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Marine ecosystems of Marion Island

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Introduction

The vertebrate fauna of Marion and Prince Edward islands, including fur seals, elephant seals and 29 species of seabirds, depends upon the productivity of the seas surrounding the islands. Even the plants are influenced by nutrient inputs from guano and other excretions derived originally from marine organisms. All life on the islands is influenced by, if not entirely dependent upon, the surrounding sea. Thus marine biological studies must form an important part of the overall study of the ecology of these islands.

Intensive research has been carried out on the birds, mammals and plants of the islands but little is yet known of the fauna and flora of the adjacent sea. The sophisticated research being carried out in the fields of ornithology, mammalogy and botany now needs to be supplemented by comparable work on marine biology.

Not only is marine biological work required to obtain a clearer understanding of the functioning of these island ecosystems, but it may also be of academic significance. The flora and fauna of remote oceanic islands have always been of great theoretical interest and value to biologists. Charles Darwin wrote that 'It is my most deliberate conviction that nothing would more aid natural history than careful collecting and investigating all the productions of the most isolated islands, especially those of the southern hemisphere' (Darwin, 1857, in letter to C. Lyell). Much of our knowledge of biogeography, natural selection, ecology and other aspects of biological science has come from studies of islands which serve us as natural laboratories.

Today international interest is being focused on the Southern Ocean because of its exploitable natural living resources such as krill, squid and fish. The possibility of obtaining vast quantities of protein food from the Southern Ocean has given research in this area a new significance. It has been recognised that if the biological resources of these seas are to be wisely managed and exploited on a sustainable yield basis, a clear knowledge of their bionomics is required. If the tragedy of the great whales is not to be repeated, biological research must be concentrated on the Southern Ocean before the level of krill exploitation becomes excessive. In view of this, the international research pro-

gramme BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) has been established (SCAR, 1977.)

We are particularly interested in the interrelationship of Marion and Prince Edward islands with the productivity of the surrounding ocean. The changes that have taken place in the populations of the great whales, and the changes that are now taking place in the numbers of fur seals and elephant seals, need to be related to their food resources. Little is known of what effect changes in the numbers of krill and other exploitable organisms might have on the numbers of their mammal and bird predators and how this might affect the stability of Antarctic ecosystems.

Early scientific exploration

The *Challenger* expedition visited Marion Island on 26 December 1873. (Thomson, 1877). Deep trawling, a single plankton haul and a visit of a few hours to the island enabled the collection of some very interesting material. (Brady 1883). The statement that Charles Darwin was with the *Challenger* party which visited the island (Marsh, 1948) is incorrect. He was an old man in poor health at that time, forty years after his classic voyage on the *Beagle*. The naturalist Moseley was in the shore party and made the first observations of the shores of the island (Moseley, 1892). He drew attention to the large brown alga *Durvillea*, (Dickie, 1877), but he did not collect organisms from the shore. The only marine collections were made from deep water from the ship (Linklater, 1972).

On 23 January 1939, the French *Bougainville* expedition landed on Marion Island. The only biologist present, Jeannel, an entomologist from the Paris Museum, collected marine organisms but these have never been studied and may have been lost.

Specimens were also obtained by dredging in the vicinity of Marion Island by the *Discovery II* in 1935, and some of this material and that from the *Challenger* received attention later in the *Challenger* and *Discovery* reports and in the monograph on the Marion and Prince Edward islands.

The 1965–66 Expedition

The South African biological and geological expedition of 1965–66 undertook general marine biological studies around the coasts of the islands. The marine biologist, Mr N.R. Fuller, published only a brief preliminary report on the littoral ecology of the Marion and Prince Edward islands (Fuller, 1967). Systematic accounts of some of the groups of marine organisms collected appeared in the monograph on the islands edited by Van Zinderen Bakker, Winterbottom and Dyer (1971).

