AN ACCOUNT OF THE PRESENT KNOWLEDGE AND USE of THE GREAT BARRIER REEF from LIZARD ISLAND TO BOWEN

with recommendations for its conservation and management

A report to the GBRMPA

by

THE GREAT BARRIER REEF COMMITTEE
A society promoting scientific study of the Great Barrier Reef

February, 1979

THE GREAT BARRIER REEF, LIZARD ISLAND - BOWEN

PRESENT KNOWLEDGE AND USE

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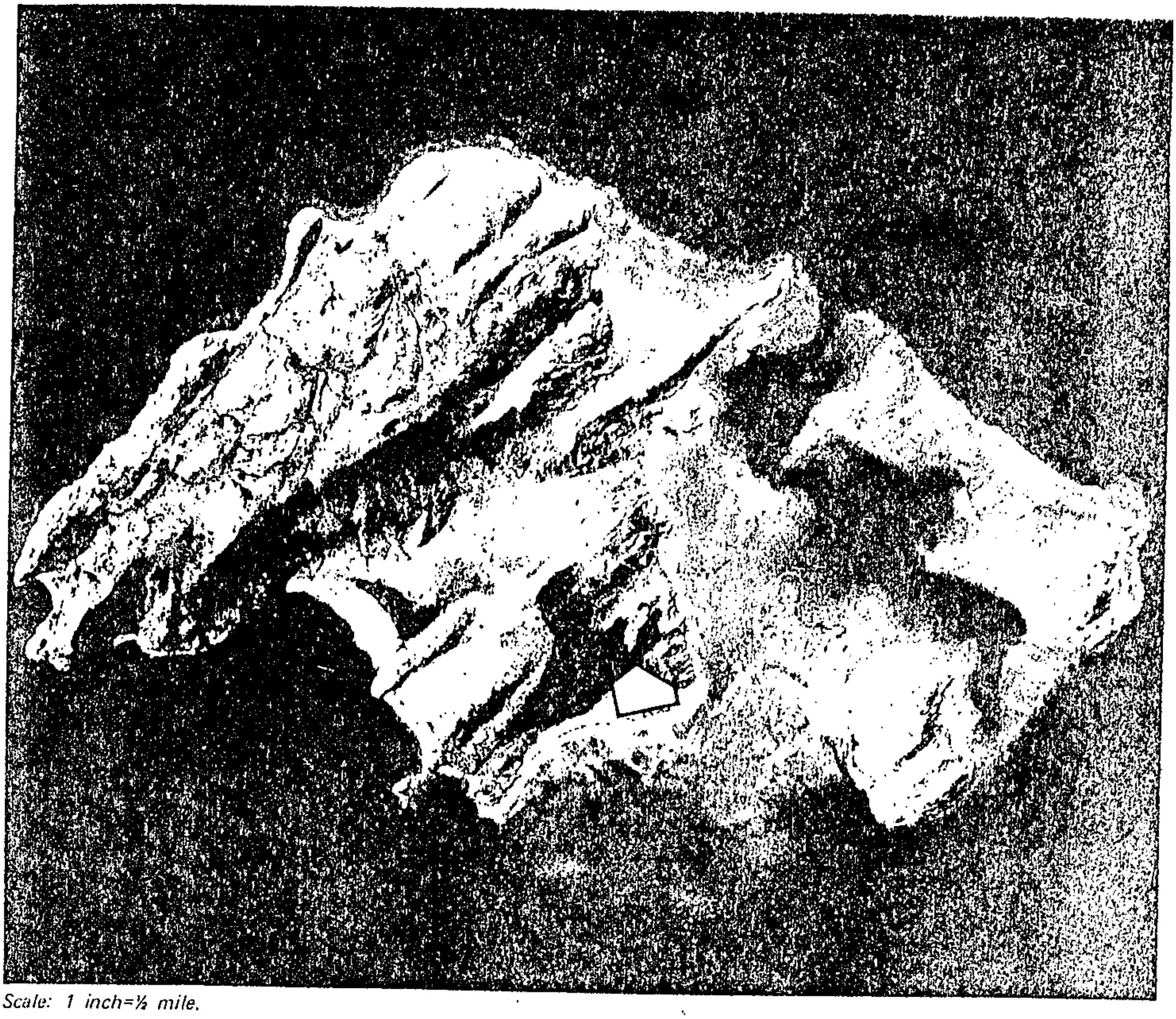

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Lizard Island from the air. The location of the Lizard Island Research Station (operated by a Committee for the Trustees of the Australian Museum, Sydney) is indicated.

PREFACE

The history of the Great Barrier Reef cannot be isolated from the history of the mainland coast and the early contacts with the reef were coincidental on exploration and development of Queensland. For instance, Captain Cook's principal concern was to navigate up the eastern coast of Australia and to establish English sovereignty over it; Flinders' survey and the others that followed were prompted by the pressures to develop the coast line and to identify navigable channels that would facilitate this development. From early 1800's timber was being exported and by 1870 was being cut along most of the rivers of north Queensland and was being exported through the available ports. The successive establishment of Bowen, Townsville and Cardwell to serve the requirements of the cattle and sheep industries; Cooktown, Cairns, and Port Douglas serving the flourishing Gold industry; and finally the "sugar" towns of Ayr, Ingham and Halifax, all resulted in increased shipping in these waters and survey of mainland coast and shipping channels. The reefs and the islands were not otherwise associated directly with the mainland development and were affected by it only to the extent that hinterland deforestation and development affected the runoff from the continent, and, to some extent the fish resources of the area were exploited. However, the latter exploitation was not significant beyond the immediate areas of settlement, and there is no evidence that this resource was over-exploited overall. Beche de mer, coral, *Trochus* and pearl shell industries all did directly affect reefal populations but were early subject to the federal Pearl Oyster Fisheries Act 1952, and the Federal and State Fisheries Acts. Exploitation of turtles by indigenous populations was in the Torres Strait area and did not extend south to the regions under consideration.

A growing tourist industry, especially from the early 1950's also affected particular and rather restricted parts of the area.

Up until this time (1950 - 1960) scientists and a restricted tourist industry maintained a continuing interest in the area. (The Great Barrier Reef Committee, a society promoting scientific study of the Great Barrier Reef, was established in 1922). The interest of a wider section of the general public was mobilised as part of the active conservation movement of the 1960-1970 decade. This coincided with increased urban populations and industrialisation of the east coast of Australia, and associated pressures for exploitation of mineral resources in addition to the use of the area for tourism, and for its renewable biological resources.

This attention, both for its conservation and its exploitation, together with an upsurge of interest in the tropical marine environment around the world has exposed the great gaps in understanding of the coral reef ecosystem in general and of the Great Barrier Reef in particular. At this time the greater part of the reefs of the Great Barrier Reef are unexplored, their hydrography neglected (except where shipping channels have imposed mandatory surveys); the inventory of their diverse biological assemblages incomplete, and the dynamics of their biological system not understood.

The following reports on the history, geology, biology and exploitation of the reefal areas (i) off Cairns (Lizard - Innisfail), (ii) off Townsville (Innisfail - Bowen), (iii) the Swain Reef complex, have been prepared by the G.B.R.C., for the Great Barrier Reef Marine Park Authority as required by a consultancy agreement, 1978. In preparing the reports an attempt has been made to review the information that is available on the respective areas set out above, to identify impacts that have resulted from uses, and to recommend on management criteria and neglected research areas where investigations could have a direct relevance to management.

ACKNOWLEDGEMENTS

We are grateful to many individuals who have helped in the compilation of these reports. In particular the following authors have supplied us with papers that represent an up-to-date assessment of knowledge in the respective fields:

S. Bandaranaike, James Cook University of North Queensland (fisheries); J. Bunt, Australian Institute of Marine Science (coastal mangroves); H. Chesterman, Australian Lighthouse Service (navigation); P. Flood, University of Queensland (sediments); B. Goldman, Lizard Island Research Station (scientific history, tourism and recreation); J. Hampton, James Cook University of North Queensland (fisheries); N. Harvey, James Cook University of North Queensland (naming of coastal and reefal features, geomorphology); H. Heatwole, University of New England (biota of islands); D. Hopley, James Cook University of North Queensland (geomorphology); P. Isdale, James Cook University of North Queensland (naming of coastal and reefal features); J. Kikkawa, University of Queensland (birds); B. Kuchler, James Cook University of North Queensland (effects of tourism on Green Island); C. Limpus, Queensland National Parks and Wildlife Service (turtles); R. Pearson, Queensland Fisheries Service (coral cover in the Swain Reefs); P. Saenger, SEQEB (algae and other vegetation in the Swain Reefs); H. Silver, University of Queensland (beche-de-mer fishery); C. Wallace, Queensland Museum (Low Isles).

R. Olafson (Australian Institute of Marine Science); A. Chase (Griffith University), N. Haysom (Qld. Fisheries Service), B. Whiteman (Qld. Dept. Harbours and Marine) have also provided us with information that is included here. R. Martin has correlated much of the material and we are grateful for his conscientious attention to the development of the reports.

The field notes on Lizard Island and Low Isles contained in the appendices were originally prepared for the Second International Symposium on Coral Reefs (1973). They are included here for those who need specific information on those important areas. They are the work of I. Bennett (invertebrates, Low Isles); A.B. Cribb (sea grasses, algae and vascular plants, Low Isles); R.F. McLean (geology, Low Isles and Lizard Island); J. Kikkawa (birds). Species lists for terrestrial plants, vertebrates and invertebrates of several of the islands between Bowen and Lizard Island, prepared by H. Heatwole are also included.

We are aware that there are many areas that are not covered, and that for some subjects there is a greater amount of detail included than there is for others that are no less important. The detailed papers that are presented here are those on subjects for which there is no easily accessible treatment available. Other subjects are treated fully elsewhere and there are also many areas where a detailed treatment of the subject could not be undertaken in the time that was available. We have included an extensive reference list in order that sources may be readily consulted. The reports have been assembled and edited by Dr. P. Mather (Queensland Museum). The Council of the Great Barrier Reef Committee has monitored the progress of the report and has adopted it and its recommendations.

INTRODUCTION

CRITERIA FOR MANAGEMENT

The recommendations that are set out below are based on:

(1) An assessment of the factors that are relevant to management; and

(2) The currently available information on these factors.

We wish to stress that, at this stage, there is such ignorance of the dynamics of coral reef ecosystems in general, and of the Great Barrier Reef in particular, in most cases it is not possible to make any reliable predictions regarding the likely effects of certain uses; nor is it possible to assess the long, or even short-term significance of much of the information that is available to us.

Further, while supra-tidal areas are easily surveyed and mapped, and changes in their biota are broadly monitored, most of the subtidal areas are not known. Subtidally the shapes of reefs, the undercuts, the channels and the angle of the reef slope are not known, changes in biota from time to time and from place to place pass unrecorded and the work that would identify their significance generally remains to be done.

At this stage there are no indicators documented which can be used to identify ocean currents from which reef waters are derived and in which the larval organisms from each reef are circulated. So far the provenance of the nutrients on which the whole energetics of the Reef are based and the pattern of their circulation through the ecosystem are not known.

Areas where communities contain abnormally high components of one organism or another (e.g. coralline algae or soft coral) are not identified; nor could we judge their significance.

The geographic range and the habitat requirements of most of the species are not known and the populations that are important genetically (because of the particular selective pressures to which they have been subjected) are not known.

Nevertheless, recommendations based on what is known are valid. In the present circumstances it is essential for the conservation of the reefs that management suggested here be put into practice.

At present, evidence suggests that the separate reefs of the Great Barrier Reef are biologically connected; and that they are part of the greater Indo-Pacific coral reef system. We are not aware of great gaps in the distribution of any species although the range of many is limited toward the south. Although the actual pattern of recruitment, if there is any pattern, is not known there appears to be gene flow (probably through the recruitment of juveniles) from reef to reef and consequently each single reef is an integral part of the whole system.

Where a reef represents the limits of a range of a species that reef or that habitat is important. These populations, subjected to stringent selective pressures, can confer important genetic vigour to the species over its whole range.

There is also quite firm evidence to show that changes in sediment content of the waters and changes in the sedimentation pattern over the reefs are critical to the pattern of their growth. It is also likely that pollutants of any kind will affect the composition of the biota and in turn, the composition of the sediments, the facies of the reef and the cycling of its energy. The uses of land on the mainland and their effect on the runoff from the continent are therefore of direct concern to those charged with the management of the reef. In this respect also, deposit feeders and filter feeders, boring and scraping organisms and organisms that bind the sediments are of paramount importance.

The fact that the large climax organisms and some smaller carnivors are critical to the energy cycle of the reefs is known. Consequently fishing and other activities that affect populations of these organisms directly or by alienating their habitats or their prey organisms must be stringently controlled.

We know that the past history of the reefs will affect their subsequent development; and that changes caused by mechanical means or by erosion will interfere with their subsequent growth and development. The growth forms of the reef - building corals respond to light and characteristics of current flow. Changes in either of these conditions will also affect the growth and evolution of the reef. The building of wharf and harbour facilities, dredging of channels, building of paths, should always be undertaken only after the most exhaustive assessment of their likely affects on coral growth.

We know that there are certain organisms that comprise the structure components of the reefs such as the corals themselves; and we know that there are binding organisms such as soft corals and algae whose chemistry is an integral part of the growth process of each reef. These organisms are all vulnerable to chemical and biological interference and special account needs to be taken of their actual needs.

It is known that there are seasonal and other changes due to wave action, currents, cyclones, freshwater run-off, and extremely low tides and that these will affect the biota. Resultant mortality, changes in spawning behaviour, or periodicity and in recruitment will all affect the succession of colonising organisms and the composition of communities. It is essential that provisions be made to monitor these changes and to ensure that further interference does not inhibit the natural regeneration of the communities. Such monitoring will also contribute to the body of data that will, in due course, enable us to understand the dynamics of the system.

It is known that run-off from the land will affect the reef and it is also known that it is vulnerable to the insecticides, fertilisers as well as the sediments that are contained in their run-off. This matter must concern the managers of the reef.

It is also known that the transfer of nutrients from the sea to the land is essential to the evolution and stabilization of coral cays. Sea birds are therefore of prime importance and the conservation of their nesting sites and of their food organisms is mandatory. In fact the whole fabric of terrestrial communities is of concern in managing these areas. The fact that much of this terrestrial biota is derived from the mainland should not be overlooked and it should also be remembered that the role of any single component is often vastly amplified in the context of a coral cay. For instance, the few lizard species that reach the cays may have a profound effect on the mainland-derived insect species that become established whenever suitable habitat and food species are also available. The habitats occupied by lizards (e.g. under logs) should be preserved. The introduction of mainland species at a rate and in numbers that would preclude their gradual accommodation in the island ecosystem could have similar affects on the dynamics of the coral cay as the direct removal of one of the components of the ecosystem, alienation of one or another of the available habitats, and alteration in the behaviour of any of the species (e.g. changes in food sources due to garbage storing and disposal, burning of wood or hand feeding)*.

CONCLUSION

We wish to stress that the task of managing a reef, including the preparation of zoning plans, can be compared with the management of a large tract of variable land with different, largely inpenetrable vegetation types, no road access, permanently covered in cloud, where knowledge rests on a low scatter of very brief helicopter drops.

For this, and for other reasons that are set out above, it is essential that any management plan be flexible and over protective rather than under-protective.

It is essential to good management that the body of knowledge on coral reefs that is accumulating be included in a resource management programme. However (1) management techniques cannot be based on a concept of separate systems; (2) the dynamic elements of temporal and spatial variations should be given special attention in a coral cay environment. It is critical to understand these components if management is seeking solutions that enhance long term stability of the biota and of the islands and reefs.

Funds should be made available for the research that would remove the restraints on good management that are presently imposed by the many areas of ignorance and doubt concerning the dynamics of the ecosystem.

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* See "Conservation and Use of the Bunker and Capricorn Groups of Islands and Reefs" The Great Barrier Reef Committee 1977.

DISCOVERY AND EARLY SETTLEMENT

It is believed that aborigines were in the Cape York Peninsula from at least 14,000 years BP (*fide* Specht unpublished) and probably inhabited most coastal regions of north east Queensland at that time. However the Australian continent was certainly well colonized by 26,000 BP (Bowler et al. 1972) and strong arguments can be advanced in support of a similar date for the colonization of the Great Barrier Reef region (Beaton, 197?). The aborigines were apparently not a great sea-going people but did have the capacity to travel regularly to the nearshore reefs and islands. Joseph Banks reported the presence of Aboriginal shelters on Lizard Island in 1770 and Huxley met Aborigines there in 1852. Middens have been recorded on Lizard, Nymph and the Turtle Islands (Beaton, 197?). As late as 1873 the natives in the Cairns area possessed large outrigger canoes up to 40 feet long, capable of carrying 20 people. It is, however, unlikely that the coastal Aborigines were regular visitors to the outer Barrier Reefs even in the northern region where these are less than 40 km offshore.

The evidence of early European and Asian contacts with Australia are based on the appearance in maps and charts of a land mass situated in the region of the Australian continent having some resemblance to the Australia coast. It is evidence such as this that suggests that ancient Egyptians, Phoenicians, Greeks, and after them the Chinese and Japanese knew of the Australian continent and very likely the north eastern coast of that continent (McIntyre, 1977, Whitehouse, 1977). Chinese maps of the 17th Century and earlier show the north and east coast of Australia with remarkable accuracy. A recently discovered Chinese map of 1602 (ascribed to the Jesuit Father Matteo Ricci) shows identifiable continental features all down the eastern Queensland coast from Cape Flattery to Sarina (E. Whitehouse, pers. comm.). Malay beche-demer fishermen are believed to have been exploiting these waters for about 1,000 years (McIntyre *loc. cit.*).

Evidence of Portuguese exploration of the whole of the east coast of Australia in 1522 by Cristoval de Mendonca, with a fleet of 3 Caravels is now well documented. This is not surprising in view of the navigational skill of the Portuguese who had been exploring in these waters from 1512 and had colonial settlements in Timor and other places in the East Indies from about that time. "They had the ships, the navigators and the expertise to sail the 20,000 miles from Lisbon to Timor and back again, and therefore were quite capable of sailing the extra 285 miles to the Australian coast" (McIntyre, 1977).

Therefore, although the Spaniard de Torres is given the credit for being the first through the Strait that bears his name (1606) and Captain James Cook is generally recognised as the first to navigate in waters of the east coast of Australia (1770), Portuguese mariners had sailed in these waters before them and had explored the north east coast of Australia, which they had named Coste Dangereuse. What is now Repulse Bay is on their charts as Bay Perdue and there is a harbour in the vicinity of the mouth of the Endeavour River where Cook beached his vessel some 250 years later.

The Dutch, successors to the Portuguese in the commerce of the East Indies and prominent in charting the west and north coasts of Australia, did not penetrate Torres Strait from the west although both Cartenz (1623) and Tasman (1644) had tried to find an opening there. There was a probably French contact in 1768 when Bougainville, sailing west from Tahiti saw "an endless line of shoals and rocks on which the sea thundered with great violence" (Beaglehole, *fide* Whitehouse, 1977). Bougainville's log suggests that he was only 15 miles off the outer edge of the Great Barrier Reef and 50 mls S-E of Cooktown when he turned away.

Captain Cook sailed up inside the Great Barrier Reef for some 750 miles before running on a reef near Cooktown. After repairs to his ship in the Endeavour River, he sailed north as far as Lizard Island before clearing the reefs and making the freedom (albeit temporary) of the Coral Sea. Cook then re-entered the reef further north and at Possession Island established British Sovereignty over eastern Australia.

With the establishment of New South Wales as a penal colony in 1788, exploration of the region to the north was inevitable, thus creating a need for surveys of these waters. This need was emphasised with the subsequent development of agriculture in the colony, when trade routes were established between Sydney and Asia (Bolton, 1972). Early shipping also went from Sydney via the southern route (the Bight) to England, the round trip taking 8 months. An alternative, shorter route around northern Australia was clearly desired.

At the end of the 1700's, however, the only charts available for the northern coasts were those made by Cook and as a consequence the Barrier Reefs and Torres Strait still represented formidable obstacles to navigation.

After the mutiny on the 'Bounty' in 1789, Bligh sailed his ship's longboat into the northern reef waters landing at Restoration Island, then north and through the Torres Straits before heading west to Timor. About this time James Martin and Mary Briant sailed an open boat up the Queensland coast, into the Gulf and then also headed for Timor.

The first survey of reef waters was made by Matthew Flinders in the 'Investigator' during his circumnavigation of Australia in 1802-3. Flinders sailed north up the inside of the reef to point at about lat. 18°50'S, passed eastward through the reefs and continued his voyage up the outside to just north of Raine Island. Here he re-entered reef waters through what is now called Pandora Passage and sailed west to the Torres Strait.

Some years later more detailed surveys were undertaken by Jefferys on the brig 'Kangaroo' (1815) and by Philip King on the 'Mermaid' (1815) and later on the 'Bathurst' (1822); both these men sailed up the inside of the reef to Torres Strait. In 1839 and 1841 they were followed by J.C. Wickham and John Lort Stokes on the 'Beagle'.

In 1824 a second penal settlement was established on the banks of the Brisbane River. Brisbane became a free city in 1842 and thus port facilities became available to settlers, resulting in the spread of the rural industry even further to the north, creating demands for further port facilities, increasing the shipping operating in these waters and emphasising the needs for surveys to determine navigable routes. At the time of the separation of Queensland and N.S.W. in 1859 two ports had been established on the coast north of Brisbane; Port Curtis (est. 1847) and Rockhampton (est. 1858).

Although early surveys demonstrated the navigability of the 'inner' route', the main disadvantage suffered by ships using this passage was the necessity to anchor at night. Masters plying the trade routes and not wishing to do this took the 'outer route', standing off to the east of the Barrier Reefs before passing westward through one of the narrow northern entrances, usually at Raine Island, and sailing for Torres Strait. The disadvantages of this course were the not inconsiderable dangers presented by the largely uncharted Coral Sea reefs and the problems of locating the unmarked northern entrances after several days out of sight of land. From 1800 to 1850 the outer route claimed over a dozen vessels (Bateson, 1972) including 'Porpoise' and 'Cato' (1803), and the 'Stirling Castle' (1836).

In 1841 the Admiralty decided that a survey would be undertaken to accurately fix the position of the northern entrances and in 1842 HMS 'Fly', under the command of Capt. F.P. Blackwood, and the 'Bramble' under Lieut. Charles Yule began their historic survey of reef waters. During three years under sail, Blackwood surveyed over 1,000 miles of the reef, including the Capricorn Group, the Swain Reefs, the outer edge from lat. 16°40'S to lat. 19°20'S, most of the navigable entrances and established the first beacon on Raine Island. Many of Blackwood's soundings, particularly those in the Swain Reefs and along the outer edge of the Barrier Reefs, are still incorporated in modern charts.

Blackwood was followed in 1848 by Owen Stanley in the 'Rattlesnake' who surveyed the inner waters from Rockingham Bay to Jarvis Island thus delineating the dangerous closed section of the inner routes, and in 1855 Jeffries sailed the first commercial ship through the inner route. In 1859 the first edition of Vol. II of the 'Australian Director', compiled by Commander Charles Yule, was published and contained the first sailing directions for the Australian east coast. The second edition, published in 1864, contained for the first time details of the surveys of the Coral Sea made by Capt. H.M. Denham in the 'Herald' between 1853 and 1861.

In 1860, under pressure from an expanding rural industry in the Burdekin region, the Queensland Government despatched J.W. Smith in the 'Spitfire' to examine Port Denison and to locate the mouth of the Burdekin River. The town of Bowen was established in 1863 as the main port for the region. Two years later J.M. Black set up a boiling down works on the banks of the Ross River. Townsville, as Black named the settlement, expanded rapidly and by the end of 1865 wool was shipped through the port. By 1868 the new town had usurped most of the trade and inhabitants of Cardwell which was established a year earlier (Bolton, 1972).

In 1860 the only regular service on the northern coast was that provided by the Australian Steam Navigation Co. (ASN) which ran a fortnightly service between Brisbane and Rockhampton. With the opening of northern ports during the late 1860's coastal trade grew rapidly and ASN established a virtual monopoly on northern services. The reliability of ASN's services apparently left much to be desired and many of the traders and shopkeepers in Bowen and Cardwell relied heavily on private schooners and small craft (Bolton, 1972). Foreign trade increased at the same time, however, and the volume of commercial shipping grew, with 34 vessels using the inner passage between 1870 and 1873. Passenger ships began to use the route in 1874 and at that time the northern ports were connected to Brisbane by a regular service.

In 1873, when James Mulligan returned from the Palmer River with 102 oz. gold, the now famous north Queensland gold rush began. The Government appointed G.E. Dalrymple to explore all ports and inlets between Cardwell (which was then the most northern Port in Queensland) and the Endeavour River, to find a suitable port for access to the new goldfields. His party explored the Moresby, Mulgrave, Port Douglas, Mossman, Daintree and Bloomfield Rivers before reaching the Endeavour, in October of that year. The Government, however, had become impatient and 'Leichhardt' arrived from Brisbane with an official party and the first batch of diggers for the goldfields. Cooktown was officially declared a port and it grew so rapidly that within a few years it was second only to Brisbane in its size and volume of trade (Holthouse, 1973). In the three years following its opening an estimated 35,000 men passed through the port on the way to the Palmer Goldfield (Meston, 1895).

With the discovery of gold, the expansion of the coastal trade attracted other companies to the northern run, including the Howard Smith Steamship Co. and later the Queensland Steamship Co., and something of a price-cutting war developed.

The search for gold continued and in 1876 it was found on the Hodgkinson, a tributary of the Mitchell River. The need for easy access to this isolated field led to the establishment of ports at Cairns and Port Douglas. The Port of Cairns was officially declared open in November, 1876 (Anon, 1926), the port and Trinity Inlet having been explored by W. Ingham in the 'Louisa' earlier that year. Development, however, was more concentrated in Smithfield, on the banks of the Barron River and some 20 miles closer to the new Hodgkinson goldfields. But Smithfield suffered heavily when the Barron flooded each wet season. After a few years it was abandoned and development moved further north to Port Douglas, which was first established 1877, and which grew so rapidly that by 1881 it was twice the size of Cairns. Further development of Port Douglas languished, however, as the soil was not ideal for sugar which was increasingly being grown at many centres. Further, speculators had tied up much of the land (Bolton, 1972). Ultimately, Cairns evolved as the dominant port and major city serving far north Queensland.

The sugar industry benefited greatly from the regular shipping services from these developing ports and 1883 saw the establishment of 'sugar towns' at Ayr, Ingham and Halifax.

Channel marking of the inner shipping route began in 1872 with the first of 36 markers being set up 25 miles south of Cooktown. Many of the old coasting captains also adopted the practice of lighting fires on the islands to serve as directional beacons for a nights sail ahead (Jones, 1976, p. 13). While the early surveys did much to hasten the acceptance of the inner passage as the main route to Torres Strait, later surveys, noteably those by HMS's 'Dart', 'Myrmidon' and 'Paluma' during the 1880's and by HMS's 'Dart', 'Penguin', 'Fantome' and 'Herald' during the early 1900's, were to provide the basis for the modern charts of Barrier Reef waters (Ingleton, 1944).

The availability of more accurate charts and the establishment of navigation aids undoubtedly did much to reduce the dangers of sailing in reef waters, but many hazards still remained. In the 60 years from 1800 less than 10 vessels were lost in the region between Bowen and Lizard Island while using the inner route. In the same area from 1860 to 1911, over 70 vessels were reported as aground or lost. Most of those wrecked were small schooners and ketches attracted to reef waters by the rapidly expanding coastal trade during the early days of the gold rush. Marine inquiries into the loss of these vessels not infrequently cast doubts on the seaworthiness of both vessels and their masters.

