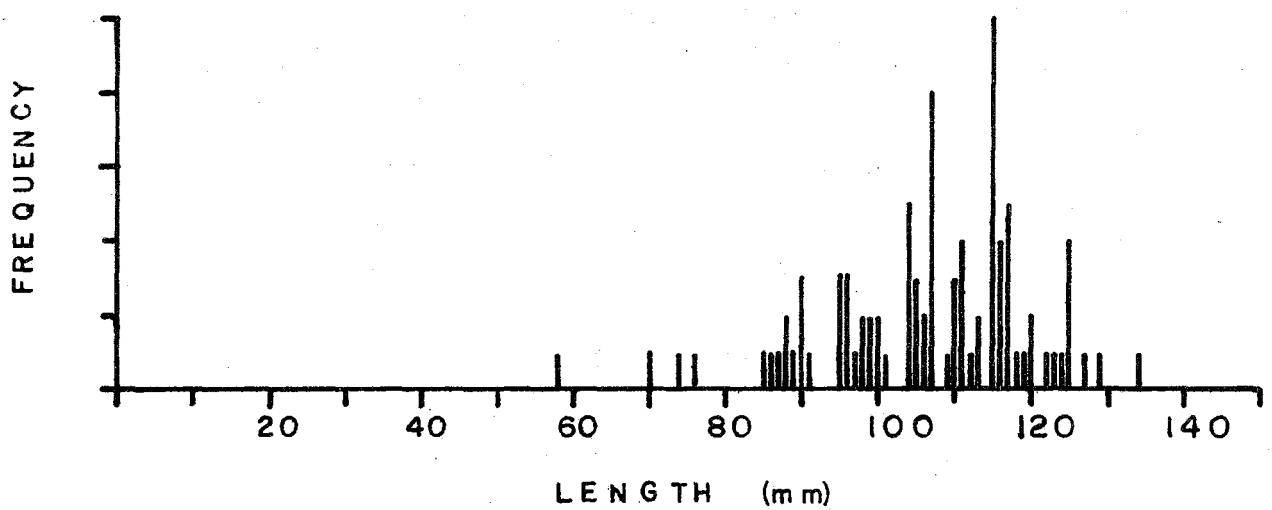


Fig. 21. Abalone population structure at site 18.

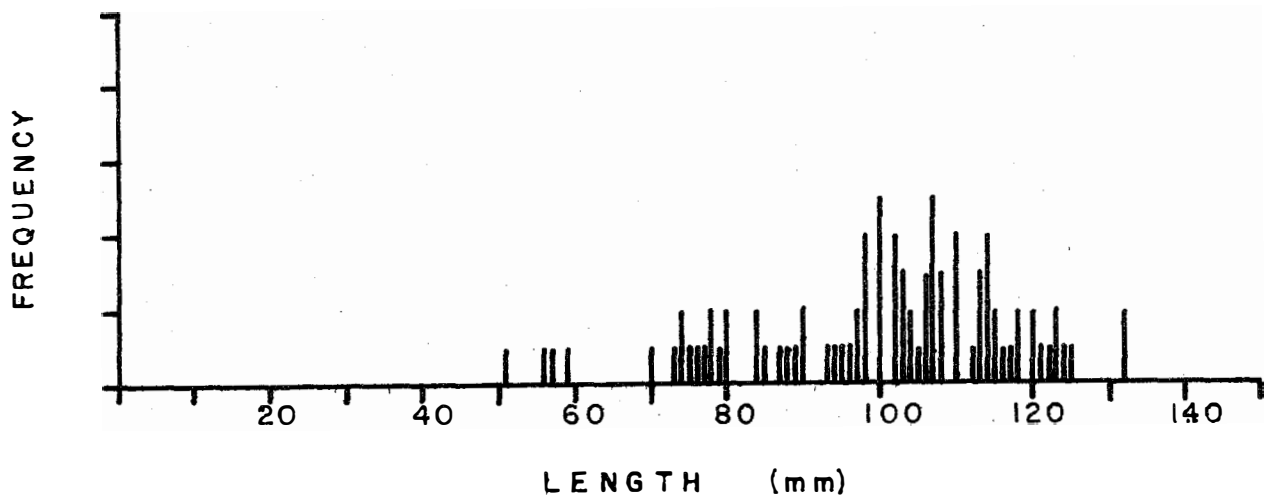


Fig. 22. Abalone population structure at site 19.