Only three species of fish were recorded in the brief report by Andriashev (1971): *Notothenia coriiceps*, *Notothenia macrocephala* and *Harpagifer bispinis* subsp. *marionensis*. Bernasconi (1971) described four species of Asteroida and a new species of Ophiuroida, *Nullamphiura marionensis*. Pawson (1971) described the four species of Holothuroidea so far recorded from the intertidal zone of the islands. A survey was given by Gaillard (1971) of the 51 species of marine Mollusca which have been recorded from the littoral zone of the islands and the surrounding ocean. Only 10 of these species were collected in the littoral zone during the expedition. Of the remaining 41 species, 17 have been recorded only once, by the *Challenger* and *Discovery* expeditions, which indicates how little is known of the Mollusca of the Southern Ocean. Van Pletzen and Kok (1971), in their account of the oribatid mites of the islands, describe *Halozetes edwardensis* from Transvaal Cove Gully on Prince Edward Island (sic) where it was collected on Tunicata at the low tide mark. Smith and Sayers (1971), in their account of the Entomostraca, recorded the occurrence of *Tigriopus angulatus*, and Grindley (1971) described and illustrated this species from rock pools on the upper part of the sea shore. Two new species of asellote Isopoda from the shores of Marion Island were described by Cléret (1971). A collection of 25 species of Polychaeta from the intertidal zone of Marion Island was described by Day (1971). All of the species recorded are known from other southern islands. Dollfus (1971) described two species of marine Hirudinea from Marion Island. Eleven species of Hydrozoa were described by Millard (1971), including two new species, *Campanularia subantarctica* and *Symplectoscyphus marionensis*. Two species of Actinaria are recorded by Cutress (1971). Among the Diptera described by Seguy (1971), *Paractora dreuxi* subsp. *mirabilis* and *Apetenus litoralis* are kelp flies recorded from both Marion and Prince Edward islands.

In general, the species of marine organisms discovered appeared to be related to those found on other sub-Antarctic islands. They showed little relationship to the fauna and flora of South Africa or the other southern continents, except the southern tip of South America which extends into comparable latitudes.

Offshore studies

Mitchell-Innes (1967) published a paper on primary production studies in the South-West Indian Ocean 1961-63, which included observations made around Marion Island during the International Indian Ocean Expedition. An account of the microplankton collected during the same cruises of the *Africana II* was published by Nel (1968). She described the distribution of diatoms and other microplankton.

Littoral ecology

During 1972-73, De Villiers (1976) undertook a comprehensive study of the littoral ecology of Marion and Prince Edward islands. He recognised a number of different types of shores, such as cliffs and boulder beaches, and noted that all of the shores of the islands were exposed. The shores on the western sides of each island are extremely exposed with almost constant severe wave action. Even on the eastern shores, wave heights are up to four metres. Tidal range is exceptionally slight, being 71 cm at springs and 21 cm at neaps. The climate is characterized by gales, high humidity, abundant precipitation and relatively little fluctuation of temperature. Average sea temperatures are 4,0°– 6,1°C with a maximum recorded range of 2,1°– 8,0°C.

Intertidal zonation on sloping rocky surfaces consists of a *Verrucaria* (black lichen) zone in the supra-littoral, a *Porphyra* zone in the mid- and upper littoral, a *Durvillea* (kelp) zone in the lower littoral and a zone of delicate rhodophytes in the upper sub-littoral. Five transects on different types of shores revealed variations on the basic pattern of zonation.

The shallow sub-littoral is characterized by abundant corallines and other rhodophytes, as well as phaeophytes including *Desmarestia* and *Durvillea antarctica*. Aggregations of the limpet, *Nacella delesserti* (formerly *Patinigera*), occur in some places. Rock pools are infrequent and their fauna dependent largely on their salinity. A wide variety of invertebrates is associated with the kelps such as the lamellibranch *Gaimardia* on the offshore kelp *Macrocystis pyrifera*.

The biographical affinities of the fauna and flora lie largely within the sub-Antarctic and, to a lesser degree, with the Antarctic. The closest relationships are with the Crozet and Kerguelen groups of islands. The young age of the islands and relatively recent glacial and volcanic activity are probably the causes of the low species diversity and low endemicity which characterizes the littoral fauna and flora of the islands.