Tropical cyclones were one hazard of reef waters that the surveys did not reduce. From 1800 to 1911 over 30 vessels were lost during cyclones in the region between Bowen to Cooktown. Again it was the small sailing vessels that suffered most, many being driven ashore while at anchor. Other victims, however, included the gold ship 'Gothenburg', which sank off Cape Bowling Green with an estimated £43,000 worth of gold aboard, and the steamer 'Yongala' which was lost in the same area during a cyclone in 1911.

Undoubtedly much of the increase in shipwrecks during the latter half of the 1800's was attributable to the vastly increased number of vessels in reef waters during the period.

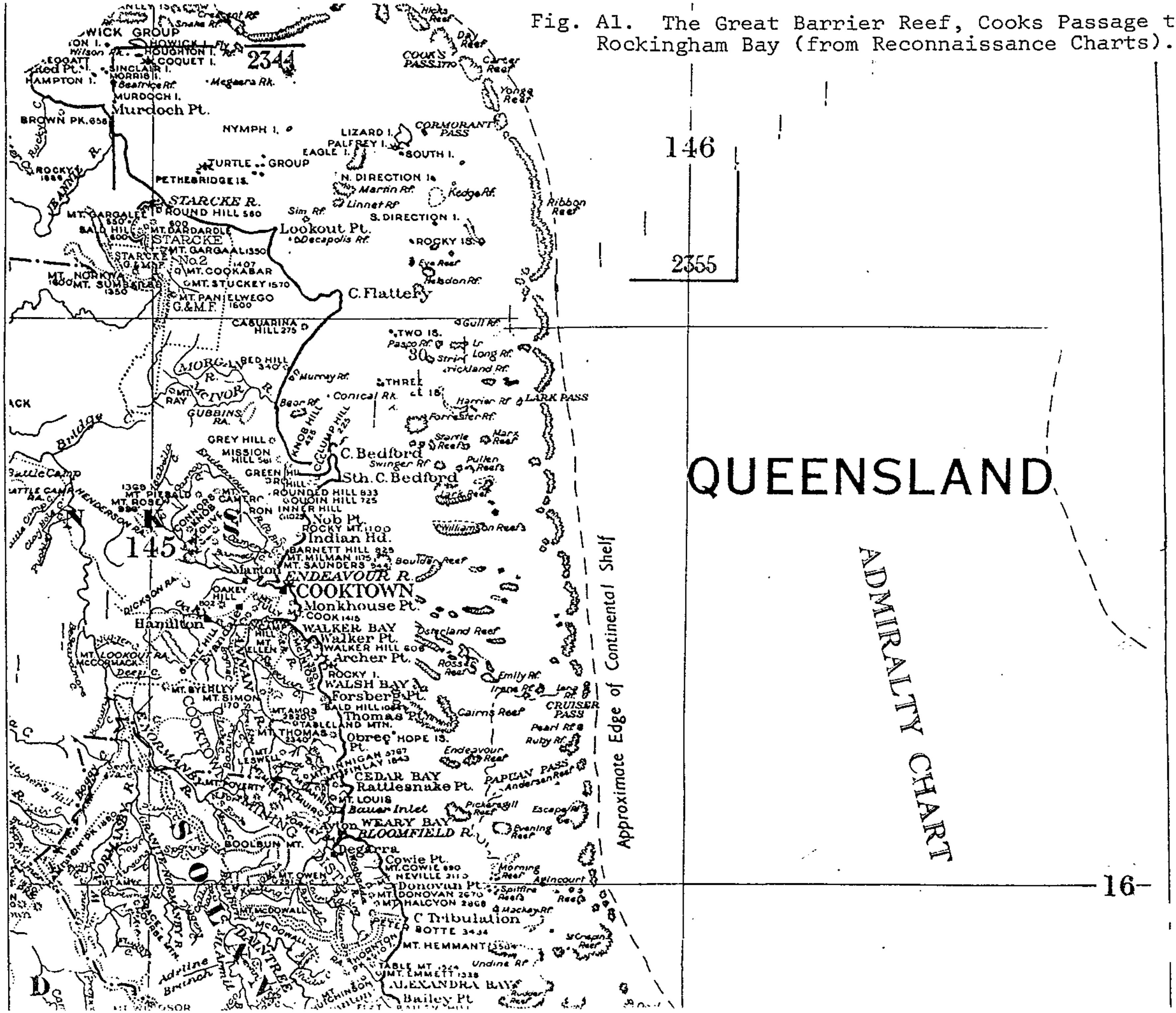
Although ASN had gone into liquidation in 1886, it was absorbed by the Queensland Steamship Co. to form the Australian United Steamship Navigation Co. (AUSN) which ran weekly services between Brisbane and Townsville and in 1890 extended the run to Cairns. In the early 1900's the AUSN, with a substantial subsidy from the Queensland Government, operated a three weekly service to the Gulf ports but in 1921 this contract passed to the John Burke Co.

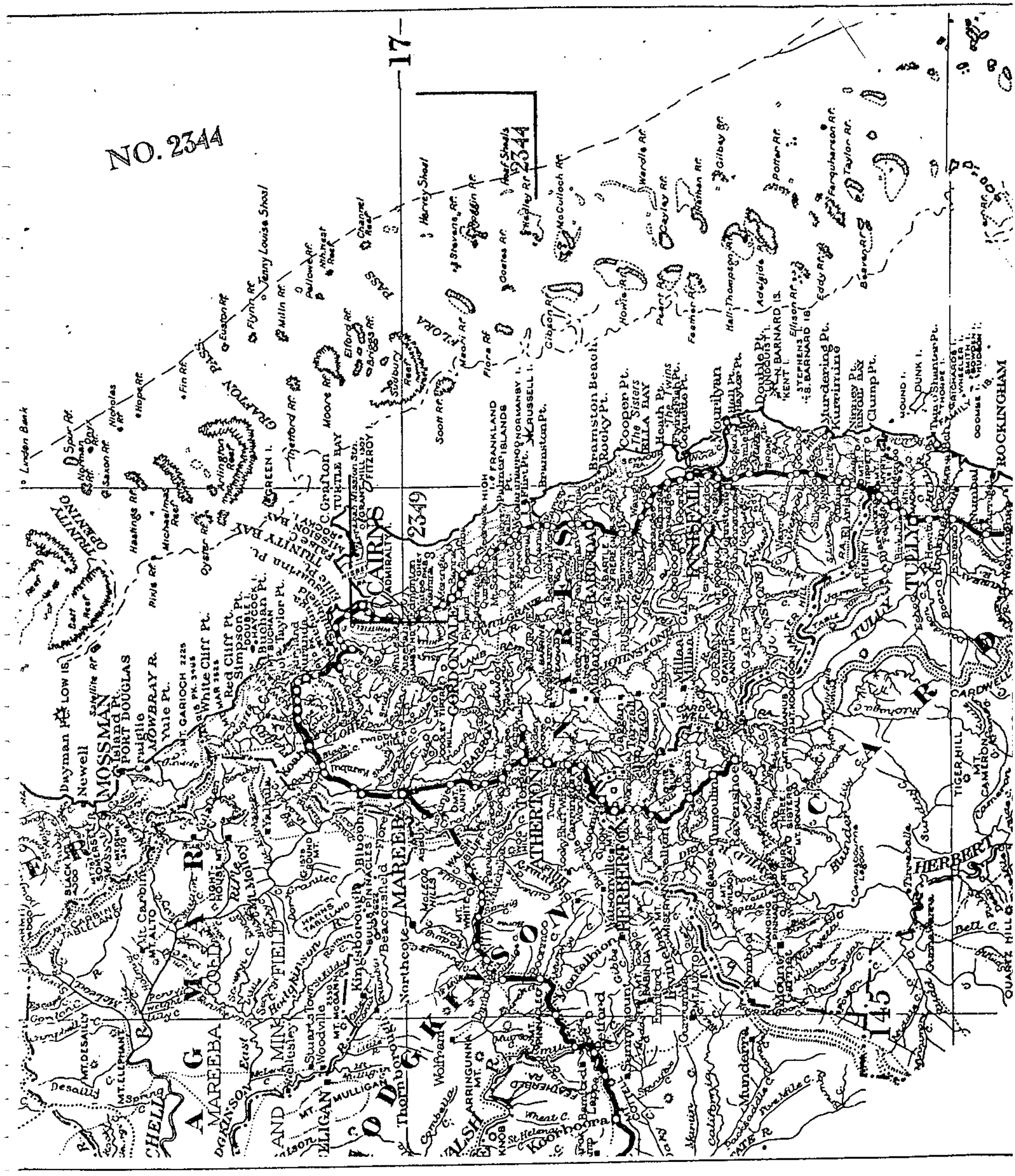
The establishment of regular shipping services did much to develop the tourist potential of north Queensland. In 1899, Robert Hayles opened the first 'resort' at Picnic Bay on Magnetic Island. A regular service was maintained between the island and Townsville by the ex-Manly ferry 'Bee'. In 1926 Hayles moved to Cairns and shortly after opened a second resort at Green Island. By the 1930's charter boats from Bowen, Townsville and Cairns were regularly taking fishing parties to the outer reefs, thus beginning a pattern of use that has persisted to the present day.

PART I

THE GREAT BARRIER REEF
LIZARD ISLAND - INNISFAIL

Fig. A1. The Great Barrier Reef, Cooks Passage to Rockingham Bay (from Reconnaissance Charts).

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Tolga
Yungaburra
Malanda
Millaa Millaa
Ravenshoe
Evelyn
Watsonville
Irvinebank
Chillagoe
Kingsborough
Thornborough
Northcote
Beaconsfield
Woodville
Stuartstown
Mt. Carbine
Mt. Molloy
Biboohra
Kuranda
Redlynch
Herberton
Walsh R.
Barron R.
Tully R.
Herbert R.
Mt. Bartle Frere
Mt. Bellenden Ker
MAREEBA
FIELD
CARBINE TABLELAND
TIGER HILL
MT. CAMERON
Koorboora
Lappa
Petford
Sunnymount
Montalbion
Mt. Garnet

THE ENVIRONMENT - LIZARD ISLAND - INNISFAIL

COASTAL PHYSIOGRAPHY, METEOROLOGY AND HYDROLOGY

PHYSIOGRAPHY OF MAINLAND COAST

The mainland coastline between Cape Flattery (just south of Lizard Island) to Innisfail, lies between 14°57'S to 17°50'S. Its length (based on 1:250,000 charts) is approximately 500 km. The principal characteristics of the land mass are set out in Maxwell (1968, Fig. 1). The Great Dividing Range, extending north to south more or less parallel and close to the coast attains elevations of 1525 m. It directly influences the character of the coastline and the run-off to the sea. In this part of the coast, the watershed is narrow and although areas of high rainfall are drained, the catchment areas are small. With the exception of the Herbert River, which extends over 120 km inland, the eastward flowing rivers are all short, with watersheds within 80 km of the sea (see Table 1).

Generally the coast line of the region rises abruptly from the sea and low-relief areas are intermittent and generally restricted to estuarine sections between Bingil Bay and Innisfail, around Cairns, from Port Douglas to the Daintree River and around the Endeavour River at Cooktown. Although dune formation has influenced much of the low-lying coastal margin, the underlying sediments, exposed intertidally and extending sub-tidally, are moderately to strongly muddy. In estuaries and sheltered bays, these fine sediments determine coastal character.

Seaward from the coast, the continental shelf is narrow (65 km wide off Innisfail and less than 50 km off Cape Flattery). Only a few continental (High islands) surrounded by fringing reefs occur on the continental shelf. Of these only Lizard Island exceeds 800 ha. It is of the usual rugged topography that is characteristic of the continental islands further to the south. North of 18°S the reef zone is only 15-35 km wide and approaches within 15-30 km of the coast. Ribbon reefs on the outer edge of the shelf and Low Wooded Isles on the inner shelf are characteristic features of the continental shelf north of Cairns. Coral development is largely restricted to the marginal shelf east of the 36 m (20 fathom) line. The reef zone is only 15 to 35 km wide and approaches within 15 to 30 km of the shore. Ribbon reefs arising from the outer edge of the Continental Shelf and Low Wooded Islands on the Inner Shelf are characteristic features of the shelf waters to the north of Cairns.

The Commonwealth Bureau of Meteorology is the basic source of meteorological data for the reef. Detailed information and general accounts of climatic conditions are published by the Royal Air Force (1942), The Royal Netherlands Meteorological Institute (1949), The Hydrographic Department Ministry of Defence, Great Britain (1973) and publications of the Department of National Development (1970, 1971). It should be noted that much of the information contained in these publications is derived from land stations and its applicability to offshore areas remains uncertain. Pickard (1977) has reviewed climatic factors relevant to the physical oceonography of the Great Barrier Reef region.

METEOROLOGY

WIND: The area south of 15°S latitude comes under the influence of the South-East Trade Winds and the wind direction for much of the year is from between south and east. The easterly component prevails from August through to January or February with southerly winds prevailing for the remainder of the year. North of 15°S the north west monsoon invades during the summer months and may extend its influence as far south as 16°S (Pickard, 1977). Wind speeds are seldom high, except during the process of tropical cyclones, but calm days are rare. Average wind speed is usually higher during the winter months.

CYCLONES: The majority of cyclones that effect the Queensland coast originate in the Inter-tropical Convergence Zone between 8° and 18°S in the north Coral Sea. Their subsequent paths are highly variable but most either curve south east to parallel the coast or track south west and cross the coast at some point north of Brisbane. Conditions associated with tropical cyclones include high winds, rough seas, torrential rain and coastal flooding. Wind gusts may approach 200 km/hr and storm surges in coastal areas may add more than 6 m to predicted tide heights (May, 1976).

From 1909 to 1975 a total of 75 cyclones entered the 5° square area extending from 15°S to 20°S and lying between 145°E and 150°E (Lourensz, 1977). Of the 42 cyclones that crossed the coast between Bowen and Lizard Island, 15 made land fall between Cairns and Cooktown. Table 1b indicates that in addition to those cyclones which make landfall a high proportion that approach the coast are likely to affect offshore reef areas.

AIR TEMPERATURE: Mean monthly air temperature cycles for coastal centres in this region show a maximum in December or January and a minimum in June or July (Hydrographic Department, 1973). The monthly mean maximum temperature shows little variation (30°-32°C) north of 29°S while the monthly mean minimum declines steadily (19°-14°C) from north to south. Highest and lowest recorded temperatures for Cairns and Cooktown (up to 1966) are 40°/7°C and 42°/6°C respectively (Hydrographic Department, 1973). The few data available suggest that temperature ranges offshore are comparable with those observed on the adjac coast.

RAINFALL: Coastal areas of tropical Queensland are characterized by a distinct wet season with about 70% of the total annual rainfall occurring in the three months from January to March. Mean annual rainfall for the coast is between 1,000 and 2,200 mm except in the south of the region under consideration (Tully - Babinda, 17°20' to 18°S) where the annual totals average 3,600 to 4,400 mm. Large year to year variations in rainfall are typical of the whole region with individual annual registrations ranging from around 40 to 190% of the mean annual totals. Monthly rainfall registrations show even larger variations. For example, the January range for Innisfail is 6 to 294% of the mean monthly value. Tropical cyclones cause local heavy falls which often result in 24 hr totals in excess of 250 mm; 800 mm have been recorded in a single 24 hr period at Port Douglas. Rainfall observations for offshore islands are limited but indicate that, with the possible exception of the area around 17°40'S precipitation over reef areas is comparable with that on the adjacent coast.

RIVER RUNOFF: Information on runoff is available for only a limited number of rivers in the region. The main source of information is from the publications of the Australian Water Resources Council (see Table 1a). River discharges in this region show a narrower range of variation which can be attributed to the smaller catchment area and the fact that there are very likely dry years.

Pickard (1977) has estimated that rain falling directly over the sea contributes almost twice as much freshwater to the Great Barrier Reef lagoon than does river runoff. The latter, however, being more localized, is likely to have a significant influence on near shore salinity regimes.

TIDES: Information on tidal heights and times are to be found in tables published by the Australian Department of Defence and the Queensland Department of Harbours and Marine. Easton (1970) has described tidal patterns around Australia. Tides are semi-diurnal with considerable neap-spring variation and pronounced diurnal inequalities. The mean spring range at Lizard Island is 1.6 m. Charts given by Maxwell (1968) indicate that tidal ranges on the reefs are similar to those on the adjacent coast but are approximately 10-20 minutes earlier. Recent studies however, suggest that the tidal maxima at Low Isles and at the Trinity Opening occur 2-3 hours earlier than at Cairns. Information on the direction and strength of tidal currents is set out in the *Australia Pilot*. This indicates that the tide floods to the north or north west at locations north of 17° 41'S, and to the south, at locations south of that latitude. Near the direction of the set is modified by the proximity of openings through the reef, the set being towards the openings during the ebb and away during the flood. In open waters inside the reef, flow rates average 0.25 to 0.5 m/sec with speeds of 2 m/sec occurring in narrow passages and channels.

HYDROLOGY

HYDROGRAPHY: The only systematic study of the water column in Great Barrier Reef waters is that undertaken by Orr (1933) at Low Isles during the Great Barrier Reef Expedition

(1928-29). Much of the remaining data is scattered covering limited areas and/or restricted time periods. An account of the general properties of the waters of the region was given by Brandon (1973) and this and other studies up to 1975 have been reviewed by Pickard (1977).

TEMPERATURE AND SALINITY: Between 14°6'S and 19°5'S the temperature of near shore waters averages 29.1° to 22.2°C, the temperature range increasing from 6°C in the north to 7.4°C in the south. The only time series data on sea temperatures for a specific locality in the region are those given by Orr *(loc. cit.)* for Low Isles. Low Isles temperatures showed a range of 8.4°C with a maximum of 29.9°C in February and a minimum of 21.5°C in August.

Near shore surface salinities range from 35°/00 in October to less than 32°/00 in February. The low value in February results from freshwater input from rain and river runoff during the wet season. Below 10 m and at greater distances from the shore the water column is more stable. For most of the year mixing within the lagoon is sufficient to prevent stratification. Temperature/salinity time plots given by Pickard *(loc. cit.)* show that changes in density of the surface waters result from changes in salinity from January to March and from changes in temperature from April to December. This contrasts with conditions outside the reef, where changes in density can be almost solely attributed to variations in temperature. There is almost no data to indicate the level of interchange between lagoon waters and those outside the reef.

CURRENTS: Information relating to water movements within reef waters is scant and to some extent contradictory. The *Australian Pilot* states that during January the current is to the north or north west under the influence of the south east trades. March and November are reported to be 'transitional' with the direction of the set described as highly variable. Notes on Admiralty charts (2349, 2923 and 2924) state that from April to November currents run northward and during December to March the current is irregular but more frequently sets south. The monthly charts of current vectors given by the Royal Netherlands Meteorological Institute (1949) indicate a net northward flow for most of the year and a southward set from October to December. Current speeds are reported to average 0.1 to 0.4 m/sec, however Admiralty charts note currents as high as 1.3 m/sec running north during the south east trades. Semi-diurnal variations in current speeds occur as a result of changes in the direction of the tidal stream. Little information exists concerning currents immediately seaward of the Great Barrier Reef. Admiralty charts record a current setting south at 0.25 to 0.5 m/sec along the outer edge of the reefs from May to December.

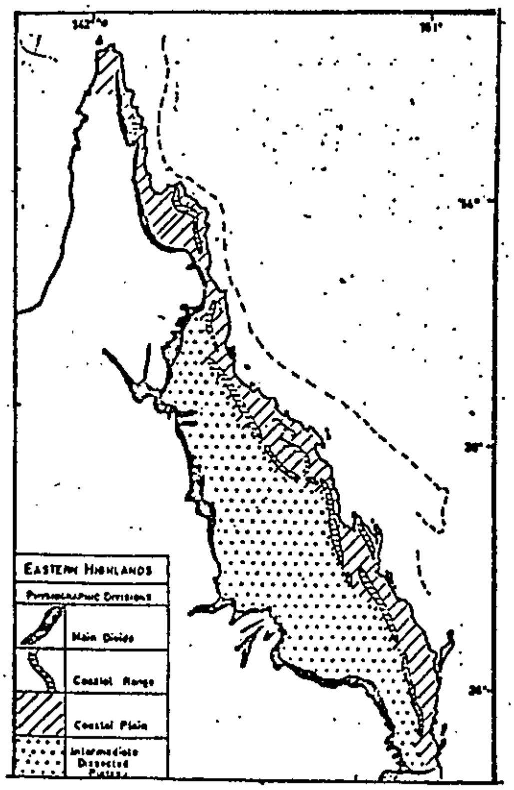

Fig. A2. Major Physiographic Division of the Queensland coast (after Maxwell).

TABLE 1 a. WATERSHEDS AND STREAM FLOW

(Data from Australian Water Resources Council 1976)

	km^2	Annual discharge $10^6 m^3$		
	Catchment area	Mean	Useage	% Useage
Endeavour River Basin				
Endeavour R.	311			
Annan R.	313			
Daintree River Basin				
Bloomfield R.	117			
Daintree R.	824			
Mossman River Basin				
Mossman R.	114			
Barron River Basin				
Barron R.	1940	819	(2401-2057)	29-251
Mulgrave-Russell Rivers Basin				
Mulgrave R.	554	899	(286-2079)	32-231
Russell R.	321	1,128	(456-2522)	40-223
Johnstone River Basin				
North Johnstone R.	958	1,779	(1014-3154)	57-177
South Johnstone R.	474	809	(295-1587)	36-196

TABLE 1b. CYCLONE LANDFALLS AND APPROACHES

(to within 50, 100 and 150 km of the coast for 100 km units of coast north of Cairns)

Note: Cyclones are not recorded as approaches in those units where they make landfall.

(Data from Laurensz, 1977)

Latitude			Cooktown		Cairns
Landfalls	2	4		15	
50 km	4	2		1	
100 km	7	5		4	
150 km	9	8		0	
TOTAL	22	19		20	

GEOMORPHOLOGY OF THE GREAT BARRIER REEF PROVINCE BETWEEN INNISFAIL AND LIZARD ISLAND

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INTRODUCTION

The Great Barrier Reef Province between Innisfail and Lizard Island is situated on one of the narrowest sections of the continental shelf which in places is less than 50 km wide. The distinctive features of this area are related to this narrow box shaped shelf structure which has generally less than 50 m of water across it but is deeper than 1000 m within a kilometre of the outer reefs. Across this shelf it is possible to recognise four major zones of reef development.

1. A line of ribbon reefs, less than 600 m wide but individually up to 28 km long with narrow intervening passages situated on the outer edge of the shelf. The southern limit of these is just north of Port Douglas, but a number of submerged ribbon features occur down to Wardle Reef in the extreme south of the region.

2. A mid-shelf zone of reefs up to 26 km long and 12 km wide, often with narrow intervening passages. In the same zone exist a number of smaller irregularly spaced reefs separated from others by up to 8 km of open water. These mid-shelf reefs are characterized by extensive reef flat development, algal rims and often a predominant orientation to the trade winds. On the leeside of a number of these reefs sand cays have developed, but only a few are stable enough to maintain vegetation.

3. An inner zone of low wooded island reefs and small reefs with sand cays generally within 20 km of the coast. These islands of reefal origin generally include cemented deposits, extensive shingle ridges, spits or islets and vegetated sand cays, and often extensive mangrove development. The southern limit of the low wooded islands is north of Cairns, although some of the characteristic features are found on high islands further south.

4. Mainland fringing reefs. These vary in size and have an irregular distribution along the coastline, related to the local water quality and sediment budget. Fringing reefs also occur on a number of high islands.

PREVIOUS WORK

Early explorers through the Barrier Reef waters were primarily concerned with discovery and it was not until the mid-nineteenth century that significant geomorphological observations were made. Observations from northern reefs on the voyages of HMS Fly (1843-45) and HMS Rattlesnake (1846-50) suggested that raised reefs and raised beaches existed in this area (Jukes 1847, MacGillivray 1852). These observations were supported by later workers in the area (Rattray 1869, Haddon *et al* 1894, Mayer 1918) and their evidence was quoted as recently as 1967 by Fairbridge. However more recent work (Stoddart *et al* 1978) has shown that the raised reefs and beach rocks of some of this earlier work were misinterpreted. Alexander Agassiz also visited this area aboard the steamer 'Croydon' in 1896 and commented on the same features but his views on reef evolution are now outmoded (Agassiz 1898).

A major impact on the geomorphological information available for the area came about during the 1928 Royal Society Expedition which was based on Low Isles in the southern section of the area (Steers 1929, Spender 1930). A second geographical expedition was carried out in 1936 by Steers and Kemp, and together the two expeditions provided a great deal of information on the low wooded islands in particular, and stimulated discussion on the origin of low wooded island features especially in relation to higher sea levels (Steers 1937, 1938). Further reconnaissance level work on the northern reef was carried out by Fairbridge and Teichert during World War II and fitted into the picture of the total Great Barrier Reef (Fairbridge 1950, 1967). More recently Maxwell (1968, 1973) has examined the sediments of the total reef region.

A second major impact on the knowledge of the area occurred in 1973 when this region formed part of the research area of the Royal Society-Universities of Queensland Expedition to the northern Great Barrier Reef (Stoddart *et al* 1978). Geomorphological mapping was carried out for most of the low wooded islands and some of the cays in the region. Radiocarbon dating of samples from many reefs and islands was also carried out. Additional structural information was obtained on this expedition using continuous seismic profiling techniques in the intereefal areas of the Cairns/Low Isles region in the south, and in the Lizard Island region in the north.

Subsequent to the 1973 expedition some work has been carried out on carbonate productivity at Lizard Island reef (LIMER 1975 Expedition Team), but the only recent geomorphological investigations have been carried out by the authors during 1976, 1977 and 1978. These studies have included geophysical investigations of the pre-Holocene reefal substrate (Harvey 1977a, 1977b), shallow drilling of reef flat surfaces and radiocarbon dating (Hopley 1977) and remote sensing of reef surfaces (Hopley and Van Steveninck 1977). Further studies during 1978 have been carried out by the authors, including continuous seismic profiling in conjunction with the Queensland Geological Survey. This programme of work has provided further data on reef development in the area, and has also tied in the structural reef information with intereefal seismic discontinuities.

MAINLAND GEOMORPHOLOGY

Mainland geomorphology of the area between Innisfail and Lizard Island may be divided into four sectors:

1. Innisfail to Cairns

A low coastal range is separated from the Bartle Frere-Bellenden Ker massif by a narrow corridor of alluvial deposits occupied by the Johnston, Russell and Mulgrave Rivers. This is the wettest part of the Australian coast and annual rainfall totals exceed 3600 mm. The effect on coastal geomorphology has been described by Bird and Hopley 1969). Major features are lack of active cliffing, vegetation extending down to high water mark, and essentially quartzose beach sediment in beach ridge form in pocket beaches and close to river mouths. Development of alluvial ferruginised sand rock (coffee rock) occurs in Pleistocene barrier systems. Dune development is very limited except where there is an abundant supply of fluvially derived sand and coastal orientation is towards the prevailing and dominant south-east winds, eg at Oombunghi, south of Cape Grafton.

2. The Barron River deltaic Plain

The deltaic plain and adjacent areas of the Cairns area have been described in detail by Bird (1969, 1970a, 1971a, 1971b, 1973a, 1973b). Deltaic deposits are at least 40 m thick. The surface formation consists of up to 4 m of quartzose sand with occasional pebbles and shells, underlain by a soft blue-grey clay formation of mangrove muds. The soft clays thicken southwards, reaching a depth of 24 m beneath Cairns harbour. Underneath them is a firm yellow-grey clay up to 12 m thick which in turn rests on a basement of sandy gravel. Since Holocene sea level first rose to its present position about 6000 years ago, the Barron River has been building up a deltaic sequence much of which consists of beach ridges. The oldest of these has been dated at 5530 ± 130 years BP. Sea level may have been approximately 1 m above present at about this time. Bird (1969) has suggested that present erosional problems on the coast north of Cairns are at least in part due to sand extraction and damming of the Barron River.

