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14

MACQUARIE ISLAND

Prepared By

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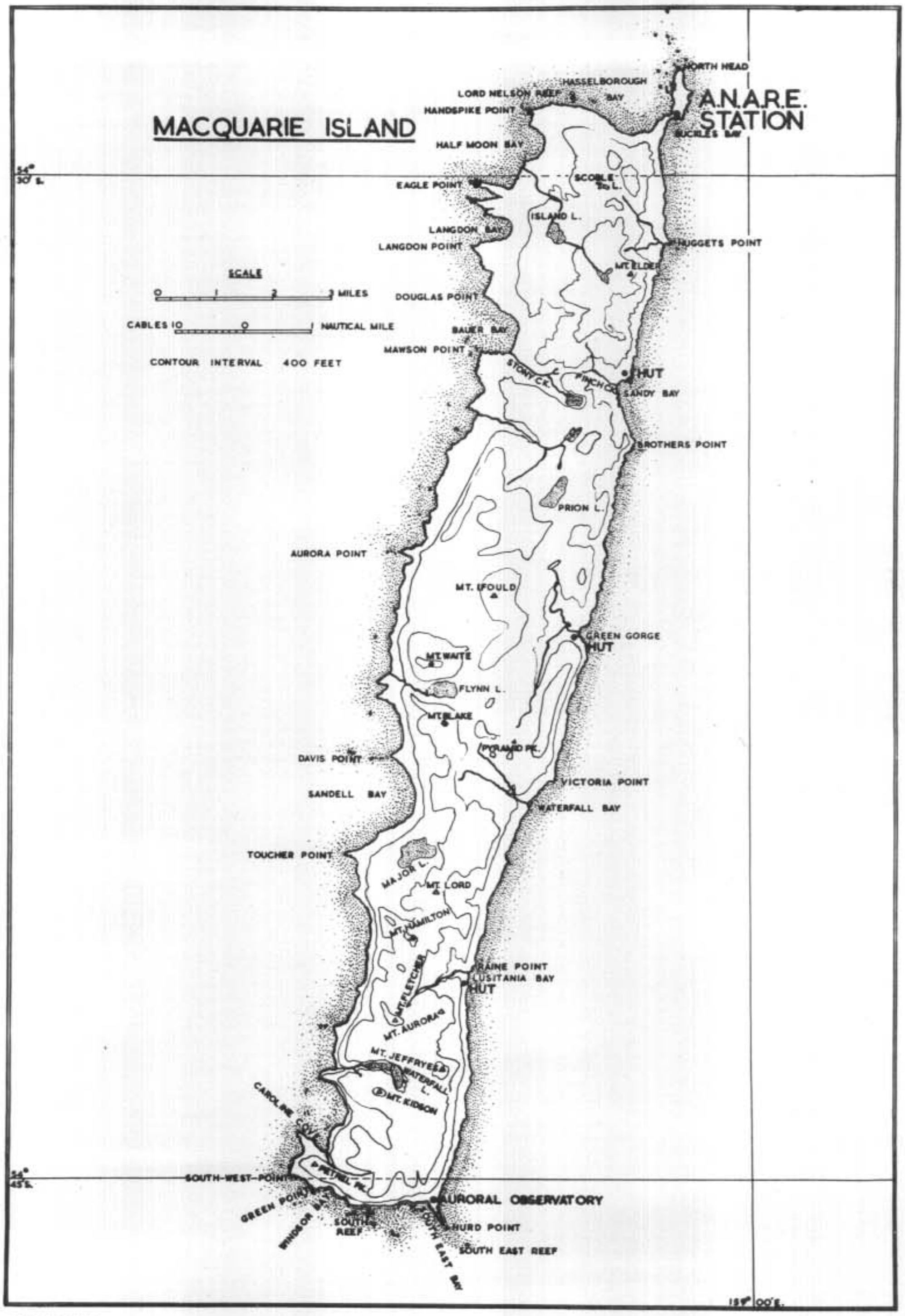

MACQUARIE ISLAND
A.N.A.R.E.
STATION
NORTH HEAD
HASSELBOROUGH
BAY
LORD NELSON REEF
HANDSPIKE POINT
BUCKLES BAY
HALF MOON BAY
EAGLE POINT
SCOBLE L.
ISLAND L.
LANGDON BAY
LANGDON POINT
HUGGETS POINT
MT. ELDER
SCALE
0 1 2 3 MILES
DOUGLAS POINT
CABLES 10 0 1 NAUTICAL MILE
BAUER BAY
MAWSON POINT
CONTOUR INTERVAL 400 FEET
STONY CK.
FINCH CK.
HUT
SANDY BAY
BROTHERS POINT
PRION L.
AURORA POINT
MT. IFOULD
GREEN GORGE
HUT
MT. WAITE
FLYNN L.
MT. BLAKE
PYRAMID PK.
DAVIS POINT
VICTORIA POINT
SANDELL BAY
WATERFALL BAY
TOUCHER POINT
MAJOR L.
MT. LORD
MT. HAMILTON
MT. FLETCHER
HAINE POINT
LUSITANIA BAY
HUT
MT. AURORA
MT. JEFFRYES
WATERFALL L.
MT. KIDSON
CAROLINE COVE
SOUTH-WEST-POINT
PETREL PK.
AURORAL OBSERVATORY
GREEN POINT
WINDSOR BAY
SOUTH REEF
SOUTH EAST BAY
HURD POINT
SOUTH EAST REEF
54° 30' S.
54° 45' S.
159° 00' E.

PLATE 1.

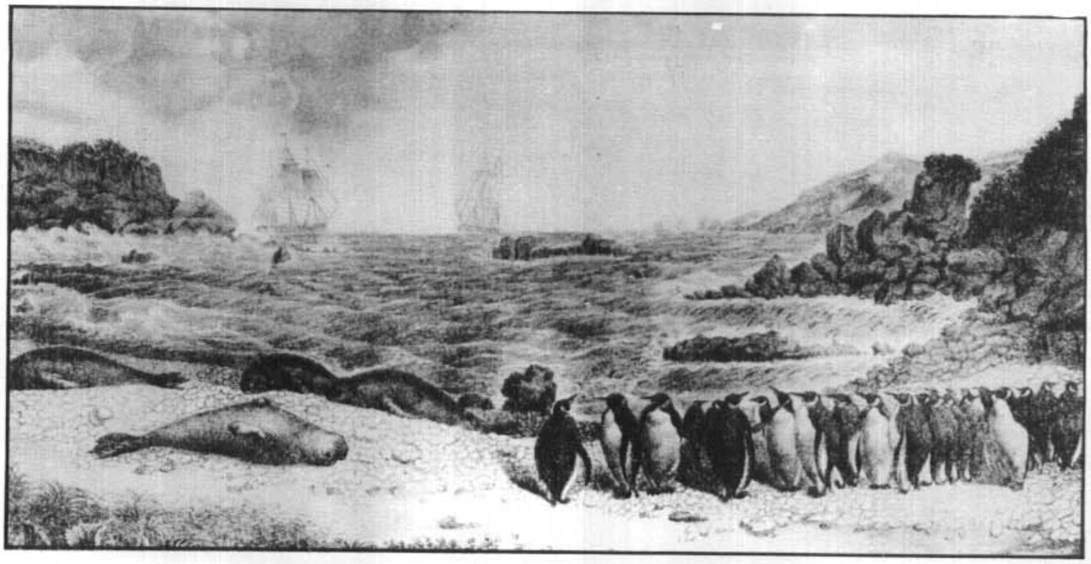
INTRODUCTION

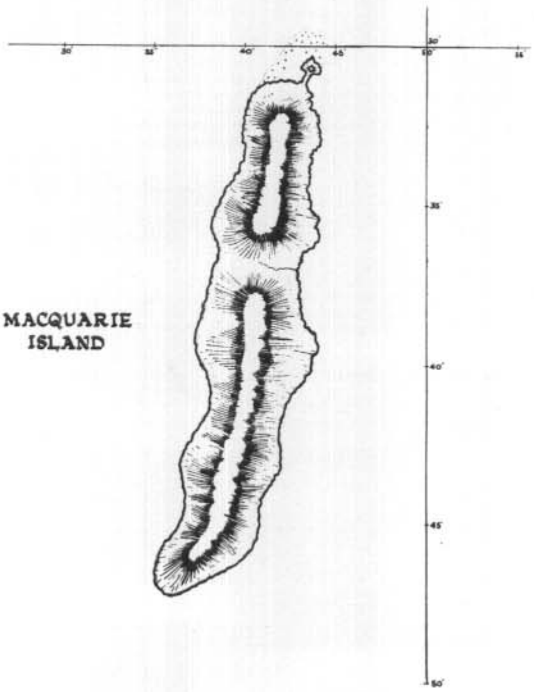
The ocean surrounding the Antarctic Continent is known as the Southern Ocean. It extends from the coast of Antarctica to the southern coasts of South America, Africa, Australia, and New Zealand; an imaginary line joining the southern coasts of these countries forms its northern boundary.

The Southern Ocean is divided into two main hydrological zones by the Antarctic Convergence, the line of demarcation at the surface of the ocean between the cold antarctic water and the warmer subantarctic water. These zones, the antarctic and subantarctic, are significant not only because they determine the distribution of marine life but also because they influence the properties of the air masses above them and consequently the meteorology of a large part of the southern hemisphere.

The Southern Ocean contains several isolated islands and groups of islands: South Georgia, the South Sandwich Islands, Bouvetoya, the Prince Edward Islands, Iles Crozet, Iles de Kerguelen, Heard Island, Macquarie Island, Campbell Island and Auckland Island. Differences in their altitudes, atmospheric circulation and ocean currents, combined with their positions relative to the Antarctic Convergence, have resulted in some of these islands being ice-covered and glaciated while others are clothed in grass and other non-arboreal vegetation. The former can be classified with the Balleny-Islands, Peter 1 Oya, etc., as antarctic islands; the latter can be classified with Tristan da Cunha, the Antipodes Islands, etc., as subantarctic islands and it is to this group that Macquarie Island belongs.

Macquarie Island (lat. $54\frac{1}{2}^{\circ}$S., long. 159°E.) which lies about 900 miles north of the eastern sector of Australian Antarctic Territory, is the southernmost island in the chain of New Zealand subantarctic islands. Politically it is a part of the District of Esperance in the Australian State of Tasmania. The recent establishment there of a research station by the Commonwealth of Australia makes it possible to provide additional scientific information on the island's geography, geology, meteorology, flora and fauna.





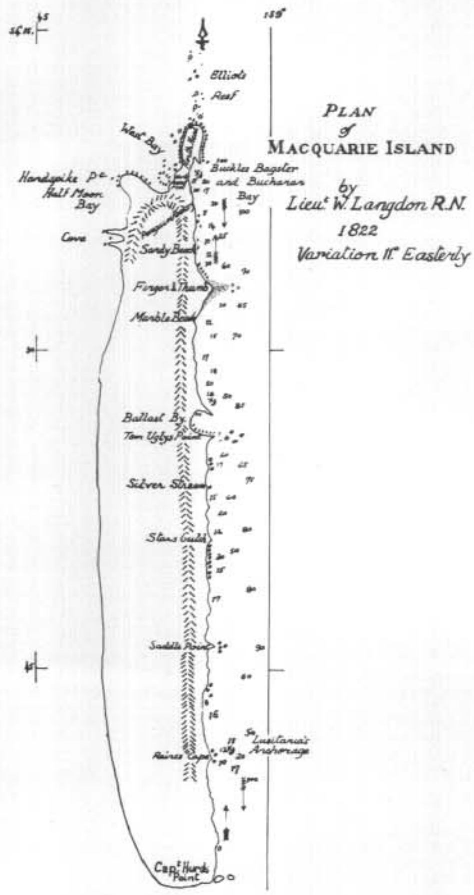


PLATE 2. ABOVE: GARDEN COVE SKETCHED BY BELLINGSHAUSEN'S OFFICIAL ARTIST, MIKHAILOV, NOVEMBER 1820.
BELOW LEFT: EARLIEST EXTANT MAP OF MACQUARIE ISLAND DRAWN BY BRITISH SEALERS AND FIRST PUBLISHED BY BELLINGSHAUSEN.
BELOW RIGHT: MAP OF MACQUARIE ISLAND DRAWN BY LIEUT. LANGDON R.N., 1822.

HISTORY [1]

Macquarie Island was discovered on 11 July, 1810, by a Sydney sealer, Captain Frederick Hasselburgh [2], in the brig "Perseverance", while taking stores to Campbell Island. He named it after Lachlan Macquarie, then Governor of New South Wales. There were large rookeries of fur seals on the island, so Hasselburgh landed a party of men under Captain Miles Holding and returned to Sydney to inform his employers Robert Campbell and Company, of the rich new field. However, news of the discovery seems to have leaked out, as rival sealing vessels were despatched from Sydney shortly after the "Perseverance" set sail again for the island. By April 1811, the gangs from the "Perseverance" and the "Elizabeth and Mary" - which had also been sent out by Campbell and Company - had together taken a total of 56,974 fur seal skins.