During the course of the littoral investigations, many observations on feeding behaviour could be made and a food web diagram (De Villiers, 1976) was compiled. Certain links could not be confirmed and some links clearly related to offshore fauna. For example, the fish *Notothenia corriiceps* at times had their stomachs distended by great quantities of calanoid copepods, chaetognaths and hyperiid amphipods. Thus it became clear that even the littoral fauna was linked to offshore productivity, as were the marine mammals and seabirds. More information was needed on the almost unknown fauna and flora of the seas surrounding the islands.

A few recent papers have appeared on the basis of material collected by De Villiers during 1972–73. These include a new leech (Hirudinea) described by Sawyer (1972) from a notothenid fish, oribatid mites (Engelbrecht, 1974), Echinodermata (Rowe & Clarke, 1975) and Isopoda (Kensley, 1975).

Investigations with the *Marion Dufresne*

In 1976 there was an opportunity to carry out marine biological studies in the seas around the islands. Through the co-operation of TAAF and the CSIR, the French research and supply ship *Marion Dufresne* was used to carry out successful marine biological and oceanographic investigations around Marion and Prince Edward islands during March 1976. The work included an intensive study of the benthic fauna and flora, the interesting nature of which was first revealed by the *Challenger* in 1873. Hydrology, water chemistry, primary productivity, phyto- and nannoplankton, zooplankton, meiobenthos and fishes all received study.

The South African contingent on cruise MD–08 of the *Marion Dufresne* included the author and Mr P. Frost of the University of Cape Town and Mr T. Wooldridge of the University of Port Elizabeth. The chief scientist for the investigations around Marion and Prince Edward islands was Dr P. Arnaud. Professor S.Z. El-Sayed was in charge of primary productivity and phytoplankton investigations. The total complement of scientists and scientific technicians was 24, of whom 15 were from France, 3 from South Africa, 3 from the United States, 1 Portuguese, 1 Canadian and 1 from Reunion.

Scientific operations were carried on for 24 hours a day and duties were shared among the scientific staff who were divided into 3 watches each working 4 hours on and 8 hours off. During periods of intensive work when record-keeping, photography of specimens and other activities added to the work load, several periods of working more than 20 hours at a stretch resulted.

The *Marion Dufresne* sailed from Reunion on 8 March 1976. After working in the Indian Ocean and at the Crozet islands, Marion Island was reached on 24 March. Stations 10-36 were worked from 24–29 March 1976. Returning via the Crozet islands and Kerguelen, Reunion was reached on 8 April 1976. (Frost, Grindley & Woolridge, 1976).

The gear and methods employed during the cruise included reversing bottles for water samples, siffican bathythermographs (XBT), Nyskin bottles for phytoplankton and nannoplankton standing crop, nutrient chemistry, A.T.P. fluorometry, and Secchi disk for transparency. Primary production measurements were carried out *in situ* with flasks on a series of frames. A 35 μm mesh phytoplankton net was used to determine phytoplankton species composition. A WPII zooplankton net hauled vertically from a depth of 300 m to the surface was used for zooplankton. An Isaacs–Kidd midwater trawl and a large pelagic trawl were used for bathypelagic fauna. A 5 m beam trawl, a Charcot dredge, a Reineck corer (for meiofauna), an Okean bucket grab, shrimp traps and *Lithodes* traps were employed for benthic fauna. Satellite navigation was used throughout the voyage.

The following stations were worked around Marion and Prince Edward islands:

Station 10	46°52,8′S	37°52,5′E
Station 11	46°52,2′S	37°53,9′E
Station 12	46°55,7′S	37°54,1′E
Station 13	46°57,2′S	37°57,6′E
Station 14	47°01,2′S	37°47,4′E
Station 15	46°57,7′S	38°00,0′E
Station 16	46°50,2′S	37°59,1′E
Station 17	46°52,5′S	37°53,5′E
Station 18	46°49,6′S	37°56,3′E
Station 19	46°45,6′S	38°02,9′E
Station 20	46°47,2′S	38°03,5′E
Station 21	46°53,3′S	37°52,8′E
Station 22	46°52,4′S	37°51,9′E
Station 23	46°57,9′S	38°00,4′E
Station 24	46°52,8′S	37°52,5′E
Station 25	46°44,3′S	37°56,6′E
Station 26	46°50,6′S	38°00,6′E
Station 27	46°45,7′S	37°53,8′E
Station 28	46°42,6′S	37°57,6′E
Station 29	46°51,0′S	37°58,0′E
Station 30	46°47,7′S	38°00,4′E
Station 31	46°59,6′S	37°46,0′E
Station 32	46°59,1′S	37°47,2′E
Station 33	46°52,2′S	37°51,5′E
Station 34	46°50,2′S	37°57,2′E
Station 35	46°39,7′S	38°00,4′E
Station 36	46°40,7′S	38°06,7′E

These stations ranged in depth from 30–600 m and lay mainly to the east of Marion and Prince Edward islands.

The benthic fauna and flora found during these investigations included a wide variety of organisms. Many species of algae were obtained in dredgings and other bottom samples, and some species of rhodophytes were found down to more than 50 m. Among the protozoa some large Foraminifera were obtained. Many species of Porifera were present and sponges were particularly abundant in deep water beyond the shelf. One large siliceous sponge was the size and shape of a rugby ball. A great diversity of Coelenterata was obtained. These included species of Hydroida, Alcyonacea, Gorgonacea, Pennatulacea, Actiniaria, Madreporaria and Antipatharia. More than one species of Nemertean was obtained, many species of Polychaeta and more than one species of Sipunculoidea. The Crustacea included Tanaidacea, Isopoda, Amphipoda and Decapoda. The latter included the large king crab, *Lithodes murrayi*, obtained in deep water off Prince Edward Island. The Arachnida included several species of Pycnogonida. Mollusca included Amphineura, Gastropoda, Scaphopoda, Lamellibranchiata and Cephalopoda. At least two species of Brachiopoda were common. A

diversity of species of Bryozoa was found on the shelf. Echinodermata were also particularly abundant on the shelf between 100 and 200 m. They included Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea and Crinoidea. The Protochordata included several species of Ascidiacea.

The material collected is now being studied by taxonomists in several different countries and it will be some time before full identifications are available. Reference specimens and paratypes of any new species will be deposited in South Africa. The procedure is that each group of specimens is sent to an appropriate specialist who, as soon as his taxonomic studies are completed, will send a representative series to South Africa.

Plankton samples from the vicinity of Marion and Prince Edward islands revealed the presence of the following groups: Copepoda, Euphausiacea, including juvenile stages, Ostracoda, polychaete larvae, copepod nauplius larvae, Oikopleura, Radiolaria, Chaetognatha, gastropod larvae, lamellibranch larvae, medusae, eggs, Foraminifera, algal detritus, diatoms and Dinoflagellata. The Copepoda included the Antarctic species *Calanus propinquus*, *Calanoides acutus*, *Rhincalanus gigas* and *Oithona frigida*. Some samples included large amounts of phytoplankton including *Chaetoceros flexuosus*, *Chaetoceros neglectus*, *Rhizosolenia hebetata*, *Rhizosolenia alata*, *Thalassiothrix*, *Ceratium*, *Nitzchia*, *Rhizosolenia hebetata* var. *semispina*, *Rhizosolenia alata* var. *indica* and *Rhizosolenia curvata*.

Some preliminary general conclusions are possible on the basis of the information available so far. There would appear to be rich planktonic and benthic life around Marion and Prince Edward islands. The remarkable richness of the plankton, particularly inshore in the lee of Marion Island, would seem to indicate an area of upwelling there. The bottom is varied with many rocky areas but much of the shelf lying between 50 m and about 200 m is black muddy sand covered in bryozoan fragments. At depths less than 50 m, algae, particularly reds, are common and ophiuroids and amphipods are abundant. The shelf area is dominated by Bryozoa, Mollusca and Echinodermata. A large species of octopus is common in the shelf area. The diversity of fish (10 species) and apparently the diversity of other groups also, appears to be lower than that recorded from around the islands of Crozet and Kerguelen. This may perhaps be related to the shorter geological history of the Prince Edward islands. In deep water down to 600 m, the faunal diversity appears to increase and the dominant groups are Coelenterata and Porifera. Many interesting species occurred in this deep area including the king crab, *Lithodes murrayi*.