3. The Macalister Range coast

This extends from the Barron Delta to the Daintree River and has been described by Bird (1970b). The seaward slopes of the Macalister range consisting mainly of piedmont aprons have been modified by marine processes. The coastline consists of headlands of exposed weathering fronts, bayhead beaches of sands derived from the reworked piedmont fans, and some intervening areas of boulder and shingle beaches, the coarser residual materials from the same piedmont aprons. Coral reefs are developed sporadically close inshore and small fringing reefs are found off south rocky shores. The best known is that at Yule Point which has been described by Bird (1971b). It is a former patch reef joined to the mainland by sedimentation of the Mowbray River. The lower part of this reef is related to a sea level of at least 1 m above present and has been dated at 4130± 110 years BP.

4. The Cape Tribulation coastline

No geomorphological work has been carried out on this coast. However, it is a high rainfall area with rainforest extending down to HWM. The features of the coastline are similar to those described for further south by Bird and Hopley (1969).

5. The sand dune complexes north of Cooktown

The most impressive parabolic dunes on the tropical Queensland coast occur along the eastern seaboard of Cape York Peninsula north of Cooktown, most notably in the Cape Bedford and Cape Flattery areas. This dune field, covering an area of 700 km^2 consists largely of elongate parabolic dunes up to 5 km in length and over 100 m in height (Pye, in Coventry and Hopley, in press). Many of the dunes are stabilised beneath heath, scrub or vine forest (Story 1970; Pedley and Isbell 1971) but up to 15% of the Cape Flattery dune field consists of active dunes and a further 10% comprises swamps and lakes enclosed between the trailing arms of the dunes (Galloway et al 1970). The direction of movement of the dunes from south-east to north-west parallel to the prevailing wind direction is clearly seen and an active example has been described by Bird (1965) south of the McIvor River.

Several generations of dunes are evident but their evolutionary history is not clear. Two distinct sand units have been identified in the Cape Flattery deposit (Lucas and de Keyser 1965a,b). Near the McIvor River mouth a younger, white dune sand is seen to overlap an older, ferruginised cross-bedded sand. This older sand forms inliers within the younger white dune mass, and it is best exposed in a 70 m high cliff section 6 km west of Cape Bedford. Here orange, yellow and white cross-bedded sands are separated by white kaolinitic sand layers and have a thin, pisolitic, iron-enriched capping. de Keyser and Lucas (1968) have remarked on the similarity of this sequence with the Teewah Sands in south-eastern Queensland described by Coaldrake (1960).

The formation and Quaternary history of the Cape York sand deposits remain speculative. Steers (1929) and Lucas and de Keyser (1965a) considered that the Cape Bedford and Cape Flattery deposits represent giant tombolo-like barrier features on which dunes have developed and moved inland, possibly aided by a slight fall in sea level. Others have considered that the dune systems have developed as a result of aeolian reworking of the underlying Mesozoic sandstones (Willmott et al 1973). Yet others (Whitehouse 1963) believe that the dunes were formed largely during times of glacial low sea level when wide areas of adjacent continental shelf were exposed to wind action and when the south-easterly trade winds may have been even stronger than at present. In view of the lack of radio-metric dates or detailed geomorphological information, it is not possible to confirm or refute any of these hypotheses.

SHELF STRUCTURE AND SEDIMENTS

Although very little structural information is available for the reefal areas of the continental shelf the region between Innisfail and Lizard Island has had a number of seismic surveys carried out (mainly during the 1973 reef expedition) which provide information on shelf sedimentation. Other geophysical investigations have been carried out locally for inshore sedimentary information at Cape Flattery and recently in Trinity Bay. South of Cairns continuous profiling has also been carried out on the shelf edge and across the shelf in the southernmost section of the area. Apart from these investigations some gravity surveys were carried out by BMR extending over the north Queensland shelf, but, of course, provide little in the way of subbottom information or sedimentary structure (Dooley 1963).

Only one bore has been put down through reef material in this region, at Michaelmas Cay (16°36'S) in 1926 by the Great Barrier Reef Committee. The bore penetrated reef material to 145 m, then quartz sands with shell fragments and foraminifera to 183 m at the bottom of the bore (Richards and Hill 1942). From the evidence of the limited boreholes on the whole Barrier Reef it has been suggested that coral reefs began growing in this area about 18 million years ago. Unfortunately the core recovery from the Michaelmas bore was patchy and does not provide detailed structural information on the reef sediments. This places a heavy reliance on geophysical, geomorphological and bathymetric data for structural interpretations.

Continuous seismic profiling was carried out during 1973 in the Cairns region and in the Lizard Island region (Orme and Flood 1977). In both areas they found a major reflector which they interpreted as a disconformity representing an ancient karst surface developed during low sea levels and consequent shelf emergence. Continued sea level regression caused rivers to erode deep channels and the greater relief and complexity of this surface in the Cairns region is attributed to greater dissection by rivers across this section of the shelf. Some of the reefs appear to be resting on this surface while others towards the shelf edge overlie ancient reef material extending below the disconformity. Orme and Flood suggest that this surface is the result of emergence during the Wisconsin glacial low.

In the Lizard Island region, Orme *et al* (1978) describe 'bank' forming deposits overlying the prominant reflector. These banks are up to 18 m thick and have a fairly uniform depth of -25 m. Orme *et al* attribute this to luxuriant *Halimeda* growth and sea level control of sediment accumulation in a tidal environment. The reflector beneath these banks in the Lizard Island area extends to the back reef of Carter but the accoustically transparent reef material prevented the collection of any structural data using the continuous profiling equipment.

However, shallow seismic refraction investigations in this region have identified seismic discontinuities (Fig. 1) beneath the reefs themselves (Harvey 1977a, b). The major conclusions from these surveys are that the Holocene reefs are relatively thin and represent only a veneer of recent coral growth over a subaerially modified pre-Holocene substrate. A disconformity identified beneath the ribbon reefs (Fig. 2) at -10 m suggests that they have been at or near modern sea level for some time. Beneath other reefs a deeper disconformity suggests that it is related to their present morphology, whereas a shallow disconformity beneath Nymph Island in a lower energy environment suggests that the extensive reef flat and mangrove development is related to the shallowness of the pre-Holocene substrate.

Shallow drilling on reef tops has backed up conclusions from seismic refraction work. Dating from cores (Figs. 3,4) on the ribbon reefs (Hopley 1977) indicates that these reefs have been at or near modern sea level for about 6000 years, and contrary to earlier theories demonstrates that there has been little or no hydroisostatic warping of the shelf. Similarly dates from the low wooded islands indicate that sea level was achieved prior to 6000 years ago and was marginally higher than present by 5000 years ago.

The ancient surface identified from the seismic work is shallow beneath the ribbons and some of the low wooded islands. However in the outer shelf area near Lizard Island large areas of sub-surface 'karst like' topography exist, which even the distinctive cover of *Halimeda* has not been sufficient to mask. This surface at a depth of 30 m has been mapped (Hopley 1978) and consists of irregular series of closed depressions analogous to an ancient 'karst plateau' which forms a major part of the shelf structure in this region.

REEF MORPHOLOGY

OUTER RIBBON REEFS

Narrow linear or ribbon reefs are a distinctive feature of the Great Barrier Reef north of Cape Tribulation. Individual reefs vary from less than 2 km to over 26 km in length. Smaller oval plug reefs of Maxwell's (1968) terminology may occur within or just behind the passages between the ribbons. Width of these linear reefs is very constant, varying from about 400 to 600 m from the reef front to the back reef detrital slope. These reefs occur at or close to the edge of the continental shelf, with deep water of 500 m or more found within a few hundred metres of the reefs, and over 1000 m within a kilometre. South of 17°S are a number of submerged reefal areas on the edge of the continental shelf which resemble ribbon reefs. It appears these are a continuation of the ribbon reefs further north but to date have not been investigated because of their depth. For example, see attached echogram across RAAF shoals (Fig. 5) on the edge of the shelf in the southern section of the region .

The reef front on the ribbons is steeply sloping in excess of 20°, occasionally interrupted by minor terrace levels (eg at c 10 m on Carter Reef). The surf zone is one of prolific coral growth up to the level of tidal datum. At this level the reef top is reached and extends back from the reef front to a maximum level of approximately 0.4 m, apart from higher shingle banks and boulders. The outer flat is a planar surface of encrusting coralline algae with low flat lying corals, mainly *Acropora* sp occurring only in gentle undulations on the surface. Approximately 200 m from the reef front the algal surface is covered by rubble with occasional *Acropora* shingle banks rising to c 0.8 m. It is in this zone that the reef flat surface reaches its highest elevation. At the rear of the zone the algal surfaces continue as narrow linear fingers overlying massive corals, separated by parallel channels up to 4 m deep. This morphology is continued into the aligned coral zone, which is identical apart from the lack of an algal crust. The lineaments are usually normal to the reef front or at a slight angle to it and appear to be determined by the pattern of refracted wave fronts. The back reef area consists of a steeply inclined sand ramp sloping into water depths of c 14 m from which rise isolated massive coral colonies.

Shallow drilling has been carried out on Carter (Hopley 1977) and Lark Pass Reefs, typical ribbon reefs of the Lizard Island area (Figs. 3 and 4). Radio-carbon dating of cores from these reefs suggests that they have developed from coral colonies first reaching modern sea level about 200 m from the reef front. From this area the reef has slowly widened by growth both towards the reef front largely by consolidation of debris by cementing coralline algae, and towards the rear of the reef by coral growth over which the coralline algae form a veneer.

MID SHELF REEFS

The mid shelf reefs in this region have varied forms which are coincident with the southern boundary of the ribbon reefs, the low wooded islands and to the north with the appearance of the high islands.

In the south the mid shelf reefs of up to 12 km in length are in close proximity to the submerged ribbons. The width of the reefal area here is less than 20 km wide and south of this region the mid shelf and outer reefs merge together. From 17°S to 16°10'S the mid shelf reefs form massive reefs up to 26 km long and 12 km wide, with crescentic reef fronts facing the SE trades. North of these the mid shelf reefs are smaller in reef flat area but still retain a predominant lineation to the trade winds or have a characteristic crescentic reef front. In the northernmost section the presence of basement rock is the major feature in the mid shelf region, with a number of high islands or rocks and their associated fringing reefs. The largest reefs in this area are Eagle, Martin and Linnet which lie to the SW of Lizard Island.

The morphology of these reefs varies. In the south, massive reefs such as Tongue and Batt have hard line development only on their southeastern margins and their perimeters enclose areas of complex patch reef development and numerous bommies. In the central section reefs, such as Cairns reef, have a south easterly orientation with hard line development on the windward edge and often shingle banks. The south easterly alignment of these reefs and also the more crescentic reef front development in the same region often enclose deep lagoonal areas, as compared to the shallower areas of Tongue reef for example in the south.

Within the zone of mid shelf reefs are a number with sand cays developed on their leeward margins. These reefs are usually characterised by extensive reef flat development with sufficient sediment production, and are situated away from the high energy zones so that most sand cays are found on reefs on the inner mid shelf area.
Many of these sand cays were mapped by Stoddart in the course of the 1973 Expedition. The cays can be divided into vegetated and unvegetated types:

1. Unvegetated cays

These are generally small and also variable in form and size over time. Comparison of cays mapped both by Steers in 1936 and Stoddart in 1973 showed substantial changes, all cays having decreased in size since 1936. The amount of movement over short periods of a similar cay on Wheeler Reef near Townsville has been described by Hopley (1978) Three sub-types of unvegetated cays have been recognized, which may represent a progression in their development:

i) Small ephemeral cays - intertidal sand patches possessing no beach rock. The majority of the cays on the mid-shelf reefs are of this type, eg Pickersgill, Arlington, Upolu cays

ii) Large, generally oval islands up to 300 m long and 100 m wide. These have steep beaches and pronounced swash ridges, eg Sudbury cay

iii) Cays of more variable dimensions, surrounded by extensive beach rock. The present form and size of the cay may differ from that outlined by the beach rock, presumably as the result of cyclonic activity.

2. Vegetated cays

The 1973 expedition found that vegetated cays were ten times the size of unvegetated cays. On the northern reef the orientation tends to be east-west to the south of Cape Melville. Three sub-types were recognized by the 1973 expedition.:

i) Elongate narrow islands with steep beaches often surrounded by dunes to a maximum altitude of 7 m (TD). The vegetated area ranges from 10 to 66% of the total area of the cay. Numbers of plant species range from 2 to 11 for the smallest and up to 34 for the largest, consisting of herbs, grasses and low scrub. Examples are Eagle and Michaelmas

ii) A group of larger, oval islands, averaging 530 m in length, 200 m in width. The islands are flat topped though sometimes displaying an upper and lower terrace similar to those on the cays of the low wooded islands. Beach rock is extensive and superficial phosphatic cay sandstone may be found in the interior of the cay, eg Green Island (see report section IV).

iii) Equidimensional islands, up to 500 m in maximum diameter. On the northern reef these generally maintain a vegetation of scrub, herbs and grasses, eg East Hope Island

LOW WOODED ISLANDS

1. Description

The low wooded island reefs are by far the best known of all the reef types of the Great Barrier Reef. The following description of the characteristic features is based on Stoddart, McLean and Hopley (1978).

i) Windward reef flat

The windward reef flat, normally 60-100 m wide, usually dries at low water springs. Its outer edge is formed of living corals the innermost zone of corals frequently being *Porites andrewsi*. This merges into a flat or gently sloping algal surface, drilling through which suggests that it overlies an older coral fringe, which has been infilled and veneered with encrusting coralline algae. Beyond this is a zone of rubble, mostly broken *Acropora* beneath which the algal surface may be continued.

ii) Ramparts

Ramparts are asymmetric ridges of coral shingle with steep inward face (up to 80^{0}) and gentle seaward slopes of less than 10^{0}, which merges into the reef flat rubble zone. Tongues of shingle form extensions inwards over the reef flat from the ramparts which generally have a width of about 50 m. Mean heights of ramparts measured in 1973 was 1.8 m (TD), but they may be as high as MHWS. Remnants of lithified rampart foreset beds forming projecting steeply dipping ridges known as basset edges occur on the reef flat where the uncemented upper rampart materials have been eroded. Ramparts may be colonised by a low scrub of *Aegialitis annulata* and *Avicennia marina*, whilst higher shingle sheets, may be covered by succulents (*Sesuvium* sp, *Salicornia* sp, *Arthrocnemum* sp and *Sueda australis*).

iii) Moat

Shallow ponds may be enclosed by the shingle ramparts on the inner reef flats. In these moats corals commonly in the form of micro-atolls grow to heights of 1.0 m (TD) and, exceptionally, to MSL.

iv) Platforms or promenades

Conglomerate platforms of cemented coral shingle with horizontal upper surfaces often fringe the inner margins of moats and form the seaward edge of the land bodies of low wooded islands. Frequently the platforms overlie fossil micro-atolls. They appear to have resulted from basal cementation of old ramparts. The height of cementation varies considerably, and earlier workers, notably Steers and Spender identified an upper and lower platform, Steers (1938) in particular arguing that both features were the result of higher sea levels. However, the majority of "lower platforms" have elevations at or below MHWS, ie within the range of modern intertidal cementation. However "high" platforms may reach 3.5 m (TD) which may imply a higher relative sea level of up to 1.2 m at time of cementation. These platforms are commonly 30 to 40 m in width though erosion, often in the form of deep circular potholes, is severe on the outer edge.

v) Shingle Island

Platforms are frequently surmounted by a series of old shingle ridges, which may be older equivalents of the modern ramparts. Their maximum elevation is about 5 m (TD).

vi) Mangrove swamp

Mangrove areas vary from less than 1 ha to 125 ha on Bewick and even larger areas on the compound island (i.e. low wooded island cum high island) of Howick). *Aegialitis annulata* and *Avicennia marina* are characteristic of shingle ramparts and moats by *Rhizophora stylosa* is the main coloniser of reef tops with some *Sonneratia alba*. At higher levels, *Rhizophora* is replaced by *Ceriops tagal*, several species of *Bruguiera* and

Xylocarpus and at the highest levels by *Osbornia octodenta* and *Excoecaria agallocha*. Within many of the mangrove swamps are fields of fossil micro-atolls in position of growth, which, within the Howicks especially, reach elevations of 1.35 m, 0.35 m higher than presently living moated corals.

vii) Sand cay

Leeward sediment accumulations are characteristic of most low wooded islands but vary from discrete unvegetated sand cays to larger vegetated cays or sandy areas forming an integrated land area with windward platforms and shingle accumulation (eg the Turtle Group). Larger vegetated cays frequently comprise a low terrace around a central, higher and more extensive core. The higher terrace usually carries woodland or dense scrub, the lower a more open community of shrubs and herbs. Beach rock associated with erosion of the higher terrace is wider, more continuous and higher. Steers (1938) considered some of these higher beach rock outcrops to be raised features, associated with the lower platform at Bewick, Pipon and King Islands and with the higher platform at Nymph and Ingram. The vegetated discrete cays of low wooded islands investigated on the 1973 expedition had a mean area of 12.0 ha almost exactly twice the area of isolated vegetated sand cays of the region.

viii) Boulder zone

A recurrent feature of the low wooded islands is a boulder zone up to 200 m long with boulders reaching 3-4 m in greatest dimension, occurring on the leeward reef edge. These storm deposits, frequently consisting of single coral colonies, are sometimes cemented into platform rocks or pass beneath sand cays (as on Sherrard Island).

2. Types of Low Wooded Islands

Great variation exists in the size and morphology of low wooded islands, both in size and the distribution, presence or absence of the features listed. The major types are:

i) Islands with mangroves of limited extent and separate sand cay.

The reef top is large and the cay and mangrove-shingle rampart-platform island are well separated. The reef flat may be completely sanded or have areas of moated micro-atolls. Low Isles, Three Isles and Two Isles are all of this type (Figs. 13,14,15).

ii) Islands with extensive mangroves forming shingle and sand cays.

Nymph has extensive mangroves, though with a large enclosed lagoon (Fig. 16). Low Wooded Island is a more typical example of this type of low wooded island (Fig. 17).

iii) Turtle type islands (Figs. 18 and 19)

These islands lack a central open flat and have the mangrove-shingle cay dominating and frequently enclosing the sand cay. The shingle ridges dominate the reef top, occasionally with a lower terrace surrounding a higher central area with old beach rock slabs on the slope between, similar to some sand cay morphology (eg Turtle VI).

REEF EVOLUTION

Understanding of reef morphology has increased significantly over the last ten years, from work carried out elsewhere in the world and on the Great Barrier Reef (eg see the Proceedings of International Coral Reef Symposia in Brisbane, 1973 and Miami, 1977). In most areas, present reefs have developed as veneers of Holocene growth over older Pleistocene foundations which were exposed to subaerial processes during the low sea levels of the late Pleistocene. The morphology of the Pleistocene foundation is dependent on both the original morphology of the earlier reef and the modifications resulting from exposure during the Quaternary which may develop a karst relief. In turn the degree to which this Pleistocene morphology influences modern reef morphology is a reflection of the depth of the antecedent platform, the nature of the rise of sea level over it, together with the response of reef building organisms and the sediments they produce to the prevailing environmental conditions including wave and tidal regimes.

1. The pre-Holocene surface

Seismic profiling by Orme *et al* (1978) and by Harvey (1977a,b) together with drilling by Thom *et al* (1978) all in the Lizard Island area, indicate that in this area at least the surface on which the Holocene reefs and sediments have been laid largely mimics an older pre-existing surface. Similarly in the Cairns area Orme and Flood (1977) reported an ancient dissected karst surface underlying Holocene shelf sediments. Hopley (1978) suggested that a submerged karst area existed behind the ribbon reefs in the Lizard Island area (Fig. 20), and that this surface was now covered with a veneer of Halimeda deposits. It has been suggested that reefless areas were not recolonized immediately because of a rapid transgression and local turbidity resulting from the removal of regolith behind the sheltering effect of the residual ribbon reefs.

Seismic refraction survey over reef flats by Harvey (1977a) has shown that on Carter Reef a pre-Holocene rim lies beneath the algal surface of the ribbon reef at a depth of only 9.5 m, descending to 19.3 m in the aligned coral zone (Fig. 2). In conjunction with the C14 dates (Hopley 1977, Figs. 3,4) it is clear that initial growth of Holocene corals on the ribbons has been over this high rim. On Nymph Island, the pre-Holocene surface has been identified at a maximum depth of 9.35 m (Harvey 1977a) which is also shallow when compared with depths from other reefs in this region. It is significant that Nymph Island has a well developed reef flat, sand cay and extensive mangrove cover (Fig. 16). Although the ribbon reefs appear to have a thin veneer of Holocene reef growth they are also in a high energy environment which does not permit accumulation of reef top sediments. However on Nymph Island a similar shallow unconformity but a lower energy environment is reflected in extensive reef flat development and subsequent cay, rampart and mangrove cover. A comparison between a similar situation at Bewick reef to the north and Wheeler Reef off Townsville with a much deeper unconformity was made by Harvey (1978). He concludes that the ephemeral cay on Wheeler Reef and lack of cemented deposits reflect a juvenile reef compared with Bewick which has a shallower unconfirmity.

Similar conclusions have been made by Stoddart from the northern reefs (Stoddart *et al* 1978) and by Davies (1977) and Davies *et al* (1977) from the southern reefs. Where the pre-Holocene surface is deep, inundation during the Holocene transgression took place when the rate of sea level rise was rapid (up to 10 mm/year), probably twice the maximum rate of possible upward reef accretion. Thus reefs with pre-Holocene surfaces at c -20 m would have been inundated about 9500 years BP, and (based on upward growth rates of about 5 mm/year) reached modern sea level by 5500 years BP, probably 1000 years after modern sea level was actually achieved. Deeper surfaces would have reached present sea level later, leaving less time for reef flat development, whilst shallower surfaces would reach modern sea level relatively earlier, possibly growing upwards at the same rate as the latter part of the transgression at about 5 mm/year. Such reefs, like Nymph or Low Wooded Island would develop reef flats very early, allowing formation of cays, ramparts and mangrove swamps. As the degree of reef flat development and cover of sediments apparently decreases eastwards across the shelf from the low wooded islands, to the sandier reef tops, to the submerged reefs, the implications are that the pre-Holocene surfaces beneath reefs deepen seawards. This may be so although no evidence is yet available. Other factors which need to be acknowledged are variations in apparent sea level curves, and the influence of turbidity produced by removal of the pre-Holocene regolith, as discussed above.

The exact nature of the sea level rise is of great importance to reef development because of the relationship between reef accretion rates and the depth to the pre-Holocene platform. This will be especially so where the pre-Holocene surface is shallow and the upward growth of the reef will have closely followed the rise in sea level. All other factors being equal, reef flat development would be expected to be greater where modern sea level had been achieved earlier. Sufficient radiocarbon dates are available for the northern Great Barrier Reef to indicate the significance of the sea level factor.

On the low wooded islands to the south of Cape Melville is evidence again with numerous radiometric dates for a sea level marginally higher than present (c + 1.0 m). Evidence comes in the form of:

i) the high terrace levels of the cays;

ii) the level of the higher platform;

iii) levels of fossil micro-atolls;

iv) levels and morphology of beach rock outcrops.

The evidence has been discussed by McLean *et al* (1978) who, within the limitations of the types of evidence used, conclude that on the low wooded islands,

i) modern sea level was achieved prior to 6000 years ago and was marginally higher than present by 5000 years ago;

ii) by 4900 years sea level was even higher;

iii) by 3000 years BP the outlines of leeside cays and windward ramparts were established. Much of the evidence for higher sea levels greater than 1.0 m above present give dates of 3200-3800 years BP.

iv) between 2000 and 3000 years BP sea level gradually fell;

v) sea level has probably not varied greatly over the last 2000 years.

Evidence of former sea levels on the outer reefs is generally lacking. A date of 1180 ± 65 years BP (ANU 1551) for a *Tridacna* incorporated in beach rock and overlain by phosphatic sandstone gives a minimal date for island and reef flat accumulation at modern sea level. More significant are dates from Carter Reef (Hopley 1977) and from Lark Pass Reef (Hopley 1978) (see Table 11).

Clearly on the outer reef modern sea level had been achieved by or shortly after 6000 years BP, possibly only a few hundred years later than on inner reefs. Thus previous suggestions that higher sea level evidence on inner reefs was due to the very recent growth of the outer ribbons and their effects on tides (ie reducing tidal range) are no longer tenable. Shelf warping normal to the coastline appears to have been minimal although outer reefs bear no evidence of higher sea level evidence. In terms of the northern reef as a whole, however, it must be concluded that regional Holocene sea level variations have been minimal and that contrasts in the degree of reef flat development are due to other factors, most probably the depth to the pre-Holocene surface being the most influential.

2. Responses to prevailing environmental conditions

As modern sea level was achieved by 6000 years ago and has not varied significantly since (within 1-2 m), and as the majority of pre-Holocene reef platforms appear to be within 20 m of present sea level, the majority of reefs have had sufficient time to grow upwards and reach modern sea level, converting upward growth to vertical accretion and reef flat formation with infilling of central reef flat lagoons. Further, on the linear outer reefs it would appear that an equilibrium state has been achieved in the manner suggested by Kinsey and Davies (in press) in which, once a reef flat of c 400 m width has been achieved further widening of the flat is unlikely as production and loss of calcium carbonate are balanced. There is therefore an explanation for the more or less constant width of the reef flats of the ribbon reefs.

Of the prevailing environmental conditions to which the reef flats have responded, by far the most influential is the predominance of sediment moving waves from the south-eastern quarter. The reef organisms themselves have responded and it is mainly in the windward sides that "hard line" reef development is greatest. Coarser, less mobile sediments have accumulated on the windward reef margins in the form of ramparts, and shingle banks, whilst more mobile sediments have accumulated over the inner reef flats or as cays on the leeward edge at the point of intersection of refracted wave trains. Variation exists, however, in the intersection points of these waves and short term modifications to even vegetated cays are constantly taking place. From the results of the 1973 expedition, long term changes in the cays appear to be towards a reduction in size.

Tropical cyclones, with their high wind speeds and higher than normal sea levels produced by storm surge are also influential in developing reef top features. Boulder zones and reef blocks are certainly deposited during cyclones whilst many of the high shingle accumulations are also initiated during such storms and only modified during normal south-easterly weather. Hopley and Harvey (1978 in press) indicate that both cyclone frequency and intensity and storm surge risk is low along the northern Great Barrier Reef and generally reduces northwards. Nevertheless extremely intense cyclones with high storm surges can be experienced. The 1899 Bathurst Bay cyclone (Whittingham 1958) had a central pressure of 915 mb. Its reported 12.2 m surge is greatly exaggerated. The remnants of former cays, now seen as only outlines in beach rock on reefs just to the north of this region, are adequate testimony to the effect which cyclones may have on reef islands.

CONCLUSIONS

The zonation of reefs and islands noted at the start of this report is the result of variations in the depth and nature of the pre-Holocene surface, the nature of the Holocene sea level rise and the response of the reefs and reef organisms to this rise and to prevailing environmental conditions. The low wooded islands result from generally shallow pre-Holocene platforms and a long period of sea level at or close to its present position. Slightly higher sea levels are also responsible for some features. An exposure factor, as discussed by Stoddart (1965) may also be involved. Declining reef tops to the east may represent deeper pre-Holocene platforms combined with the rapid rise of the Holocene transgression through the -35 to -15 m levels. High turbidity levels at time of intial submergence may be a related factor in the lack of development of mid-shelf reefs and the complete lack of Holocene reef on the karstified surfaces of the outer shelf shoals. The ribbon reefs have developed on a pre-Holocene rim, which together with a comparatively long period of sea level stability (5000 years +) has allowed the reefs to develop in equilibrium with prevailing conditions.

A number of geomorphic factors have implications for management of the northern Great Barrier Reef.