Uncontrolled exploitation of the fur seals followed for the next ten years until stocks were so depleted that the trade turned its attention to the elephant seals, slaughtering them for their oil. In 1820, when the Russian Exploring Expedition ships "Vostok" and "Mirny" paid a brief call at the island, their commander, Captain Bellingshausen, described the sealers' method of killing the sea elephants as follows:-

"One of the sealers accompanied us. He had with hin an implement with which to kill sea elephants, which consisted of a club 4½ feet long and two inches thick. The end was bell-shaped, 4 or 5 inches in diameter, bound with iron and studded with sharp nails. When we approached a sleeping sea elephant the sealer hit him with this implement over the bridge of the nose; the sea elephant opened its mouth and gave a loud and pitiful roar. It had already lost all power of motion. The man took out his knife, saying 'it is a pity to see the poor animal suffer' and stuck it into its neck from four sides. The blood poured out in torrents forming a red circle. The animal then gave a few heavy breaths and died at once. Large sea elephants, after this blow which stuns them, are pierced through the heart with a lance so as to kill them on the spot."

From 1820 onwards sealing interests in Hobart began to enter the Macquarie Island trade in competition with the Sydney firms and in 1825, when Van Dieman's Land was proclaimed a separate colony, Macquarie Island was included within its jurisdiction.

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(1) This account is based on an unpublished history of Macquarie Island by Dr. J. S. Cumpston.

(2) Hasselburgh spelt his name in a number of different ways; Hence Hasselborough Bay.

The total production of oil from Macquarie Island during the years 1826 and 1827 was over 1000 tons. A description of the conditions on the island at this time is given in Cunningham's "Two Years in New South Wales" (1827) :-

"Gangs of men remain on the island throughout the year, to kill the sea elephants that frequent it, and to boil down the oil. Parties belonging to two or three individuals are frequently living here at one time, and as keenly contested wars have occasionally raged among them for the dominion of a half mile of coast of this dreary purgatory as ever took place between the rival heroes of Rome for the dominion of the world; and the combatants, in their long beards, greasy seal-skin habiliments and grim, fiendlike complexions, look more like troops of demons from the infernal regions, than baptized Christian men, as they sally forth with brandished clubs to the contest. Their provisions are supplied from Sydney, the fire for cooking and the light for their study and their toilet being all derived from the oil, which is kept burning in a dish with an ample wick; and the wretched stone and turf-walled and grass-roofed hovels they inhabit are rendered as dingy and dismal thereby as the interior of an Esquimaux palace, and send forth an odour to which that of the nightman's museum of foul abominations is myrrh and frankincense. They are paid according to what oil they procure, and expend their earnings chiefly on the island in such necessaries as they may want, but principally in wines, spirits, and tobacco."

By 1834, the sea elephants had almost been exterminated and the trade in oil continued only intermittently. In 1840 the "Peacock" and "The Flying Fish" of the United States Exploring Expedition (1838-42) under the command of Captain Charles Wilkes paid a brief visit to the island and sent boats to erect signals ashore. Landing was found difficult owing to the surf and the island was reported to be dreary and inhospitable.

The final phase of sealing at Macquarie Island (1873-1919) was conducted from New Zealand first by Messrs. Elder and Nichol but later principally by Joseph Hatch, one time Member for Invercargill in the New Zealand House of Representatives. Various New Zealand scientists secured passages to Macquarie Island on these firms' sealing vessels, the most notable being Professor J.H. Scott and A. Hamilton who made biological observations.

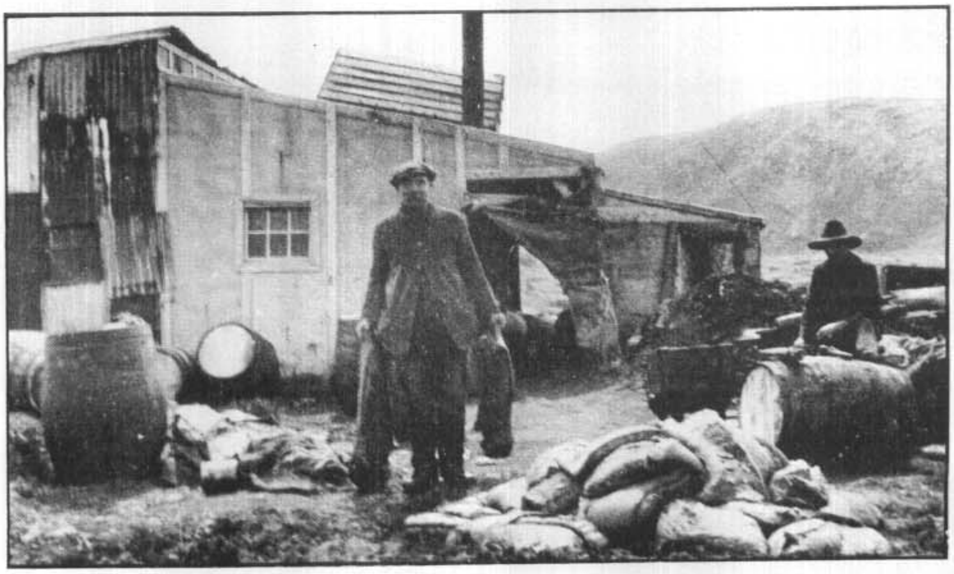

PLATE 3. ABOVE: THE WRECK OF THE SCHOONER "CLYDE", ONE OF HATCH'S SEALING VESSELS, 1911.
BELOW: HATCH'S SEAL–BLUBBER WORKS ON THE ISTHMUS.

Short visits were paid to the island by Scott's first expedition in 1901 and Shackleton's first expedition in 1909 but it was not until the visit of the Australasian Antarctic Expedition, led by Sir Douglas Mawson, that a scientific station was established. During the years 1912 and 1913 a party of five, under the leadership of G. Ainsworth, carried out comprehensive work on the island's meteorology, geology, and animal life. L.R. Blake drew up the first reliable map of the island. The meteorological and wireless stations were subsequently taken over for a further two years by the Commonwealth Meteorological Bureau.

The activities of Hatch (which had come to include the exploitation of penguins for their oil) received a good deal of adverse publicity in the Australian press. This, combined with the efforts of Sir Douglas Mawson to have the island declared a natural sanctuary, resulted in the Tasmanian Government refusing to renew further sealing licences after 1919. Sir Douglas Mawson's second expedition, the B.A.N.Z.A.R. Expedition, visited the island in 1930 for magnetic determinations and also to check on "the state of the animal population" after its ten-year respite. On 17 May 1933, Macquarie Island was proclaimed by the Lieutenant Governor of Tasmania to be a sanctuary.

In 1947 the Australian Government established the Australian National Antarctic Research Expeditions (A.N.A.R.E.) administered by the Antarctic Division of the Department of External Affairs. A number of other Government departments, as well as the Universities and various scientific institutions, were asked to assist in directing and organizing the scientific programme and a Planning Committee representing these bodies and the Armed Services was set up to advise the Government on general policy.

Plans were laid for three permanent research stations - one at Heard Island, one at Macquarie Island and one on the Antarctic Continent itself. The research station at Macquarie Island was established on 7 March 1948, and is now in its ninth year of operation. It is manned by a party of about fifteen men who volunteer for twelve months' service, the composition of the party depending upon the scientific programme planned each year. In 1956, the team comprised an officer-in-charge, 3 weather observers, 4 physicists, 3 radio operators, a doctor-biologist, a biologist, an engineer and a cook.

PLATE 4. A.N.A.R.E. STATION, WINTER 1953.

The station is one of the most important scientific observatories in the Southern Hemisphere, carrying out continuous meteorological, ionospheric, magnetic, seismological, auroral and cosmic ray observations throughout the year. It is now quite an extensive establishment, comprising upwards of 40 huts, including a diesel power-house which supplies 15 Kilowatts for heating, lighting and scientific equipment. The station has a fully equipped surgery, including a modern X-ray unit.

Parties are relieved annually by ship.

GEOLOGY

Macquarie Island lies approximately 600 nautical miles southwest of New Zealand and 800 nautical miles southeast of Tasmania. Nine hundred miles to the south is the Antarctic Continent while the Auckland and Campbell Islands, 400 miles to the northeast, are the island's nearest neighbours.

Macquarie Island is 21 miles long with its main axis running N.15^{o}E. It has a maximum breadth of 3 miles and an area of 46 square miles. Its outlying islands, Judge and Clerk, 9 miles N.N.E., and Bishop and Clerk, 20 miles south, are only barren rocks.

The geology of Macquarie Island has already been fully described (Mawson, 1943). The following brief outline has been composed from Mawson's account and some recent observations made by A.N.A.R.E. men at the Island.

Orogenically, Macquarie Island is probably a horst block which has been subject to extensive marine erosion. Off the east coast, the sea floor drops steeply, but off the west coast, where most erosion has taken place, the slope is more gradual. The result is a long, narrow plateau, bounded on all sides by steep cliffs, from the foot of which a narrow coastal terrace extends to the sea. This terrace is most clearly defined along the northern half of the west coast, where it is up to a quarter of a mile wide, and along the southern part of the east coast. Just south of Green Gorge it appears as a well defined rock platform, a few feet above present sea level, but in places it rises up to forty feet above sea level.

The level of the plateau rises slightly from the

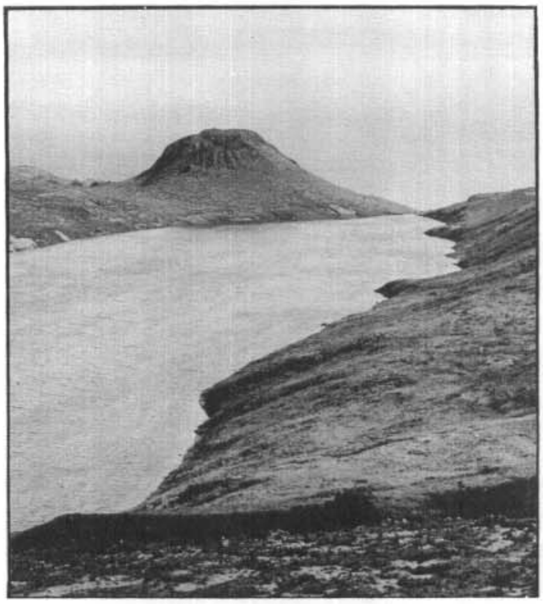

PLATE 5.

ABOVE LEFT: WATERFALL LAKE.
ABOVE RIGHT: A WATERFALL ON THE EAST COAST.
BELOW: VIEW OF ISTHMUS FROM NORTH HEAD.

northern end, where the general level is about 800 feet, with peaks up to 1200 feet, to the southern end, with a general level of 1,000 feet and peaks up to 1400 feet. The northern quarter is separated from the rest of the plateau by the col between Sandy Bay and Bauer Bay which is less than 500 feet in height.

The surface of the plateau exhibits the typical features of a well-glaciated topography and is dotted with lakes, the largest being Major Lake with an area of 113 acres. Blake, the A.A.E. geologist upon whose notes Mawson based his account, believed that the present surface was glaciated by an ice-sheet moving from the west, and accepting this view, Mawson put forward the hypothesis that there had once been a substantial extension of the present land mass in that direction, which has since disappeared by faulting. However, Gwynn, A.N.A.R.E. biologist in 1949, believes the northern end of the plateau to have been glaciated from the present backbone of the island, at least during the last phase of glaciation. This is indicated by the form of roches moutonnees and surface lakes. Blake considered that lakes such as Prion Lake were formed by an ice sheet moving from the west, but Gwynn believes it equally possible for Prion Lake to have been excavated by a local glacier moving north from Mount Eitel. A line of soundings was taken down the centre of this lake in 1952. These gave a maximum depth of 110 feet near its northern end (Macgregor, 1953). The occurrence of the large western lakes - Lake Flynn, Major Lake, and Waterfall Lake - could be explained by the action of glaciers moving from the present backbone of the island. Blake's other evidence for his theory that Macquarie was glaciated from the west was a trail of erratic boulders, identical with the harzburgite outcrop on the west coast near Eagle Point, which extends across the island right to the east coast. If no other possible source for these erratics can be found, one must still accept the existence, in early glacial times, of a high land mass, extending to the west of the present island. Ivanac (1948), who paid a short visit to the island in 1948, accepts this postulate and suggests three stages of glaciation:-

1. An overriding ice-sheet moving from south-west to north east.

2. A n almost continuous ice-cover with glacial tongues reaching into the sea.

3. Cirque glaciers.

He considers that the third stage is responsible for the present topography.

It is usually assumed that Macquarie (and other subantarctic islands) were completely ice-covered at the height of the Pleistocene glaciation, and that the pre-glacial fauna and flora must have been completely exterminated. However, Gwynn points out that at the height of the glaciation the sea level was probably lowered by some hundreds of feet, which means that considerable areas, now submerged, would then have been uncovered. Whatever the relationship of land and water, he considers there would always have been ice-free headlands projecting between the glaciers where the ice-sheet met the sea, and that many elements of the fauna and flora could have survived the glaciation on such promontories. This does not dispose of the question of the origin of the fauna and flora of these isolated islands, but it does mean that it would be unnecessary to suppose that the entire fauna and flora arrived since glacial times.

The rocks of the island are almost entirely of igneous origin. Blake divides the rocks into three series:

1. The Older Basic Group, consisting of a thick series of basaltic flows and sills with associated tufaceous greywacke which are probably pre-Tertiary in age. These have been subject to intense folding and are intruded by gabbroic masses from which radiate numerous dykes and sills.

