Ecology of Rocky Shore Organisms at Macquarie Island

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IN 1948 the Antarctic Division, Australian Department of External Affairs, established a research station at Macquarie Island. As part of the biological work a study of the rocky shore ecology of the island was made (by R. K. during 1948–49 and N. H. in 1949–50).

Although large general collections have been made at Macquarie and other subantarctic islands by various expeditions (notably the Australian Antarctic Expedition, 1911–13, and the British, Australian, and New Zealand Antarctic Expedition, 1929–31) comparable ecological programmes in southern latitudes have been few. Of the papers on similar topics from temperate southern latitudes those of Isaac (1937) on South Africa, Guiler (1952) on Tasmania, Knox (1953) and Batham (1958) on South Island of New Zealand, and Guiler (1959) on Chile are relevant to this study.

MACQUARIE ISLAND

Macquarie Island (54° 29′ S, 158° 58′ E) is situated midway between Tasmania and the Antarctic mainland. The island, with associated rock outcrops to the north and south, is the exposed cap of an extensive submarine ridge running in a general north-south direction. The nearest neighbouring islands are the Auckland Is. and Campbell I., some 400 miles to the northeast (Fig. 1) and separated from the Macquarie Ridge by depths of more than 2,000 fathoms.

The upper levels of this ridge are narrow, a sounding of 1,548 fathoms having been recorded 5 miles east of Macquarie I. (Mawson, 1943).

A complete account of the geography and geology of Macquarie can be found in Mawson (1943). The island, 21 miles long and up to 3 miles wide, is largely composed of volcanic rock. Most of the eastern coastline is formed of a series of sand and shingle beaches separated by rocky headlands or reefs (Figs. 2, 3, 4) but in many places steep cliffs descend almost vertically to the sea (Fig. 5). Much of the west coast has extensive flat reefs and gradually sloping beaches often strewn with large boulders.

The sites investigated in detail (Fig. 6) were all at the north end of the island and were selected to give a variety of habitats and exposures to wave action. General observations were made at other locations.

The climate is typically subantarctic. Meteorological details made available by the Commonwealth Meteorological Bureau, Melbourne, are given in Table 1. The air temperature range is small, the maximum recorded during the period of this survey being 10.7 C (Jan 1950) and the minimum −8.3 C (Aug 1950). Although the total rainfall is not excessive, precipitation—rain, hail, sleet, or snow—occurs almost daily. Strong winds, including gusts of more than 100 knots, are a striking feature of the climate and are predominantly (more than 70%) from the north and northwest. However, climatically the island is milder than other subantarctic islands of similar latitude and there is no permanent ice sheet.

Heavy seas occur at all seasons of the year, and the coastline would be considered an exposed one by any standard (Fig. 7).

Macquarie I. lies within the area of Antarctic surface waters during part of the year, at least. The R.R.S. "Discovery II" plotted the Antarctic convergence in latitudes 53° and 54° S in this region during the winter months of 1932 (Mackintosh, 1946). In the 1948–50 period the monthly mean sea temperatures ranged from 7.2 C (Jan) to 2.8 C (July). Surface salinities to the west and east of the island were recorded by R.R.S. "Discovery II" during the 1932 winter and varied from 33.8‰ to 34.4‰ (Deacon, 1937).

A tide gauge was set up in Buckles Bay (see Fig. 6) but was wrecked by storms after a short

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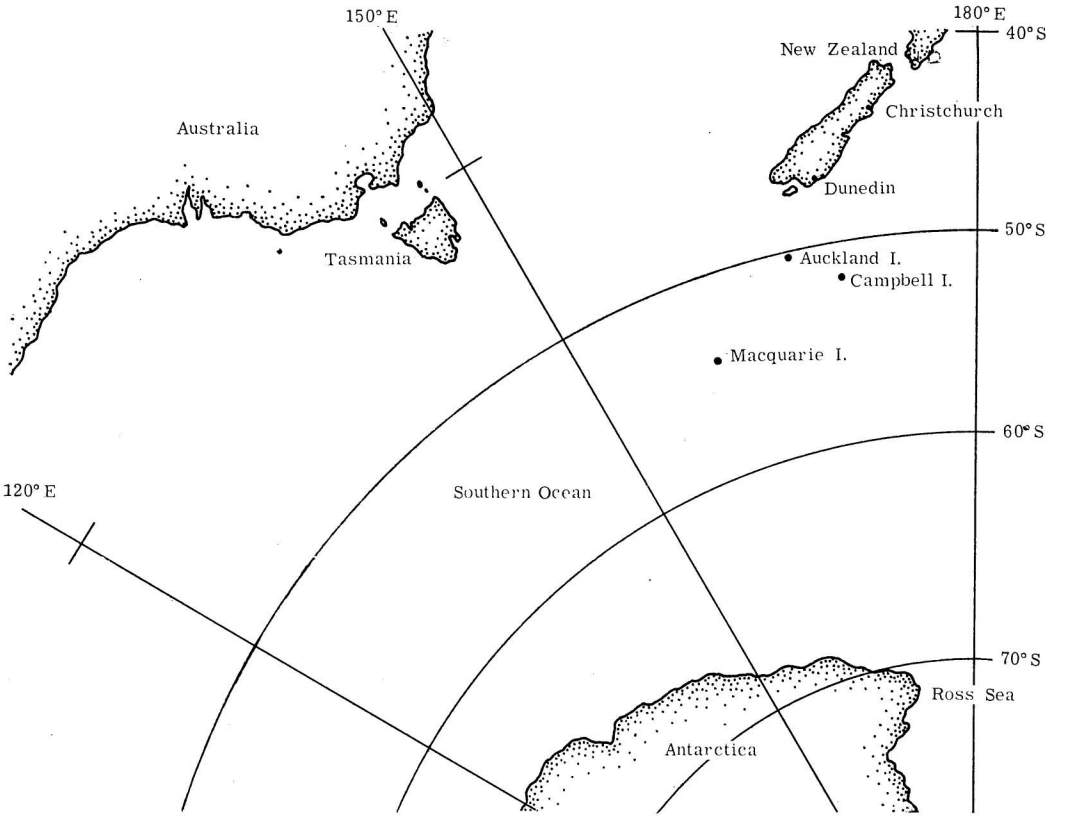

FIG. 1. Macquarie Island and its relationship to surrounding land masses.

period of operation. From the records available the spring range is 4 feet 6 inches and the neap range a little more than 2 feet.

General Features of Zonation

Six zones can be recognized on the rocky shore extending from above high-water springs to below low-water springs. The zones have been described in terms of "effective tidal heights" by Endean, Kenny, and Stephenson (1956) and other authors. These effective tidal heights are based on the correlation of data from the tide gauge at station 2 (see Fig. 6) and from general observations at this and other stations.

The sequence of dominant organisms forming the zonation pattern is:

(i) LICHEN ZONE: Extending from the area dominated by maritime terrestrial flora (Taylor, 1955), down the beach into the region of splash. The common organisms are lichens interspersed with some mosses.