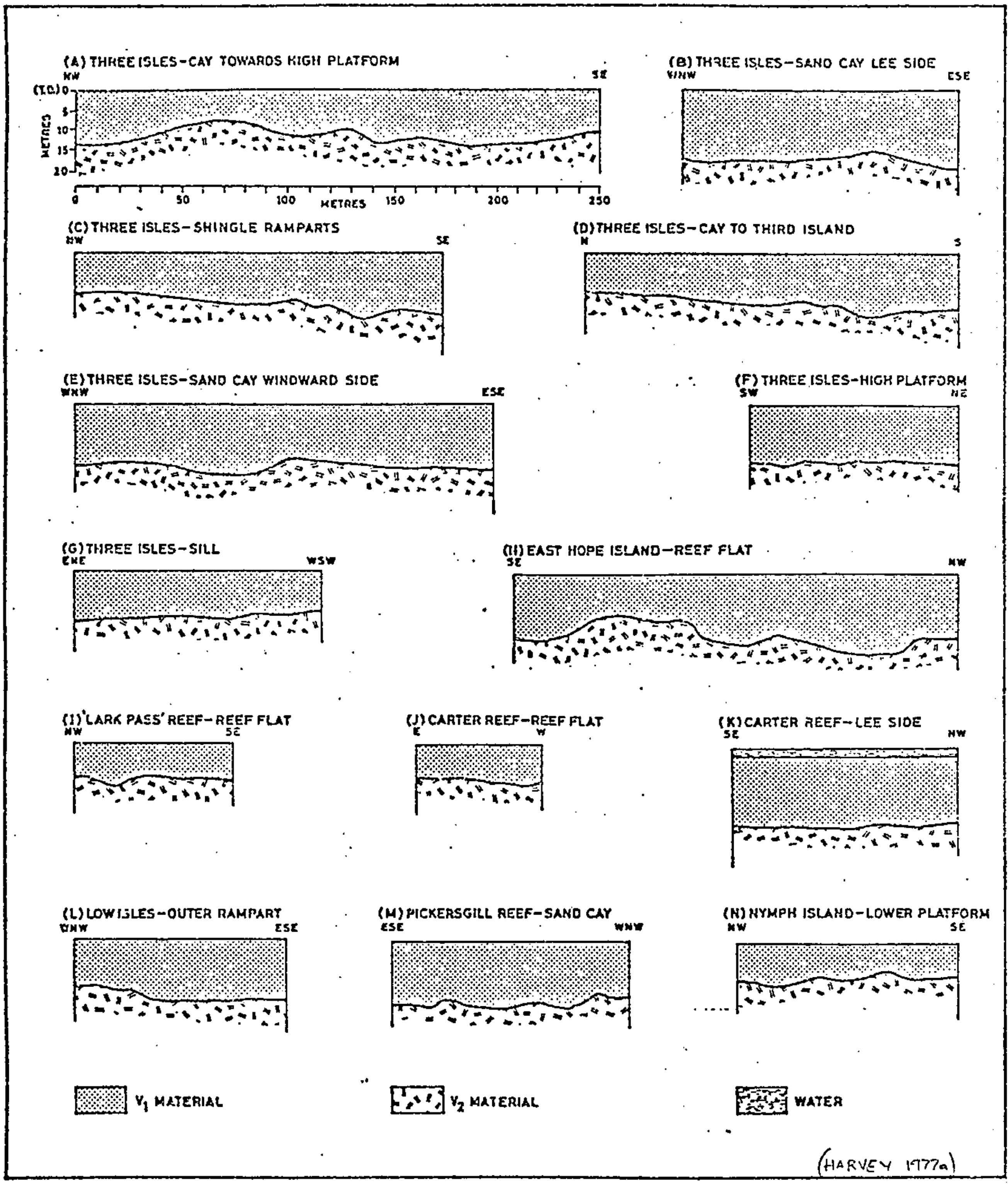
1. Largely because of variations in the depth of the pre-Holocene surface, the reef tops display a series of different stages of development. Lack of corals in a reef top may not indicate the effects of ***Acanthaster planci*** or man but result from a long period of reef flat development. However, other reefs just changing from essentially vertical to lateral accretion may be in a critical state of balance which will make them vulnerable to such influences.

2. Although the risk from cyclones and storm surges is much reduced on the northern reef, a certain degree of risk is still present. Cyclones may completely remove sand cays.

3. Sand cays are constantly undergoing modification in response to minor changes in wind and waves. Construction should take this into account and lower terrace levels especially should be avoided. The higher terrace is the most stable area of the cay. Unvegetated sand cays may migrate several hundred metres, and provide no permanent base for navigational or research platforms. It is notable that most cays over the last 50 years have been reducing in area.

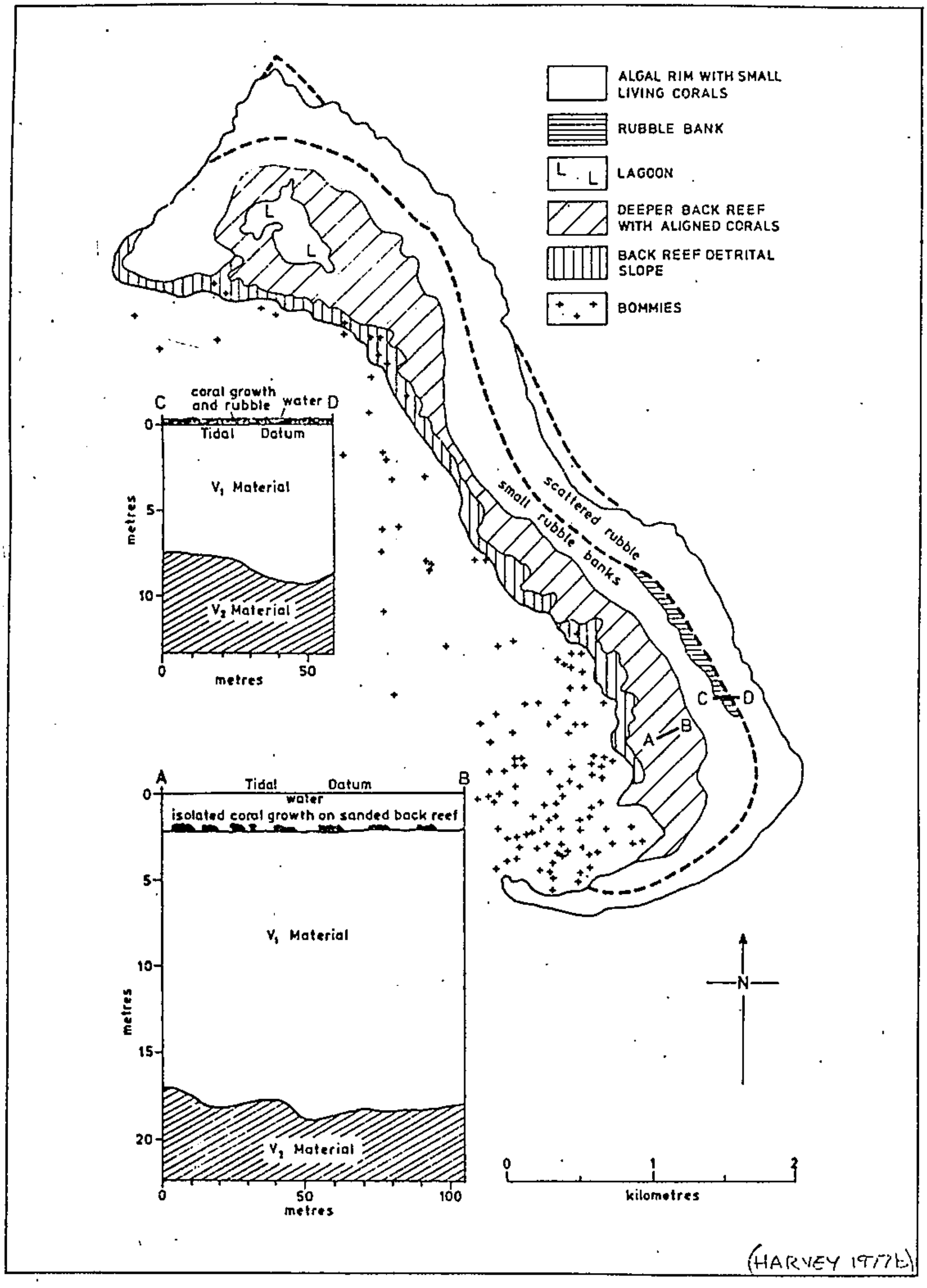
TABLE II

GaK-6477	Carter Reef	0.70 m below reef top	5420 ± 130 yrs BP
GaK-6478	Carter Reef	1.40 m below reef top	5750 ± 130 yrs BP
GaK-6479	Carter Reef	0.05 m below reef top	3760 ± 100 yrs BP
GaK-6480	Carter Reef	0.55 m below reef top	5800 ± 110 yrs BP
GaK-6481	Carter Reef	0.10 m below reef top	4480 ± 100 yrs BP
GaK-6482	Carter Reef	0.50 m below reef top	4870 ± 120 yrs BP
GaK-6681	Lark Pass Reef	0.08 m below reef top	4940 ± 140 yrs BP
GaK-6682	Lark Pass Reef	0.50 m below reef top	4040 ± 130 yrs BP
GaK-6683	Lark Pass Reef	0.14 m below reef top	4910 ± 110 yrs BP
GaK-6684	Lark Pass Reef	1.30 m below reef top	5720 ± 130 yrs BP



(HARVEY 1977a)

Figure 1 : Seismic profiles, Northern Great Barrier Reef.



(HARVEY 1977b)

Fig. 2: Seismic transects: Carter Reef

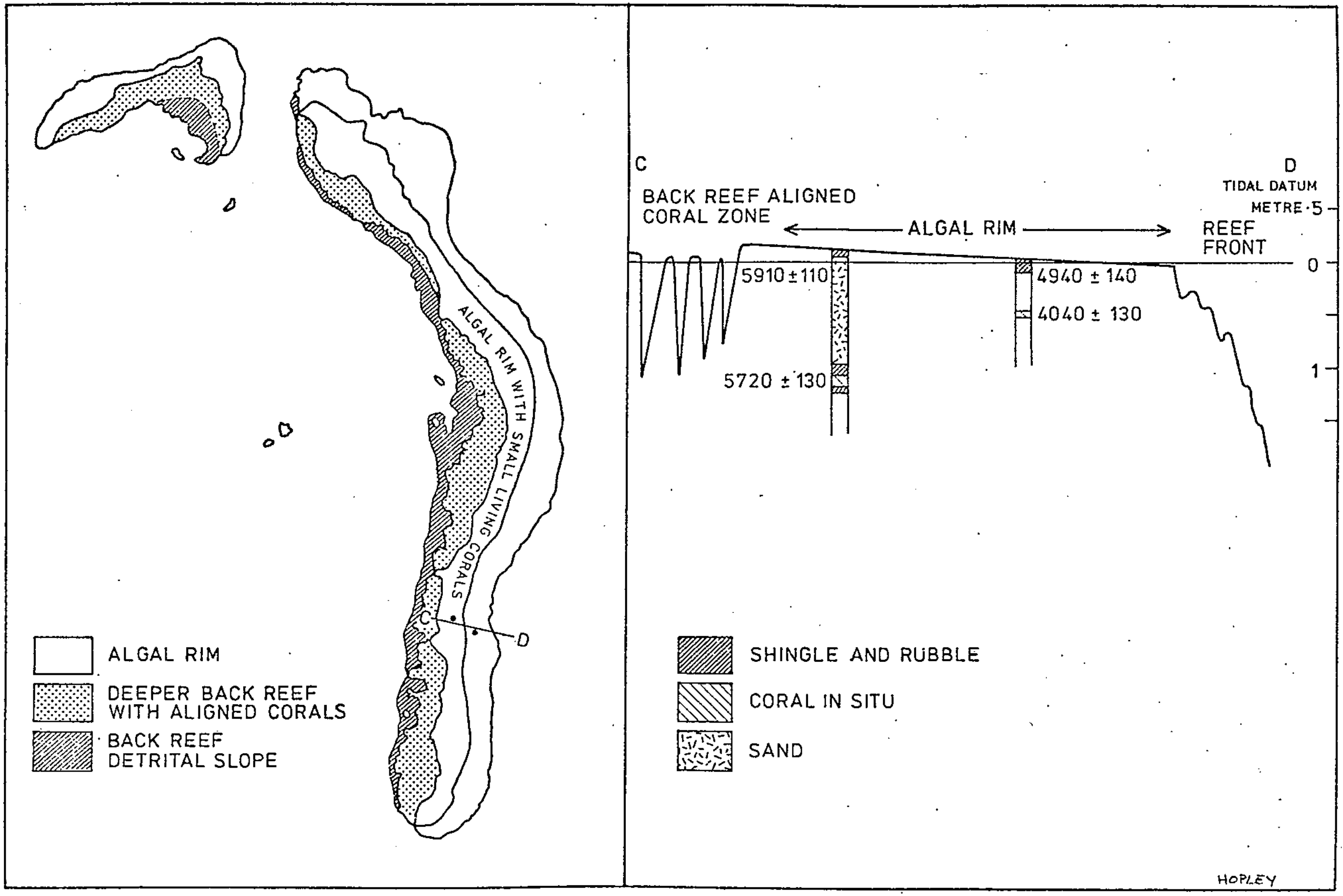


Figure 3: shallow drilling, 'kirby' ribbon reef

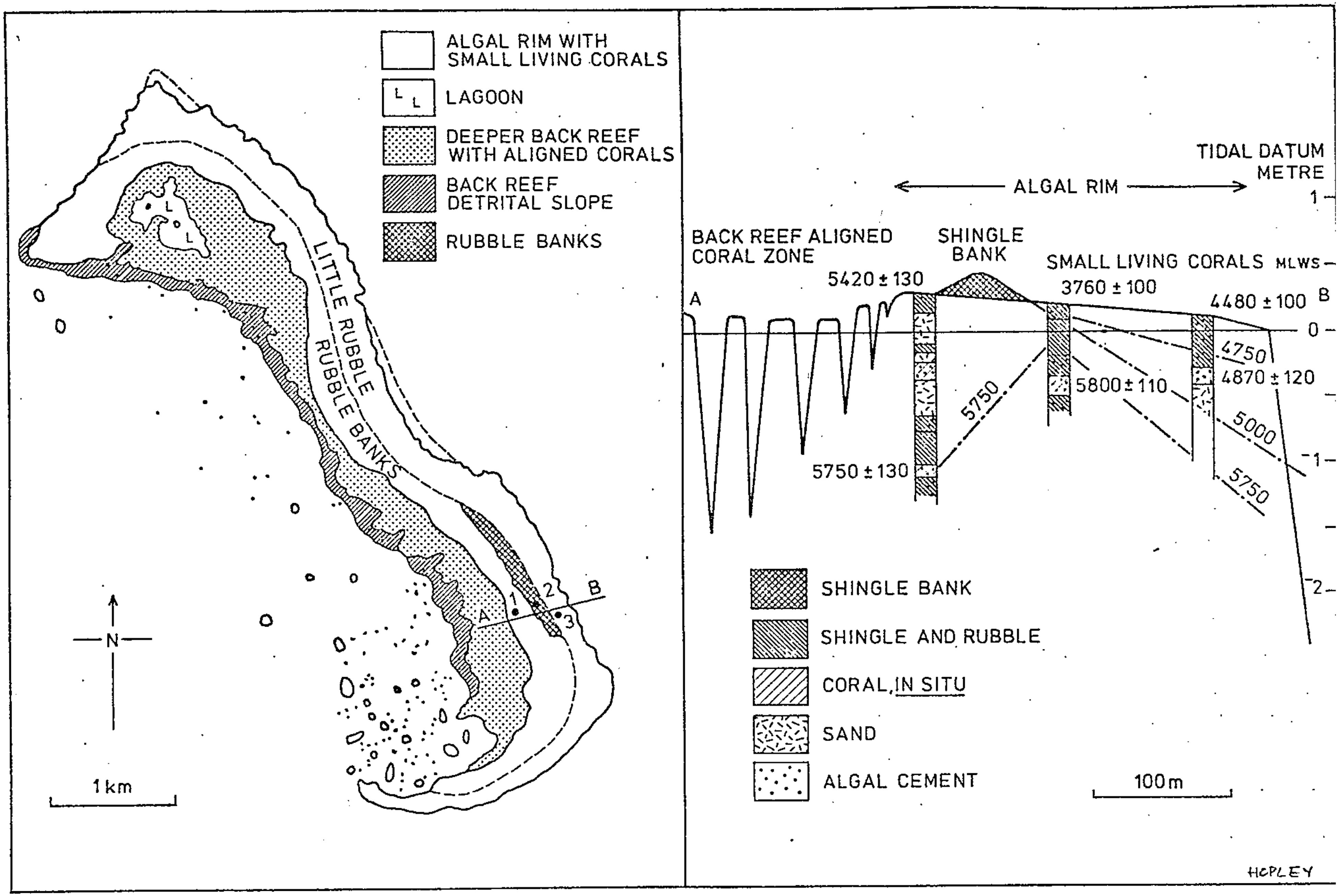
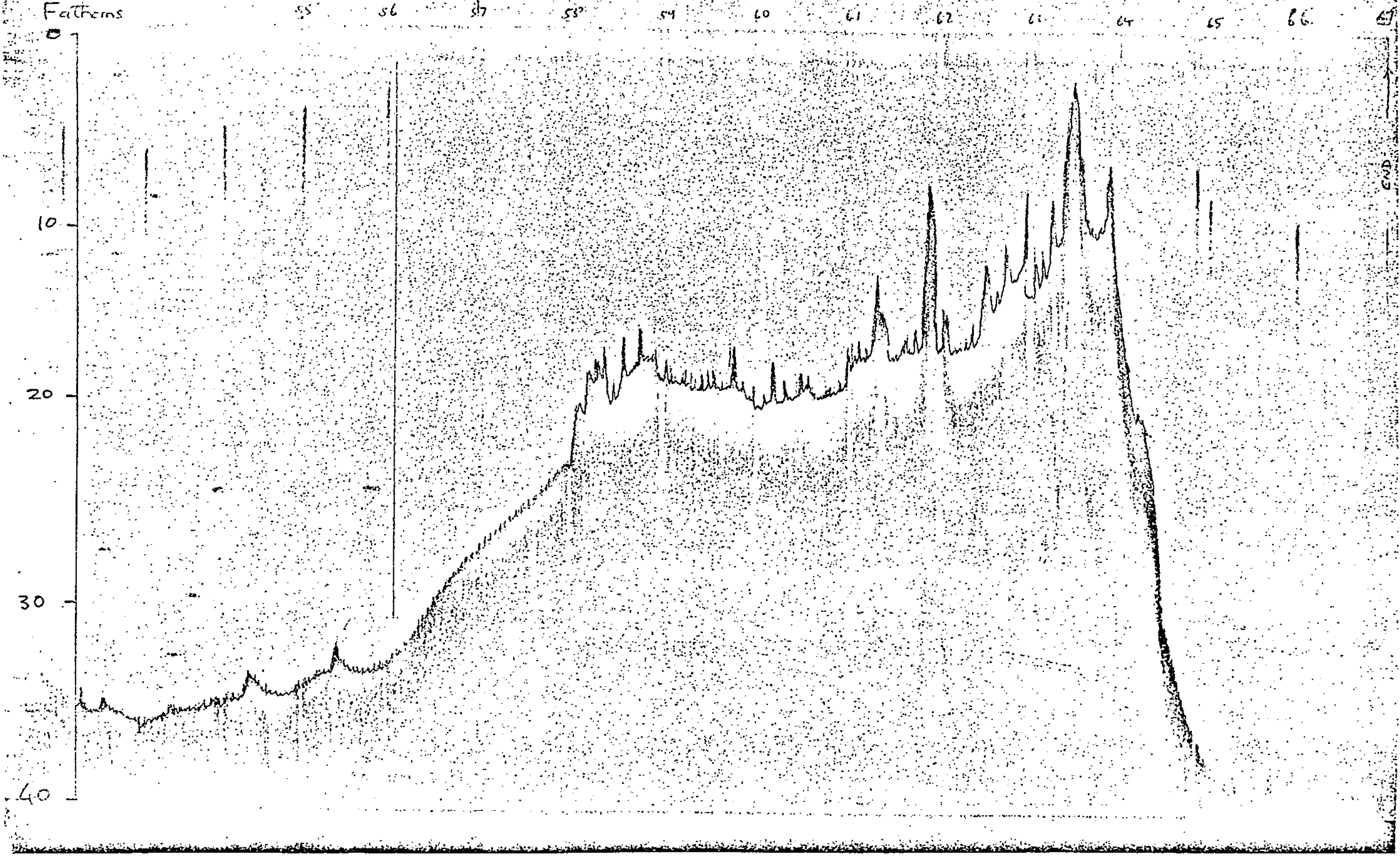


Figure 4: shallow drilling, Carter ribbon reef

(Figure 5) echogram across RAAF shoal.



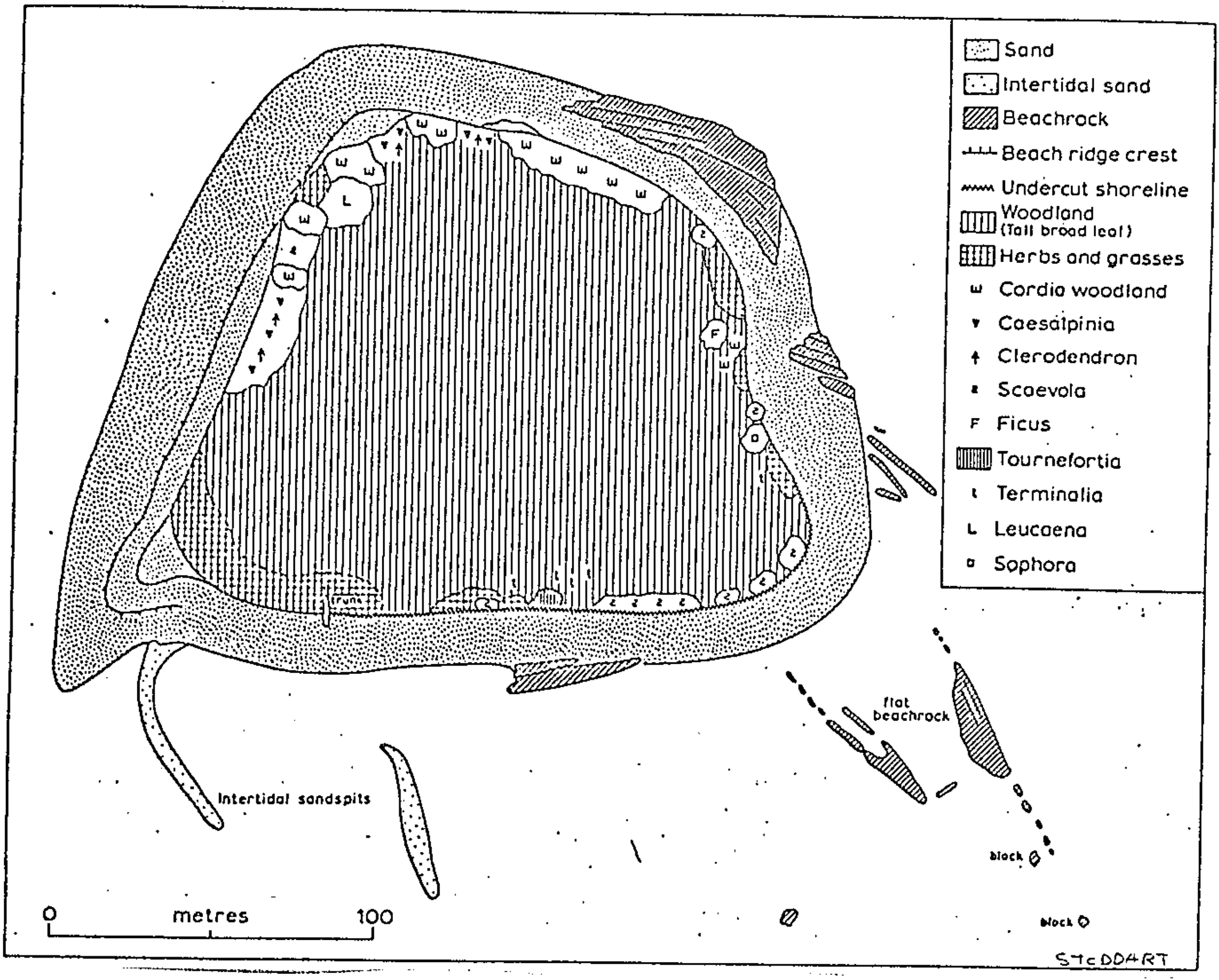


Fig. 6. A vegetated sand cay: East Hope, 1973.
(From Stoddart, McLean and Hopley, 1978)

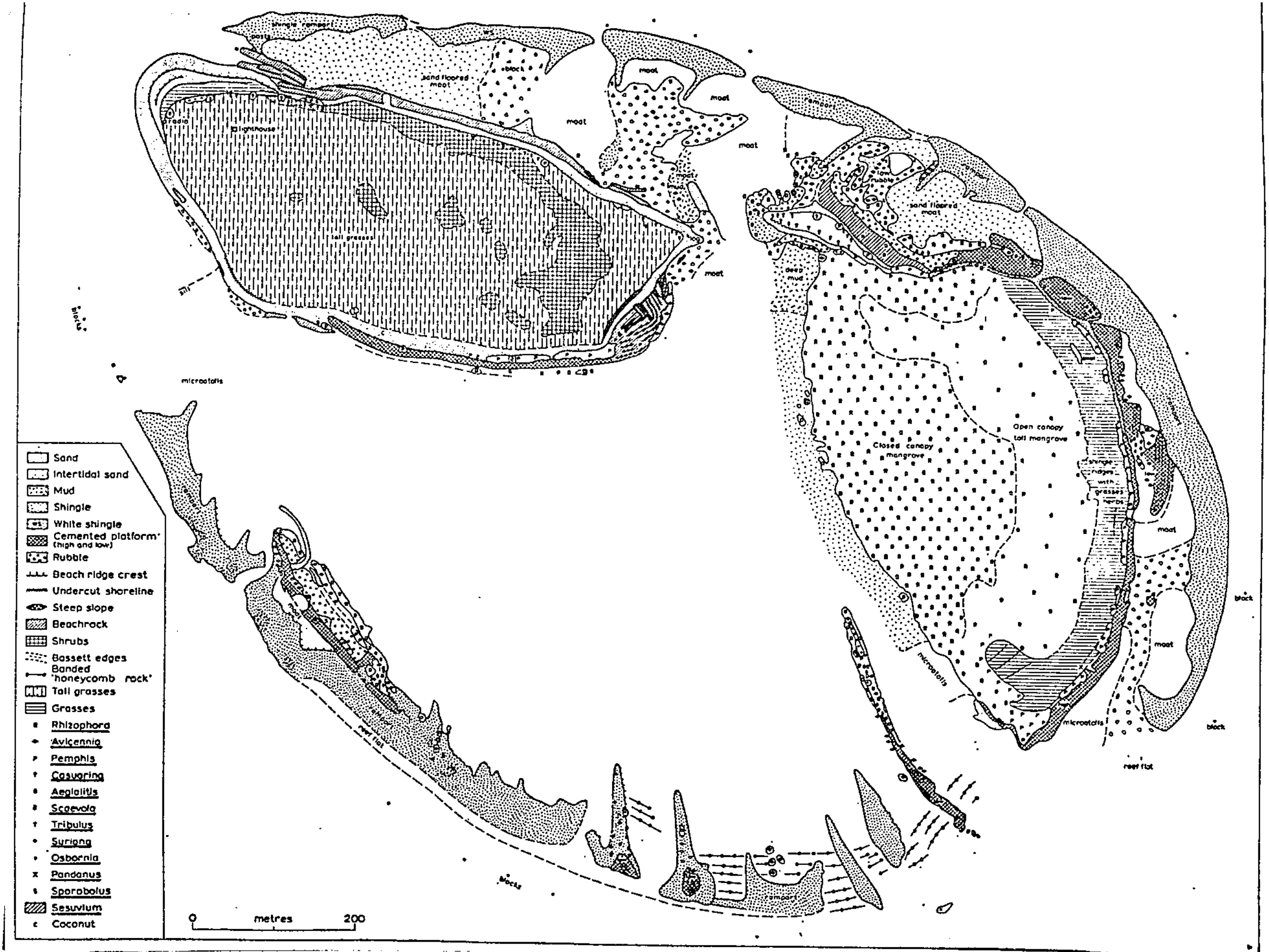


Fig. 7. Three Isles, 1973.
(From Stoddart, McLean, Scoffin and Gibbs, 1978)