2. The Gabbroid Group, consisting of a well graded series of gabbros and peridotites, which Mawson suggests are of the same age as the Dun Mountain ultramafic intrusion of New Zealand.

3. The Younger Basic Group, consisting of pillow lavas with associated dykes, breccias and agglomerates, which may correspond in time with tachylitic pillow lavas of the Marine Miocene of Oamaru. Consolidated globigerina ooze is found as a filling among the pillow lavas and associated deposits.

Up to the time of the gabbroid intrusions of the second series there is no evidence as to whether the rock formation was sub-aerial or sub-marine.

Then followed a period of erosion, apparently sub-aerial, which laid bare the plutonite masses. This appears to have been in late Cretaceous and early Tertiary times.

The eroded land surface then subsided to some considerable depth beneath the sea, receiving over it a deposit of globigerina ooze. Then followed another period of volcanic activity with large outpourings of glassy basaltic pillow lava, which burst through the globigerina ooze of the sea floor. The volcanic period ended with a period of upthrust and faulting, resulting in an area of land in the region of Macquarie Island probably considerably greater than exists at present. After some degree of peneplanation of the land had been effected, the Pleistocene Ice-Age intervened.

The northern quarter of the island consists mainly of rock of the Older Basic Series and gabbroid intrusions. South of a line running from Sandy Bay to Eagle Point the Younger Basic Series outcrops along the coast at Lusitania Bay and around Sandell Bay. Blake postulated a major fault along this dividing line, but Ivanac (1948) was of the opinion that the features along this line were the result of differential erosion along the contact between the Older and Younger Basics.

Surface deposits. Most of the surface of the island, excepting the coastal terraces, is covered with a mantle of unsorted glacial drift. On the hillside above Nuggets Creek this reaches at least 50 feet in thickness. The floor of the old U-shaped valley north-westerly from Nuggets Point is covered with a thick layer of glacial drift, in which Blake distinguished three distinct overlapping deposits differing widely in composition one from the other. The lowest of these deposits is composed almost entirely of rocks which Blake believed were derived from an outcrop at Eagle Point.

Well-marked terminal moraines occur in some places, notably in the Rookery Creek valley and at the foot of Brothers Creek.

Water-born deposits. Of particular interest are the Finch Creek bone beds, which Blake regarded as late-glacial or early post-glacial in age. The wide floor of this valley exhibits well-defined river terraces and at one point on the banks of the present creek there is an exposure of fluvio-glacial deposits about 15 feet in thickness. Some distance down in this deposit are well-defined layers containing numerous bird bones. The specimens brought back by Blake were too fragmentary for identification, but in fact many of these bones are very well preserved and they consist mainly of bones of royal penguins. There is little doubt that these layers mark the site of an early rookery of this species. King penguin bones picked up on the banks of the creek may be from the same deposit, and one small bone from the bone layer was identified as belonging to a diving petrel (1). The deposits of this valley would appear to merit further investigation.

Sand deposits. There is a curious error on p.7 of H. Hamilton's "Ecological Notes and Illustrations of the Flora of Macquarie Island", where he refers to the sand slopes north of Gadget Gully as 'the only sand area in the island'. This is a very insignificant deposit of sand banked against the foot of the hillside. He has overlooked the far more extensive sand-hills in Bauer Bay. Here an interesting section is exposed where the stream cuts through these sand-hills at their northern end. One bank of the stream is a cliff of bedded sand, 10 to 12 feet high, capped by a layer of boulders. As the boulder layer probably belongs to the time of the raised beach, the bedded sands must date from an earlier period.

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(1) A collection of bones from this site was made in 1949, and is now in the National Museum, Melbourne.

BOTANY

FLORA. A detailed survey of the flora, vegetation and soils of Macquarie Island was carried out by B. W. Taylor, A. N. A. R. E. biologist during 1950 (Taylor, 1955a).

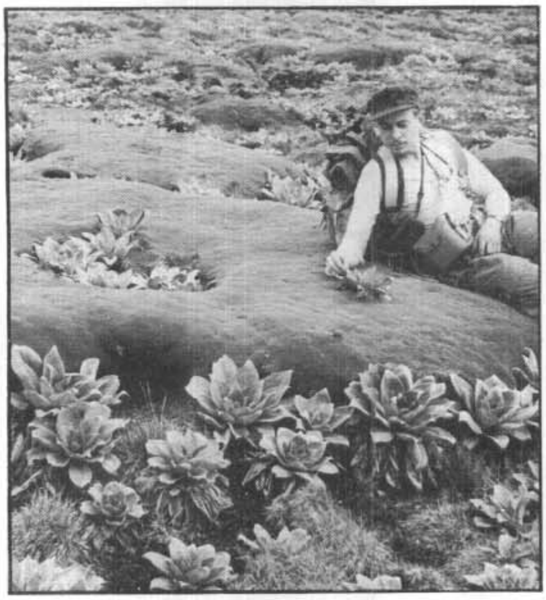
The vascular flora has only 35 native species and 3 introduced species, Poa annua, Cerostium triviale and Stellaria media which were accidentally brought to the island in the 19th Century by sealers. 41 species of moss are known (Clifford, 1953). No trees or shrubs are found and there is only one woody species Coprosma pumila, a creeping mat plant. Three of the native grasses Poa hamiltoni, Deschampsia penicillata and Puccinillia macquariensis are endemics; the remainder are distributed variously in New Zealand, South America and other sub-antarctic islands.

The native flora is presumed to be post-glacial in origin, reaching the island by some means of long distance dispersal, probably through the agency of sea birds (Taylor, 1954).

Despite the small number of species present the vegetation has five formations:- Grassland, herbfield, feldmark, fen and bog. More than half the island has a ground cover of 100 per cent and this includes practically all of the island below 600 feet elevation.

The wet tussock grassland is a community up to 4 feet high, dominated by tussocks of Poa foliosa. The tussocks are discontinuous at their bases but have a densely interlacing leafy canopy. Other dominants in this formation include Stilbocarpa polaris (Macquarie Island cabbage) and Poa hamiltoni, the latter being confined to the vicinity of penguin rookeries. This formation is by far the most conspicuous when viewed from the sea and grows in the more favourable sites on the island. It covers all the steep plateau slopes at lower elevations and extends up to 1,200 feet in protected sites. It also occurs on the newly arisen coastal terrace where it is growing on gravel deposits which permit of good drainage. The presence of a water table within 18 inches of the soil surface limits the occurrence of the formation.

The herbfield consists of a continuous cover of herbs, relatively rich in species, the dominant



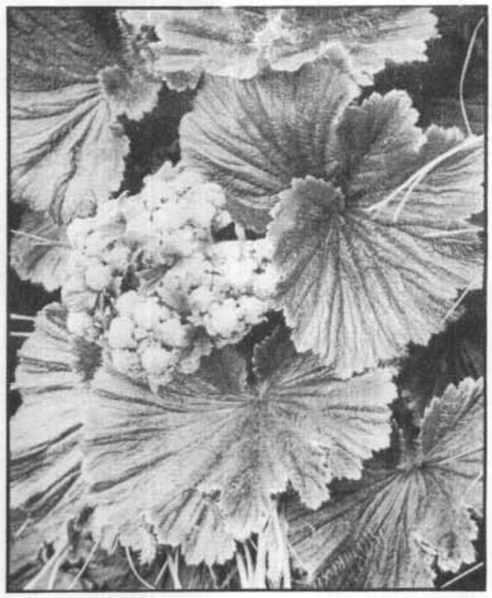


PLATE 6.

ABOVE LEFT: ROSETTES OF PLEUROPHYLLUM HOOKERI AMONGST AZORELLA HUMMOCKS.
ABOVE RIGHT: MACQUARIE ISLAND CABBAGE.
BELOW: GIANT KELP.

being Pleurophyllum hookeri. Festuca erecta and Carex trifida also occur as dominants in a few stands. The formation is found on flat areas with a permanent water table 3-18 inches from the soil surface, and is common in upland valleys and in some areas of the coastal terrace. Herbfield is sometimes found as a narrow band on well-drained slopes where the wind exposure is just too severe for the growth of grassland. The formation occurs in sites where grassland cannot grow but is also limited by severe wind exposure and by a permanent water table within 3 inches of the soil surface.

Feldmark is an open sub-glacial community dominated by mat and cushion plants. The dominant species is Azorella selago but at higher elevations this is replaced by many species of mosses. It occurs in all sites with severe wind exposure, covering half the area of the island. It is generally found above 600 feet elevation but in one exposed site it is found as low as 300 feet. The ground cover varies from almost 100 per cent in the most favourable sites to less than 1 per cent in the most exposed positions.

Fen is a hydrophyllous community generally dominated by Juncus scheuchzerioides. Other dominants are Scirpus auklandicus and Deschampsia penicillata. It is found in sites with a permanent water table not more than 3 inches below the soil surface. Extensive stands are found in the poorer drained sections of upland valleys and of the coastal terrace. Small open stands are also found where small soaks arise on the higher slopes where the community is surrounded by feldmark formation.

The bog formation is a closed community of hydrophyllous mosses or moss-like species, notably Colobanthus muscoides and Colobanthus crassifolius. It is limited by a water table more than 3 inches below the soil surface but only replaces fen where the soil water is low in nutrients, having never been in contact with mineral soil. The only large stands are found on extensive flats on the coastal terrace.

Many transition stages between formations (ecotones) occur, and there is a wide variety of aquatic communities. The vegetation has undergone severe alteration due to rabbit grazing over the greater part of the island but fortunately a large area at the north end is virtually untouched. The native fauna is responsible for many local variations in the vegetation. The elephant seal has formed a characteristic modification of tussock grassland over most of the coastal terrace.

LICHENS. 44 species of lichen are known from Macquarie Island (Dodge and Rudolph, 1955). About one third of these lichens are listed as endemics, though it is expected that many of them will later be found to be present on the other sub-antarctic islands of New Zealand.

SOILS. There is a close correlation between the distribution of soil and vegetation types. The soil types encountered include a range of peat types (highmoor, rich fen, poor fen and bog) and one mineral soil (dry tundra).

Highmoor peat is confined to well drained areas not exposed to severe winds and normally carries tussock grassland. It consists of a peat layer which may be up to 8 feet thick. It is normally 3-5 feet thick but is sometimes much less. Near the surface the peat is very fibrous but halfway down the profile there is transition to amorphous peat. Throughout the peat profile mineral matter brought down by land slips may be found. The mineral subsoil is normally a yellow or green gravelly loam; the transition between peat and mineral subsoil is sharp and may be marked by the presence of an iron pan. Where highmoor peat has formed on the coastal terrace the subsoil consists of undecomposed marine deposits.

Rich fen peat is found in the upland valleys where a permanent water table is present in the soil. It carries either herbfield or fen vegetation. The top few inches of peat are fibrous below this layer which is a mass of sticky amorphous peat from 2-8 feet in depth. The mineral subsoil is generally a green gravelly loam, but occasionally deep layers of organic sand are found where the peat has formed on old lake deposits.

Poor fen peat covers that part of the coastal terrace bearing herbfield or fen vegetation. There is a permanent water table in the top 3 inches of the peat profile and this water is lower in nutrients than is the case of soil water of the rich fen peats, only a small proportion of the water having drained through mineral soil. The top few inches of the profile are fibrous peat; below this is pseudo-fibrous peat with an estimated average depth of 15 feet, overlying marine deposits. This peat, which appears fibrous, retains some morphological features of the plant species from which it was formed, but it has no strength at all and is extremely porous.

Bog peat is very similar to poor fen peat but without a fibrous surface layer and even more porous.

Dry tundra soils are brown to yellow-brown in colour and frequently have a high organic content at the surface (up to 15%) which rapidly decreases with depth. The textures of the soils vary greatly as they have been formed from glacial till ranging in texture from gravel to fine sand and clay. There is some evidence of a movement of iron in the profile.

A feature of the dry tundra soils is the formation of terraces and stone lines (Taylor 1955 b). These terraces have been formed by the restriction of the downward movement of soil material by plant growth which can only accrue in areas locally protected from the wind. The stone lines are formed as a result of ice action.

SOIL MICROBIOLOGY. A survey of the microflora and fauna of the soils of Macquarie Island was undertaken by J. Bunt ANARE biologist during 1951. He compiled data relating to the numbers and activities of the major groups and investigated the qualitative composition of the population as a whole and of the major components within it. (Bunt, 1954a, 1954b, 1954c, 1954d, 1954e, 1954f, Bunt 1955a, 1955b, Bunt and Tchan 1955, Bunt and Rovira 1955a, 1955b).

With this evidence, an assessment of the influence of the microflora and fauna on the character of the island soils was made. In addition, the effect of various environmental factors upon the soil populations was studied. As a basis for this work, Bunt determined the following characters :- pH, organic matter content, carbon/nitrogen, chloride content and composition of the organic materials in a range of the island soils.

The following groups of organisms were found to be present :-

Fauna

Crustacea. Represented by copepods; most prominent in the bog peats of the west coast.

Insecta. A number of types, especially collembolates, which were often found in large numbers.