(ii) *Porphyra* ZONE: *Porphyra umbilicalis* dominant from HWS[3] to below HWN.

(iii) "BARE" ZONE: Extending from just below HWN to approximately MSL in which the most obvious species was *Siphonaria lateralis*.

[3] In this paper the following abbreviations have been used:

high water spring tide, HWS
high water neap tide, HWN
mean sea level, MSL
low water neap tide, LWN
low water spring tide, LWS

TABLE 1

METEOROLOGICAL DATA FOR MACQUARIE I., 1948–50

	1948 Apr.–Dec.	1949	1950
Air temp. °C			
maximum	8.75	9.65	10.7
minimum	−3.65	−5.9	−8.3
mean	–	4.25	4.35
Total precip. (inches)	–	37.06	42.55
No. of days precip.	–	336	333
Mean wind vel. (knots)	–	18.2	19.3

(iv) UPPER RED ZONE: In which *Rhodymenia* sp. is dominant from MSL to LWN.

(v) KELP ZONE: *Durvillea antarctica* stipes cover almost the whole area of rock between LWN and LWS, overlying a layer of encrusting red coralline algae.

(vi) LOWER RED ZONE: The red corallines extend below LWS and support a variety of red algae (*Dellesseria* spp., and *Iridea* sp.) and brown algae (*Desmarestia* sp.).

The most striking features of this zonation pattern are the absence of an upper "littorinid" and a "barnacle" zone, and the plant domination of the shore. In five of the zones the obvious and dominant organisms are botanical, and although animals are common they are, generally, small and secondary to the algae and lichens in biomass. It is only in the "bare" zone, where *Siphonaria lateralis* is the commonest organism, that there is a faunal dominant.

Details of Particular Zones

LICHEN ZONE: This area is characterised by several species of lichen, the most obvious being *Verrucaria* sp. and an unidentified bright yellow form, and the red alga, *Hildenbrantia* sp.

Many plants, common in the terrestrial maritime association (Taylor, 1955) extend seawards into this zone in varying densities. The moss *Muelleriella crassifolia,* and the grass *Puccinellia macquariensis,* are more noticeable in relatively exposed locations. The vascular plants *Colobanthus muscoides* and *Cotula plumosa,* and the moss *Ceratodon purpureus* occur commonly in more sheltered areas. Isolated plants of tussock grass, *Poa foliosa,* are scattered through the upper section of this zone.

The faunal element of this zone is restricted to small species of cryptic habit living among the plants. The variable densities of these species at different localities appear to be controlled by the amount of detritus, forming a suitable habitat, in the rock crevices and around the plants.

The most frequently recorded animals are the mite *Halozates* sp., the beetles *Antarctotachinus crozetensis* and *Antarctophytosus macquariensis,* larvae of dipterans, *Coleopa macquariensis* and others, and various collembolans.

Porphyra ZONE: *Porphyra umbilicalis* forms a thick mat, the upper limit of which is reached by the sea only at high water of spring tides. In calm weather the dry weed forms a conspicuous band around the island's coastline.

The upper part of the zone is formed frequently of an association in which as well as the dominant *Porphyra* there are many plants of *Rhizoclonium* sp. and *Iridea boryana* and, less commonly, *Prasiola* sp. In some situations *Acrosiphonia pacifica* is found in patches, and this alga and *Chaetangium fastigium* are common in the lower part of the *Porphyra* complex.

Where pools or similar suitable habitats are available *Ulva lactuca, Enteromorpha intestinalis,* and *Cladophora* sp. extend throughout the *Porphyra* mat.

The animal species common at this level are those noted in the lichen zone, with fewer Collembola, and the addition of the oligochaetes *Lumbricillus macquariensis* and *Marionina antipodum.* The gastropod *Macquariella hamiltoni* has been observed in the *Porphyra* zone but typically is found at lower levels of the beach.

"BARE" ZONE: Considerable variation in the horizontal and vertical extent of this zone was observed (see below) and at some stations the "bare" zone was not noted. However, when well developed, it is marked by the close-cropped nature of the algal constituents, the common forms being *Chaetangium fastigium* and *Acrosiphonia pacifica.*

The dominant organism is *Siphonaria lateralis* which, though common throughout this level of the beach, appears to favour dissected and creviced rock surfaces. The species attains its maximum density at the lower limit of this zone (approximately MSL) and in suitable locations

numbers up to 1,500 individuals per square metre.

Other common animals include *Macquariella hamiltoni,* the limpet, *Nacella delesserti, Lumbricillus macquariensis, Marionina antipodum,* numerous amphipods, *Hyale novae-zealandiae* being the most frequently recorded, and many small nematodes.

Some specimens of *Halozates* sp. and *Coleopa macquariensis* range down to this level but they are essentially fauna of the upper zones. Similarly a few nemerteans and turbellarians have been recorded from the "bare" zone but they are more common below MSL.

UPPER RED ZONE: This is a narrow zone in which the red alga *Rhodomenia* sp. is the dominant organism. In general, the boundaries of the zone are sharply defined. On certain reefs, however, the lower limit was ill marked and many plants of the dominant alga were observed among the stipes of the kelp and extending below LWS. The dense growth of *Rhodomenia* forms a thick covering, protecting a wide range of small animals.

The fauna shows elements from the higher zones and also many species which are usually found at lower levels.

Hyale novae-zealandiae is, numerically, the dominant animal and *Siphonaria lateralis, Nacella delesserti,* and *Macquariella hamiltoni* are the common secondary animals. *Lumbricillus macquariensis* and *Marionina antipodum* were recorded in small numbers.

Other animals noted are representatives of the fauna of lower tidal levels and are not as common as those mentioned in the preceding paragraph. They include the lamellibranchs *Kidderia pusilla* and *Gaimardia trapesina,* the

FIG. 2. View from Wireless Hill looking south along the isthmus with Hasselborough Bay on the right. Station 4 in the right middle distance. (Australian Department of Information photo.)

FIG. 3. Garden Cove, at low water. Traverses A and B (Fig. 9) were on rock faces in right middle distance.

gastropod *Laevilittorina caliginosa,* the isopod *Exosphaeroma gigas,* and small numbers of the polychaetes, *Boccardia polybranchia, Cirratulus cirratus, Platynereis magalhaensis,* and *Spirorbis aggregatus.* Small colonies of the bryozoan *Barentsia aggregata* are present.

KELP ZONE: In this zone the rock surfaces are dominated by the massive stipes of *Durvillea antarctica* (Fig. 8), many of the plants having holdfasts 40 cm in diameter. Among the *Durvillea* stipes the rock is covered by a layer of encrusting red coralline, alga, the upper limit of which is usually a little below that of the kelp. In the few situations (usually protected from wave action) where the kelp is poorly developed the coralline alga is the dominant organism.