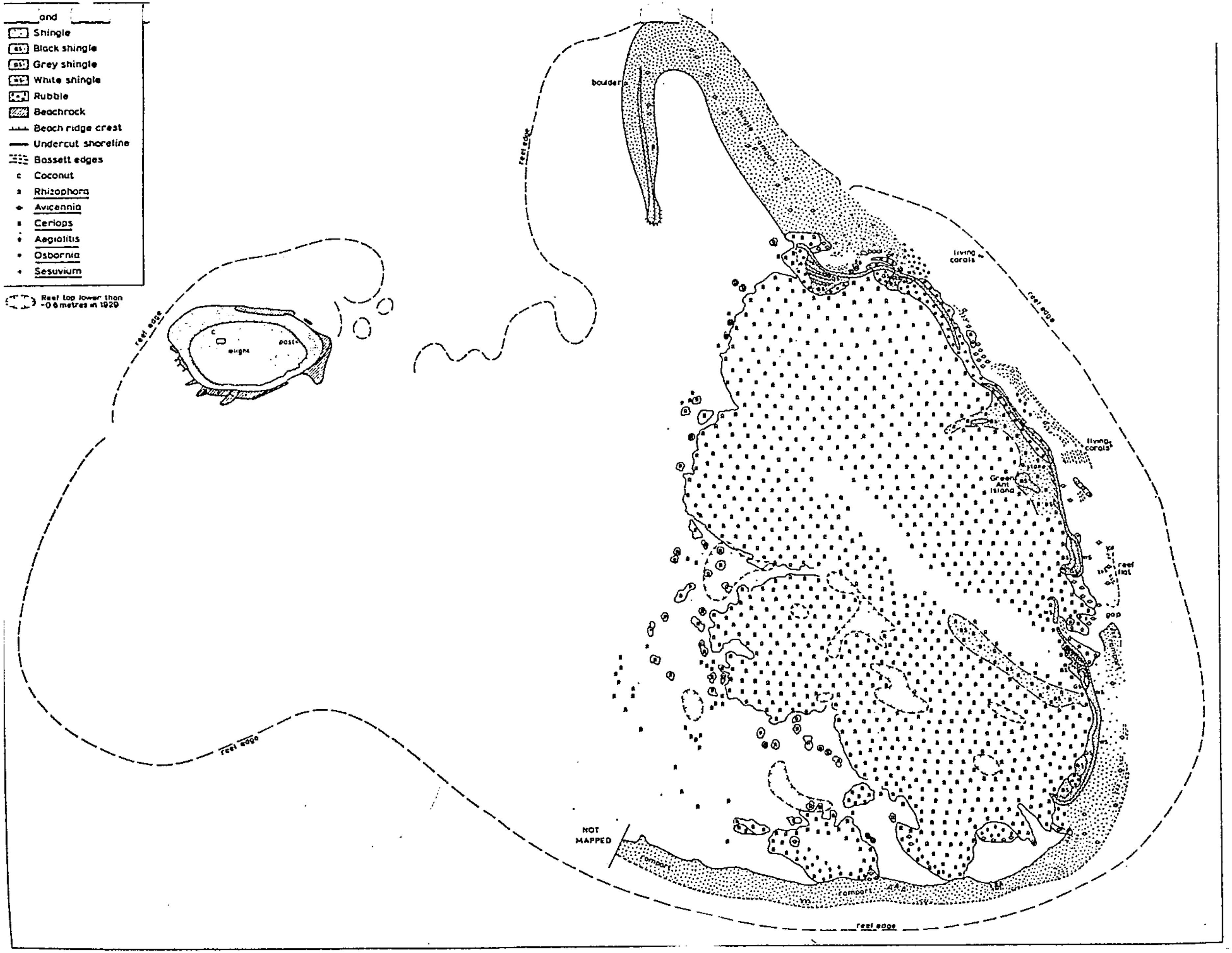


Fig. 8. Low Isles.1973. (From Stoddart. Mclean, Scoffin and Gibbs, 1978).

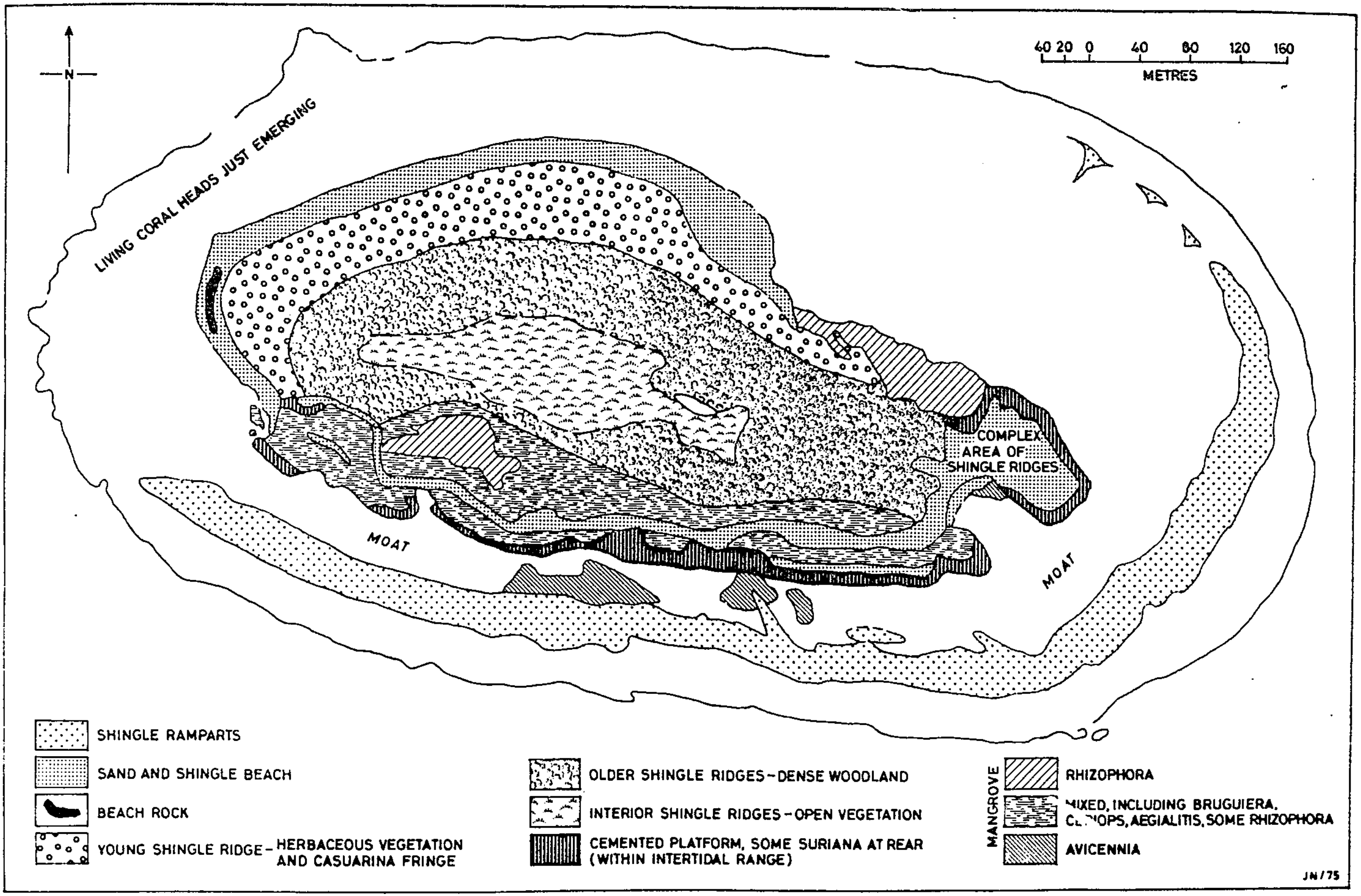
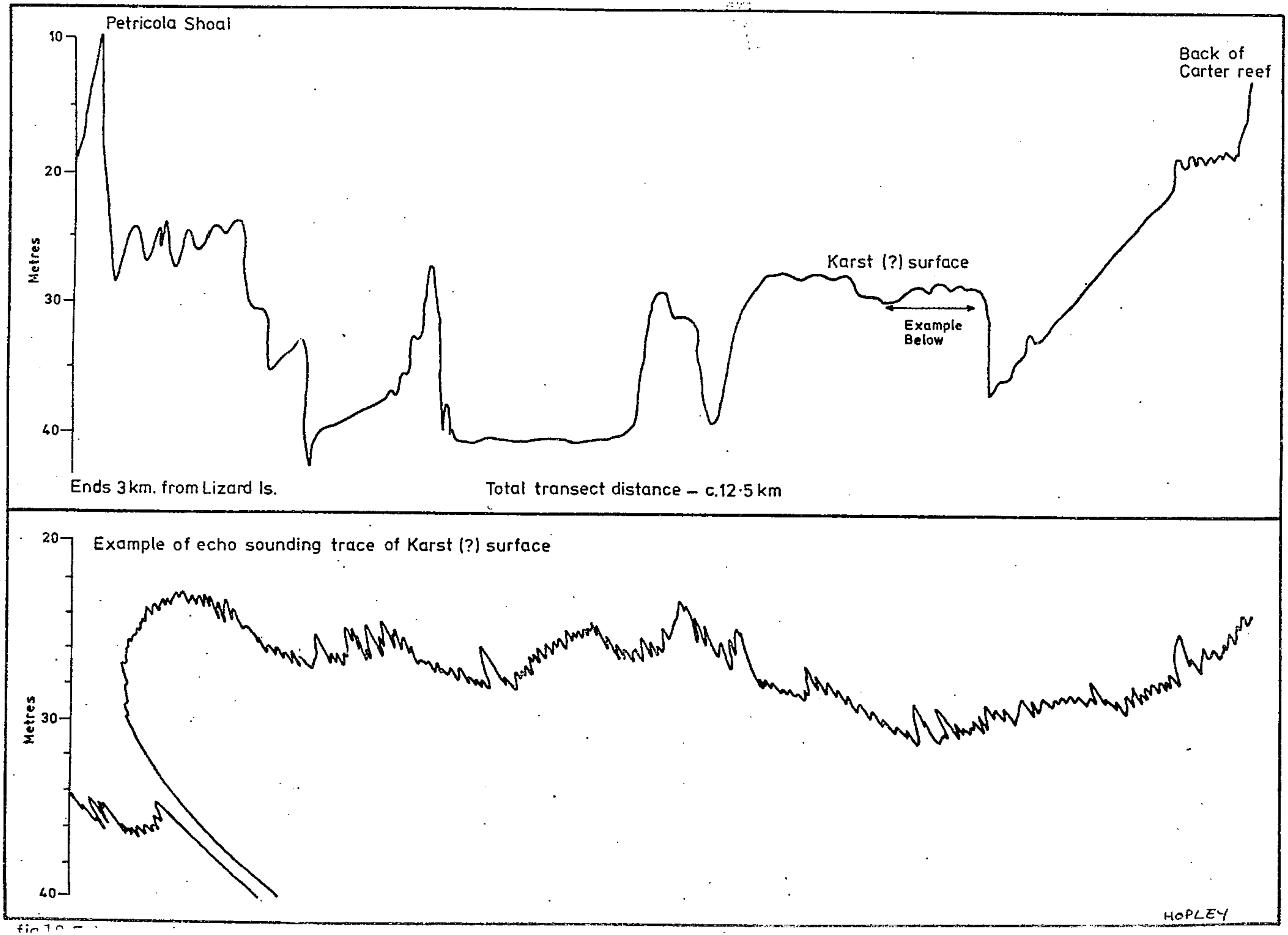
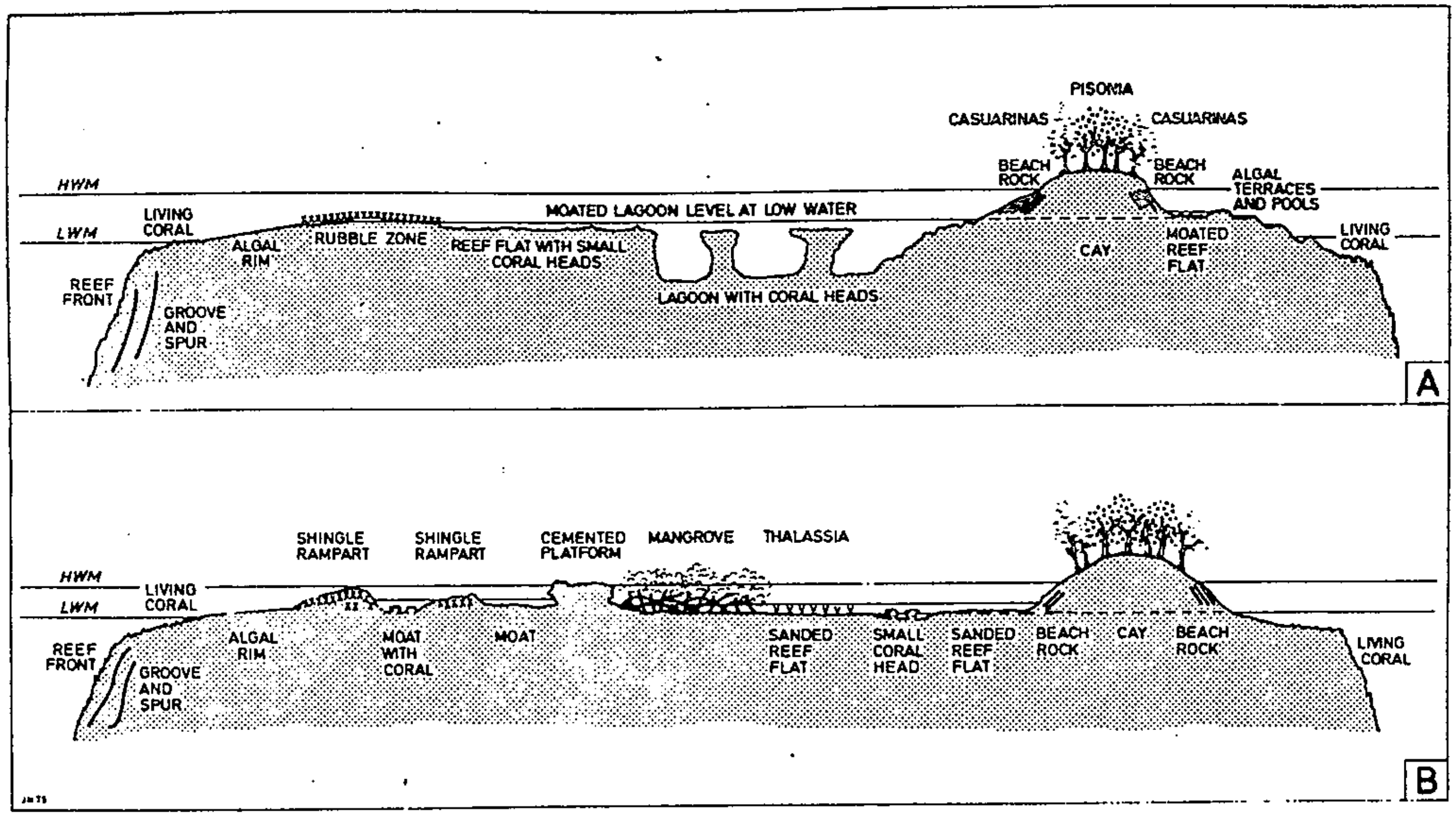


Fig. 9. Turtle I (Hopley)


Petricola Shoal
Back of Carter reef
Karst (?) surface
Example Below
Metres
10
20
30
40
Ends 3 km. from Lizard Is.
Total transect distance – c.12·5 km
Example of echo sounding trace of Karst (?) surface
Metres
20
30
40
HOPLEY



Diagrammatic cross-section of lagoon and low-wooded island reefs of the Great Barrier Reef showing spatial relationships of morphological and ecological zones

REEFAL SEDIMENTS OF THE GREAT BARRIER REEF BETWEEN INNISFAIL AND LIZARD IS.

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INTRODUCTION

This paper provides a summary account of knowledge concerning the unconsolidated sedimentary deposits which occur on reefs within that area of the Great Barrier Reef between Innisfail and Lizard Island (see Fig.A2, p.14). Detailed sedimentological studies of both subtidal and reef-top accumulations are contained in the published works of the 1928-29 and 1973 Expeditions to the Great Barrier Reef (Steers, 1930; Marshall and Orr, 1931; Flood and Orme, 1977; Flood and Scoffin, 1978; McLean and Stoddart, 1978; Orme, Flood and Sargent, 1978) and in unpublished research theses at the Department of Geology and Mineralogy, University of Queensland (Greenfell, 1974; Flood, 1978a).

Within the area of the Great Barrier Reef between Innisfail and Lizard Island (approximately 17°30'S and 14°30'S respectively) reefs may be catagonized as belonging to one of five main types, viz.

1. shelf-edge ribbon reefs (north of Trinity Opening),
2. shelf-edge platform reefs (south of Trinity Opening),
3. mid-shelf platform reefs,
4. inner-shelf low wooded island reefs, and
5. near-shore reefs of the mainland and continental islands.

Unfortunately, to date, published information is not available for sediments occurring on the first three types. However, these notes are based upon the author's observations of the sediments and sedimentary deposits occurring on the following reefs: fringing reefs on Double Island, Lizard Island, and Conical Rock; low wooded island reefs on Low Isles, Three Isles, Two Isles, and islands of the Turtle Group; mid-shelf platform reefs such as Green Island, Arlington, Michaelmas, Pickersgill; and shelf-edge ribbon reefs such as Yonge and Carter Reefs.

The perfunctory nature of the knowledge regarding reefal sediments will be obvious; long-range co-ordinated research is needed to quantify the nature of sediment sources, transport, and accumulation on all these reefs before any meaningful statement could be made concerning man's impact on the reef ecosystem.

SEDIMENTARY DEPOSITS

Traversing the reef from the windward side to the leeward side, the following sedimentary deposits may be encountered:

(a) Windward reef-slope deposits which consist predominantly of detritus of branching corals and minor proportions of dish-shaped corals and foraminifera. The former are deposited *in situ* whereas the latter are washed from the reef top on the ebbing tide. The composition of this talus slope accumulation is similar to that occurring in the shingle ramparts. These deposits rarely extend greater than 0.5 km from the reef.

(b) Shingle islands, ramparts and spits which occur on the windward reef rim of the mid-shelf to near-shore reefs consist of *Acropora* branches which are fragmented and deposited during cyclone activity. Subsequently the moulding action of waves produces large asymmetrical ridges (or called ramparts if they are continuous) 50 to 100 m in wavelength and 0.5 to 3 m in amplitude. The outer slope of the shingle deposit is usually less than 5° and the inner slope is as great as 60°. The inner margin of the ridge is often cuspate shaped with tongues of steeply banked shingle projecting onto the reef flat surface. Commonly several sets of ramparts occur on an individual reef and seawater may be ponded between adjacent sets forming moats at low tide. The shingle deposit may be emergent at high water spring tides and then it is referred to as a shingle island. Sediment consists predominantly of branching coral sticks (mainly *Acropora*). These rod-shaped clasts are moderately to well sorted. The obvious source is the coral thickets which grow in the windward reef slope. Reworked fragments of the cemented rampart-rock are a minor constituent. Other branching coral forms including *Porites, Seriatopora* and *Pocillopora*, and rounded corals especially Faviidae also occur. The stabilized shingle deposits are a dull grey whereas corals of the active beach shingle are brilliant white. This is related to post-depositional modification by algae.

(c) Reef-flat sediments on the mid-shelf to near-shore reefs are normally only a few centimetres thick, whereas, they are absent from the surface on all but the largest shelf-edge reefs. Typically there is a concentric variation in the sediment thickness across the reef flats and it is this variability which produces the marked concentric zones of algal vegetation. *Thalassia* grass and some algal species live only where the sediment thickness is greater than 5 cm. Compositionally the sediments consist of grains of coral, benthic Foraminifera, *Halimeda*, molluscs, and green and red calcareous algae. The coral sand is supplied by the mechanical and biological breakdown of corals growing mainly on the windward reef slope. Benthic Foraminifera grow attached to the soft plants which frequent the reef flat. *Marginopora* is particularly abundant on *Thalassia*, whereas, *Baculogypsina* and *Calcarina* occur in vast quantities attached to the short fronds of *Laurencia* alga. These reef-flat sediments are sand-sized and moderately to poorly sorted. The grains can be whole or broken, angular to subrounded, and occasionally are polished.

(d) On the low wooded island reef types mangroves may colonize the sheltered leeward size of the shingle deposits. The sand and silt sized sediment which is moving across the reef flat may be trapped and immobilized within the mangrove area. Organic mud, produced by the decay of the mangrove vegetation, extends only a short distance away from the leeward fringe of the living trees. Parts of this muddy environment appear to be a favourable locality for *Thalassia*, molluscs, and *Halimeda*. Considerable *in situ* additions of biogenic skeletal carbonate may be found within the mud. On several reefs it can be observed that mangrove sediments and vegetation are prograding across the reef surface towards the leeward sand cay. In some instances the mangroves have completely surrounded a pre-existing cay (e.g. Low Wooded Island). These reefs, as well as the nearshore reefs of the mainland, are situated within the zone of influence of terrigenous mud; however, the percentage of terrigenous mud rarely exceeds 15% (notable exceptions are the fringing reefs south of Port Douglas).

(e) Blanket sands of the reef flat on mid-shelf platform reefs and fringing reefs occur to leeward where the sediment has accumulated. These deposits are sufficiently thick (> 5 cm) as to be mobile. Asymmetrical sand ripples form under the action of bed-load transportation associated with the wave action. These sediments differ from the normal reef-flat sediments by being well sorted, and the grains are often well rounded.

(f) Cays may develop towards the leeward reef flat of the mid-shelf platform reefs where opposing sets of refracted waves converge. The intertidal sediment bodies may become a morphologically coherent accumulation emergent above high water spring tides and a cay is formed. Several distinct cay types may be recognized; sand cays, sand/shingle cays, and composite cays. The sand cays may be either unvegetated, with or without beachrock, or vegetated with beachrock. The former types are located on the large reefs possessing shallow lagoons (e.g. Pickersgill Reef); the latter are located on lagoonless reefs (e.g. Turtle Islands). In spite of the range of variability of size, shape, vegetation developments, etc., these cays display a homogeneity of sediment composition consisting of skeletal detritus derived from the reef rim and reef flat. The percentage contribution of the various skeletal types differs on different islands suggesting that each reef possesses a unique biota (as is the case with the reef flat sediments). Also the component composition of the island sediments has changed throughout the history of their development. This presumably reflects the changing nature of the reef biota related to change in the physiographic/depositional environment.

(g) Boulder tracts on the windward side of the shelf-edge reefs or on the leeward reef rim occur as isolated boulders or may be so numerous that they form a continuous deposit. Each boulder is normally one coral colony (usually *Porites*) which formerly grew on the leeward reef slope in relatively shallow water (< 10 m). The boulder-sized coral heads are cast up onto the reef rim during storms or cyclones. There is no evidence to suggest that the boulders move; successive boulder tracts are separated by shallow moats.

(h) Leeward reef-slope deposits occur adjacent to all reefs except the fringing reefs and consist predominantly of reef-derived medium to very fine sand-size bioclastic sediments and benthic foraminiferans. These particles are transported from the reef flat by both translatory wave action and tidal run-off thereby producing a sediment cone in the energy shadow of the reef. The sediment is usually poorly sorted and rounding of the coarser particles attests to their bed-load transport history. However the very fine sand is frequently angular, having been transported in suspension. This sediment body usually does not exceed 2 km in length measured away from the reef.

(i) The back-reef area of most mainland fringing reefs are now filled with a mixture of biogenic and terrigenous sediment. In fact in many instances the reef growth has ceased owing to the influx of large quantities of terrigenous mud; this occurred long before the advent of agriculture in this region.

COMPOSITION OF THE SEDIMENTS

Reefal sediments consist mainly of five dominant skeletal types; coral, coralline algae, *Halimeda*, benthic foraminiferans, and molluscs. The distribution of skeletal detritus is controlled by either one or a combination of the following;

(a) the distribution and abundance of living organisms,

(b) the susceptibility of the skeletons to mechanical breakdown,

(c) the production of specific size ranges upon breakdown, and

(d) the movement of the skeletal detritus from growth areas to depositional areas under the action of breaking waves, translatory waves, and tidal currents.

Therefore a complex arrangement of compositional types may exist on any one reef. A typical reef-flat sediment might consist of the following: coral 30%, coralline algae 10%, molluscs 10%, *Halimeda* 20%, benthic foraminifera 30%. However, the size of the skeletal particles does appear to present a systematic pattern with a gradual decrease in particle size from coarse sand and gravel (shingle) sizes on the outer portion of the windward side grading to fine sand towards the centre of the reef (lagoons such as those on Pickersgill Reef have a significant proportion of very fine sand and silt sizes). Smaller reefs have coarser sized sediments than the larger ones and this merely reflects the marked decrease in the wave energy available to transport sediment from windward to leeward across the larger reefs.

SIGNIFICANCE OF SEDIMENTOLOGICAL STUDIES

Basic inter-relationships between the stages of reef evolution, biota, sediments, dynamics, and environments may be illustrated, however, subtle departures from the norm do exist. They may be related to:

(a) intensity of cyclonic activity experienced by different reefs from time to time,

(b) different sizes of individual reefs,

(c) influence of terrigenous mud which progressively diminishes across the shelf,

(d) degree of exposure of the reef to the prevailing energy conditions (primarily wave action),

(e) different hydrodynamic behaviour of skeletal carbonate particles of similar size, and

(f) hitherto unrecognized changes in environmental conditions existing during the period of Holocene reef growth.

The author (Flood, 1978b) presented a scheme which attempted to explain the serial changes evident within the morphological development of platform reefs (including the low wooded island type).

Holocene reef morphology is initially controlled by the shape of the pre-existing reef which was exposed to subaerial weathering by the lowering of the sea during the Pleistocene glaciations (see Orme and Flood, 1977). The dissolving action of meteoric water may differentially lower any area on the carbonate platform and subsequent reef growth during the Holocene transgression colonizes the topographic highs on the platforms (antecedent karst theory).

The stage of development of an individual reef is also related to the height of the carbonate platform (i.e. the pre-existing reef) with respect to sea level at the commencement of the Holocene transgression. Reef growth on the higher platforms will reach modern sea level before that on the lower platforms (see Davies 1975; Orme and Flood, 1977).

When reef growth reaches the level of mean low water springs, only then does it interact with the prevailing hydraulic regime as envisaged by Fairbridge (1950) and Maxwell (1968). Subsequent modification is related to; lateral growth which is primarily to leeward (see Scoffin *et al.*, 1978; Davies, 1977), sediment infilling of the lagoons, replacement of the framebuilding organic groups including coral and coralline algae by the epithytic and benthic organic types such as soft algae, Foraminifera, *Halimeda*, and molluscs.

Shingle spits or ramparts are formed on the windward rim of the nearshore reefs (see Scoffin *et al.*, 1978).

Subsequently their less exposed parts are colonized by mangrove vegetation. Pioneer growth occurs on the loose ramparts but later extends onto the sheltered parts of the reef flat and eventually surrounds the leeward sand cay. The "low wooded island" variety represents surficial modifications of either the platform or lagoonal platform varieties (see Spender, 1930).