The peculiar species composition of the zooplankton community, which is Antarctic rather than sub-Antarctic in character, is very interesting. It is suggested that this unexpected species composition probably results from the upwelling of water from deeper levels in the lee of the islands. Typical sub-Antarctic species, such as *Calanus simillimus* were absent from our catches, while Antarctic species, such as *Calanus propinquus*, *Calanoides acutus* and *Oithona frigida*, characterized the samples. The nature of the zooplankton and some discussion of its composition is given by Grindley & Lane (1978).

Future research

Future marine biological research on Marion Island must nclude more quantitative studies. We need to build up a body of quantitative data on the marine fauna and flora, including numbers, biomasses and, where possible, productivity. In order to relate the marine biological data to the studies of bioenergetics and nutrient cycling, information on nutrient contents of organisms and relevant bioenergetic data will be required. Without such information it will not be possible to determine the contributions of marine components. Organisms that are abundant or are important in the diets of other organisms, including seals and seabirds, must receive particular attention. Something of the life histories and general biology of the dominant intertidal organisms must be established. Aspects of intertidal ecology that are unique to these island systems are particularly deserving of study. These include the role of the excreta of birds in fertilizing or smothering intertidal life and the physical impact of the trampling of penguins and the wallowing of elephant seals. The extent of survival of tidepool biota during the coldest months in relation to snow cover requires investigation. A number of specific problems relating to the biology of individual intertidal organisms deserve attention as indicated by Grindley (1974).

A knowledge of the pelagic organisms of the ocean surrounding Marion and Prince Edward islands is basic to an understanding of the ecology of the whole island ecosystem. The abundance and productivity of the plankton and other pelagic organisms and their availability to predatory seals and seabirds needs to be established. Amongst the important food organisms for birds and mammals are pelagic fish and invertebrates such as squids, shrimps, euphausiids and other macroplankton. Quantitative sampling of such organisms is difficult but it is necessary if a proper understanding of these island ecosystems is to be achieved.

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The distribution and abundance of southern elephant seals *Mirounga leonina* (Linn.) on the Prince Edward islands

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On Marion (46°54′S, 37°45′E) and Prince Edward (46°38′S, 37°57′E) Islands, southern elephant seals (M. leonina) *occurred mainly on the leeward east and north coasts between 1973 and 1977. During the spring breeding haul-out, adults and pups remained on beaches scattered along these coasts. During the summer and autumn moult haul-out, adult and subadults arrived on the beaches and then moved inland into moulting areas, while moulting yearlings remained on the beaches. Moulting areas also occurred mainly on the leeward coasts, though their distribution differed slightly to that of the breeding beaches. The distribution of elephant seals during the breeding and moulting phases of the summer haul-out season therefore differed both vertically and horizontally. Pup counts totalled 1 115 and 386 on Marion and Prince Edward Islands respectively, indicating a 69,5 per cent decline in population size on Marion Island between 1951 and 1976. Competition with man for fish in winter feeding grounds, predation by killer whales at the islands and competition for local food resources with fur seals, are considered to have led to the population decline.*

Introduction

The southern elephant seals (*Mirounga leonina*) which occur at Marion Island (46°54′S, 37°45′E) were first investigated by Rand (1955, 1962) in the austral summer of 1951/52. La Grange (1962) also obtained some data on numbers and annual haul-out cycle. No data on southern elephant seals on Prince Edward Island (46°38′S, 37°57′E) have been published, although Grindley (*in litt.*) recorded the abundance and distribution of moulting and moulted elephant seals on the island in April 1973. In 1973 a study on the southern elephant seals was initiated under the auspices of the Mammal Research Institute. The data presented here were obtained between August 1973 and December 1977, and formed part