The laminae of *Durvillea* are singularly devoid of life. However, the goose barnacle, *Lepas australis,* was recorded from pieces of kelp found on the beach after gales.

The recesses of the holdfasts support a dense and varied population which is listed in Table 2.

In contrast there is a marked paucity of species associated with the encrusting coralline where the kelp is absent. Small groups of *Spirorbis aggregata* and a few specimens of the echinoderms *Pseudopsolus macquariensis* and *Stichaster suteri* were noted.

LOWER RED ZONE: Below the *Durvillea* zone in the truly infralittoral is a community comprised of several species of red algae: *Ballia callitricha, Ceramium rubrum, Delessaria* sp., *Iridea* sp., *Plocamium coccineum,* and *Schizoseris* sp. The brown alga *Desmarestia rossi* is common and (as mentioned above) *Rhodymenia* frequently extends below the kelp zone. The coralline covering the rocks continues below LWS except in certain silted areas.

The fauna of this zone is a large and varied one with some animals dependent on a particular type of habitat and others distributed widely. In Table 3 the common species are listed with their representative habitats.

Comparison of Traverses

As would be expected, the vertical dimension of each of the dominant zones is influenced by the combined effects of the slope of the rock surface and the exposure to wave action.

Comparable measurements were made at particular localities and the zonation picture for each is shown in Figure 9.

> Garden Cove, traverse A; slope 80°, on the north shore of the cove, near the entrance to the cove and exposed to all weather from the east or southeast (Figs. 3, 10).
>
> Garden Cove, traverse B; slope 60°, on the north shore of the cove, partially protected from surf but covered by the wash from swell.
>
> Fish Trap, vertical; facing southeast, partially protected by offshore rocks and kelp (Fig. 5).

The obvious differences at these three localities are:

1) On traverse B the extension upwards of the zones above MSL, their greater width and greater density. The raising of effective tidal heights at the upper levels of sloping shores has been discussed by Endean, Kenny, and Stephenson (1956).

2) The wider "bare" zone and its sparser flora and fauna on the vertical slope.

3) The deeper extension, below LWS, of the kelp on traverse A due, presumably, to the heavier surf in this area.

The species composition was essentially the same in each case and only minor variations in density were noted. *Chaetangium fastigiatum* was less dense at A than at B and absent on the vertical face. *Rhodymenia* sp. was observed on the exposed rock face at A but not at either of the other localities.

Two "flat" reefs were surveyed in detail, station 1 in Buckles Bay being considered as typical of this type of rock formation, and a gently sloping platform near the fishtrap (Fig. 11) as a contrast to the nearby vertical face (see above).

Station 1 was reasonably protected by offshore rocks and a wide belt of *Durvillea.* The true tidal levels given in Figure 11 are those recorded from the tide gauge (which was installed on this reef) during its functional period in 1950. Although spread horizontally and modified by the intrusion of pools and gutters the vertical range of the major zones is comparable with that of the steeper reefs (Fig. 9).

The more protected and gently sloping (10°) reef near the fishtrap showed a simplified version of the typical zonation pattern with only the dominant organisms present in any density, and an expanded "bare" zone (Figs. 9, 11), which supported more gastropods, *Macquariella hamiltoni,* than usual as well as the typical *Siphonaria lateralis.*

The gullies crossing this reef were awash and many small *Durvillea* plants grew there.

The *Porphyra* and *Rhizoclonium* zone was protected from all but the heaviest weather and normally was dampened by fine spray only.

Station 2 (Fig. 9) was a vertical rock face on the shoreward side of a reef near station 1 and

TABLE 2

FAUNA OF *Durvillea* HOLDFASTS
(Arranged alphabetically)

VERY COMMON	COMMON	PRESENT
Hyale novae-zealandiae	*Barentsia aggregata* *Laevilittorina caliginosa* *Macquariella hamiltoni* *Nemertopsella marri* *Spirorbis aggregata*	*Aphroceros* sp. *Exosphaeroma gigas* *Hyale hirtipalma* *Ias pubescens* *Jassa falcata* *Munna maculata* *Paramoera schellenbergi* *Procerodes ohlini* *Pseudopsolus macquariensis*

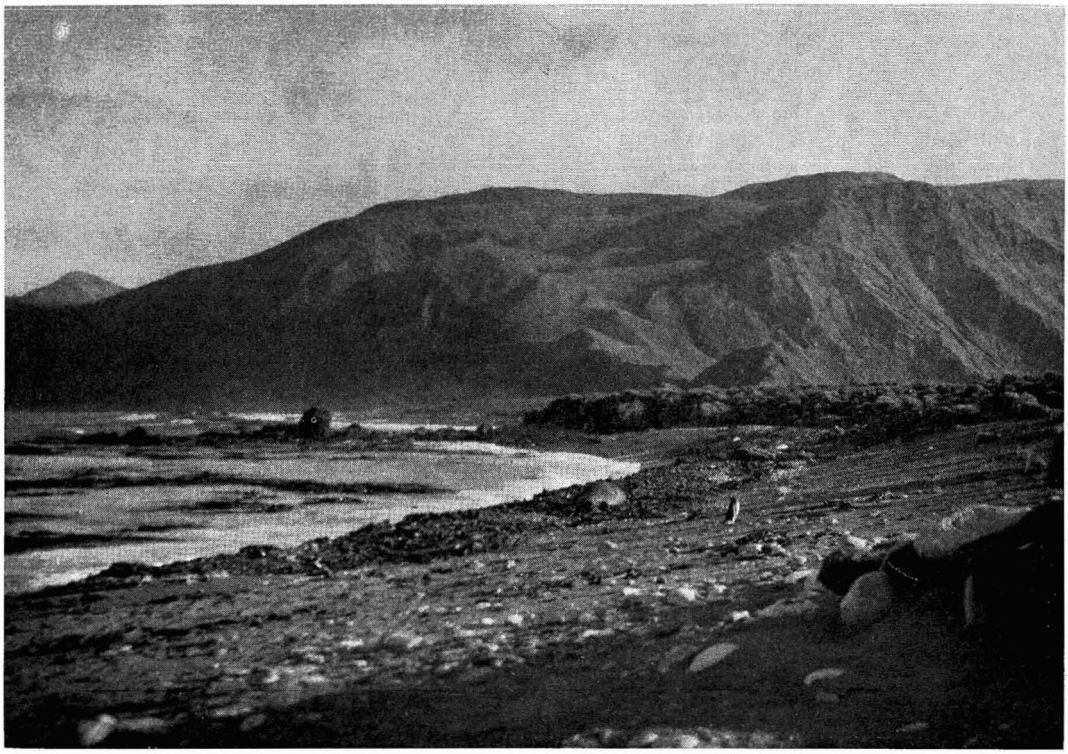

FIG. 4. Buckles Bay with Station 1 reef in the middle distance.

sheltered from surf but washed by spent waves. The main variation from the typical pattern was the obliteration of the "bare" zone by the overlapping of the *Porphyra* and Red belts.