The changing nature of the skeletal-component composition of the reefal sediments collected from reefs at different stages of morphological development is manifested in the varying percentage contribution made by frame building organisms and epiphytic, sessile, or vagrant organisms. Throughout that period of reef development occurring since post-glacial sea-level rise (i.e. the Holocene Transgression) framebuilders appear to be most important during the initial stage of dominantly vertical growth, whereas, subsequent changes which are related to horizontal modifications consequent upon sediment infilling of lagoons and the formation of sediment bodies upon the reef surface appear to favour an increase in the significance of the organic groups which are substrate controlled. Therefore throughout the past few thousand years sedimentation and the biota have been not only more closely interdependent but critically sensitive to minor perturbations of environmental conditions.

CONCLUSION

Parallelism between reef morphology, stage of reef type development, and the skeletal composition of sediments has been briefly outlined by the author (Flood, 1978c). Recognition of this inter-relationship enables reef development, biota, sedimentation, etc. to be viewed temporally as well as in their present day spatial context. This undoubtedly must have significance to authorities charged with the responsibility of planning the future resource utilization of this part of the Great Barrier Reef. However, further research is urgently needed to quantify the interrelationships which have been documented. Thresholds, effects, and tolerance levels still have to be established for reef types which are subjected to stress. Otherwise the effects of human interference on any reef could be confused with long term evolutionary trends of reef development.

ACKNOWLEDGEMENTS

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LIZARD ISLAND TO INNISFAIL

THE BIOTA OF THE CONTINENTAL LAND/SEA INTERFACE

THE TERRESTRIAL MARGIN

Prior to development, most of the coast from the Bloomfield River south to the Hull River was dominated by vine forest (Anon, 1971). The watershed of the Endeavour River is generally eucalypt forest or woodland. Similar vegetation reaches the coast again south of the Hull and Tully Rivers and extends southward to Townsville. (See Specht, Boughton and Roe, 1974).

THE MANGROVES

Although discontinuous, mangrove communities are a distinctive feature of this coastline. At least 30 species are represented. Areas of mangrove established in current programmes at the Australian Institute of Marine Science are set out in Table III. Further information may be found in a recent review by Saenger, Specht, Specht and Chapman (1977) who list a good deal of the relevant literature.

None of the presently available accounts of the mangroves provide details on their total or local extent. Because this information has basic relevance, an attempt has been made to assemble guiding statistics (Table III) from 1:250,000 survey maps. The figures are only approximate but suggest a total area around 880 km^2 divided into pockets ranging in size from 1 to more than 200 km^2. Indications of extent from Halifax Bay south to Bowen are especially tentative because of the complex intermingling with salt marsh.

Unpublished data from the Australian Institute of Marine Science indicate that net productivity probably may be accepted as lying within the range 16-25 kg.ha^{-1}day^{-1}, equivalent to a regional yield of 0.5-0.8 x 10^6 mt.yr^{-1}. There is an outstanding need to explore the reliability of these predictions.

Although it is clear that the mangroves serve not only to enhance coastal productivity but also provide shelter and breeding grounds for many elements of the marine biota as well as influencing coastal stability, critical assessments in these respects have yet to be undertaken.

The various elements of the fauna associated with the mangroves remain incompletely known. However, Saenger *et al* (1977) provide useful check lists. Their compilation also covers the salt marshes.

SEAGRASSES AND OTHER PLANT COMMUNITIES

It is likely that individual publications on these topics are available. However it has not been possible to locate a synthesis of such information. It is an area of general neglect. Den Hartog (1970) includes the Australian sea grasses in a comprehensive global review of the group. Dr. I. Borowitzka (pers. comm.) has begun a study of the macroalgae associated with mangroves. Endean, Kenny and Stephenson (1956) discuss the macroalgae of the Queensland coast. (The sea grasses and algae of Low Isles have been documented by Dr. A.B. Cribb and are set out below).

Table III

MANGROVE AREAS, COOKTOWN TO INNISFAIL

Mangrove community	Area, km^2
Endeavour R.	13
Annan R.	1
Bloomfield R.	1
Daintree R.	20
Pt. Douglas	1.5
Mowbray R.	13
Trinity Inlet	55
Mission Bay, Cairns	3
Buddabadoo Ck.	4
Russell, Mulgrave R's	7
Bramston Beach	4
Johnstone R.	27
Moresby R.	41
Kurrimine	6
Hull R.	25

REPORT ON TERRESTRIAL BIOTA OF THE ISLANDS OF THE GREAT BARRIER REEF REGION FROM INNISFAIL NORTH TO LIZARD ISLAND

H. Heatwole, University of New England.

INTRODUCTION

The islands in this area for which data are available are Lizard Island, Palfrey Island, Nymph Island, Pethebridge Island, Three Isles and Low Wooded Isle. There is now a research station on Lizard Island and a paper has been published on the vegetation occurring there. The environment of the island is well-known and is not described in detail here.

Palfrey Island is a large, high continental island. The leeward side is covered mostly by grass and boulders with a few scattered shrubs. On the date visited (28th July, 1969) it had been burned off by lighthouse workers several years previously. The windward side was similar but with wind-pruned trees and shrubs in dense thickets and gulleys. Shrubs and trees were on the beach as were herbs and vines. *Pandanus* and a species of palm were not collected.

Nymph Island was different from Lizard and Palfrey Islands in that it was a large sand island rather than a continental, rocky one. It was heavily vegetated, however, and had a diverse biota. Petherbridge Island, Three Isles and Low Wooded Isle are all rather small coral cays.

On each of these islands as much time as possible was spent in making collections of the plants, invertebrates and reptiles. Notes on the avifauna were also made when possible. Because of the short time available on some of the islands complete collections could not be made. The plants, ants and reptiles are considered nearly complete whereas the observations of birds and the collections of the invertebrates are probably less complete.

THE BIOTA

The information on the invertebrates is too sparse to permit a reasonable summary. However the records obtained are listed in the appendices (Part III) of these reports. Lizard Island has by far the most diverse flora which is consistent with the fact that it is the largest in area of any of the islands and is also higher in altitude. It has in addition to various species characteristic of coral cays in the area, a significant number of species found on the adjacent mainland including ferns and flowering plants. Nymph Island also has a very rich flora and in fact has a very high number of species for a coral cay of its size. The flora of Palfrey Island is largely a subset of that of Lizard Island and the vegetation on the small coral cays are primarily species characteristic of such islands; only a few typical mainland species are part of the resident flora.

The reptile fauna is listed in Appendix 3. No reptiles were found on Low Wooded Isle. All of the rest had at least one species. Most of the species on all of the islands are those characteristic of sandy islands and which are widely dispersed in the general region. Lizard Island had the greatest number of species including several forms more characteristic of mainland habitats than of islands.

The avifauna on Nymph and Lizard Islands was surveyed. The numbers of species on the two islands were remarkably similar considering the fact that one is a high rocky continental island and the other one a low sandy coral cay. There were 21 species recorded from Lizard Island and 22 from Nymph. These species are listed in Appendix 3. Not only were the numbers of species similar but their distribution into different ecological types was almost identical; for example there were six species of sea birds on Lizard and five on Nymph; eight species of coastal and shore birds on Lizard and nine on Nymph; seven species of land birds on Lizard and eight on Nymph. Many of the same species occurred on both islands but there was some substitution. Insufficient information was collected in the short time available for the survey to be able to add to what is already known (Kikkawa, 1976; Lavery and Grimes, 1971) of the breeding status of the various species.

More detailed information on the avifauna of this region is set out below.

SUMMARY

The flora and fauna of the islands in the region under consideration are very diverse and include a number of mainland species on the larger islands as well as species typical of insular situations, on all of the islands. A broad range of island type and size in the area provides an ideal situation for studying the effect of such variables on numbers of species and their interactions on islands. A sufficient sample from a given latitude is important in order to be able to make comparisons with the insular situation at other latitudes. One of the real values of the islands of the Great Barrier Reef in terms of basic ecological study is that there are many islands over a wide range of latitudes but which draw upon the same basic source for their fauna and flora (the Australian mainland). There are few archipelagos that have such a wide latitudinal distribution, thereby making it possible to separate out latitudinal effects from other kinds of regional effects.

BIRDS OF ISLANDS BETWEEN LIZARD ISLAND AND INNISFAIL

SEA BIRDS

A total of 23 species of sea bird have been recorded from the reefs and islands of the region. Of these, 12 are known to breed in the area and include the Australian Pelican, Common Noddy, Silver Gull, Caspian Tern, Bridled Tern, Lesser-crested Tern, Crested Tern, Roseate Tern, Sooty Tern, Black-naped Tern.

The number of species recorded, the number breeding (in parenthesis) and the relative status of the major breeding colonies are set out below. The information is from Kikkawa (1976) and Lavery and Grimes (1971) and Heatwole and Goldman (unpublished).

LIZARD ISLAND: 14(8). The only known breeding locality for the Caspian Tern in the region. The Crested Tern is also known to breed here.

PETHEBRIDGE ISLAND: 8(1). One of 15 major breeding colonies of the Bridled Tern on the G.B.R.

ROCKY ISLAND: 2(1). One of seven major colonies of the Black-naped Tern on the G.B.R.

HOPE ISLAND: 4(3). One of 15 major colonies of the Bridled Tern.

PICKERSGILL REEF: 2(1). The Lesser-crested Tern is the only species known to breed on this island. Not a major colony.

LOW ISLAND: 10(5). One of 8 important breeding sites for the Silver Gull and one of 7 important sites for the Black-naped Tern.

WOODY ISLAND: 6(2). One of the seven major breeding sites for the Black-naped Tern on the G.B.R.

MICHAELMAS (OYSTER) CAY: 10(5). One of six major breeding sites for the Common Noddy and one of four for the Lesser-crested and Sooty Terns.

UPOLU BANK: 4(4). One of the six important breeding sites for the Common Noddy and one of four for the Lesser-crested Tern.

NYMPH ISLAND: 5(?).

FRANKLAND ISLAND: 1(1). One of the two recorded breeding sites for the Roseate Tern in the central region of the G.B.R.

Lavery and Grimes (1971) list Michaelmas Cay among the nine most important sites on the G.B.R. for breeding sea birds. Upolu, Low, and Woody Islands are listed among 14 of lesser importance.

LAND AND WATER BIRDS

A complete list of land and water birds recorded from the reefs and islands of the region is given in Kikkawa (1976). Islands with highest bird species diversity include Pethebridge 14(7), Three Isles 10(7), Low Isles 23(9), and Green Island 16(8). Maritime species that breed in the region include the Reef Heron (Three Isles, Hope, Low and Green Islands), White-breasted Sea Eagle (Hope, Low and Green Islands), Red-backed Sea Eagle (Hope Island) and Osprey (Three Isles, Low and Woody Islands).

Records of birds occurring and breeding on certain islands are set out in Tables IV and V.

TABLE IV. ISLANDS WITH BREEDING COLONIES OF BIRDS SHOWING RECORDED SPECIES PRESENT

(Ⓧ = breeding colonies)

FAMILY	SPECIES	Lizard	Eagle	Nymph	Pethebridge	Rocky	Hope	Pickersgill	Low	Woody	Michaelmas	Upolu Bank	Frankland
PROCELLARIIDAE	Wedge-tailed Shearwater *Puffinus pacificus*					X							
PELICANIDAE	Australian Pelican *Pelicanus conspicillatus*	X		X	X		X	Ⓧ					
SULIDAE	Brown Gannet *Sula leucogaster plotus*	X							X		X		
PHALACROCORACIDAE	Little Black Cormorant *Phalacrocorax sulcirostris*				X								
	Little Pied Cormorant *Phalacrocorax melanoleucos*				X								
	Pied Cormorant *Phalacrocorax* sp.			X									
FREGATIDAE	Frigate-bird *Fregata ? minor*	X											
ARDEIDAE	Reef Heron *Egretta sacra*	Ⓧ		Ⓧ			X		Ⓧ				
	Mangrove Heron *Butorides striata*	X		X									
	Large Egret *Egretta alba*			X									
ACCIPITRIDAE	White-breasted Sea-Eagle *Haliaeetus leucogaster*	X					X		Ⓧ				
	Red-backed Sea Eagle						X						
	Osprey *Pandion haliaetus*	Ⓧ		X					Ⓧ				
MEGAPODIIDAE	Scrub-fowl *Megapodius freycinet*	X											
RALLIDAE	Banded Land Rail *Hypotaenidia philippensis*			X									
HAEMATOPODIDAE	Pied Oystercatcher *Haematopus ostralegus longirostris*	X		X									
	Sooty Oystercatcher *Haematopus fuliginosus*	X											
CHARADRIIDAE	Spur-winged Plover *Pluvialis dominica*	X											
	Eastern Golden Plover *Pluvialis dominica fulva*	X	X						X				
	Mongolian Sand-dotterel *Charadrius mongolus mongolus*		X						X				
	Double-banded Dotterel *Charadrius bicinctus*								X				
SCOLOPACIDAE	Grey-tailed Tattler *Tringa brevipes*								X				
	Tattler *Tringa* sp.	X	X	X									
	Knot *Calidrus canutas*		X										
	Red-necked Stint *Calidris ruficollis*	X											
	Bar-tailed Godwit *Limosa lapponica baueri*								X				
	Turnstone *Arenaria interpres interpres*	X	X						X				
	Whimbrel *Numenius phaeops*		X										
	Eastern Curlew *Numenius madagascariensis*	X		X					X				

BURHINIDAE	Beach Stone Curlew *Orthorhamphus magnirostris*	Ⓧ		X									
LARIDAE	Caspian Tern *Sterna caspia*	Ⓧ					X	X	X				
	Black-naped Tern *Sterna sumatrana*	Ⓧ	Ⓧ	X	X	Ⓧ			Ⓧ	Ⓧ	X		
	Silver Gull *Larus novaehollandiae*	Ⓧ	X	X	X		X		X	X	X		
	Roseate Tern *Sterna dougallii*	X	Ⓧ										Ⓧ
	Crested Tern *Sterna bergii*	Ⓧ	Ⓧ	X	X	X			X	X	Ⓧ	Ⓧ	
	Lesser Crested Tern *Sterna bengalensis*	X	Ⓧ				Ⓧ	Ⓧ	Ⓧ	X	Ⓧ	Ⓧ	
	Little Tern *Sterna sinensis*				X				X		X		
	Sooty Tern *Sterna fuscata nubilosa*								Ⓧ		Ⓧ	Ⓧ	
	Bridled Tern *Sterna anaethetus anaethetus*	Ⓧ	Ⓧ		Ⓧ		X		Ⓧ	Ⓧ	Ⓧ		
	White-capped Noddy *Anous minutus*	X									X		
	Common Noddy *Anous stolidus*	X		X						X	Ⓧ	Ⓧ	
	Eastern Common Tern *Sterna hirundo longipennis*								X				
	Gull-billed Tern				X								
COLUMBIDAE	Torres Strait Pigeon *Ducula spilorrhoa spilorrhoa*	Ⓧ							Ⓧ				
	Purple Crowned Pigeon *Ptilinopus superbus superbus*								Ⓧ				
	Nutmeg Pigeon *Myristicivora spilorrhoa*	X		X									
	Green-winged Pigeon *Chalcophaps indica chrysochlora*	X		X					X				
	Bar-shouldered Dove *Geopelia humeralis*	Ⓧ		X					Ⓧ				
	Red Crowned Pigeon *Ptilinopus regina*	Ⓧ											
CUCULIDAE	Pheasant Coucal *Centropus phasianinus*	X											
ALCEDINIDAE	Kingfisher *Halcyon* sp.	X		X					X				
MEROPIDAE	Rainbow Bird *Merops ornatus*	X											
CORACIIDAE	Dollar Bird *Eurystomus orientalis*	X											
CAMPEPHAGIDAE	Cuckoo Shrike *Coracina* sp.	X		X					X				
	Black-faced Cuckoo Shrike *Coracina novaehollandiae*	X											
MONARCHIDAE	Satin Flycatcher *Myiagra cyanoluca* (spp. not definite)	X											
GRALLINIDAE	Magpie-lark *Grallina cyanoleuca*								X				
ZOSTEROPIDAE	Silverey *Zosterops lateralis*								X				
NECTARINIIDAE	Yellow-breasted Sunbird *Cyrtostomus frenatus* ?	X		X									
	Nectarinia jugularis	X											
MELAPHAGIDAE	Varied Honeyeater *Melaphaga versicolor*								X				
	Mangrove Honeyeater *Lichenostomus fasciogularis*	X											
PLOCEIDAE	House Sparrow *Passer domesticus*	X											
DICRURIDAE	Spangled Drongo *Dicrurus hottentottus*	X											
ARTAMIDAE	White Breasted Wood Swallow *Artamus leucorhynchus*	X		X					X				

Table V

NUMBER OF BIRD SPECIES RECORDED FROM REEFS AND ISLANDS OF THE G.B.R. (Kikkawa, 1976)

LIZARD TO INNISFAIL

Locality	Sea Birds		Land and Water Birds	
	Total Number	Number Breeding	Total Number	Number Breeding
Lizard Is.	14	8	30	11
Palfrey Is.	2	-	8	2
Eagle Is.	6	5	12	5
Petherbridge Is.	9	1	14	7
Rocky Is.	2	1	2	-
Three Isles	2	-	10	7
Gubbins Rf.	4	-	1	-
Hope Is.	5	3	8	7
Pickersgill Rf.	3	1	1	-
Low Is.	10	5	23	9
Woody Is.	6	2	4	1
Michaelmas Cay	10	5	2	-
Upolu Cay	4	4	-	-
Arlington Rf.	1	-	-	-
Double Is.	-	-	2	-
Green Is.	4	-	16	8
Fitzroy Is.	2	-	7	4
Little Fitzroy Is.	3	-	6	5
Frankland Is.	1	1	3	-
Russell Is.	-	-	7	4
Nymph Is.	5	?	9	?

TURTLES OF THE REGION

C.J. Limpus, National Parks & Wildlife Service

LIZARD ISLAND TO BOWEN

Five species of turtles have been recorded from these waters as follows:

Green turtle *Chelonia mydas:* a common turtle in shallow inshore waters, bays and estuaries common on most coral reefs. Nests sporadically throughout the region with a very small colony (almost insignificant) nesting on Lizard Island.

Flatback turtle *Chelonia depressa:* a common turtle in inshore waters. Nests sporadically in many parts of the region. Small nesting colonies occur near Ayr, Cape Bowling Green and Cape Cleveland.

Loggerhead turtle *Caretta caretta:* Only occasionally sighted in any one area, occurring from inshore waters to reef habitats. Sporadic nesting occurs throughout the region. Lizard Island is the northernmost recorded nesting location for the species in eastern Australia.

Hawksbill turtle *Eretmochelys imbricata:* a common turtle in coral reef habitats. There are no reliable nesting records from the region.

Pacific ridley turtle *Lepidochelys olivacea:* The only eastern Australian records of the species are of immature turtles in the Cairns inlet area. A poorly known species which most people would not recognise.

Leatherback turtle *Dermochelys coriacea:* only rarely encountered in the Great Barrier Reef and adjacent inshore waters of this area. No known nesting records. It is a temperate species and only rarely encountered north of the Capricorn/Bunker Groups.

This part of eastern Australia stands out as being relatively unimportant for sea turtle nesting. In addition while some species of turtles are common throughout the region no feeding ground of outstanding importance has been identified for any species yet. However there are few published turtle records available for most of the region and only a small proportion of the potential feeding grounds have been investigated.

LIZARD ISLAND TO INNISFAIL

SCIENTIFIC HISTORY

Barry Goldman, Lizard Island Research Station

A. EXPEDITIONS

The journals of Cook and Banks give the first descriptive accounts of the region and its natural history. Banks collected several plants and reptiles when they stopped at Lizard Island in August, 1770, adding some 20 species to their collection of land plants made earlier at Cooktown.

J. Lort Stokes recorded his visits to the reefs and islands of the northern Barrier in H.M.S. Beagle in 1839, the area being visited again by J. Beet Jukes, the naturalist on board H.M.S. Fly in 1843. H.M.S. Rattlesnake was the next vessel to bring naturalists to the region in 1852, these being T.H. Huxley and J. MacGillivray (after whom the small sand cay to the north-east of Lizard Island has been named).

During the late 1880-1890's, Saville Kent published several reports to Parliament on marine resources and fisheries (or their potential) of north Queensland, culminating in his classic, illustrated volume on the Great Barrier Reef (1893).

In 1906 Hedley and Taylor undertook some geological studies of the reefs near Cooktown (Published 1907). The Great Barrier Reef Committee was established in 1922 to promote research on the Great Barrier Reef. One of its first projects was the sinking of a deep (600 ft) bore on Michaelmas Cay to investigate the geology of the reef.

The Committee soon recognised the magnitude of the problem it had set itself especially at a time when there were few marine biologists in Australia. Through one of its founders, Sir Matthew Nathan (who had returned to England after a term as Governor of Queensland), it sought help from scientists in England to help it investigate the coral reefs. Sir Matthew addressed a meeting of the British Association for the Advancement of Science, which set up the Committee that organised the 1928-29 Expedition, led by C.M. Yonge, the first major biological expedition to north Queensland waters. Between 1928 and 1929, a party of up to 23 scientists, some spending more than 13 months in the field, worked from a small field station set up on Low Islands (off Port Douglas). Neighbouring reefs and islands were also visited as far afield as Trinity Opening and Cook's Passage, and a temporary camp was established on Lizard Island. The Reports of this expedition, published by the British Museum, form the basis of much of our understanding of coral reefs, and of the Great Barrier Reef (Jones, 1974)

Low Isles were re-visited by the Steer's expedition in 1936, and again in 1954 by another expedition organised by the Great Barrier Reef Committee and manned by scientists from the University of Queensland, Australian Museum and Queensland Museum.

Professor Disteche of the University of Liège led the Belgian Expedition to the Barrier Reef with the Frigate De Moore in 1967. The northern reef sector was visited twice and a base camp established on Lizard Island for studies on general biology, geology and coral calcification (e.g. work by Dr. D. Barnes, now at the Australian Institute of Marine Sciences).

The Scripps Institute of Oceanography Research Vessel Alpha Helix supported the Great Barrier Reef Photorespiration Expedition which was based at Lizard Island between March and May, 1973. Results of this project (published in *Aust. J. Plant Physiol.*, 1976, *3* (1):1-139 by several authors) include a check-list of the marine plants found in the area, and studies on ultrastructure, productivity, and respiratory physiology of sea grasses, blue-green algae, zooxanthellae and phytoplankton.

In June of that year (1973), the Second International Symposium on Coral Reefs, (again organised by the Great Barrier Reef Committee) was held on board the MV. Marco Polo cruising in Great Barrier Reef water between Brisbane and Lizard Island. The 300 delegates from many nations around the world were able to see the Great Barrier Reef at first hand on that occasion, both at Low Isles and at Lizard I. The meeting also resulted in a two volume publication of works on coral reef science, that gathers together much of the present day knowledge of coral and coral reefs.

In August of 1973 The Royal Society and Universities of Queensland Expedition to the northern part of the

Great Barrier Reef, led by Dr. David Stoddart (Cambridge University), worked in these waters. It was principally a geomorphological, geophysical and sedimentological expedition and the results are being published by the Royal Society. This expedition was initiated when Professor Steers and Sir Maurice Yonge, both of whom had been involved with earlier expeditions to the Great Barrier Reefs, suggested (to the Great Barrier Reef Committee) that this area in the north had been neglected and that the best way to remedy this in the first instance would be to seek support for a geological expedition. The Committee agreed, and sought support from the University of Queensland, which immediately set aside a considerable sum, and, with the Royal Society, were the principal sponsors of the endeavour. The James Cook University of North Queensland provided further assistance (their research vessel, James Kirby and logistical and other support). Scientific personnel came from many English and Australian Institutions and a vast body of geological information resulted from this major expedition.

B. RESEARCH FACILITIES

1. Queensland Fisheries Service: In August 1970, the Northern Fisheries Section was established in a small laboratory at Mourilyan Harbour. Mr. R. Pearson was the biologist in charge and the main objectives of the laboratory were studies of coral regrowth and the impact of the crown of thorns starfish. In December, 1975, the Mourilyan laboratory was closed, the staff considerably enlarged, and a new laboratory established in Cairns.

Biologists presently employed at the Northern Fisheries Station (with their projects) are:-

Mr. R. Pearson: Coral re-colonization following depredation by *Acanthaster planci*; Population dynamics of the commercial Beche de mer.

Dr. G. Goeden: Determination of extent of overfishing of certain demersal reef fish (especially *Plectropomus leopardus*); Investigation of fish standing crops on reefs of varying intensities; Development of remote controlled submersible visual recording apparatus.

Mr. G. McPherson: Population dynamics and fishery statistics of Spanish Mackerel

Mr. R. Garrett: Pre-management study of the Barramundi (*Lates calcarifer*) fishery; Growth and recruitment of *Pocillopora damicornis* related to management of fishery for decorative corals.

Mr. J. Russel: General biology of juvenile Barramundi.

In addition, Mr. F. Olsen (of the Queensland Fisheries Service laboratory in Deception Bay) is undertaking a survey of mangrove communities in conjunction with the Estuarine Inventory of the Botany Branch of the Queensland Department of Primary Industry.

2. Lizard Island Research Station: Established in 1973 under the auspices of the Australian Museum, the Lizard Island Research Station provides accommodation, boating, diving, aquarium and laboratory facilities for visiting scientists to study the Barrier Reef. Although a research staff is not specifically employed by the Station, the Director is currently investigating the relevance of standard fishery statistics in relation to the fishery of protogynous reef fishes. In the four years that the Station has been operational, there has been a wide spectrum of studies done, ranging from geomorphology to fish behaviour and coral respiration.

A list of papers published from work done at the Lizard Island Research Station is appended (Appendix 5),, together with Newsletters Nos. 3 and 4 from which brief descriptions of work done at the Station over the last few years can be obtained if required.

The Lizard Island Research Station has a permanent staff of three, with an average of 5 visiting scientists working at the Station. Accommodation is in regular houses, although some of the visitors sleep and cook in tents. Six buildings and two sheds have been constructed to date, (three houses, one laboratory block, a workshop and a powerhouse), with a communal cooking/dining/meeting room, wash room and four small two-bed bungalows being planned for the future. The Research Station has been designed to harmonise as much as possible with the island surroundings and from some directions at sea the Station is hardly discernable. Fresh water is supplied from a well although rainwater is also collected and stored in a number of fibreglass tanks spaced around the site (100,000 litres capacity). Power is generated on the Station by diesel generators. Solid wastes are disposed of by burying, burning or dumping at sea; liquid wastes are run through absorption trenches (fresh water) or returned to the sea (salt water and chemicals). Human wastes are buried dry.

The reef flats around Lizard Island are not so extensive as on a lagoonal or platform reef (like Heron). Consequently, that habitat-type is rather fragile and reef walking and shell collecting are not encouraged. The lagoon, however, is very extensive and a small number of artificial reefs placed there are considered to have negligible impact.

Most scientific work around Lizard Island is done from small boats. Anchor damage to corals is considered to be a slight problem and visitors are requested to use moorings where provided, or anchor over sand or rocky patches if possible. Visitors wishing to make major collections are requested to work on neighbouring reefs (such as Eagle Island Reef).

A management/zoning plan for the reefs around Lizard Island is currently being developed in conjunction with the Resort and Dr. Goeden of the Northern Fisheries Unit of the Queensland Fisheries Service.

The Lizard Island Research Station in conjunction with Macquarie University has also constructed a small platform on a patch reef at the southern end of Carter Reef (some 9 miles north-east of Lizard Island). The platform is an accommodation base for scientists who wish to spend a number of days on the Outer Barrier. It was constructed in January 1978, of tubular steel scaffolding pipes cemented to the reef and held down with guy-wires. Its only longterm influence on the reef platform would be a shading effect and an increase in nutrients resulting from the droppings of the sea birds which roost on it during the months January through April.