Arachnida. Principally microscopic mites.

Tordigrada. Apparently very rare in the soils.

Rotifera. Rotifers were found to be quite common. Several specimens were found apparently feeding on algae growing on inoculated artificial media.

Nematoda. Soil-inhabiting nematodes were found in quite large numbers. The populations in 40 different soil samples were estimated three times during the period August 1951 to February 1952. Nematodes are of significant importance in soil processes.

Protozoa. Flagellates, citiates and amoebae were detected but it was not until 1955 that a suitable technique was perfected for quantitative estimations. Counts were made on soils that had been collected several years previously but the results cannot be taken to indicate conditions in the field.

Flora

Algae. The numbers in ten representative soils were estimated and the qualitative composition of the populations was studied. Apart from the diatoms, which were made the subject of detailed study a number of genera including Anabaena, Chlamydomonas, Stichococcus and Mougeotia were recorded. Certain of the soils examined contained very large numbers of organisms belonging to this group, e.g., a wet upland soil with 100 x 10^6/100 grams.

Fungi. Twenty nine genera were described including plant parasites and saprophytes and soil-inhabiting fungi, both those with microscopic fruiting bodies and those which must be isolated by appropriate culture techniques. The numbers of fungi in a range of soils were estimated. Antibiotic activity was recorded in 36% of the isolates.

Bacteria. Groups responsible for a number of important soil processes were studied as well as the activities of the general teterotrophic soil population. The special groups studied included those responsible for the fixation and transformations of nitrogen, the transformation of sulphur and iron, and the decomposition of cellulose. Analysis of rain water samples indicated that much of the nitrogen available for plant growth is deposited from sea spray.

Pollen analysis. Pollens were collected from a number of the vascular plants. By comparison with fossil pollens extracted from lignites, it should be possible to obtain direct evidence relating to the floral history of Macquarie Island since the close of the last ice age. A change in the diatom flora has already been suggested.

Kelp decomposition. Simple experiments have indicated the important role played by micro-organisms in the breakdown of kelp. The presence of a wide diversity of bacteria and other micro-organisms in the seawater at Macquarie Island has been shown. Most of the air-borne bacteria in this area is of marine origin.

Fresh-water diatoms. Fortyone species have been described, collected in situations ranging from plateau lakes to small brackish pools close to the sea.

Micro-organisms in the faeces of antarctic birds and mammals. Escherichia coli (Migula) was found in six species of bird and the sea elephant. Bacillus and Micrococcus species were also fairly common.

ZOOLOGY

SEALS. Five species of seal have been recorded at Macquarie Island — the elephant seal (*Mirounga leonina*), leopard seal (*Hydrurga leptonyx*), Weddell seal (*Leptonychotes weddelli*), New Zealand fur seal (*Arctocephalus fosteri*), and Hooker's sea lion (*Phocarctos hookeri*).

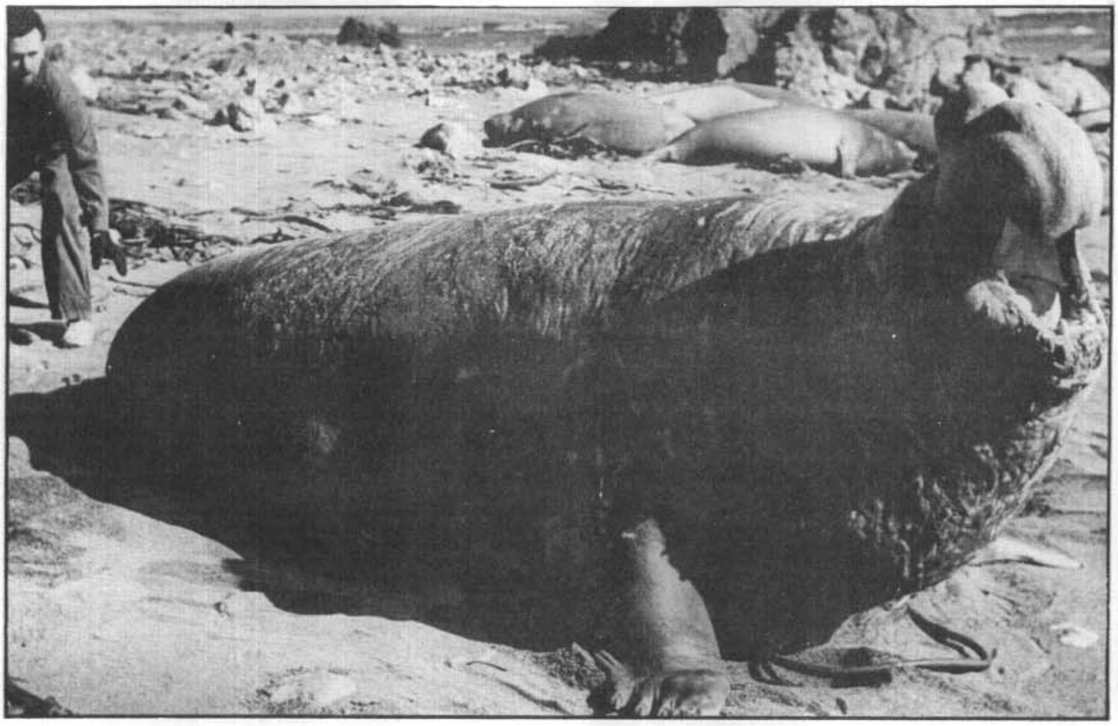
The elephant seal. After the extermination of the fur seals, the sealers turned their attention to elephant seals which were boiled down for their oil. The industry continued intermittently throughout the nineteenth century and finally ceased in 1919. At times the seal population was drastically reduced, but the species has shown great powers of recovery, and elephant seals are probably now as abundant as they have ever been in the history of the island. A count of weaned pups over the entire coast of the island in 1949 indicated that approximately 50,000 cows haul out to pup every year. This population is mainly concentrated along the sheltered east coast, expecially on the long sandy beaches of its northern third. Here, at the height of the pupping season, these beaches are crowded with an unbroken mass of seals from end to end. Smaller groups are found wherever suitable beaches are available, but only on the exposed western coast would there appear to be physical room for more.

The pupping season includes the whole of September and early October, the pups being born several days after the mothers arrive on the beaches and join the harems. The pups are suckled for about four weeks after which they spend about a month on land, living on their blubber reserves and moulting the black woolly fur in which they are born for a silvery grey hair coat which later turns to the characteristic brown of the adult.

They begin feeding on crustacea then the adult diet of fish and cuttle fish. During the first few months the young do not remain long away from land and frequently haul out to sleep. After the weaning of the pup the cows remain in the harems for several days before returning to sea in preparation for the moult.

The moulting season extends from January to March, the cows and immature animals preceding the bulls by several weeks. The seals spend winter at sea so that from April to the end of August the population consists almost entirely of immature animals.

The leopard seal. An account of this species at Macquarie Island during 1949 has already been published



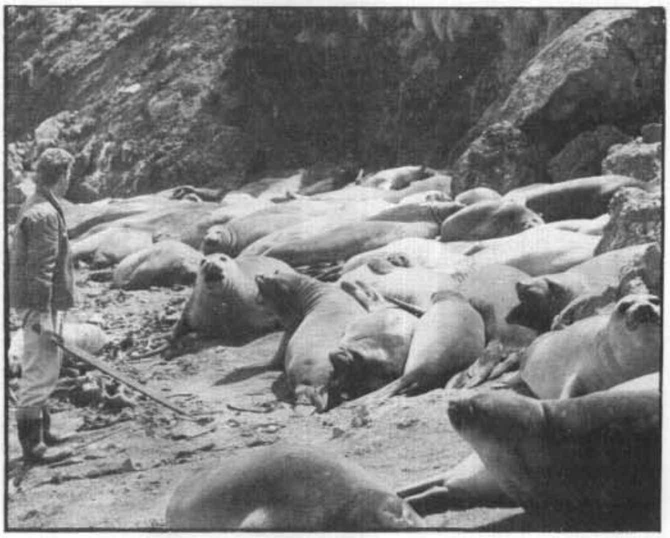


PLATE 7.

ABOVE: BULL ELEPHANT SEAL.
BELOW LEFT: FEMALE FUR SEAL WITH NEW–BORN PUP, 1955.
BELOW RIGHT: MOULTING ELEPHANT SEAL COWS.

(Gwynn, 1953a), and subsequent records differ from the pattern then recorded only in detail. Small numbers of leopard seals frequent Macquarie Island waters during the winter and early summer, the first arrivals usually appearing towards the end of June. They are most frequently seen during August and September, especially on days when the beaches are snow-covered, and a few stragglers remain till the beginning of December. The population consists largely of immature seals. A few adult males have been noted, but there are no certain records of adult females in recent years, though during the 1911-13 expedition some pregnant females were killed.

The leopard seals must take a considerable toll of the gentoo penguins, the only penguins frequenting most of the beaches during the months when the leopard seal population is at its peak; it is not known whether they inflict any considerable damage on the king penguins.

The Weddell seal. On 11 September, 1949, a small female Weddell seal, a little over 5 feet in length, was found in Aerial Cove. It was subsequently seen on several occasions, always in the same area, its last recorded appearance being on 18 April, 1950. Another small female was found in Aerial Cove at the end of September 1955. Both these strays were almost certainly animals in their first year and are the only specimens of this species so far recorded from Macquarie Island.

New Zealand fur seal. When Macquarie Island was first discovered in 1810 a huge herd of fur seals lived on the island, and during the next few years hundreds of thousands of skins were exported. So ruthless was the slaughter that when Bellingshausen visited the island ten years later he reported that the fur seals had been totally exterminated. For the next hundred years any fur seal which showed itself on the island was killed on sight, a fur-seal skin being apparently the most longed-for prize of the sealing gangs. During 1911-13 Mawson's party saw no fur seals, but with the cessation of sealing the few fur seals surviving on the New Zealand subantarctic islands began to multiply, and during recent years they have begun to visit Macquarie Island in small numbers during the late summer.

Until 1955 the visitors comprised non-breeding animals, mainly immature seals and pups a year old, a few of the latter being still accompanied by their mothers.

However, in 1955 evidence that Macquarie Island was being re-established as a breeding ground for the fur seal was provided by A.N.A.R.E. biologist, Dr. S. Csordas, who reported the birth of two pups on the island during that year. Three more pups are known to have been born on the island during the first four months of 1956. The fur seals havo been found almost exclusively on the rocky coast around the northern tip of the island. Only a few single individuals had been noted on other parts of the coast up till 1954 when a group of 17 were sighted at Hurd Point late in April. This group had increased to 22 in 1955 and other small groups were also found at different points along the coast.

In 1950 the largest number of seals counted at the north end in one day was 174, but during 1954 and 1955 there was a substantial increase in the numbers visiting Macquarie Island, totals of well over 200 being counted in both these years. (For further details see Gwynn, 1953b).

Hooker's sea lion. This species is abundant at Auckland Islands, so it is not surprising that occasional specimens appear at Macquarie. One young male established itself at Macquarie Island from 1949 to 1951, and became well known to members of the expeditions, causing great havoc among the gentoo penguins which formed its main diet. (For a full account see Gwynn, 1953 b). By the end of this period it was a well-developed young bull and presumably it returned to its native island, for it was not seen again. Other specimens recorded have all been smaller animals and their visits have in most instances been fleeting.

INTRODUCED MAMMALS. Rabbits, rats, mice and cats are all well established, having been brought to the island, intentionally or otherwise, by the sealers. Dogs were also established at one time and caused great havoc among the indigenous fauna, but there is no mention of them after Bellingshausen's visit in 1820.

Rabbits are now firmly established, and are extremely abundant in many localities over the southern two thirds of the island. In 1949-50, in many parts of this area, they had completely destroyed much of the natural vegetation, leaving little but mosses and roots. In the *Pleurophyllum* bogs, when they have eaten the leaves and the heart of the plant, they even dig out the roots, a method of attack first noted by Hamilton in 1894. Professor Scott, in 1880 reported that "the rabbit .... now swarms at the north end", but Hamilton in 1894 stated that "Rabbits ..... have disappeared from the North owing to the wild cats" and today their depredations cease abruptly at a line between Sandy Bay and Bauer Bay. North of this there are only a few small warrens, though individuals may be sometimes seen.

In 1950 a study of the rabbit population was undertaken by A.N.A.R.E. biologist, E. Shipp, who collected hundreds of specimens in selected areas, notably at Brothers Creek, a valley which had been very heavily grazed. In December 1954 A.N.A.R.E. biologist A.M. Gwynn who had spent a year on the island in 1949, paid a brief visit and found that the vegetation at Brothers Creek had completely regenerated. However, little evidence of rabbit damage was noted in other areas visited, so it is possible that there is a natural fluctuation in population, plague years alternating with periods of relative scarcity.

In 1952, at the request of Mr. P.C. Bull of the Department of Science and Industrial Research, New Zealand, material was collected for the determination of rabbit parasites. From this Mr. Bull obtained eleven species, consisting of 5 species of Coccidia, 2 Nematodes, 3 mites and a louse.

Black rabbits are unusually numerous, but few white rabbits have been seen.