Role of Kelp

The large brown algae are the most conspicuous feature of the Macquarie I. marine flora. Extensive beds of *Macrocystis pyrifera* occur offshore in several fathoms of water, and the island is fringed by *Durvillea antarctica* attached to reef edges and offshore rocks (Figs. 8, 12).

Macrocystis, growing in deeper water, escapes much of the force of wave action and is characterised by a more slender and longer form than *Durvillea.* The only conspicuous organisms on the fronds of *Macrocystis* were extensive colonies of the hydroid *Orthopyxis platycarpa,* but the tangled holdfasts showed evidence of a rich infralittoral fauna. The fauna of *Durvillea* holdfasts has been listed above (Table 2).

Durvillea antarctica plays an important part in protecting the reefs from the full force of the surf, the floating fronds damping the breaking of the swell. However, during storms the laminae of the kelp are whipped against the rock surfaces and at some localities this appears to be a factor contributing to the sparseness of the "bare" zone fauna.

Rock Pools

Many rock pools were examined and in general revealed a group of organisms similar to that of the surrounding rocks, with the addition of species from lower tidal levels.

The pools maintained by splash or the high seas of storms present a habitat of extreme conditions. During the winter months they freeze on some occasions. At any time of the year the decomposition of broken kelp, hurled onto the reefs by storms, must cause considerable variation in chemical composition of the pools. Dur-

ing the summer period they are fouled by elephant seals, *Mirounga leonina.*

A pool, 5 m wide and 25 cm deep at approximately HWS near station 1, was examined on several occasions. At the end of the 1948–49 summer (17.ii.49) there was present a rich population including *Ulva, Enteromorpha, Rhodymenia,* small patches of encrusting red coralline alga, *Macquariella hamiltoni, Siphonaria lateralis, Exosphaeroma gigas, Hyale novaezealandiae, Marionina antipodum,* turbellarians, and copepods.

The same pool at the end of the 1949–50 summer (9.iii.50) was full of rotting kelp and sea elephant faeces with no trace of the former population.

Biotic Factors

As mentioned above, the movement of the kelp fronds is a probable factor in delineating the "bare" zone, but grazing of this area by molluscs, especially *Siphonaria,* could also contribute.

Predators may play an important part in limiting the population density of some species.

The introduced, flightless "woodhen," *Gallirallus australis,* and the Dominican gull, *Larus dominicanus,* forage in the upper algal zones for food. Examination of stomach contents of Dominican gulls shows that the gastropod *Cantharidus coruscans* forms a major part of the diet of these birds. The denser populations of these molluscs occurred where there was a heavy algal cover, presumably protecting them.

Stomach contents of the kelp-inhabiting fish *Notothenia macrocephala* included a wide variety of crustacean and polychaete fragments.

DISCUSSION

In contrast to Australian coastlines the Macquarie I. rocky shore is dominated by algae;

TABLE 3

FAUNA OF THE LOWER RED ZONE*

ORGANISM	HABITAT	ABUNDANCE	ORGANISM	HABITAT	ABUNDANCE
Aphroceras sp.	A,B	4	*Munna maculata*	E	2
Myriothela meridiana	B	4	*Tanais litoralis*	E	2
Halianthella kerguelensis	C	3	*Hyale novae-zealandiae*	B,C,D,E	2
Parantheopsis cruentata	C	3	*Jassa falcata*	B,C,D,E	2
Procerodes oblini	D,E	3	*Paramoera schellenbergi*	B,C,D,E	2
Nemertopsella marri	B,D	4	*Halicarcinus planatus*	B	4
Lineus scotti	B,D	4	*Pycnogonum platylophum*	D	4
Nematoda (unidentified)	C	2	*Tanystylum neorhetum*	D	4
Arenicola assimilis	D	4	*Tanystylum styligerum*	D	4
Boccardia polybranchia	C	3	*Cantharidus coruscans*	A,B	3
Cirratulus cirratus	C	3	*Laevilittorina caliginosa*	A,D,E	2
Fabricia alata	C	3	*Macquariella hamiltoni*	A,D,E	2
Nereis kerguelensis	C	3	*Nacella delesserti*	A,B	3
Platynereis magalhaensis	C,D	2	*Gaimardia trapesina*	E	2
Spirorbis aggregatus	A,B	3	*Kidderia pusilla*	C	2
Marionina werthi	C	3	*Barentsia aggregata*	B	4
Copepoda (unidentified)	C,D,E	2	*Stichaster suteri*	A,B	4
Cassidinopsis emarginata	E	2	*Pseudopsolus macquariensis*	A,B,C	2
Exosphaeroma gigas	D,E	1	*Molgula novae-zealandiae*	C	2
Ias pubescens	D,E	3			

* Letter symbols refer to type of habitat; numerical symbols to relative density of species; organisms are listed alphabetically within taxonomic groups.

A, upper surface of rocks
B, crevices
C, sand and mud
D, under embedded stones
E, algal fronds

1, very common
2, common
3, present
4, occasional specimens

FIG. 5. Fish trap station, showing dense masses of *Durvillea.*

Porphyra, Durvillea, and various red algae being the most obvious organisms. The greater role played by the algal elements of the biota in higher southern latitudes has been noted by other writers, like Bennett and Pope (1952), Guiler (1960), and Knox (1960). The observations in this report suggest that Macquarie approaches the extreme condition of this latitudinal progression in the Australian sector of the Southern Ocean. Other islands in comparable southern latitudes, Kerguelen I. and Heard I., show a similar algal predominance (personal observation, R. K.).

Stephenson and Stephenson (1949) have suggested that a "littorinid-balanoid-laminarian" zonation is of almost universal occurrence on cool temperate exposed rocky shores although the species present may vary. The kelp zone at Macquarie can be considered as the "laminaria" of the typical plan. Nothing equivalent to the "littorinid" or "balanoid" zones was observed. With the absence of these zones and the climatic conditions of frequent storms, high winds, and large spray areas, it is difficult to correlate the Macquarie pattern with the generalised plan of either Stephenson and Stephenson (1949) or Womersley and Edmonds (1952).

Doty (1957), in his review, comments on the intermingling of the terrestrial and truly littoral flora in areas of heavy spray, and equates the laminarian and Delesseriaceae zone of the North Pacific with the infralittoral zone of Stephenson and Stephenson (1949). A similar situation prevails at Macquarie I.

A littorinid and a balanoid zone are recorded from Tasmania (Guiler, 1952) and southern New Zealand (Batham, 1960), although in the former area the barnacles were considered to be of reduced importance, compared with lower latitudes. Powell (1955) reports littorinids from Auckland I.

Mussels, common on coasts of southern Aus-

tralia (Bennett and Pope, 1952), New Zealand (Batham, 1960), and Chile (Guiler, 1959), and recorded by Powell (1955) at Auckland I., were not collected in this survey.