C. OTHER RESEARCH ACTIVITIES

There have been a number of minor research projects undertaken in North Queensland waters. Results of these should shortly be accessible through the Bibliography of Research on the Barrier Reef produced by Dr. E. Frankel of Sydney University. But two individuals merit some mention here. First is the late Noel Monkman who set up a private laboratory on Green Island and pioneered a lot of marine micro-cinematography. Many of his films on corals and plankton are still shown to the tourists to Green Island today. Secondly is Dr. Barnes, an M.D. in Cairns, who has helped considerably in studies on the sea wasp *(Chironex fleckeri)* and ciquatera fish poisoning.

SIGNIFICANCE OF LOW ISLES

C. Wallace, Queensland Museum

The Low Isles complex and some of its neighbouring reefs are of special significance to coral reef science. In 1928-29 it was the site and base for an expedition which spent one year studying a variety of aspects of coral reef structure and function. Many of the findings of this expedition provide the bases of theories of coral reef structure; zonation, ecology and physiology which have only relatively recently been refined and elaborated. The reports of this Expedition are published in seven large volumes (see Appendix 5, below).

Over the years scientific groups and individuals have returned to the area to re-examine some of the topics treated by the Expedition using its data as a baseline for later research. The comprehensive investigations that were undertaken by the 1928-29 Expedition and the investigations that have taken place since then have resulted in repeated, reliable and objective monitoring of this site. Data over a very long period is therefore available for Low Isles and it is one of the very few coral reefs in the world for which such long term data exists.

Low Isles is a lighthouse station of the Australian Government and detailed meteorological records are available thus augmenting the scientific data on other aspects of the reef that exists.

1. EARLY REFERENCES TO LOW ISLES

Captain Cook discovered Low Isles on his first voyage of scientific enterprise on 10 June 1770. He did not land: "At 11 we hauled off N., in order to get without *a small Low Island* which lay about 2 leagues from the Main." Captain King in the H.M.S. Mermaid was probably first to follow Cook; he passed the island in June 1819. The name *Low Isles* is written on the fair copy of his chart. "At noon our latitude was 16°28'48" and *three small islands* were in sight ahead, which we passed seaward of. They are laid down by Captain Cook as one island, whereas they are distinctly *three*, but all connected by a reef which was covered when we passed." Captain Owen Stanley in H.M.S. Rattlesnake called at the island in July 1848 and his party spent 3 or 4 days there. Macgillivray, the surgeon-naturalist stated: "This small group may be said to consist of *three islets*. One is low, sandy and well wooded, about 300 yards in diameter ..., the other two may be looked upon as merely groves of mangroves on the reef." And Stanley: "Low Isles are properly *two* in number: the larger ... low, sandy and well wooded; the other island is composed of one or two clumps of mangroves..."

2. THE GREAT BARRIER REEF EXPEDITION 1928-1929

The historical and scientific significance of the Low Is. reef is based on The Great Barrier Reef Expedition of 1927-28. It resulted from an appeal from the Great Barrier Reef Committee to British marine biologists to undertake investigations on biological aspects of the Great Barrier Reef (Richards, 1928). The purpose of the expedition was "to examine a sector of the Great Barrier Reef off Cairns, from the shore to the open ocean, marking down the association of plants and animals, studying the food and capacity for lime deposition of the same, and all such matters as concern the formation and growth of the Reef" (Richards, *loc. cit.*).

From the outset it was an historic event. For the first time, an expedition was mounted for experimental research - to discover the way the system worked - rather than for the collection of specimens. It was also unique in its long duration (12 months) at the one site, and in the large number of scientists (12) involved. There were also short term visitors. Specially constructed accommodation and laboratories were built on the cay that provided a permanent base for the scientists and the facilities for the work they were to do.

The Low Isles cay was the site for much of their work, but other reefs, in particular Three Isles reef to the north, and Lizard Island and Yonge Reef to its north, were studied in detail. There is a full account of the Expedition and of those who contributed to its success in Yonge (1930 and 1931). It more than succeeded in realising the purposes for which it was set up:

The structure of Low Isles and Three Isles reefs, and the distribution of organisms on them were mapped in painstaking detail. A system of nomenclature for the different reef zones was devised and hypotheses were put forward on the manner in which a series of shingle banks, a coral cay, and then a mangrove area can be added to a developing coral reef. These were among the first reefs in the world to be thoroughly documented, and their position in the history of coral reef science is undisputed.

The Expedition also studied in detail a range of aspects of the physiology of corals and other reef organisms, in particular feeding excretory and digestive mechanisms, the relationship between corals and their algal inhabitants (zooxanthellae), reproduction, development and growth. Very little had previously been known on any of these topics.

Detailed morphological, taxonomic and some life history studies were made of many bottom inhabiting (benthic) animal groups, and their distributions and abundances were recorded. The corals, molluscs, echinoderms and some crustacea were particularly well documented.

Studies on the seasonal occurrence and distribution of zooplankton organisms were also made, and constitute one of the very few such studies that have been done on the eastern seaboard of Australia to this day. The production of phytoplankton was also studied. There was only one botanist with the Expedition, however, who stayed only 5 months. Although much was collected, no report has yet been written on the reef algae (see below).

3. STUDIES SINCE THE EXPEDITION

Geography and Geology

The structure of the Low Isles reef, in particular, aspects of the origin and continued development of the reef, have been monitored in some detail.

In 1931 F.W. Moorhouse revisited Low Isles and reported a number of modifications to the shingle ramparts. He was also present at the time of the March 1934 cyclone and prepared a useful map (using Spenders base map) showing changes resulting from the cyclone.

In 1936 J.A. Steers spent a second season on the Barrier Reef, accompanied by F.E. Kemp. The main field of this new geographical expedition was the Bunker and Capricorn group and low wooded islands (including Low Isles).

Australian geologists, R.W. Fairbridge and C. Teichert carried out an aerial and 5-day land reconnaisance of Low Isles in 1945 under the auspices of the RAAF. They attempted a new analysis of Low Isles in light of events there over the previous 17 years, with particular emphasis on the rampart system. A map detailing changes from 1929-45 was prepared.

Members of the Royal Society and Universities of Queensland Expedition to the Great Barrier Reef in 1973 also visited the area and it was included in their geographical, geophysical and sedimentological investigations.

Zoology

An ecological expedition under the auspices of the G.B.R. Committee visited Low Isles from 12-26 August 1954. Members included W. Stephenson, R. Endean, Isobel Bennett, F.W. Whitehouse. Objectives were to:
(a) assess the extent of damage to the island, and its fauna and flora, caused by a cyclone in 1950; and
(b) to ascertain the extent and nature of changes undergone by the island, its fauna and flora since 1929.

The zonation and ecology of the reef flats were documented, and some animal groups were treated in detail, attention being given particularly to echinoderms (Endean, 1956) and the corals (Stephenson and Wells, 1956). The information on reef flat corals has since been augmented by a detailed study of the reef slope corals (Limpus and Wallace, unpublished).

Botany

The algae of the Low Isles reef, their structure, distribution and nomenclature have been the particular interest of Dr. A. Cribb (University of Queensland) since 1954. He has studied the material from the GBRE, as well as visiting the reef several times himself.

4. FUTURE

The Second International Coral Reef Symposium visited the Low Isles reefs in 1973, and the comments of visiting scientists, including some who had visited the island in 1954 led to some interest in re-surveying the reef in order to monitor changes which appear to have occurred (see GBRC Annual Report for 1975). Owing to lack of funds this survey has not been done. In view of the existing data base, and the scientific and historic importance of the site, it is unfortunate that the proposed survey has not taken place.

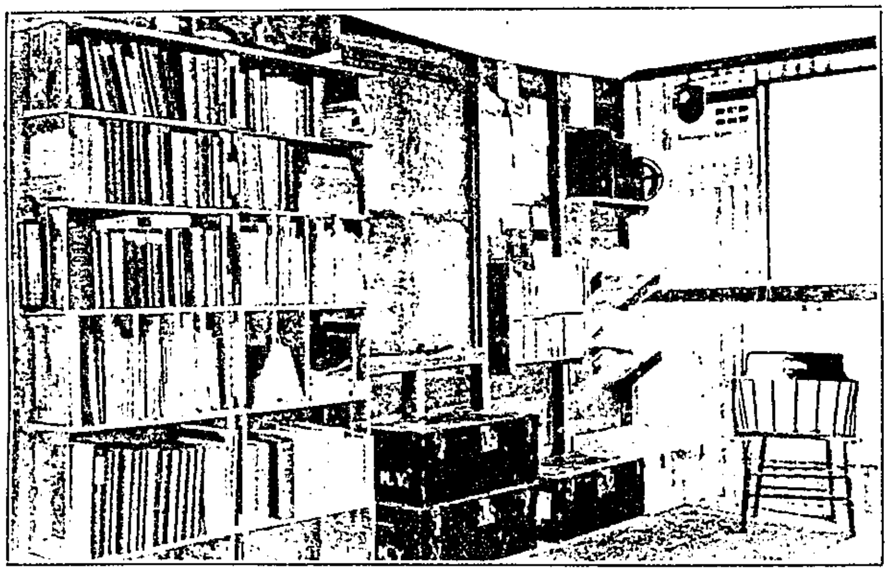


FIG. 6.—LIBRARY OCCUPYING NORTH-EASTERN CORNER OF LABORATORY HUT.
[*Photo., M. J. Yonge.*

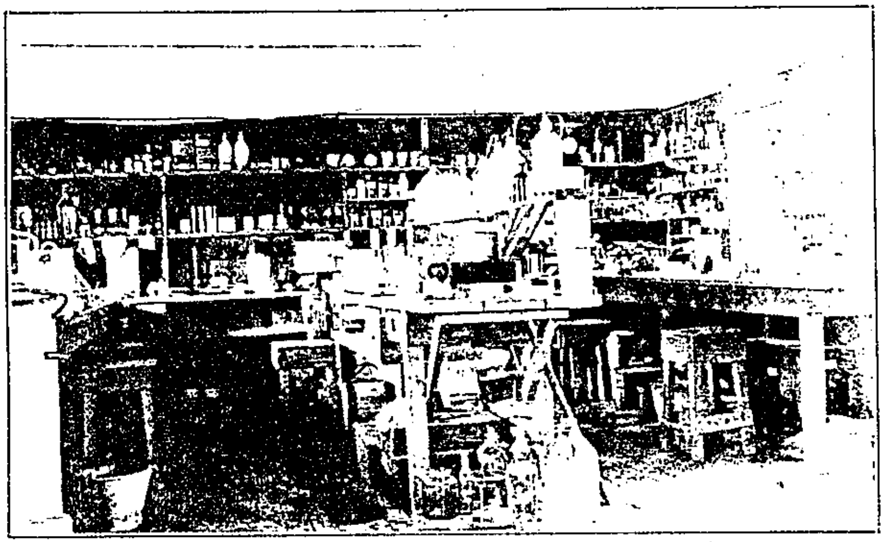


FIG. 7.—WESTERN HALF OF LABORATORY HUT.
Showing plankton bench on left, chemical bench in centre, and physiological bench on right.
[*Photo., M. J. Yonge.*

Great Barrier Reef Expedition 1928-29. Interior of Laboratory hut (from Yonge, 1931).

USE AND IMPACT LIZARD ISLAND TO INNISFAIL

HUMAN OCCUPATION AND ACTIVITIES ON THE MAINLAND

This report covers the coastal areas of North East Queensland lying within the Far North Queensland Statistical Division, specifically, the coastal shires of Douglas, Mulgrave, Johnstone and Cardwell, and the Tableland shires of Atherton and Eacham. The principal sources of information are the report by the Department of National Development and the Queensland Department of Industrial Development, "Resources and Industry of Far North Queensland" (1971) and various publications of the Australian Bureau of Statistics, Queensland Office.

POPULATION DISTRIBUTION AND DENSITY

The coastal shires of Douglas, Mulgrave, Johnstone and Cardwell contain approximately 69% of the total population of the Far North Queensland Statistical Division which, at June, 1977, was estimated to stand at around 131,100. On the coastal strip roughly 40% of the total population is located in the city of Cairns and a further 15% occupy the surrounding urban areas. Average population density on the coastal strip is low, particularly north of the Daintree River and south of Innisfail. Similar population densities occur on the Tablelands. The degree of urbanization in the region is low (56%) when compared with the state average (77%).

Estimated population and density, east coast shires, Far North Queensland Statistical Division (June, 1977).

Local Authority Area	Estimated Population		Population Density
Coastal Shires:			
Cairns City	36,000		643/km^2
Douglas	4,980		2
Mulgrave	25,500		15
Johnstone	17,400		11
Cardwell	6,750		2
Total	90,630	Mean	12
Tableland Shires			
Atherton	6,750		11/km^2
Eacham	3,660		3
Total	10,350	Mean	6

LAND USE

The coastal shires cover an area of some 7713 km^2 and contain the high rainfall areas of the coastal plains and foothills. Agriculture on the coastal strip is intensive and the majority of the farms are small and freehold. The gross value of rural production from this region during 1968-69 was ten times greater than that derived from mining, forestry and fishing combined. Sugar cane is the most important crop and provides the basis for much of the prosperity of the region. The degree of industrialization is low on the coastal strip.

The Tableland shires of Atherton and Eacham have a combined area of 1762 km^2. Dairying and mixed farming are the dominant activities with dairying being the most important. Maize is the principal crop grown in the region.

HISTORY AND CURRENT STATUS OF THE MAJOR INDUSTRIES

1. FORESTRY

During the early days of settlement timber was cut to provide for local building requirements and later to clear land for grazing and sugar cane. By the early 1800's a limited export trade in sandalwood had been established and by the beginning of the 1870's red cedar was being cut along most of the rivers of north Queensland. Most of the good red cedar had been cut from the area between the Johnstone and Daintree Rivers by the early 1900's and fellers turned to varieties such as Kauri pine and maple to maintain the 'export' trade with the southern states.

Rainforests are by far the most important source of timber in far north Queensland. These forests occur in the high rainfall coastal ranges and Tableland country between Mt Spec and Cooktown and, although greatly reduced in area when compared with early days, are estimated to cover around 3,000 km^2. Much of this area includes steep, rugged country not suitable for logging and some is currently gazetted as National Park. Most of the remaining forest is contained within state forests or timber reserves between Tully and the Daintree River.

Rainforests provide the bulk of local building requirements and a range of high quality joinery and plywood timbers. Plywood manufacture has become an important industry utilizing a wide range of north Queensland softwoods. At June, 1978, a total of 48 mills were operating in the region, 40 producing mainly structural timbers and eight producing plywood/veneer. In the June quarter, 1978, the total timber output was 36,000 cu. metres and north Queensland rainforests provided over 70% of the states rainforest structural timber and over 65% of the cabinet woods.

2. SUGAR CANE

Sugar cane was first planted along the Herbert River in 1872 and by 1883 further plantations were established in the Mulgrave Valley and at Hambledon. By 1885 cane was planted as far north as Cooktown but by the early 1890's most of the smaller ventures north of Cairns had been abandoned and growing was confined to the Mossman and Cairns - Innisfail areas. Unlike those in the Mackay and Burdekin regions, the northern plantations did not rely heavily on imported kanaka labour.

Today cane growing is restricted to the wet, frost-free, fertile lowlands lying between the coast and the foothills of the coastal ranges. Rainfall is high and irrigation is used on less than 1% of the total plantings. Planting occurs from April through to May and the cane is harvested between June and December. Fertiliser and pesticide use are high. During the 1975 season almost 78,000 ha were under cane and the region produced over 25% of the total Queensland harvest.

3. OTHER CROPS

Other important crops grown in the region include (production figures are for 1975-76 season):

Maize - grown mainly in the Atherton shire where maize accounts for almost half the total land under crops. The Atherton shire produces approximately 22% of the Queensland maize crop.

Bananas - grown mainly on the slopes of the coastal ranges in the Cardwell and Johnstone shires. Over 66% of the total Queensland crop is produced in the region.

Tobacco - over 75% of the Queensland crop is produced in the Mareeba-Dimbula irrigation area.

Peanuts - grown mainly in the Atherton shire. Around 10% of the Queensland crop produced in the region.

4. PASTORAL INDUSTRY

The discovery of gold gave a much needed boost to the pastoral industry in north Queensland. The increased local demand for beef during the gold rush led to the establishment of stations at Mareeba and Atherton and substantial increases in herd size. During the 1890's the region became infested with cattle tick and with the contraction of the local market following the end of the gold rush, the industry declined. Renewed expansion and some degree of market stability were not achieved until the 1920's when the completion of the Cairns to Townsville railway provided ready access to export facilities at Townsville.

At the present time beef cattle are mainly run on the dryer country to the west of the coastal ranges. Smaller herds are maintained on the poorer, often swampy soils of the coastal flats and on the foothills above the south Johnstone and Tully Rivers. In coastal areas cattle are often run as a sideline to sugar cane. The dairy industry was largely responsible for the clearing and closer settlement of the Atherton Tableland and dairying is still mainly confined to the tableland shires of Atherton and Eacham.

5. EXTRACTIVE INDUSTRIES

Gold was first discovered at Etheridge in 1870 and further discoveries followed at the Palmer (1873) and the Hodgkinson River (1875). The Palmer was the most spectacular of the Queensland gold fields and up to 1973 had produced 41,493 kg of gold (Queensland Yearbook, 1975). Problems of access to the isolated fields and consequent high transportation costs made only the richest claims payable and by the 1890's the gold boom was over. With the decline of alluvial gold mining other base metals discovered with the gold were worked. Tin mining began at Granite Creek in 1878 and at Tinaroo Creek in 1879 and by 1883 there were 160 lode tin mines and 32 silver-lead mines in the Herberton and Irvinebank areas. In

1883 copper was discovered at Mt. Malloy, Mt. Garnet and later at Chillagoe. By 1907 minerals accounted for 28% of exports through the Port of Cairns. Peak production at the Herberton and Chillagoe fields was reached in 1911.

In recent years falling mineral prices and increased mining costs have forced the closure of many mines in far north Queensland and total mineral production for the region has declined significantly. Tin is still extracted from alluvial deposits in the Herberton and Mt. Garnet areas. In 1969 these deposits yielded tin concentrate with a total value of close to $3 million. The only other major extractive industry in the region is at Cape Flattery where high grade silica sands are mined for export.

THE IMPACT OF HUMAN ACTIVITY ON THE COASTAL MARGIN

A detailed assessment of the impact of human activity on the coastal margin would require an exhaustive analysis of resource flow within the system which is beyond the limits of this short report. Preliminary considerations suggest that the necessary information base is almost certainly incomplete. Nevertheless, it is possible to identify a number of examples of coastal land use which may have both immediate and long-term effects on nearshore and coral reef environments and in the context of a Great Barrier Reef Marine Park would require careful monitoring and management. On the far north Queensland coast the most important of these are the continued destruction of tidal wetlands, especially mangrove forests, and the practice of high intensity agriculture in high rainfall areas on the coastal plains.

DESTRUCTION OF TIDAL WETLANDS

Accurate estimates of the rate of destruction of mangrove forests are difficult to obtain as there are no precise figures on the areal extent of wetlands on the north Queensland coast. The survey of Queensland wetlands currently being undertaken by the Queensland Fisheries Service should do much to redress this situation. Studies undertaken by the Australian Littoral Society in the Trinity Inlet region do provide some indication of the rate which the destruction of wetlands can occur in situations where land use conflicts are high. From the analysis of aerial photographs, Hegerl and Davie (1977) have estimated that approximately 25% of the Trinity Inlet mangrove forests and saltmarshes have been destroyed in the past decade. Reclamation of wetlands for growing sugar cane and increasing pressures on available land in the Cairns area are the main factors responsible. In the Cairns region wetlands have been reclaimed to provide wharf facilities, airport runways, industrial and residential land and rubbish dumps. With continued population growth in the area, land use conflicts can be expected to increase with the most likely outcome that more wetland areas will be reclaimed.

In view of the magnitude and rate of this destruction it is disturbing to note the paucity of data on the importance of mangroves in tropical areas of north Queensland. As has been found in similar systems in the Americas, north Queensland mangroves are an important site of marine primary productivity. Data on litter fall on Hinchinbrook Is indicate production rates of 1.0 - 7.7 $gC.m^{-2}day^{-1}$ (Bunt, 1978) which are, in general, up to twice those recorded in the Americas. However, while it is safe to state that north Queensland mangroves do represent an important primary marine food source the subsequent fate of the material produced is not known. Large tidal amplitudes and regular and efficient flushing result in much of the detrital material produced being exported out of the system. Subsequent pathways of conversion and utilization remain to be established. To what extent this material is utilized by near shore and reef communities is very much an open question. It is interesting to note, however, a close correspondence between the total live weight of fish landed along the north Queensland coast during 1968-69 (0.5×10^6 kg) and the possible yields from the conversion of predicted mangrove litter inputs at the third trophic level ($0.5 - 0.8 \times 10^6$ kg).

The capacity of mangroves to colonize and hold soft sediments has led to the belief that they exert a considerable influence on coastal stability. Bunt (1978) has pointed out that there is evidence for the view that mangroves are "buffering stabilizers" capable of preventing serious deterioration under normal conditions but probably unable to prevent excess sediment loss from the land resulting from ill-managed development. There is considerable support for the view that the relationship between mangroves and their environment is one of delicate balance. If this does prove to be true for north Queensland mangroves then the need for careful management of this resource cannot be over emphasised.

COASTAL AGRICULTURE

On the basis of the information available it is possible to make only a very general assessment of the influence of coastal agricultural development on the adjacent marine ecosystems. In the high rainfall areas the most important effects are undoubtedly mediated through river runoff and likely influences on the marine environment will result from excess freshwater inflow, sediment load, and deleterious effects due to pesticide and fertilizer residues.

The destruction of coral reefs as a result freshwater runoff and sediment deposition following cyclonic rains is well documented (Hedley, 1925; Rainford, 1925; Fairbridge and Teichert, 1947, 1948). Any agricultural or pastoral activity that leads to increased runoff will almost certainly have some effect on total freshwater discharge and the amount of sediment reaching the sea. Gilmore (1971) has demonstrated increased sediment loads associated with poor logging practice in some north Queensland forestry areas and similar problems are likely to occur in situations where annual cropping exposes bare soil to storm rains during the summer months.

Soil fertility on the coastal plains is generally low and intensive agricultural development requires high fertilizer use. In the cane growing areas of north Queensland fertilizer is applied at a rate of around 1 tonne per hectare. There is no information to indicate what proportion of this reaches waterways and is discharged into the sea. The sugar cane industry in the region is also a high user of pesticides. Lindane is most frequently used with around 42 tonnes being applied annually to the cane fields in the Mossman-Babinda and Innisfail-Tully areas (Olafson, in press). The available evidence suggests that pesticide residues, particularly Lindane, are transported by rivers from the cane growing areas (Olafsen, in press) and has been found in marine organisms, but levels in off-shore reef areas are still low by world standards. No data is yet available for near-shore environments.

CONCLUSIONS

In the far north Queensland region between Innisfail and Lizard Island the most significant land-sea interactions probable occur via river and estuarine outfalls and in the mangrove areas. Further, it is safe to say that the climatic variability over this coastline and the intensity of land use are such that detailed studies covering long time intervals for a number of watersheds would be necessary to properly evaluate terrestrial influences on the surrounding sea. Categorizations and documentation of levels and trends in human impact certainly could be achieved. However, it is clear that this has not yet been attempted although the need is most apparent. It would appear to be in the direct interest and perhaps responsibility of the GBRMPA to move for substantive initiatives in this direction. The effort in time and resources would be substantial.

LIZARD ISLAND TO INNISFAIL

TOURISM AND RECREATIONAL USE

B. Goldman, Lizard Island Research Station

Because the Great Barrier Reef approaches closer to the Queensland coast in the north compared with the south, access to it is easier and it receives perhaps the greatest human impact, especially near Cairns.

During the year 1977-78, over 300,000 tourists visited the Cairns region, numbers being greater in winter than summer, but peaking during periods of school vacations. It is estimated (Far North Queensland Development Bureau) that this tourism generates in the order of $50 M annually and that 40% of this is due to the Great Barrier Reef and off-shore islands. Approximately 30,000 overseas tourists visit the Cairns region each year and for these the Great Barrier Reef is the main attraction.

Visitors to the reef mostly go for day trips to the various locations, although there is a growing number spending longer periods, either camping, or staying at one of three holiday resorts - Green Island, Lizard Island and Double Island.

GREEN ISLAND: This is the dominant tourist destination in the mid-northern Great Barrier Reef. More than half the visitors to Cairns each year visit Green Island (i.e. 180,000) and at an average of about $15 per head per visit, the island is obviously a multi-million dollar industry. It is now apparently approaching saturation point for visitors. Green Island will be the subject of a management and impact investigation by the Queensland National Parks and Wildlife Service.

Green Island is one of the oldest resorts on the Great Barrier Reef and one of only two located on the Barrier Reef proper. It is a low wooded island of approximately 12 ha surrounded by a well developed reef. Seven hectares of the island is national park and the surrounding waters have been declared a marine national park by the Queensland Government. Accommodation for over 80 guests is provided on the island but resort guests are usually outnumbered by day tourists from Cairns.

DOUBLE ISLAND: Situated some 30 kilometers north of Cairns, and about 1 kilometer off the coast, Double Island is a small 'continental' island covering 16 hectares, with a large, 120 hectares mud-reef flat to the south-east. The whole of the island has been leased for tourist accommodation, and the first stage of accommodation facilities has been completed. Ultimately, it is proposed to have a regular hotel/guest house with 60 beds with guests arriving via cable car from the adjacent mainland, or via a 200 passenger vessel operating daily out of Cairns. The island will shortly be opening for guests, and at that stage approximately $750,000 will have been invested (this includes the initial lease of the island).

Building construction has been restricted mostly to the western end of the island and efforts have obviously been made to minimise its visual impact. From the air, the main building blends well with the surroundings, and with its Canadian Red Cedar shingle roof gives the impression of a Polynesian bungalow.

The management claims, however, that there is a large reef flat for coral viewing and exploring at low tide. However, although there is a fringing reef around the island, this reef flat is mostly mud flat with some soft corals and the occasional hard coral and does not resemble the reef flat zone of a coral reef.

LIZARD ISLAND: Another, but much larger 'continental' island, Lizard Island lies some 80 kilometers from the true Outer Barrier, or Ribbon Reefs. Among islands on Australia's Great Barrier Reef, Lizard is perhaps unique in all the attributes it possesses. Lizard Island itself covers a little over 500 hectares, but the total system which includes a large lagoon fringed by a connecting coral reef between Lizard, South and Palfrey Islands (some half a kilometer distant) is quite extensive. The island has: a high central ridge rising to 370 meters which commands a spectacular view of the mainland and Outer Barrier reefs; a number of isolated beaches for swimming and diving; good walking tracks; permanent freshwater; a variety of vegetation types; several excellent anchorages for vessels (some up to 20,000 tons); a flat central plain on which a small airstrip has been constructed; extensive fringing coral reefs and a large deep lagoon surrounded by a true coral reef and having a deep passage into open water.

Lizard Island is a Queensland National Park. However, three special leases have been excised - one, by Lizard Island Lodge Pty. Ltd. for the construction of their airstrip in August 1969, the second for the construction of their guest house in August 1972; and the third by the Trustees of the Lizard Island Research Station in October 1973. The Research Station has been described in the report on Scientific History.

The Lizard Island Lodge is a private guest house, originally conceived as a support facility for marlin fishing off the northern Barrier Reef, and built to accommodate 12 visitors in luxurious surroundings. In September 1977, the buildings were extended and now contain 22 beds. A 'Barn' was also added to cater for, and separate, the growing number of 'day trippers' from the resident guests.

In 1977-78, there were 2,230 day trippers on "Blue Lagoon Tours" operated by Bush Pilots Airways of Cairns. These tourists are given a brief tour of historical Cooktown before flying to Lizard Island where they receive lunch and a glass-bottom boat inspection of some coral patches in front of the Resort.