Rats and mice are both widely distributed around the coast and appear to have no difficulty in obtaining a livelihood. There is no doubt that rats must have been an important factor in the extermination of many of the smaller indigenous birds, but they now probably depend largely on vegetable matter for food. Damage to Macquarie cabbage, where the heart only has been eaten, is probably due to rats, and one instance was observed in which a mouse had been feeding on the ripe seeds of the same plant.

Cats have been noted in all parts of the island and they are probably more numorous than one might first suspect. Even when the animals themselves are not seen, a line of footprints or their droppings may be noticed. The 1953 party killed about sixty cats at the north end of the island in an attempt to reduce their numbers, but this does not seem to have had any great effect. Cats have probably played a part in the extermination of some of the native birds, and they still take some of the dove prions, but their effect is likely to be small compared with the toll taken annually by the skuas. One instance is known in which a small colony of antarctic terns was wiped out by a large tom-cat. Now, however, cats must depend largely on rats, mice, and young rabbits for food, and it seems very possible that they are at present valuable as a check on these pests. Hunting cats may sometimes be seen going from burrow to burrow on rabbit infested hillsides and once, in a remote part of the island, a cat was seen carrying a half-eaten rat. The rats are undoubtedly a greater menace to bird life and the disappearance of the cats might lead to a disastrous increase in their numbers.

The commonest cat colouring is the type often known as "marmalade" (i.e. with ginger stripes), but ordinary tabbies are often seen, as well as a few black cats and some of mixed colouring. Hamilton in 1894 stated that they were "very numerous and of great size", but many of the cats now seen are rather small and their average size is probably about the same as that of ordinary suburban cats.

DOMESTIC ANIMALS. In 1917 sealers took horses to help in their operations and at the time of Larsen's visit in 1923, after sealing had come to an end, two of these were seen running wild on the isthmus.

When the A.N.A.R.E. station was established in 1948 small flocks of sheep and goats were introduced for meat and milk. For some years the goats maintained themselves on North Head, but they were eventually killed to prevent damage to the flora. About a dozen sheep are brought down each year, and these do very well on the abundant grazing. They require no attention except to see that they do not wander too far from the station. In December 1953 a cow was landed and kept the party supplied with an abundance of fresh milk. A calf was born in September 1954, in December 1954 a young bull was added, and a second calf was born in November 1955.

In December 1953 four pigs were brought down and fattened and killed during the year. They were fed on swill from the kitchen, supplemented by kelp and seal meat, both of which they ate readily.

During 1915 the meteorological party kept sheep, hens and ducks, and their leader, A.C. Tulloch, wrote a favourable report on the prospects of keeping domestic animals on the island.

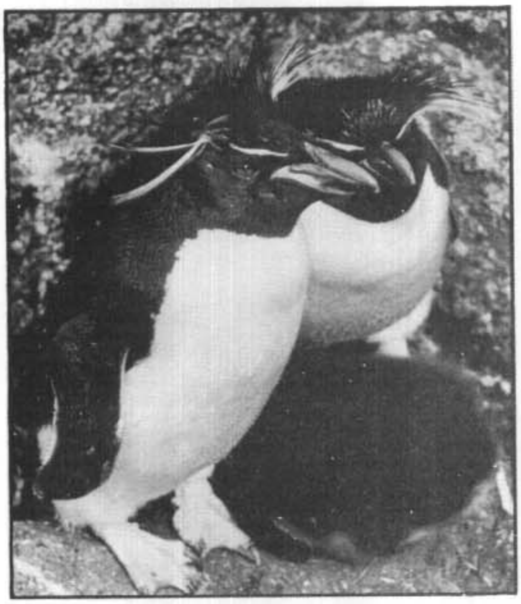
BIRDS. The birds at present breeding on Macquarie Island are:-

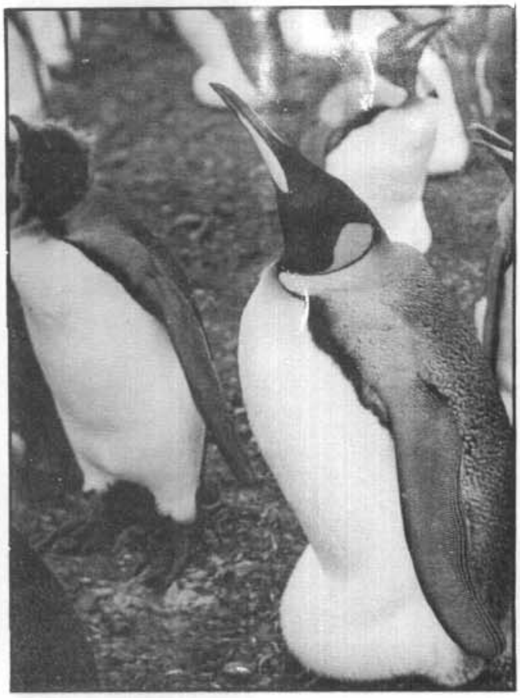
King penguin	Aptenodytes patagonica
Gentoo penguin	Pygoscelis papua
Royal penguin	Eudyptes chrysolophus schlegeli
Rockhopper penguin	Eudyptes chrysocome
Wandering albatross	Diomedea exulans
Black-browed albatross	Diomedea melanophus
Grey-headed albatross	Diomedea chrysostoma
Light-mantled sooty albatross	Phoebetria palpebrata
Giant petrel	Macronectes giganteus
Cape pigeon	Daption capensis
Dove prion	Pachyptila desolata
Macquarie Island cormorant	Phalacrocorox albiventer purpurasceus
Brown skua	Stercorarius skua Lonnbergi
Dominican gull	Laras dominicanus
Antarctic tern	Sterna vittata
Black chick	Anas superciliosa
Weka	Gallirallus australis
Red poll	Acanthis cabarel
Starling	Stüruus valgaris

Species reported as casual visitors to Macquarie Island are:-

Adelie penguin	Pygoscelis adeliae
Chin-strap penguin	Pygoscelis antarctica
Erect-crested penguin	Eudyptes pachyrhynchus atratus
Snares crested penguin	Eudyptes pachyrhynchus robastus
Black cormorant	Phalacrocorax carbo
White heron	Egretta alba
Mallard	Anas platyrhynchos
Swamp harrier	Circus approximans
Bar-tailed godwit	Limosa lapponica
Snipe	Gallinago sp.
Knot	Calidris canutus
Arctic tern	Sterna paradisaea
White-eye	Zosterops lateralis

The penguins in this list are wanderers from elsewhere in the antarctic or sub-antarctic regions. The chin-strap penguin is remarkable in that this individual





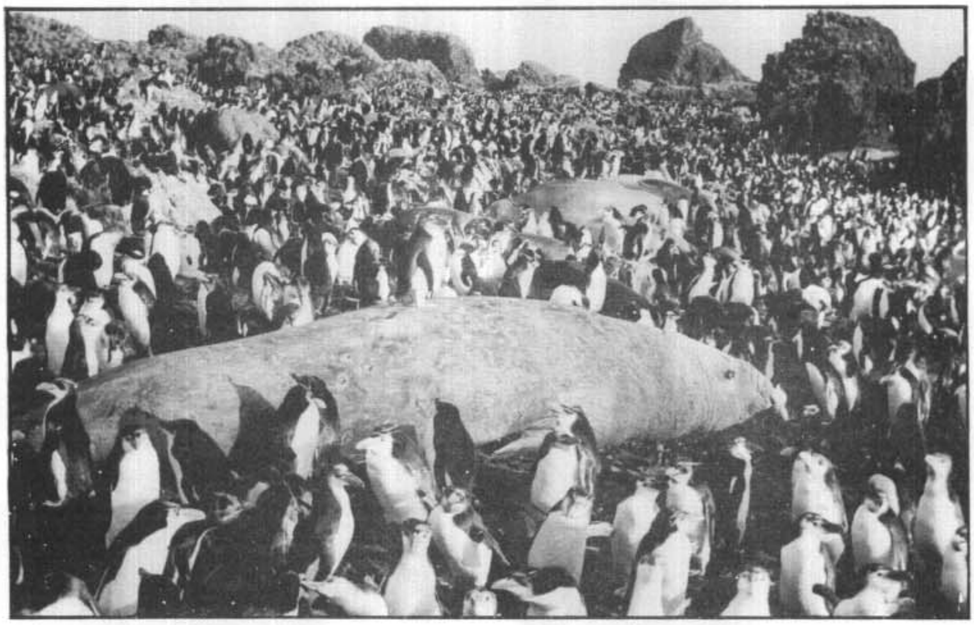


PLATE 8.

ABOVE LEFT: ROCKHOPPER PENGUINS BROODING CHI CK.
ABOVE RIGHT: KING PENGUINS:
BELOW: ROYAL PENGUIN ROOKERY, HURD POINT.

had wandered from the opposite side of the world. The erect-crested penguin has occurred on several occasions, notably in 1953 when at least five individuals were seen. Its breeding colonies are found on the Bounty Islands and the Snares.

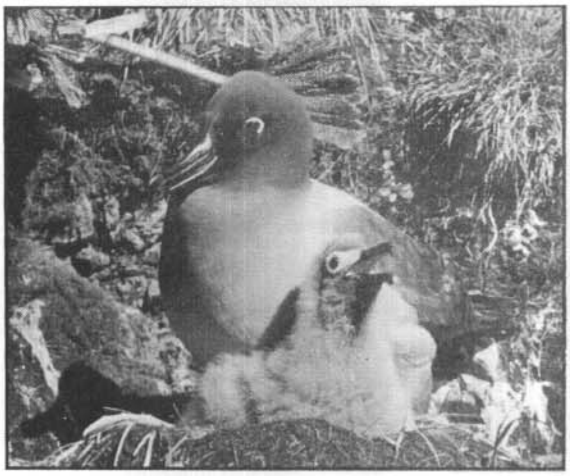
The arctic tern may be a regular passage migrant in small numbers, though so far only one specimen has been recorded. The other species are clearly strays or over-carried migrants, probably from New Zealand, and it is probable that if careful watch were kept, such wanderers would be recorded annually and other species added to the list.

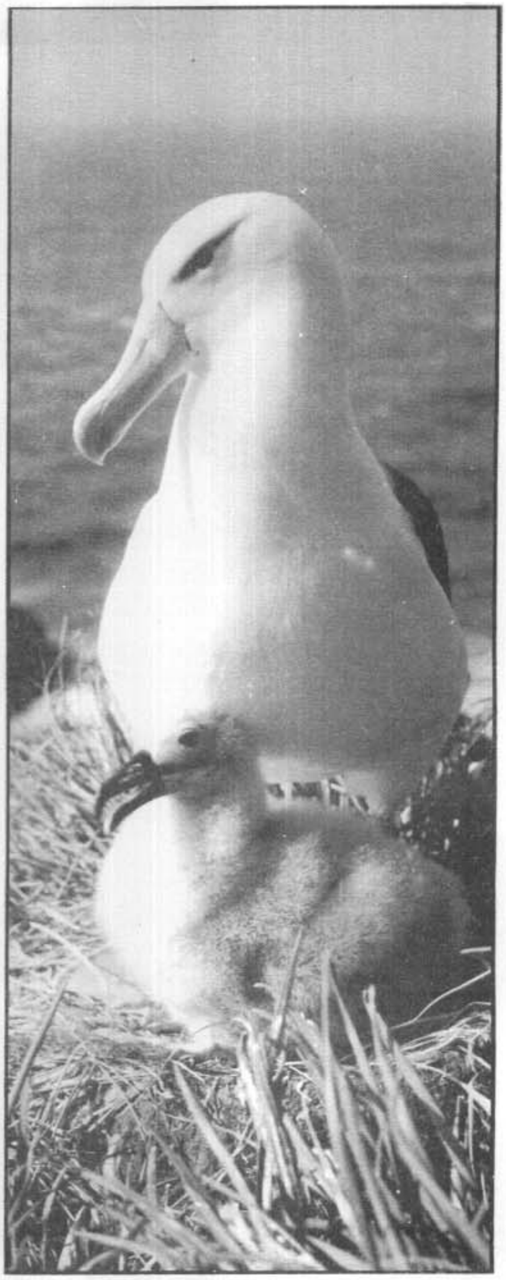
Species once native, but now extinct, or almost so, are as follows:-

Brown petrel	Procellaria cinerea
Blue petrel	Halobaena caerulea
South Georgian diving petrel	Pelecanoides georgicus
Banded rail	Rallus phillippensis
New Zealand parakeet	Cyanorhamphus novaezealandiae

In addition to the foregoing lists, two species, the cape hen (Procellaria acquinoctialis), and the grey-backed storm petrel (Garrodia nereis) are recorded by Oliver (1955 - New Zealand Birds) and in the New Zealand Check-list from Macquarie Island. The latter was placed by Hamilton (1894) in a list of birds likely to be found on Macquarie Island, but this list was largely guess work, and Hamilton produced no evidence to support it. There is no other evidence for the inclusion of either species, and though it is possible that they once nested on Macquarie Island, both had disappeared before any systematic investigation was made of the fauna of the island.