The tube worm, *Spirorbis aggregatus,* occurs in patches and cannot be considered ecologically equivalent to the zones of tube-building polychaetes in warmer latitudes (Dakin, Bennett, and Pope, 1948; Bennett and Pope, 1952). In New Zealand the tube-building polychaete, *Pomatoceras coeruleus,* is less common in the south, near Dunedin (Batham, 1956), than near Christchurch (Knox, 1953).

The *Pyura* zone, so prominent on Australian shores (Dakin, Bennett, and Pope, 1948), New Zealand (Batham, 1956), and South American shores (Guiler, 1959) is not represented at Macquarie, although small ascidian (*Molgula*) communities were noted at the lower levels of the shore.

On the Pacific coast of South America species of *Siphonaria, Nacella,* and *Lessonia* are important organisms (Guiler, 1959) and these genera are represented in the collections from Macquarie.

Of southern hemisphere localities at which comparable investigations have been made, the west coast of South Africa (Isaac, 1937) shows a general format similar to Macquarie I. There, the shore is alga-dominated and shows zones

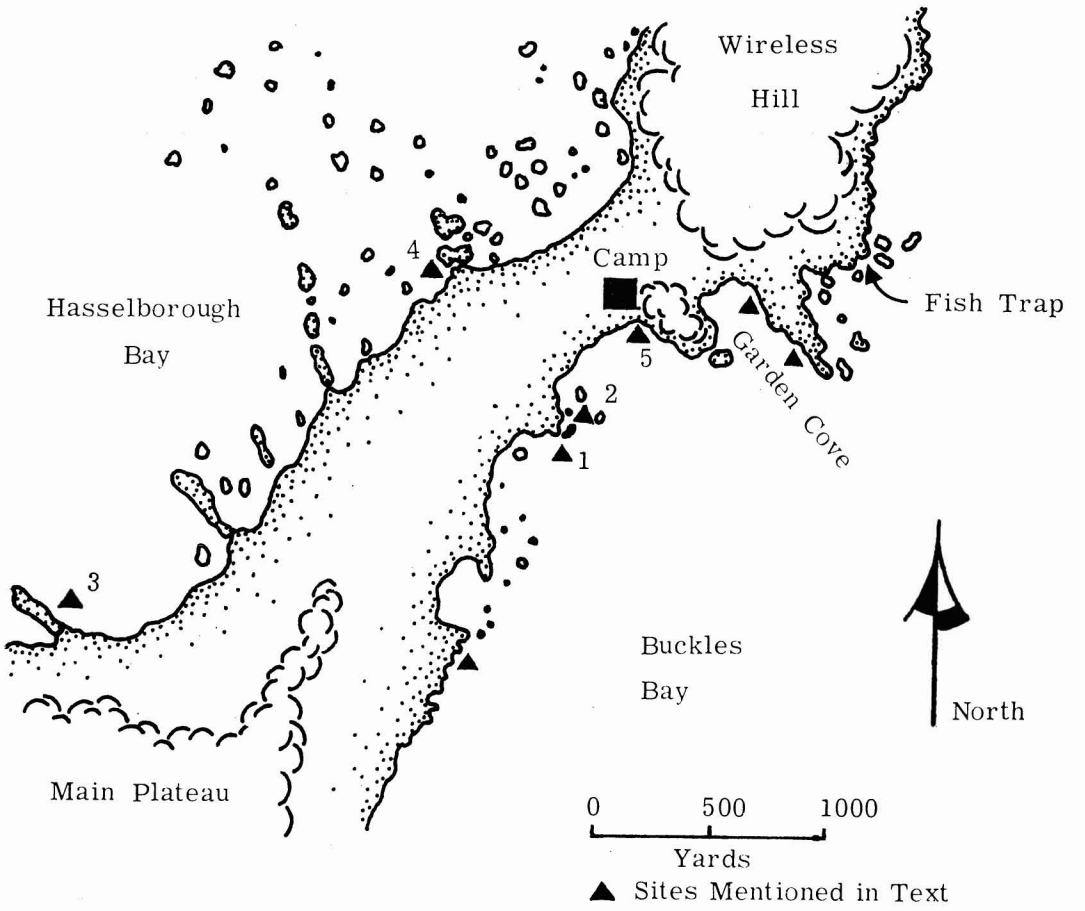

FIG. 6. Isthmus area, Macquarie Island, showing localities mentioned in text.

FIG. 7. Surf conditions at Station 1 during heavy weather.

of *Porphyra, Chaetangium,* a "bare" area with limpets, *Iridaea,* a *Champia*-Corallinaceae complex, and an *Ecklonia-Laminaria-Macrocystis* belt. This coast is affected by the Benguela current and, although in latitude 31° S, is essentially a cold water environment.

In the northern hemisphere there have been many reports of rocky shore zonation in latitudes similar to Macquarie I. For example, Kitching (1935) noted the typical littorinid-balanoid-laminaria pattern on the coast of Argyll, in latitude 56° N, but this area is not isolated by a sea barrier (Crisp and Southward, 1953) and apparently is subjected to less rigorous climatic conditions.

Madsen (1936), discussing the shore fauna of East Greenland, recorded no barnacles or molluscs, presumably due to the short duration of ice-free conditions. He considered that the northern limit of *Balanus balanoides* and littoral molluscs formed the zoological boundary of the Arctic. If the Macquarie fauna is examined on a similar basis, the absence of barnacles and the concentration of molluscs at the lower tidal levels suggest that this locality is near the zoological limit of the Antarctic, with respect to the littoral fauna.

This suggestion is borne out by the seasonal movements of the Antarctic Convergence from north to south of the island and the recorded inshore sea temperatures (see above). Vaughan (1940) delineates the "subpolar" water mass as varying from 5 to 10 C, which is a higher range than that recorded at Macquarie I.

However, Southward (1958) remarks that the differences between the Antarctic and Subantarctic littoral fauna result from varying degrees of tolerance of cold and ice action rather than from particular differences in the species composition of the zonation plan.

Table 4 lists 58 species of plants and animals collected in this survey for which definite dis-

tribution records have been traced. Of this number, 8 species appear to be endemic to Macquarie, 14 have been noted in the New Zealand area, 12 have been recorded from Kerguelen, 18 have wide Subantarctic distribution, and 6 have been recorded from Antarctica. It is possible that species listed from the Kerguelen and Magellan areas may in fact have a wider Subantarctic distribution and further collections may increase the listing of Antarctic littoral forms.