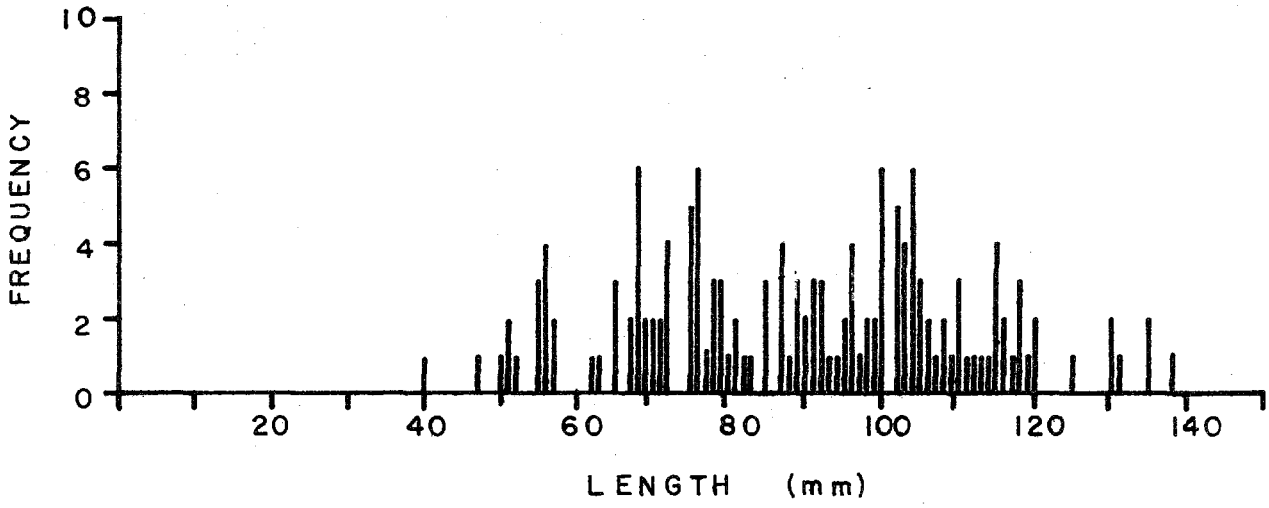


Fig. 23. Abalone population structure at site 20.

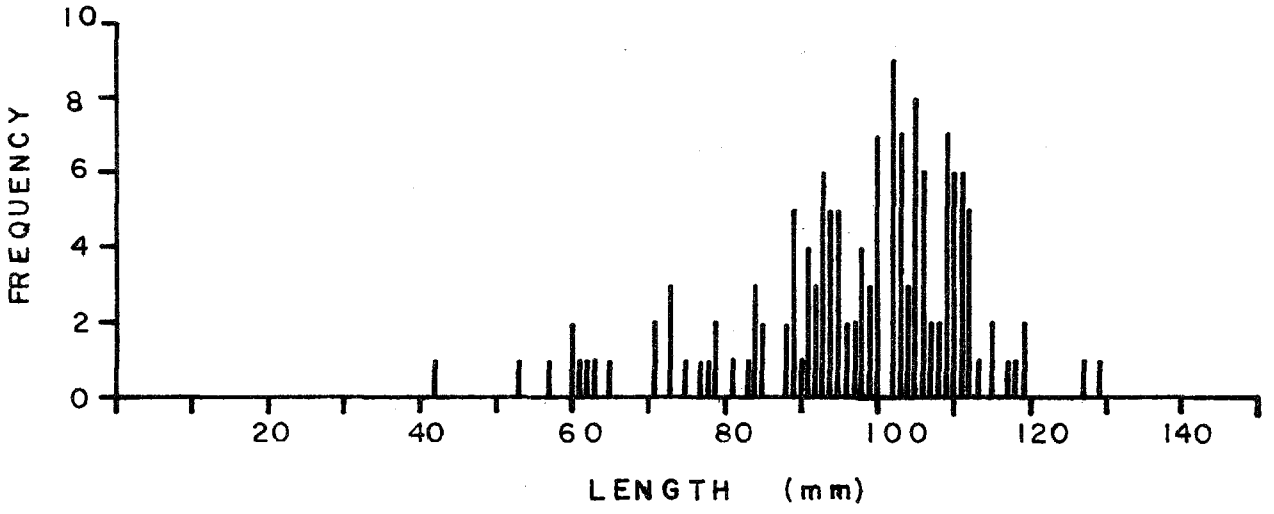


Fig. 24. Abalone population structure at site 21.