Of the four breeding species of penguin, the royals and rockhoppers are both extremely abundant. The great royal penguin rookery at Hurd Point contains about half a million breeding adults, and is one of the largest penguin rookeries in the world. Many other colonies of this species exist on the island, some also very large, and some are a considerable distance from the coast and up to 500 feet above sea level. The white-faced royals may be considered as the Australasian representative of the more wide-spread, black-faced macaroni penguins, but this form is peculiar to Macquarie Island. A curious feature of both the royals and rockhoppers is that they lay a clutch





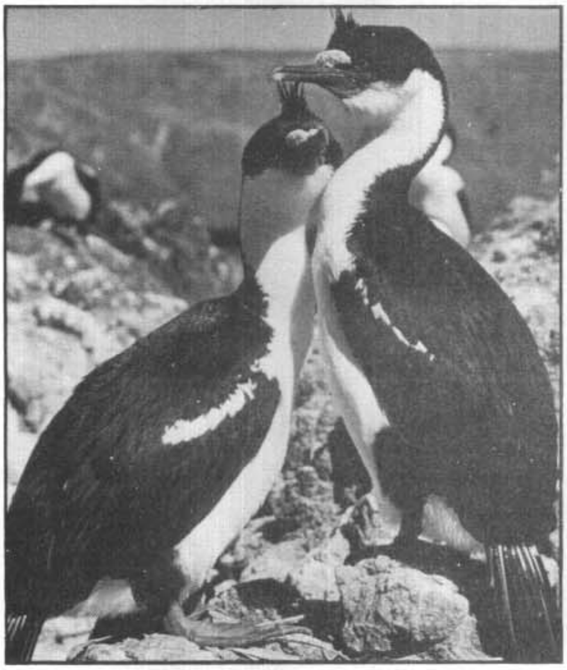


PLATE 9.

ABOVE LEFT: LIGHT–MANTLED SOOTY ALBATROSS WITH CHICK.
RIGHT: BLACK–BROWED ALBATROSS WITH CHICK.
BELOW LEFT: MACQUARIE ISLAND CORMORANTS.

of two eggs of very unequal size, of which only the chick from the larger egg is normally reared (Gwynn, 1953d). This trait is peculiar to the genus Eudyptes. Both royals and rockhoppers leave the island for six months of the year and spend the winter months wandering in the open ocean.

The gentoo penguins nest in small colonies around the coast and, though their total population is the smallest of the four species, they are the penguins most familiar to visitors to the island, as they are resident all the year round and may be seen in small groups on any suitable beach at all seasons.

The king penguins are also permanent residents and formerly lived in two great colonies, one at the north end of the island and one in Lusitania Bay. However, when the supply of seal oil dwindled, the sealers turned their attention to the kings, which were particularly vulnerable as they tend their chicks throughout the sub-antarctic winter (when seals are scarce), and the dense mobs of fat chicks provided an easy source of oil. The colony at the northern end of the island was completely exterminated and that at Lusitania Bay was reduced to a small remnant. However, the latter colony is making a good recovery and today numbers over ten thousand breeding pairs. After the extinction of the kings, the sealers turned their attention to the royal penguins during the off-season for sealing, but due to the absence of these penguins during half the year and other factors, it does not appear that the sealers ever made any great impression on their numbers.

Of the four albatrosses, only the light-mantled sooty, breeding in small groups on precipitous hillsides, is as abundant as it ever was. It is reasonable to suppose that Macquarie Island once shared the great albatross populations which still characterise Campbell Island, 200 miles to the north east, but at the time of the A.A.E.'s tenancy the only other albatross found in any numbers was a colony of the grey-headed species in the remote southwest corner of the island. This colony still flourishes and today numbers perhaps 100 pairs. Of the wandering albatross the A.A.E. party recorded only two nests, so it was probably then just beginning to re-establish itself. Today at least a dozen pairs nest every year and there is every reason to suppose that they will continue to increase, as suitable nesting grounds are extensive. Nesting as they do on level, open ground, they would have been completely at the mercy of marauding dogs, and both the birds and their eggs would have been regarded by the sealers as a welcome addition to their menu. The royal albatross (Diomedea epomophora) is common at Campbell Island, but if it ever nested at Macquarie Island, it no longer does so. Finally, the black-browed albatross (Diomedea melanophris) has recently succeeded in re-establishing itself and is now represented by a small colony of 20 to 30 pairs at North Head. A few pairs also nest near the grey-headed colony in the Southwest. If the North Head colony had existed in 1929 it could not have been missed by the B.A.N.Z.A.R.E. party which made a detailed examination of this area.

The albatrosses are probably unaffected by the rats and cats established on the island, but the situation of the petrels is wholly different. Naturalists who visited the island during the last century (Scott, 1880, and A. Hamilton, 1894) still found burrowing petrels nesting in large numbers in the steep hill-sides surrounding the island, but this is no longer true today. Among the smaller petrels, only the dove prion (Pachyptila desolata) still nests in many numbers and even these have largely disappeared from the northern half of the island. Their survival is probably due to the fact that they nest on the surface of the plateau, where rats and wekas rarely penetrate. Species which formerly nested on the lower slopes have become extinct, or almost so; this is undoubtedly due to predation by rats and wekas. The latter were introduced by the sealers for food, and they have probably proved as disastrous for the smaller native species as the accidentally introduced rats. Towards the end of the last century a collector, Burton, reported that blue petrels nested commonly "under the tussock grass, anywhere on the lower levels" and there is good reason for accepting his statement. However, in the present century this species has not been seen, except for a single specimen collected at light in 1950. South Georgian diving petrels have been taken at light on a few occasions, but their burrows have not been found in the present century and they are probably on the point of extinction, unless there are colonies on the Bishop and Clerk islets. Other small species of petrel have probably disappeared without trace.

The larger species have fared better. The giant petrels still nest in large numbers, and it is clear that none of the introduced predators have any important effect on them. In 1955 Dr. Carrick, Wild Life C.S.I.R.O., saw a weka carrying off one of their young chicks, but chicks would not normally be left unguarded at this age. The white-headed petrels still nest in large numbers around the fringe of the plateau and are clearly well able to hold their own, though they have probably suffered some reduction in numbers due to burrowing and destruction of cover by rabbits. The slopes above Lusitania Bay were formerly the home of large numbers of this species and of prions, but today they are tenanted almost solely by rabbits. The sooty shearwaters which maintain a small colony at North Head, and probably elsewhere, are also holding their own, though their losses of nestlings may be high. The brown petrel still nested in the A.A.E.'s time, but has since almost entirely disappeared. It has only once (1949) been seen by A.N.A.R.E. biologists, and no nest has been found. As this species ventures freely over land in daylight at other breeding places, it is evidently now very rare if not extinct on Macquarie Island.

Small parties of cape pigeons are seen occasionally feeding close in-shore. These were assumed to be birds from the antarctic zone until in 1951 A.N.A.R.E. biologist, E. Lindholm, found a small number apparently nesting on Anchor Rock, half-a-mile off North Head. As there is a distinct race breeding on the New Zealand subantarctic islands, it seems likely that there may be a colony on the Bishop and Clerk Islets, and that they may formerly have bred on the cliffs of Macquarie Island proper.

Of the other species, the Macquarie Island cormorant nests in small colonies around the coast. The dominican gull and the skua hold their own without difficulty, the latter taking an unusual toll of those petrels which still return to nest on the island. The antarctic tern maintains a small population somewhat precariously, nesting chiefly on rocky stacks off-shore. In 1950 one such small colony was destroyed by a cat which had somehow gained access to their refuge. Small parties of black duck are commonly seen on the coastal bogs, but successful breeding has seldom been noted. The younger Hamilton believed that their species migrated away from the island during the winter. It is unlikely that there is any regular movement between Macquarie Island and the New Zealand mainland. However, the discovery of a mallard drake among a flock of black duck in 1949 suggests that flocks of wild duck still reach the island on occasion, and it is possible that the local population is maintained by such means. Thomas Raines, in 1822, listed both wild duck and teal as being found on the island. This suggests that as at Auckland and Campbell Islands, the original fauna may have included more than one species of duck.

As already mentioned, the weka was introduced by the sealers during the last century, and is now abundant throughout the coastal areas. Its advent probably sealed the fate of the indigenous rail and the grass parakeet, both of which species became extinct between 1880 and 1897.

The starling and red poll were introduced into New Zealand from the northern hemisphere and have spread not only throughout New Zealand proper, but right down through the chain of subantarctic islands. There can be little doubt that they reached Macquarie Island unaided, and both species are now well established. Several other species have followed the same route as far as Campbell Island and it is to be expected that some of these will eventually reach Macquarie Island though whether they will succeed in establishing themselves remains to be seen. An unconfirmed report of one or more black birds (*Turdus merula*) seen in 1951 is quite possibly correct.

INSECTS. Though the number of species is small, the insect fauna of Macquarie Island is abundant in individuals. Small Staphylinid beetles and diptera breed in enormous numbers in the piles of rotting kelp which are a feature of the island shores, and on some days in summer these flies may be scooped up in thousands from small depressions in the beach. A small moth, *Scoparia mawsoni*, occurs commonly at the right season flying by day over the vegetated parts of the plateau. Another curious insect is a small wingless Hymenopteron, *Antarctopria latigusta*, both genus and species being peculiar to Macquarie Island when originally described.

Among parasitic insects, one species of flea has been collected from sea-birds' nests, and all birds harbour one or more species of bird louse, so that the number of species of this order is roughly proportionate to the number of species of birds.

Primitive insects of the order Collembola are also abundant.

The insects of Macquarie Island have not been exhaustively studied, and it is probable that several additional species may yet be added to the list. K.G. Brown collected there in 1953 but, as a consequence of his unfortunate death, his collection has never been described.

One species of tick, *Ceratixodes uriae*, is usually found on penguins and albatrosses.

SNAILS. The one land snail (so far recorded) Phrixgnathus hamiltoni, Suter, is an endemic species, though other species of the same genus have been described from Campbell Island. This minute snail is common in various situations, but is most easily found on stems of the Macquarie cabbage.

Three species of slug have been recorded, Agriolimax agrestis, Linn., an introduced European species; and two indigenous species of Atheracophorus (A. huttoni and A. martensi) both of which are also found on the New Zealand subantarctic islands.

FISH. Norman (1937 - B.A.N.Z.A.R.E. Reports) lists five species of coastal fishes from Macquarie Island, all belonging to the Nototheniiform group. These are:-

Notothenia macrocephala, N. Rossii, N. colbecki, Harpagifer bispinis, and Zanclorhyuchus spinifer.

The first, which resembles rock cod in appearance, is very abundant and may weigh up to several pounds. Unfortunately its flesh is often heavily infested with round worms. H. bispinis is not uncommon is rock pools. Z. spinifer is elsewhere known only from Iles de Kerguelen.

In addition, a lantern fish, Myctophum anderssoni has been recorded, and Waite (1916 - A.A.E. Reports) mentions four other deep water fishes. The strangest find in the ichthyological history of Macquarie Island was a dead shark, 8 feet long, which was washed up on the beach in 1913. This was tentatively assigned to the genus Somniosus, to which belongs the sleeper shark found in arctic waters.

LITTORAL ECOLOGY. A detailed ecological survey of the rocky littoral of Macquarie Island was carried out in 1949 by A.N.A.R.E. biologist, N.M. Haysom. Five stations were worked to cover different degrees of exposure, nature of slope, etc. and the littoral was shown to exhibit the following features:-

Sessile barnacles and supra-tidal littorinid gasteropods which are of almost universal occurrence on temperate surf-swept rocky shores, are completely absent. There are no mussels and oysters and no large communities of ascidians or tube-building polychaetes.

The usual sequence of zonation (from above) is as follows:-

1. A zone of *Porphyra columbina* which may be intermingled with *Enteromorpha bulbosa* in some areas. The chief animal life consists of two species of oligochaete worms, a mite and several insects and their larvae.

2. A zone practically devoid of algae, populated by the limpet, *Siphonaria lateralis*.

3. A zone covered by a thick mat of a red alga, *Rhodymenia* c.f. *palmatiformis*. The principal animal inhabitants are the siphonate limpets, amphipods, oligochaets and polychaets, and a minute lamellibranch, *Kidderia pusilla*.

4. A zone of lithothamnion and giant kelp, *Durvillea antarctica*. Locally numerous in this zone are several species of polychaets, including a small serpulid, *Spirorbis aggregata*; two littorinids, *Laevilitorina caliginosa* and *Macquariella hamiltoni*; a trochid, *Cantharidus coruscans*; a large limpet, *Nacella delesserti*; several chitons, including the giant *Plaxiphora aurata*; several species of amphipoda and sphaeromid isopods; as well as asteroids, actinozoans, turbellarians, bryozoans, copepods, etc. In some localities this zone is conspicuous for the large numbers of the scarlet lamellibranch, *Gaimardia trapezina*, attached to the fronds of a red alga *Phyllophora appendiculata* growing on the lithothamnion-encrusted rocks.

METEOROLOGY[1]

The climate of Macquarie Island is cloudy, wet and cold. Though one degree higher in latitude than Heard Island, Macquarie Island lies north of the Antarctic Convergence while Heard Island is some 200-300 miles south of the mean position of the Antarctic Convergence. The effect of the warmer seas around Macquarie Island is shown by the mean temperature (of three-hourly readings) being 5.8°F. higher than that of H eard Island.

Winds are strong and persistent. The station site at Macquarie Island is less sheltered than that at Heard Island and less subject to topographical influences.