From these collections it would appear that the littoral biota of Macquarie I. is of a generalised Subantarctic type (*Adenocystis, Durvillea,*

TABLE 4

BIOGEOGRAPHIC DISTRIBUTION OF SOME RECORDED SPECIES

SPECIES	ENDEMIC	N.Z. SUBANTARCTIC REG.	KERGUELEN REG.	MAGELLAN-FALKLAND-STH. GEORGIA REG.	CIRCUMPOLAR SUBANTARCTIC	ANTARCTIC MAINLAND
Enteromorpha intestinalis					×	
Adenocystis utricularis					×	
Desmarestia willi					×	
Durvillea antarctica					×	
Lessonia variegata					×	
Macrocystis pyrifera					×	
Ploccameum coccineum						×
Halcampoides kerguelensis			×			
Procerodes ohlini			×			
Lineus scotti		×				
Barentsia aggregata			×			
Hemiarthrum hamiltonorum	×					
H. setulosum					×	×
Plaxiphora aurea					×	
Terenochiton fairchildi	×					
Cantharidus coruscans		×				
Laevilittorina caliginosa				×		
Macquariella hamiltoni		×				
Margarella macquariensis		×				
Nacella delesserti			×			
Siphonaria lateralis					×	
Gaimardia smithi		×				
G. trapesina					×	
Kidderia macquariensis	×					
K. pusilla		×				
Tawera mawsoni	×					
Arenicola assimilis		×		×		
Cirratulus cirratus					×	
Nereis kerguelensis					×	
Notomastus latericeus				×		×

SPECIES	ENDEMIC	N.Z. SUBANTARCTIC REG.	KERGUELEN REG.	MAGELLAN-FALKLAND-STH. GEORGIA REG.	CIRCUMPOLAR SUBANTARCTIC	ANTARCTIC MAINLAND
Platynereis magalhaensis				×		
Polycirrus kerguelensis			×	×		×
Potamilla antarctica						×
Scolelepsis cornifera			×			
Lumbricillus macquariensis		×				
Marionina antipodum		×				
M. werthi			×			
Exosphaeroma calcareous				×		
E. gigas					×	
Ias pubescens			×			
Janira neglecta		×				
Tanais litoralis			×			
Acontiostoma marionis					×	
Hyale hirtipalma					×	
H. novae-zealandiae		×				
Jassa falcata					×	
Nannonyx kidderi		×				
Parajassa tristanensis				×		
Paramoera macquariae			×			
P. schellenbergi			×			
Pycnogonum platylophum				×		
Tanystylum styligerum			×	×		
Asterina hamiltoni	×					
Sporasterias directa	×					
S. mawsoni	×					
S. sphoerulata	×					
Stichaster suteri		×				
Pseudopsolus macquariensis		×				
Harpagifer bispinis					×	
Notothenia macrocephala					×	

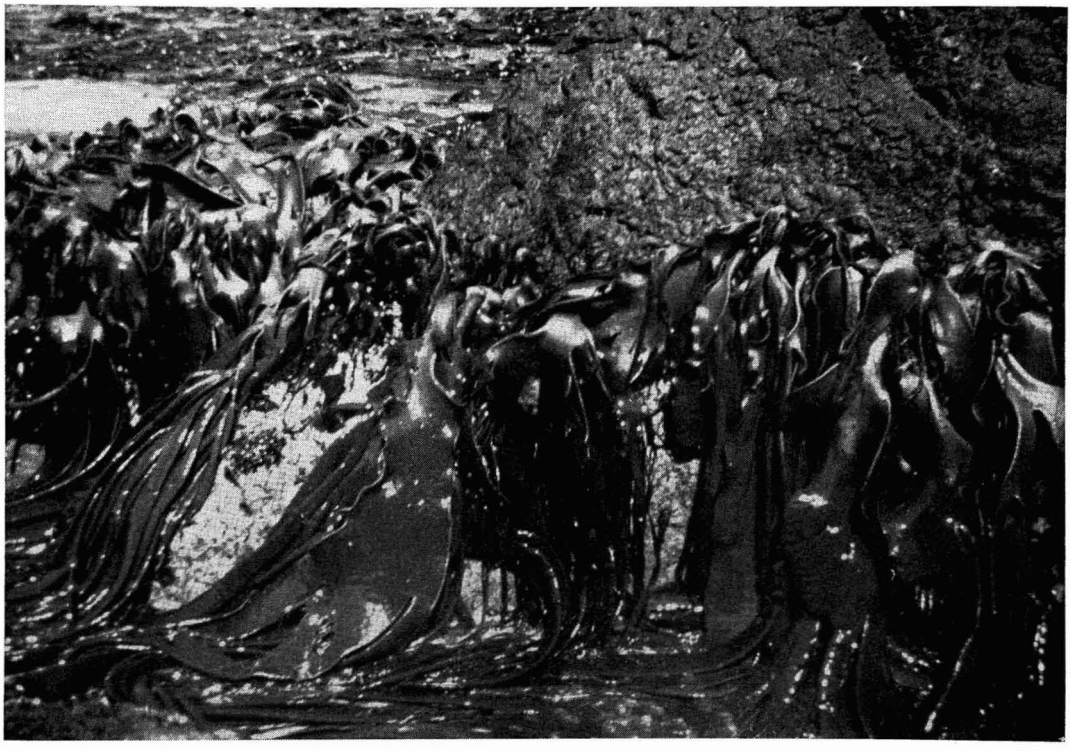

FIG. 8. *Durvillea* zone, at low water.

Exosphaeroma, Jassa, Lessonia, Macrocystis, Notothenia, Siphonaria, etc.). There is a definite relationship between Macquarie I. and the Kerguelen region, nearly 20% of the species listed being present in these two localities. This similarity has been noted previously, by Dell (1952) discussing the fauna in general and by Powell (1951) with reference to the molluscs.

The affinities with the New Zealand area (see also Chilton, 1909) are equally strong; and Powell (1955) lists *Cantharidus coruscans* and *Margarella macquariensis,* both previously considered endemic to Macquarie I., from the Auckland Is.

The endemic species (15% of those listed) are molluscs and echinoderms. Ekman (1953) has commented on the endemic nature of the echinoderm fauna, and to a lesser extent the molluscan fauna, and uses this distribution to suggest that Macquarie I., occupies a position quite distinct from the New Zealand Subantarctic islands.

With one exception, *Ploccameum coccineum,* the species reported from Antarctica are also known from Subantarctic localities other than Macquarie I.

Species Recorded

The species collected in this survey are listed below. In some groups the list is incomplete due to identification problems. Many species previously recorded from Macquarie I. were not represented in these collections.

Chlorophyceae
Cladophora spp.
Enteromorpha bulbosa (Suhr) Kuetz
Enteromorpha intestinalis (L)
Monostroma sp.
Prasiola sp.
Rhizoclonium sp.
Ulva lactuca (L)
Phaeophyceae
Adenocystis utricularis (Bory) Skottsberg

Chordaria dictyosiphon (Harvey) Kuetz
Desmarestia willi Riensch
Durvillea antarctica (Chamisso) Hariot.
Ectocarpus confervoides (Roth) Le Jolis
Geminocarpus geminatus (Hooker and Harvey) Skottsberg
Lessonia variegata Agardh
Macrocystis pyrifera (L) Agardh
Scytosiphon lomentaria (Lyngbye) Agardh

Rhodophyceae
Acrosiphonia pacifica Kütz
Ballia callitricha (Agardh) Montagne
Bostrychia vaga Hooker and Harvey
Ceramium rubrum (Hudson) Agardh
Chaetangium fastigium (Bory) Agardh
Corallina officinalis (L)
Delessaria spp.
Hildenbrantia sp.
Iridea oborata (Kütz) Setchell and Gardner
Melobesia sp.
Porphyra columbina Montagne
P. umbilicalis (L) Agardh
Plocamium coccineum Lyngbye
Polysiphonia anisogona Hooker and Harvey
Rhodymenia spp.
Schizoseris sp.

Lichens
Verrucaria sp.

Mosses
Ceratodon purpureus (Hedwig)
Muelleriella crassifolia (Hooker)

Angiosperms
Colobanthus muscoides Hooker
Cotula plumosa Hooker
Poa foliosa Hooker
Puccinellia macquariensis (Cheeseman)

Porifera
Aphroceras sp.

Coelenterata
Hydroidea
Myriothela meridiana Briggs
Orthopyxis platycarpa Bale
Actiniaria
Halcampoides kerguelensis Kwietniewski
Parantheopsis cruentata Couth

Platyhelminthes
Procerodes ohlini (Bergendal)

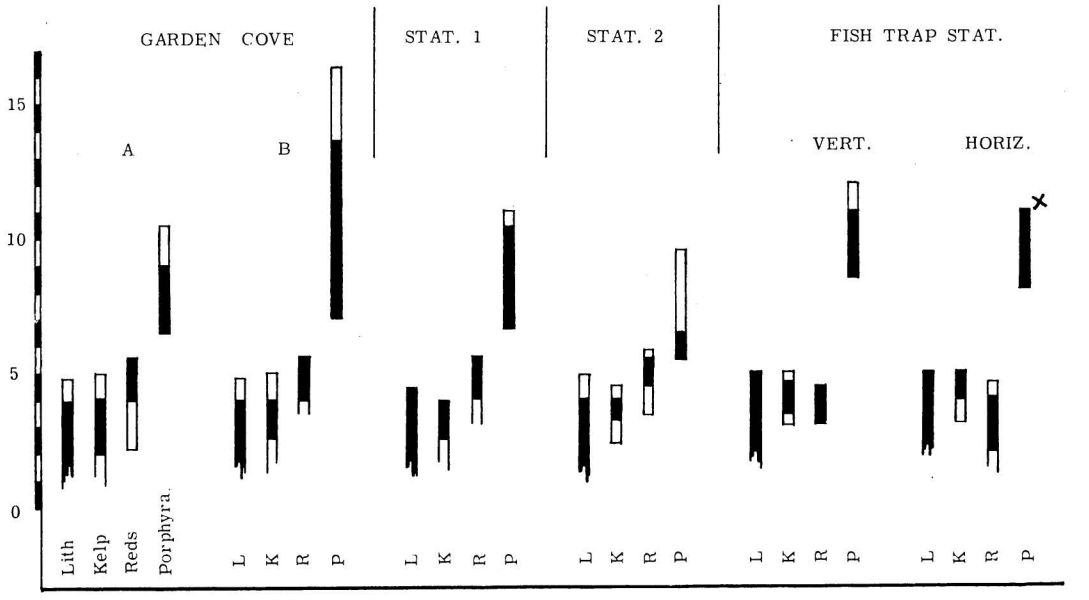

FIG. 9. Comparison of zonation at various localities:
x—see Fig. 11
solid bar—dense growth
open bar—sparse growth

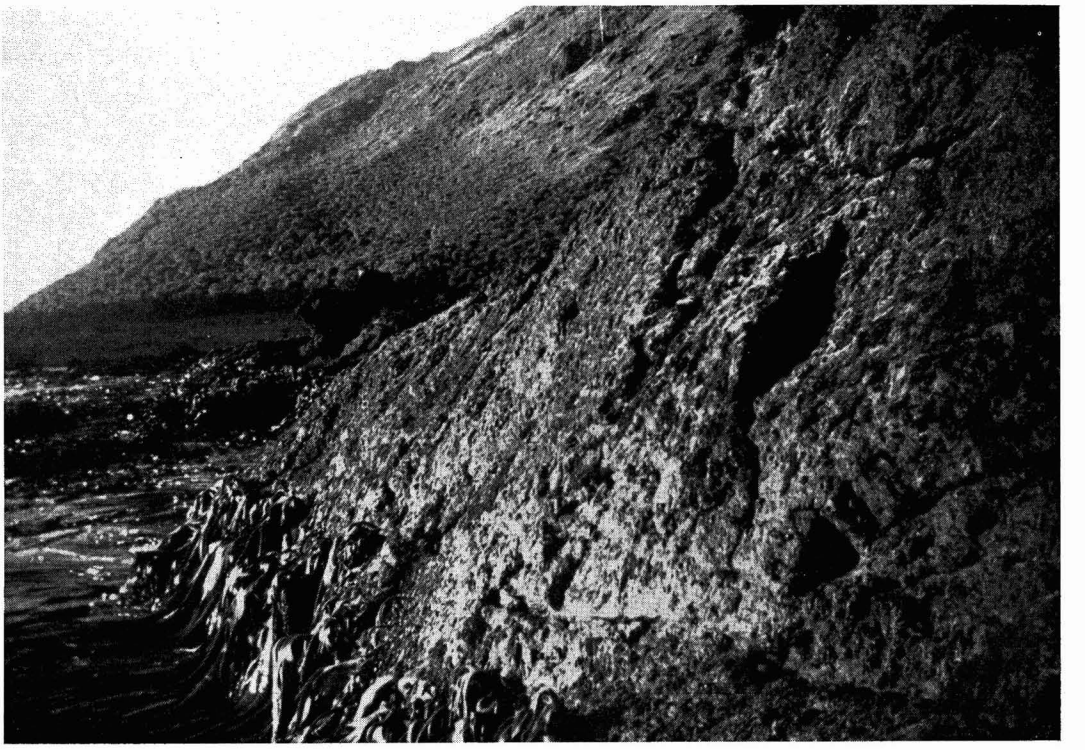

FIG. 10. Garden Cove, at low water. Main traverse area showing *Durvillea,* "bare" zone, and *Porphyra.*

Nemertea
Nemertopsella marri Wheeler
Lineus scotti Baylis
Bryozoa
Barentsia aggregata Johnston and Angel
Mollusca
Amphineura
Hemiarthrum hamiltonorum Iredale and Hull
H. setulosum Dall
Plaxiphora aurea Spalowsky
Terenochiton fairchildi Iredale and Hull
Gastropoda
Cantharidus coruscans (Hedley)
Laevilittorina caliginosa Gould
Macquariella hamiltoni (Smith)
Margarella macquariensis Hedley
Nacella delesserti Phillipi
Siphonaria lateralis Gould
Lamellibranchiata
Gaimardia smithi Suter
G. trapesina Lamark
Kidderia macquariensis Hedley
K. pusilla Gould
Tawera mawsoni Hedley
Annelida
Polychaeta
Arenicola assimilis affinis Ashworth
Boccardia polybranchia (Haswell)
Cirratulus cirratus (Muller)
Exogene sp.
Fabricia alata Ehlers
Lumbrinereis cingulata (Ehlers)
Nereis kerguelensis McIntosh
Notomastus latericeus Sars
Platynereis magalhaensis Kinberg
Polycirrus kerguelensis (McIntosh)
Potamilla antarctica (Kinberg)
Scolelepsis cornifera Ehlers
Spirorbis aggregatus Caullery and Mesnil
Syllis sp.
Thelepus plagiostoma (Schmarda)
Typosyllis sp.