The island is subject to persistent cloud cover and there is little bright sunshine. Rain, drizzle, snow and small hail are frequent but generally light, and give an annual average precipitation of 40 inches occurring on about 330 days of the year.

Fogs and misty conditions occur frequently at all seasons. Completely cloudless skies are uncommon.

Pressure. The subtropical temperate belt of high pressure is, on the average, well north of Macquarie Island, but on occasions the centre of an anticyclone may pass close to the island, either as an anticyclone on an abnormally southern track, or as a "bubble" high moving north-eastward from Antarctica bringing very cold air much further north than usual.

There are large and rapid variations of pressure, at times exceeding 10 mb in 3 hours, associated with the movements of depressions near the island. The average range of pressure in any month is from 60 to 70 mb.

The mean pressures do not show very large variations. The annual mean derived from hourly pressure readings in the period 1912-15 and from three-hourly pressure reading during 1948-1954 is 998.9 mb. No year's mean differs from this figure by more than 2 mb.

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(1) See Gibbs, Gottley and Martin(1950-52); also Meteorological Branch Melbourne,(1953a, 1953b, 1953c, 1955a, 1955b.)

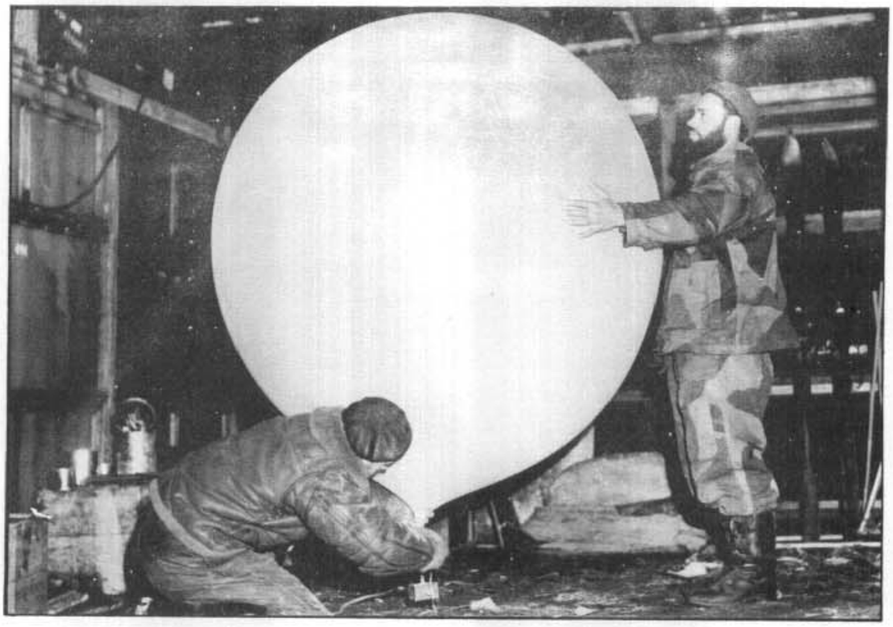

PLATE 10.

ABOVE: METEOROLOGISTS FILLING RADIOSONDE BALLOON WITH HYDROGEN.
BELOW LEFT: METEOROLOGIST SCALING A TRACE FROM THE RADIOSONDE RECORDER.
BELOW RIGHT: METEOROLOGIST CHECKING RAIN GAUGE.

TABLE I.

MONTHLY MEAN PRESSURES (mb) AND STANDARD DEVIATION

Jan.	997.5	7.1	Jul.	1002.1	4.8
Feb.	997.7	4.3	Aug.	999.7	4.2
Mar.	999.4	3.5	Sept.	996.2	3.2
Apr.	999.4	3.3	Oct.	997.6	5.6
May	1002.3	3.3	Nov.	996.2	5.0
June	1001.0	4.1	Dec.	997.2	3.1

This shows that, despite the great variability of pressure in relatively short periods, the mean pressure does not vary greatly over a period of a month.

Temperature.

TABLE 2.

MEAN MONTHLY TEMPERATURES (°F.) AND STANDARD DEVIATION (from 3-hourly readings 1948-54)

Jan.	43.8	1.0	July	37.4	2.2
Feb.	43.5	0.6	Aug.	37.4	1.4
Mar.	42.6	1.1	Sept.	38.1	1.3
Apr.	40.8	0.6	Oct.	38.9	1.0
May	39.4	1.2	Nov.	39.9	0.4
June	37.1	0.6	Dec.	43.5	1.5
			Year	40.2	0.4

The series of observations in 1913-15 shows slightly lower mean figures (based on hourly readings of the thermograph trace) but these means differ from those of 1948-54 by less than standard deviation of the mean.

It will be seen that the annual range of the mean monthly temperature is 6.7°F., a very small figure. The warmest month is January and the coldest July. The greatest month to month difference is between November and December.

TABLE 3.

MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURES (°F.)

AND DAILY RANGE

Month	Maximum	Minimum	Daily
January	46.7	41.1	5.6
February	46.3	40.0	6.3
March	45.1	39.4	5.7
April	43.5	37.4	6.1
May	42.0	36.4	5.5
June	40.0	34.1	5.9
July	40.1	34.2	5.9
August	40.3	33.7	6.6
September	41.0	34.0	7.0
October	41.7	35.4	6.3
November	43.1	36.8	6.3
December	45.7	39.9	5.8
Year	42.9	36.8	6.1

It will be seen that these means follow the general pattern of the monthly means but that the mean minimum temperatures remain almost constant from June to September, while the mean maximum temperatures, like the means of the three-hourly readings, remain almost constant from June to August.

The highest temperature recorded to date is 52.7°F. and the lowest 17.0°F., giving an absolute range of temperature of 35.7°F.

Summarising, the temperature at Macquarie Island has small daily and seasonal ranges, showing little variation of the monthly means from year to year.

Humidity. The air is rarely far from saturation. Approximately half the observations show a relative humidity of 90% or greater, while approximately one tenth show a relative humidity of less than 70% .

The mean relative humidity is 88%. This high figure is not surprising, for all air streams reaching Macquarie Island have had long trajectories over water.

Wind. Macquarie Island is in the zone of westerlies, but travelling depressions can and do cause winds from other directions to be recorded.

Approximately 50% of all winds experienced are in the sector 255° - 315° with a further 17% in the sector 315° - 345°. Thus the sector from 255° to 345° accounts for two thirds of the wind.

The wind speeds recorded in the three-hourly observations show the following frequencies of wind speeds at the Dines head, 33 feet above the ground.

TABLE 4.

WIND SPEEDS 1948-1954

Speed in knots	%
Calm	3.2
1 - 9	15.5
10 - 19	34.7
20 - 29	33.8
30 - 39	11.5
40 - 49	1.2
Over 50	0.1

The median wind speed indicated by the table is nearly 20 knots. Winds at the observing site between south and west and between north and north-east are gusty. Winds from other directions show less gustiness than is normally experienced at land stations for similar speeds.

Cloud cover and sunshine. The cloudiness at Macquarie Island is probably slightly greater than that over the adjacent sea because of the orographic cloud induced by the island. Over 90% of observations show the sky more than half covered with cloud and, of this 90%, by far the greater part is either overcast or only slightly broken.

The amount of sunshine recorded is somewhat greater than would be expected from a consideration of the amount of cloud cover. The annual average of bright sunshine as shown by the Campbell Stokes recorder is 800 hours recorded on 264 days a year. On 101 days no sunshine is received. The time the sun is above the horizon is approximately 4400 hours per annum, so that the duration of bright sunshine at Macquarie Island is about 18% of the possible. There have been some days on which the sun shone most of the time. On 18/11/52 14.1 hours bright sunshine were recorded, and on 11/12/48 13.1 hours. In the six years during which the sunshine recorder was in operation, there were 35 days on which more than 10 hours bright sunshine was recorded.

Precipitation. Precipitation is frequent and generally light; it may be rain, drizzle, snow or soft hail. Snow lies on the ground for short periods only. On the average there is precipitation on all but 40 days of each year. On 31 days the amount of precipitation exceeds 30 points and on 7 of these it exceeds 60 points.

As shown by Table 5, the average daily precipitation throughout the year is fairly uniform, with a slight peak in late summer to 130% of the annual daily mean and weak minima in winter and in the late spring of slightly greater than 80% of the average.

TABLE 5.

AVERAGE DAILY PRECIPITATION.

Month	Points	Month	Points
January	12.2	July	9.3
February	11.7	August	9.6
March	14.2	September	11.3
April	13.1	October	10.3
May	10.5	November	9.5
June	10.7	December	11.3
		Year	11.2

The rainfall of 40 inches a year is not high by Australian standards, but on Macquarie Island, where the air is much nearer saturation, the evaporation is small and the rain keeps the more poorly drained areas waterlogged.

Rainfall measurements from December 1914 to November 1915 gave a twelve month total of 45.86 inches, the recordings from July to October being the highest for each of those four months to date. This may be due to alteration of the site of the rain gauge. Year to year variation of rainfall is not great.

Visibility. Due to the high incidence of fog and light precipitation, visibility is often poor. It is very variable, ranging from 200 yards in fog to up to 30 miles under favourable conditions.

Upper winds. To date only visual methods have been employed in tracking pilot balloons. Most flights are severely limited in height by cloud, the exceptions occurring when the winds near the surface are light.

Upper air temperatures. While day to day variations in surface temperatures are small, upper air temperatures show marked variations, for the equalising influence of the sea surface in contact with the air is absent. Thus for analysis of the meteorological situation, the upper air temperatures are of great value.

Seasonal variations in mean temperature increase from 4°C. between July and January at 900 mb to 8°C. at 500 mb and then remain steady through the troposhere and stratosphere to 100 mb. Above the level of 100 mb the seasonal variation increases. Observations are less numerous but it would appear to be approximately 14°C. at 60 mb.

Water vapour content is variable; rarely is the relative humidity lower than the range of measurement of the radiosonde (about 20%). The relative humidity often exceeds 75% throughout the sounding until the temperature falls below -40°C. when the hygrometer section of the radiosonde becomes inoperative.

Representativeness of observations. In strong winds the barometer "pumps" through a range up to 4 mbs -- otherwise the pressure on the island should be representative of that of the area. The "pumping" is probably induced by topography and buildings.

Temperature has always proved a difficult element to measure, but the siting of the thermometer screens some distance from the buildings avoids any influence that the warmth of the buildings may have on the air near them. The predominantly high wind speed over the island and the narrowness of the isthmus at the observing site on Macquarie Island minimises the effect that the surface of the island may have on the temperature of the air. Under the rare, almost calm, conditions, some slight effect would be experienced.

Absolute humidity, dew point, mixing ratio and vapour pressure are independent of temperature, while relative humidity, being a ratio of vapour pressure present to saturation vapour pressure at the temperature of the air, varies with temperature for a given vapour content. Due to mixing processes in the air, measurements of absolute humidity on the island are representative of the area, while relative humidity is affected according to the effect that the island has on temperature of the air.

Any oceanic island slows down the wind passing over it but due to valleys and the like there may be areas on the island where the wind speed is greater than that in the original stream. An obstruction in the wind stream will cause eddies downwind and increase gustiness; but at Macquarie Island most winds reaching the observing site are not affected by the obstruction of the island, and show much less gustiness than is experienced at an inland station for similar wind speeds. The frictional effect of the surface causes a velocity gradient in wind downward to the surface where the air is almost stationary so that the height of the anemometer above ground is important when wind speed is being assessed.

Due to the frictional effect of an island on the air stream, cloudiness is greater over an island than over the adjacent sea, and almost certainly, the precipitation is also greater. Measurements at Willis Island show that in a short distance on an island there can be marked differences in rainfall, so that the heavier rainfall recordings of 1914-15 may be due, not to greater precipitation generally, but due to the recordings being made at a site some distance away from the original recordings probably 200-300 feet southeast, i.e. downwind and away from the nearest high ground.

The visibility observed at an island where very high relative humidities are common would probably show a higher frequency of very poor visibility in some directions than over the nearby ocean.

Upper air observations make use of a balloon which the winds carry away from the island, so such observations should be representative even though the balloon is generally downwind of the island.

PHYSICS

GEOMAGNETISM. The first magnetic station on Macquarie Island was established by the Australasian Antarctic Expedition in 1911. This station was subsequently re-occupied in 1930 by the British Australian New Zealand Antarctic Expedition (Farr, 1944).

During the establishment of a permanent scientific station in March 1948 and during the relief operations in March/April 1949 and April 1950 absolute magnetic observations were again carried out at this station.

To select a suitable site for a magnetic observatory, a vertical intensity variometer survey was carried out during the relief operations in April 1949 and in 1950 two prefabricated huts were taken to the island to house absolute instruments and recording variometers.

From July 1950 to March 1952 absolute observations were made about every two weeks and during 1951 a set of La Cour normal sensitivity variometers was installed in the variometer hut.

Continuous recording of the three components — vertical intensity, horizontal intensity and declination — together with weekly absolute observations were started in March 1952 and these have since been continued without interruption.

The magnetic observatory is operated by officers of the Bureau of Mineral Resources, Geology and Geophysics.

The results of observations up till 1952 have been published (Jacka, 1953d) and results of later years are being prepared for publication.