Oligochaeta
Lumbricillus macquariensis Benham
Marionina antipodum Benham
M. werthi Michaelsen
Arthropoda
Cirripedia
Lepas australis Darwin
Isopoda
Cassidinopsis emarginata (Guerin)
Exosphaeroma calcareous (Dana)
E. gigas (Leach)
Ias pubescens (Dana)
Janira neglecta Chilton
Limnoria antarctica Pfeffer
Munna maculata Beddard
Tanais litoralis Vanhoffen
Amphipoda
Acontiostoma marionis Stebbing
Hyale hirtipalma (Dana)
H. novae-zealandiae (Thomson)
Jassa falcata (Montagne)
Nannonyx kidderi (Thomson)
Parajassa tristanensis (Stebbing)
Paramoera macquariae Nicholls
P. schellenbergi Nicholls
Brachyura
Halicarcinus planatus (Fabricius)
Pycnogonida
Pycnogonum platylophum Loman
Tanystylum neorhetum Marcus
T. styligerum Miers

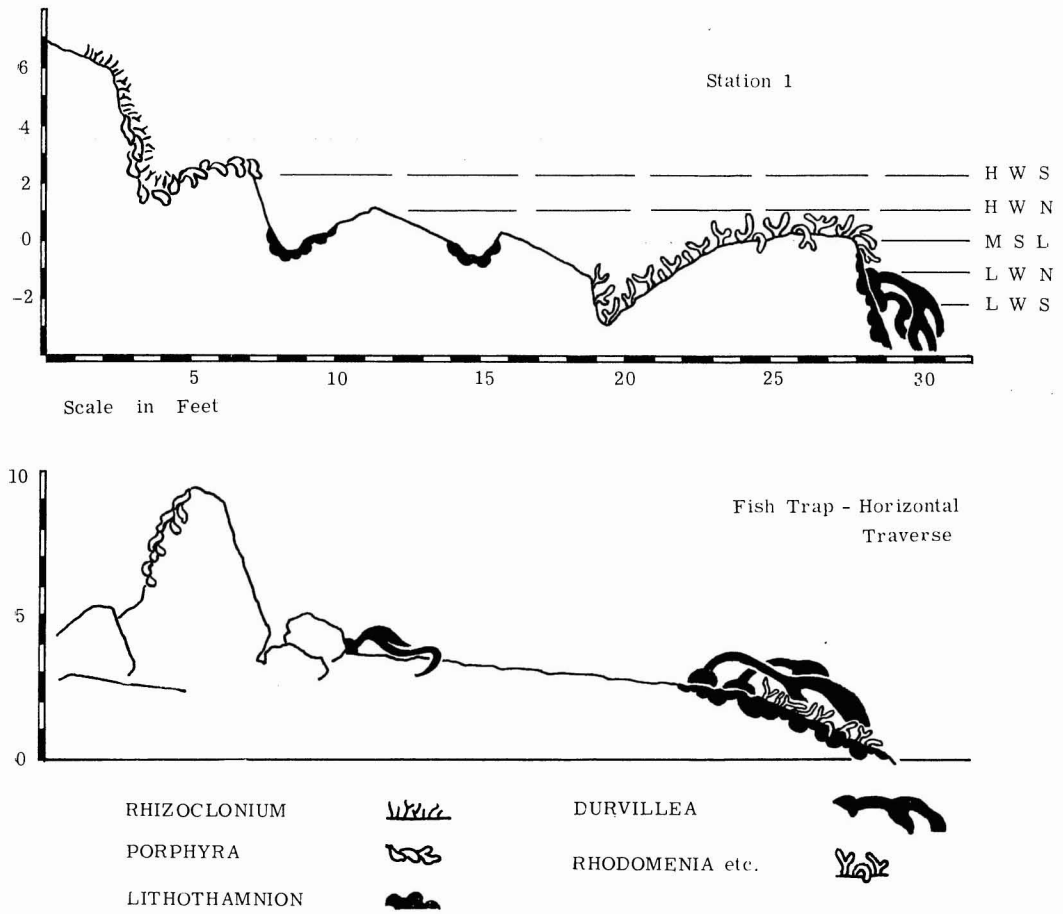

FIG. 11. Horizontal zonation.

FIG. 12. Entrance to Garden Cove, viewed from Camp Hill, showing kelp growth.

Acarina
Halozates sp.
Insecta
Antarctophytosus macquariensis Womersley
Antarctopria latigaster Brues
Antarctotachinus crozetensis Enderlein
Coelopa macquariensis Womersley
Ephydra macquariensis Womersley
Procanace macquariensis Womersley
Echinodermata
Asteroidea
Asterina hamiltoni Koehler
Sporasterias directa (Koehler)
S. mawsoni (Koehler)
S. sphoerulata (Koehler)
Stichaster suteri (Loriol)
Holothuroidea
Pseudopsolus macquariensis (Dendy)
Chordata
Urochordata
Molgula novaezelandiae (Michaelsen)
Pisces
Harpagifer bispinis (Schneider)
Notothenia macrocephala Gunther
Aves
Gallirallus australis scotti (Grant)
Larus dominicanus Lichtenstein
Mammalia
Mirounga leonina (L)

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SUMMARY

The major features of the rocky shore zonation pattern at Macquarie I., are described as comprising a lichen zone; a *Porphyra* zone; a "bare" zone dominated by *Siphonaria;* an upper red algal zone, predominantly *Rhodymenia;* a *Durvillea* zone; and a lower red algal zone of *Dellessaria, Iridea,* and *Desmarestia.*

The secondary organisms associated with the above zones are listed.

The zonation pattern is compared with similar ecological situations in southern Australia, New Zealand, South Africa, and South America. The algal domination of the shore shows much in common with the west coast of South Africa.

The absence of barnacles and littorinids suggests that the Macquarie shore is more typically Antarctic than Subantarctic. The geographic distribution of species shows the island to have a closer biogeographic relationship to other Subantarctic islands than to the New Zealand area.

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