Annual mean values for 1954 are as follows:

Declination: 24°28.7'
Horizontal Intensity: 0.13347 gauss.
Vertical Intensity: -0.64533 gauss.

SEISMOLOGY. The seismological observatory at Macquarie Island was established in 1950 when a N-S and E-W component Wood-Anderson type seismograph was installed.

The seismograph has a period of 0.75 seconds with a damping coefficient of 0.85.

The instrument has been operating continuously since its installation and a number of near tremors have been recorded, usually between 10 and 70 kilometres from the island. The data extracted from the seismograms have been published monthly by the Bureau of Mineral Resources, whose officers operate the seismological observatory.

COSMIC RAYS. Three different series of cosmic ray intensity measurements with different equipment have been made at Macquarie Island.

Cosmic Ray Recorder A . Cosmic ray recorder A was in operation at Macquarie Island during 1948, 50 and 51. This equipment contained six trays of geiger counters each 20 cm x 20 cm. Trays 1, 2, 3 and 4 were placed vertically one above the other with 15 cm spacing. A 10 cm lead slab separated trays 3 and 4. Trays 5 and 6 were placed in contact one above the other.

Threefold coincidences were recorded between trays 1, 2 and 3 giving the total intensity of cosmic radiation over a half angle of $33^{\circ} \times 33^{\circ}$; the average coincidence rate was approximately 4500 per hour. Threefold coincidences, averaging 3300 per hour, between trays 2, 3 and 4 gave the hard component intensity over the same solid angle. Twofold coincidences between trays 5 and 6 recorded the total intensity over nearly the full hemisphere, the average coincidence rate being approximately 21,200 per hour. With additional counter trays and coincidence circuits cosmic ray shower intensities were also recorded.

The Macquarie Island records have been used for the study of cosmic ray intensity variations associated with variations in atmsopheric structure and with occurrence of solar and geomagnetic disturbances. One of the main problems considered was that of describing or predicting the variations of cosmic ray intensity in terms of a linear function of barometric pressure, height of the p millibar isobar and the temperature in the vicinity of the p millibar isobar. It was shown that no one choice of the pressure p made this function a significantly better predictor than any other in the range considered. It was concluded then that this data provided no evidence in support of the conclusion reached by Duperier (1951 - J. Atmos. Terr. Phys.: 1:296) from a similar study, that the bulk of the mu-mesons at sea level were produced in the vicinity of the 100 millibar isobar and that the observed positive coefficient of temperature in the above linear function arose through the competing processes of capture and decay of the pi-mesons. Further, theoretical calculation showed that the expected temperature coefficienc was much smaller than observed. It was suggested that the temperature in the 100 millibar region was merely an indicator of another property of the atmosphere which directly determined the mu-meson intensity at sea level.

Marked changes in cosmic ray intensity at Macquarie Island were observed in association with the passage of weather fronts over the station. These changes were due to changes in the barometer coefficient which was dependent on the mode of variation of height of the meson producing level with sea level pressure and this was different for the warm moist air and the cold dry air before and after the passage of the front.

During one period in which a solar radio noise storm (on 98 Mc/sec) and an intense geomagnetic storm coincided, there was a decrease of approximately 2% in the total intensity and hard component intensity of cosmic rays at Macquarie Island. No effect of noise storms was found at other times, while the average effect of a number of geomagnetic storms showed a decrease of approximately 0.5% in the cosmic ray intensity.

The cosmic ray total intensity at Macquarie Island was found to be uncorrelated with intensity of 10 cm solar radiation. No significant variation was found at times of 'outstanding short duration occurrences' of solar radio noise on 62 or 98 Mc/sec.

The Macquarie Island cosmic ray records showed a significant diurnal variation with the maximum shortly after local noon. This result was consistent with the observations of Thambyahpillai and Elliot (1953 - Nature, 171:918) on the change in phase of the diurnal variation over the last 20 years. No significant semi-diurnal variation was present.

Cosmic Ray Recorder B . The recorder was operated at Macquarie Island during 1950 and 1951, and at Hobart during 1952, 1953 and 1954. The apparatus consisted of two Geiger counter telescopes, arranged to point at any given zenith angle on either side of vertical. Each telescope contained three trays of counters, 20 cm x 20 cm, the outer trays being separated by 76 cm, giving a half angle of approximately 15° in each direction.

Lead absorber was placed between the bottom and middle trays. The telescopes were mounted on a turntable which could be rotated through 180 degrees every hour to interchange their positions. Runs of one hour were made in each position, and the number of 3-fold coincidences in each hour was obtained by photographing, at the beginning and end of each run, mechanical registers connected to the telescopes.

The major project for which it was used was the study of the East-West asymmetry at each station. The original theory of the asymmetry was based on the effect of the earth's magnetic dipole field on charged primary cosmic ray particles. Since it was assumed that there were no field sensitive primaries contributing to the sea level radiation at places between about 45 degrees geomagnetic latitude and the poles, the theory had to be revised to account for the presence of small asymmetries in these regions. Following Johnson's (1941) suggestion that these asymmetries were due to the deflection of secondary particles in the Earth's field, the theory has been revised (Burbury and Fenton, 1952) to include more recent information on the energy spectrum and positive excess of mesons, and it has been extended to take account of losses due to the decay of mesons in flight. A table has also been compiled giving range as a function of momentum, so that the total deflections of the mesons can be readily calculated by numerical integration. During 1950, values of the East-West asymmetry for the zenith angles of 15°, 30°, 45° and 70°, using 12 cm of lead absorber, were obtained at Macquarie Island. They confirmed in general the modified theory and showed that the asymmetry increases with zenith angle, but the statistics were not good enough to disclose the presence or otherwise of a latitude effect between Macquarie Island and Hobart. During 1951 an extended run of 10 months at a zenith angle of 45° confirmed the theory more accurately for that setting at Macquarie Island.

The 1951 records disclosed two noticeable variations of the asymmetry at the zenith angle of 45°. During the winter months a significant barometer coefficient of the order of + 1%/mb was observed. This was shown to be equal to the difference between the barometer coefficients for the West and East rates. Such a large difference could only be accounted for by assuming different momentum spectra at production for mesons arriving from the West compared with those arriving from the East. Values of the barometer coefficient were calculated for a number of momentum ranges at sea level between 250 mev/e and 700 mev/c.

A marked solar diurnal variation of the asymmetry was noticed. It closely resembled the variations which Elliott and Dolbear observed in the East-West difference at Manchester in 1949, except that the times of maxima and minima occurred an hour and a half earlier at Macquarie Island. This supplied further evidence to confirm the world-wide recession of the phase of the diurnal variations of the intensities between 1949 and 1951 as shown by Thambyahpillai and Elliott. The amplitude of the diurnal variation of the asymmetry was sensitive to geomagnetic disturbances. The explanation of the daylight variations was based on a theory put forward by Sarabhai and Kane (1953) that energetic solar cosmic rays were responsible for the daylight part of the solar diurnal variation of intensity, and that at these latitudes such particles were deflected towards the west by the geomagnetic field. There were some remarkable similarities between the patterns of the variations at Macquarie Island and Hobart where the same experiment was performed concurrently during the winter of 1951, using similar equipment. The variations are at present being analysed, together with the records of the East-West asymmetry obtained from recorder 'B' at Hobart in 1953.

Theoretical values of barometer coefficients of cosmic ray intensity were calculated, using a method proposed by Rose (slightly modified), showing that the differential coefficients varied with zenith angle but the integral ones did not. It was clear from the Macquarie Island records that there was no definite indication of a trend towards larger values at large angles.

<u>Cosmic Ray Recorder A'</u>. This equipment has been in operation at Macquarie Island since 1952. The records will be used in a study of the cosmic ray diurnal variation and its dependence on geomagnetic disturbance and of the anomalous variations associated with solar and geomagnetic disturbance. In conjunction with records from Mawson and Hobart they should prove of considerable value.

This equipment contained four trays of geiger counters arranged in the same way and of the same size as trays 1, 2, 3 and 4 of cosmic ray recorder A. Slabs of lead 10 cm thick were mounted between trays 2 and 3 and between trays 3 and 4. Threefold coincidences were recorded between trays 1, 2 and 3 and between trays 2, 3 and 4, so that two measures of the hard component were obtained.

THE AURORA. Systematic visual observations of the aurora at Macquarie Island have been made since May 1950. Initially, observations were made continuously throughout the night and an attempt made to record all significant changes in the aurora. The log of observations for the period May 1950 to April 1951 has been published (Parsons and Fenton, 1953). During this period auroras were recorded on 206 nights. Disregarding continuously overcast nights this represents a frequency of 86% of all possible nights, indicating the proximity of Macquarie Island to the auroral zone.

From an analysis of these observations Jacka (1953b) has shown that the latitude of the 'homogeneous arcs' is significantly dependent on time of day and geomagnetic disturbance index K_p. For fixed K_p their latitude has a minimum value at magnetic midnight (defined by reference to the geomagnetic meridians). For fixed values of K_p and time of day the probability distribution of latitude of 'homogeneous arcs' has a sharply defined mode; the probability of occurrence drops from its maximum to half maximum in a range of 1.5 degrees of latitude.

In a further study of these records Jacka (1954) has shown that the intensity of the aurora can be expressed in terms of K_p but that the form of the expression is different for different auroral forms. After eliminating the effects of variation of K_p, the residual diurnal and annual variations of intensity are small and irregular.

Major (1954) has shown that pulsating and flaming auroras are frequently accompanied by complete ionospheric absorption of vertically directed radio signals. However the diurnal variations of frequency of occurrence of these two phenomena are markedly different in form.

The procedure now in use for visual observation of the aurora is to draw the lower border and note the form and intensity on a printed grid representing the sky divided into convenient intervals of azimuth and elevation. This observation is normally carried out at 15 minute intervals, azimuth and elevation of a number of points being determined with the aid of a simple 'open sights' theodolite designed for this purpose (Jacka and Ballantyne, 1955). Assuming a particular value for the height of the lower border of the aurora its geographical position can then be calculated.

PLATE 11.

ABOVE: PHYSICIST ADJUSTING AURORAL PHOTO-THEODOLITE.
BELOW: AURORAL DISPLAY.

Accurate determinations of position in space of the aurora have recently been started at Macquarie Island. From each of two stations on a measured baseline about 20 miles apart (one at Buckles Bay and one near Hurd Point) simultaneous photographs of the aurora are taken with photo-theodolites (Jacka and Ballantyne 1955). The azimuth and elevation of the optic axes of the photo-theodolite cameras are noted. The direction of any point in either photograph can then be computed from its co-ordinates in a grid in the focal plane of the lens (which produces a shadow on the photograph) and the known distortion characteristics of the lens. All the required information is then available to determine the latitude, longitude and height above sea level of any point in the aurora.

Communication between the Buckles Bay and Hurd Point auroral observatories is maintained by radio on a frequency of 320 Kc/sec. The Hurd Point observatory is normally operated by two men for 2 to 3 weeks at a time. The journey between Buckles Bay and Hurd Point is made on foot, usually in two days with an overnight stop at a small hut at Green Gorge.

Because of frequently overcast skies only about 30 pairs of photographs suitable for accurate position determination of the aurora have been obtained. Heights of the aurora calculated from these photographs are similar to those measured in the Northern Hemisphere. It is expected that several hundred pairs of photographs will be obtained in the next few years.

Measurement of the baseline between the two observatories is at present being checked by triangulation.

RADIOPHYSICS. A radiophysics observatory was installed at Macquarie Island in 1949 when an ionospheric recorder (p'f) supplied by the Ionospheric Prediction Service, Commonwealth Observatory, was set up and tested.

During 1950, and in following years, a continuous survey of the ionospheric parameters used in studies of the ionosphere was made. These parameters include virtual heights (at vertical incidence) of the E, F_1 and F_2 layers when they occur and of the sporadic E layers; critical frequencies or frequencies of penetration of these layers, and the maximum and blanketing frequencies of the sporadic E layer. From the records, transmission factors can be obtained. These allow the behaviour of radio waves incident at an angle to be inferred from the vertical incidence data.

Over a period of two minutes, the recorder covers the frequency range 1 - 16 Mc/s in four bands. A photographic record is obtained and the operation is repeated at ten-minute intervals.

The data covering the period 1950-54 has been published (Cohen 1952, Jeffries 1953, Major 1955, Little 1956, Firmstone 1955) and in the Ionospheric Prediction Series D publications of the Ionospheric Prediction Service of the Commonwealth Observatory.

During 1952 apparatus was assembled to detect thermal radiation from the ionosphere at radio frequencies over Macquarie Island following the method of J.L. Pawsey, L.L. McReady and F.F. Gardner (1951). Although it was hoped that the remoteness of Macquarie Island would eliminate much of the electrical interference encountered on the mainland, noise from the essential electrical supplies at the station made the observations unsuccessful.

From 1952 to 1954 a continuous recorder registered the intensity of the signal received from the Naval Station transmitter at Belconnen on a frequency of 44 Kc/s. It is expected that study of these records will give considerable information on the variation of absorption of the lower radio frequencies in the lower ionosphere.

Major (1954) published results of observations of ionospheric records in conjunction with auroral observations.

The results of observations of low virtual height have been published (Major, 1955).

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