The Lizard Island Lodge closes for the wet-season months of February and March. For the other 10 months of 1977-78, there were some 375 guests staying for an average of 8-9 days each. Basic accommodation charges are $55 per day (not including drinks) rising to $65 per day during the marlin season (September through November). There are 12 staff employed at the Lodge.

The Lodge has been built on a flat, sandy area at the southern end of Anchorage Bay, on the western side of Lizard Island. The main building is low, of timber construction, with a tin roof, and with a wide verandah, along the lines of an early settler's cottage. The Assistant Manager's residence, office, kitchen, dining room, bar, and 5 guest rooms are contained within it. The 1977 extensions consisted of three buildings - another block of 4 guest rooms, the barn (which, as its name implies is a large, open, high roofed structure, with limited cooking and bar facilities), and a dormitory/wash room (with extra laundry facilities, staff common room, some staff sleeping accommodation, or extra beds for fishing boat crews etc.). In addition, there are several other buildings - a powerhouse (large tin shed containing a 75 KVA and a 25 KVA alternator); a workshed (similar to powerhouse), a storage shed (also similar in appearance to powerhouse); and a Manager's cottage (2 bedrooms, bathroom/toilet, kitchen/dining room and verandah). The staff live in 5 caravans situated about 200 metres south of the main establishment.

IMPACT

FRESH WATER: During the busy months, July through November, the Lodge uses some 10,000 to 13,000 litres of fresh water daily. This is supplied from two wells placed near the island's centre (beside the airstrip and at the edge of a pandanus swamp). The wells were deepened in September 1978 to cater for the increased demand. It is not known what the island's water capacity is, or whether this usage is affecting the water table and subsequent drainage pattern of the grassland and pandanus swamp areas. (Note: The Research Station also draws fresh water from a well in a separate water basin, usage is currently about 1,000 litres per day).

AIRSTRIP: This is an unsealed, graded strip across the central plain of the island. It runs north-west to south-east and measures 910 meters by about 50 meters, with 50 meters cleared, grass verge on each side. The strip suffers severe erosional problems during the wet season. Wind erosion and loss of the fine sand (a major constituent of the soil on Lizard Island) is a continuous problem throughout the year when the trade winds are blowing (often at 20-25 knots) and this is accentuated each time a plane takes off (some 400-500 planes use the strip each year). It is not known what effect the noise of the airplanes has on the local fauna.

GARBAGE DISPOSAL: All food scraps and solid wastes are deposited in a depression alongside the airstrip and occasionally covered with sand. Several large goannas permanently live near here, and many (100) sea gulls are now permanently present (cf. comments on page 11 in report on Capricorn-Bunker Groups).

SEWAGE: Human wastes and fresh water wastes (showers, laundry, kitchen etc.)

are treated in underground septic tanks and then flow into absorption trenches towards the beach of Anchorage Bay.

OTHER USAGE: There are several clearly defined walking tracks over the island to which visitors are requested to restrict themselves. Human influence on the adjacent grass and shrubs is considered negligible. Two pair of peafowl have been introduced (although it is a National Park) but it is unlikely that they will breed successfully due to anticipated predation by the goannas on their eggs and chicks.

Significant noise pollution is generated by the diesel power plants of both the Lodge and the Research Station. This noise immediately destroys the wilderness or solitude feeling that otherwise pervades the island, but the problem is quite localised.

BOATING: Surprisingly little boating is carried on by guests at the Lodge. They are often taken to neighbouring beaches for picnics, and generally they take a glass bottom boat trip but there is little line fishing, or skin diving from small boats around Lizard Island. In a general, but loose agreement with the Research Station, no spearfishing is permitted around Lizard Island, and line fishing is restricted to the northern half of the island (from Osprey Is. to Lizard Head), thus leaving the southern half of the island undisturbed for scientific purposes.

However, visitors to the Lodge are often taken to nearby reefs for line fishing (mostly coral trout, red emperor, grey snapper) with Eagle Island reef to the south, and Petricola Shoals to the north being the commonest destinations. Occasional trips are also made to North and South Direction Islands, Nymph Island, the Turtle Group and the Outer Barrier reefs (Carter and Yonge).

Marlin Fishing is discussed more fully below.

OTHER VISITORS TO THE ISLAND: Most of the islands between Innisfail and Lizard Island have been proclaimed National Parks (from south to north these include - Frankland Islands, High Is., Green Is., Upolu Cay, Michaelmas Cay, Snapper Is., Hope Is., Two Isls., Three Isls., Rocky Isls. and Lizard Island). Of these, Lizard is the only one on which camping is permitted, with 312 camping permits (@$2) being issued in 1977-78. Most campers arrive by Bush Pilots Airways (but some by private charter) with the average stay being 3 days. The Queensland National Parks Service has installed a fresh-water well, fire place and camping facilities at the northern end of Watson's Bay (official camp site) with table and fire place also in Mermaid Cove (North West Bay).

There is a growing number of cruising yachts and itinerant fishermen now stopping at Lizard Island. Many of these also come ahsore and use the camping facilities (especially fresh water). A large pit has been dug for solid waste disposal (but no toilets) although many of the yachts dispose of solid wastes directly overboard.

Despite the air service, access to these waters is primarily by boat. There are 3,371 private pleasure craft (mostly outboard powered runabouts) registered in Cairns (data supplied by Marine Board Office, Brisbane) which probably also work out of Innisfail, Port Douglas and Mossman. Another 84 are registered in Cooktown. No statistics as to the sizes of these craft, the number of passengers they carry, nor the number of trips they would make, on average, to the reef each year are available. The main destinations are Fitzroy and Green Islands, and Michaelmas and Upolu Cays, and reefs within a 50 mile radius of Cairns; inshore reefs off Innisfail and Port Douglas; and to a lesser degree off Mossman and Cooktown. Most visitors to North Queensland travel to the reef in commercial charter vessels and game fishing boats. Again, by far the majority of these are day trippers travelling to Green Island on the regular ferry services operating out of Cairns (e.g. Hales Launches Pty. Ltd.). Between Dunk Island and Thursday Island there is a total of 47 licenced charter passenger vessels with combined seating for 1,817 passengers. (Finer partitioning was not available from the Marine Board but boats in the Innisfail to Lizard Island region would constitute by far the bulk of this number). Some 5 to 10 charter vessels operate out of Cairns, Innisfail and Port Douglas (mostly Cairns) taking parties of visitors to the reefs for periods of from 1 day to several weeks. Activities include picnicing, camping, reef walking, shell collecting, bird watching, water skiing, Scuba diving, spearfishing, line fishing and photography (above and below water). The general impact of these users is much the same as that already described in the report on the Capricorn-Bunker Groups.

Development recommendations for both Lizard Island and Green Island were included in the "Great Barrier Reef Visitor Plan" (Parnell, Kerr, Foster and Co., 1971). The report recommended only limited development for Lizard Island with the present facility being maintained as a high quality resort catering primarily for the hotel guests. In the case of Green Island, the report recognised that for the majority of tourists, this is the only resort which offers easy access to true Barrier Reef environments in the region. Because of this the plan recommended that the island be developed mainly as a day trip facility. Specific recommendations included the upgrading of boat services between Green Island and Cairns (this would involve the dredging of the island channel and improvements to docking facilities to accommodate larger vessels), the establishment of a single authority to co-ordinate development and running of the resort, and the return of the whole island to being a national park with interpretive facilities and rangers to provide information and necessary policing activities.

GREEN ISLAND: THE MAN-ENVIRONMENT INTERFACE, A GEOMORPHOLOGICAL PERSPECTIVE

Deborah Kuchler

James Cook University of North Queensland

Utilization of sand cays within the region Innisfail to Lizard Island is to date geographically minimal. Generally, the cays are utilized for navigation. However, man has intensified his use of both Low Isles and Green Island. Low Isles caters for a lighthouse and scientific expeditions, whilst Green Island is renowned for its tourist activities. This report looks specifically at Green Island where the man-environment interface is in a state of disequilibrium as demonstrated by shoreline movement (refer Figs 1, 2 and 3).

It is evident that on Green Island, for economic ends a knowledge of processes and the possibility of anticipating the direction of future movement are important if present tourist operations are to be maintained.

Geomorphological mapping of sand cays in the Innisfail to Lizard Island region by Steers (1928) and Stoddart (Stoddart, McLean and Hopley, 1978) illustrate shoreline movement. Changes in selected cays between 1929/36 and 1973 are given in Table 1. It is notable that all cays surveyed had declined in area between the dates of two surveys.

Even when its volume stays fairly constant the shape of a cay may still alter from summer to winter under the action of ocean waves (Beach Protection Authority, 1978, 1). This alteration, visible on aerial photographs, is expressed by dynamic zones with relatively mobile sand particles and lack of vegetation. Conversely, mature vegetation growth and tightly packed sand particles characterize a stable zone.

Shoreline oscillation is believed to be a rhythmic mechanism. Using Low Isles, Great Barrier Reef, as an example, the sand beach changes shape as two small curving sand spits grow out to the south at the eastern and western ends of the cay. The lighthouse keeper assured Fairbridge and Teichert (1947, 47) that this variation took place every year with the change of season.

Results to date for Green Island indicate an approximately cyclic oscillation of the western end of the cay with periodicity of thirty years duration according to the following pattern:

i) to c.1938 the major depositional area was on the north-west side;

ii) from c.1938 to c.1964 the main depositional area was to the south-west;

iii) since c.1964 the main depositional area has been on the north-western side.

Erosion has occurred on the side opposite to where spit formation has taken place, particularly during periods of transition. The periodicity of movement has been long enough for significant vegetation colonisation of the spit areas, giving a false impression of stability.

It has been hypothesized that rates of sediment production at Green Island may have been affected by "Crown of Thorns" *Acanthaster planci* (Linnaeus) (Weber, 1969, 37) devastation of coral and changes in lagoonal patch reef development. Man-made changes to reef geometry by dredging and constructing groynes have altered patterns of sediment deposition. For example, a beach replenishment programme was unsuccessful because unsuitable material in both quality and grading was used. Particle size differences between the borrow pit and the frontage to be protected were noticed. There has been an accentuation of spit development on the north-western side, acting as a barrier to the natural drift; it redirected natural drift, patch reefs were destroyed (Fig. 2) due to increased turbulence, and marine grass growth, took advantage of the finer sediment (Fig. 4). Marine grasses can be an important sedimentary agent because of their ability to trap sediment by their active root systems. Promotion of marine grass growth is also thought to have been aided by the effluent discharge scheme on the island. Similarly, Flood (1974, 387) claims that erosion has resulted from the construction of a concrete retaining wall on Heron Island coral cay, Great Barrier Reef. The retaining wall was constructed "without taking into account the shoreline processes in the immediate area" (Flood, 1974, 387).

Natural vegetation which stabilizes the cay against wind erosion and in some circumstances against wave erosion is being destroyed at Green Island by the implementation of both walkways and buildings on the "seafront". This destruction is especially noticeable on the windward side of the cay. The planting of less effective exotic species of vegetation in an attempt to reduce the destruction, is permitting the level of sand on the cay to be lowered and protection against erosion to be decreased. When natural vegetation is removed or destroyed, it is normally replaced by coconut palms which have a dense but shallow root mat easily undermined by marginal sapping. They are easily penetrated by sea water, frequently have no ground vegetation and the surface is consequently exposed to stripping and channelling. Management decisions need to take into account the dynamic elements of temporal and spatial variations and the management programme for a coral cay must reflect the context within which all geomorphological processes operate.

Table VI

CHANGES IN DIMENSIONS OF SELECTED CAYS BETWEEN CAIRNS AND LIZARD ISLAND 1936-1973 FROM SURVEYS OF STEERS IN 1936 AND STODDART IN 1973.

Unvegetated or partially vegetated cays	Total area (ha)		Area above high tide (ha)		Vegetated area (ha)		Max length (m)		Max width (m)	
	1936	1973	1936	1973	1936	1973	1936	1973	1936	1973
Arlington	2.05	0.46	0.97	0.13	0.05	0	295	120	90	50
Sudbury	1.72	1.40	0	0.73	0	0	230	205	105	105
Undine	1.12	0.46	0.13	0.03	0	0	275	220	50	26
Mackay	2.39	0.93	0.82	0.28	0.18	0	385	190	105	63
North Pickersgill	1.51	0.41	0.33	0.01	0	0	170	120	140	40
South Pickersgill	0.53	0.08	0.10	0.05	0	0	75	53	38	13
Vegetated cay	1929	1973			1929	1973	1929	1973	1929	1973
Michaelmas	3.13	2.90			1.46	0.76	415	385	95	70

FIG. 1 VEGETATION SHORELINES 1945-1978

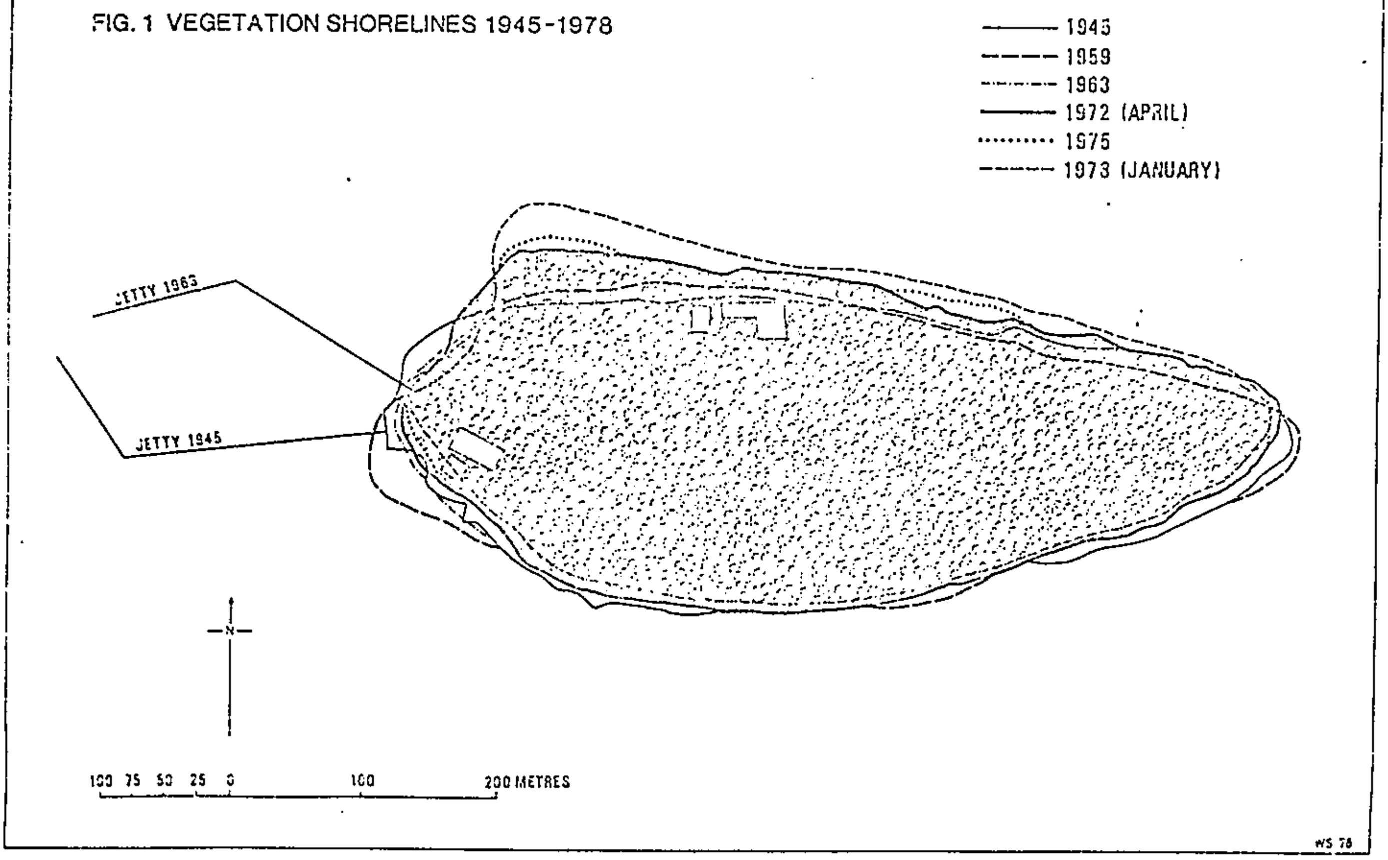


FIG. 2 LAGOONAL PATCH REEF DEVELOPMENT 1945-1978

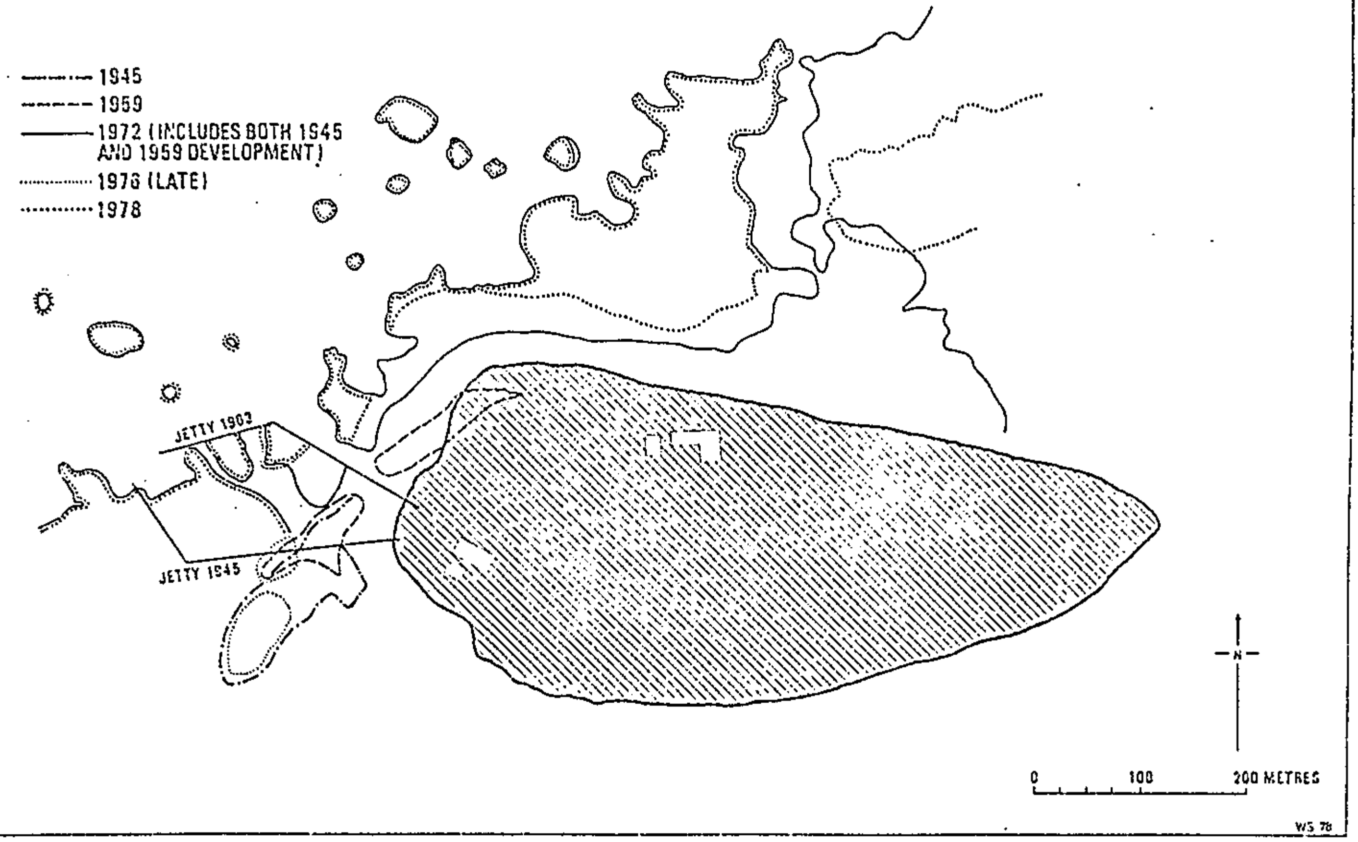


FIG. 3A VARIATIONS IN NEARSHORE SAND ACCUMULATION 1936-1964

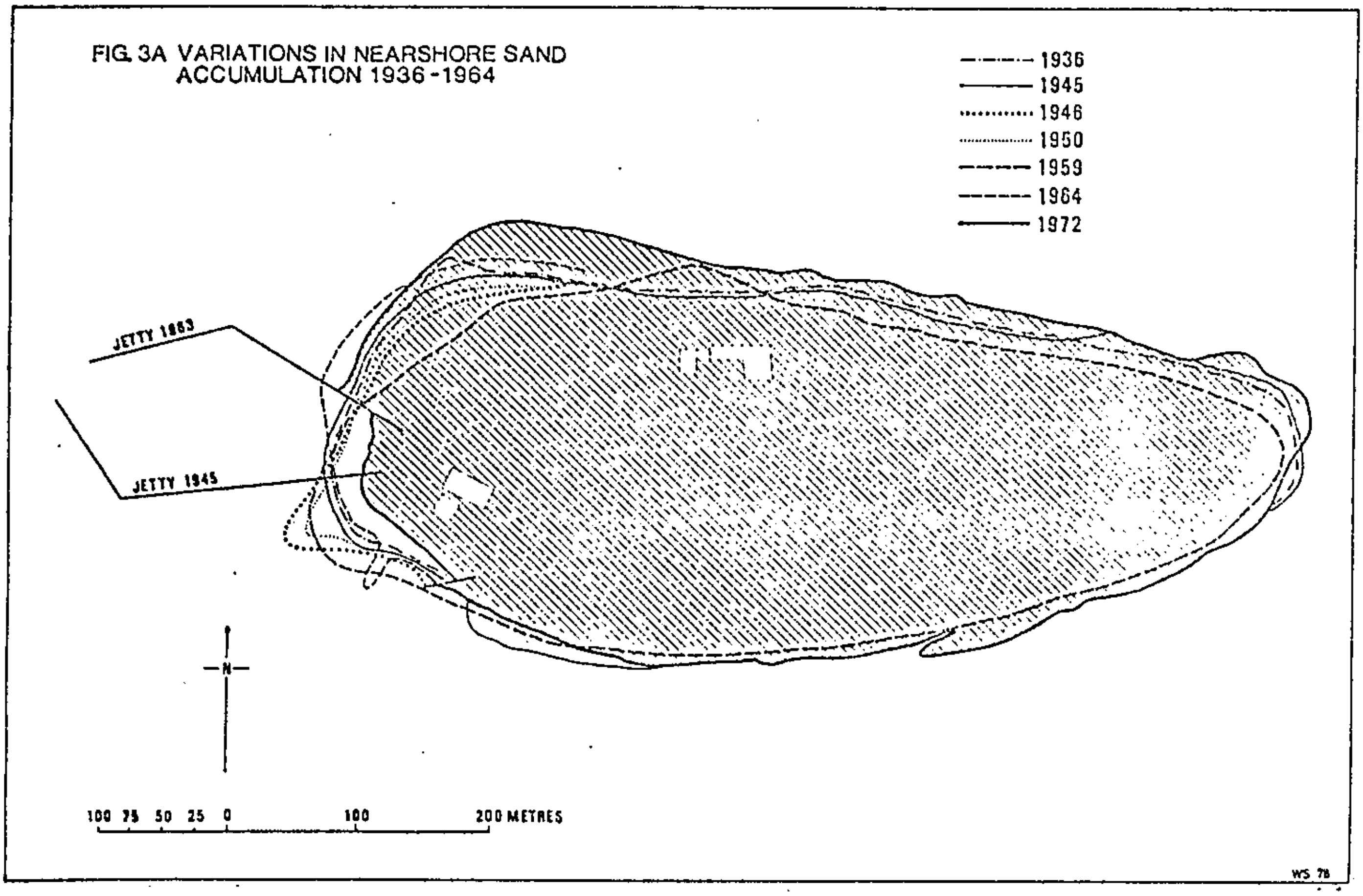


FIG. 3B VARIATION IN NEARSHORE SAND ACCUMULATION 1964-1978

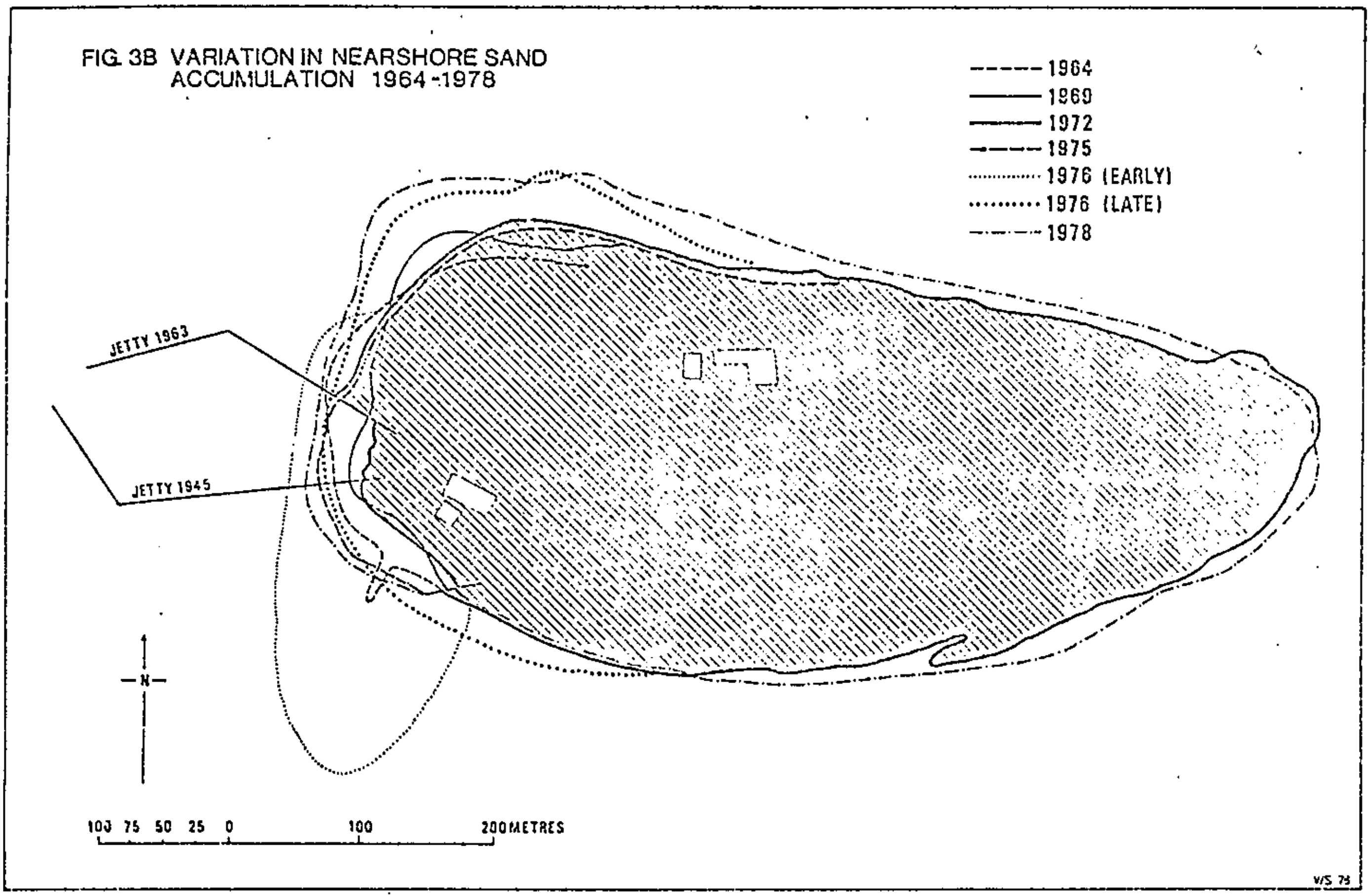


FIG. 4 THE GROWTH OF MARINE GRASSES 1936-1978

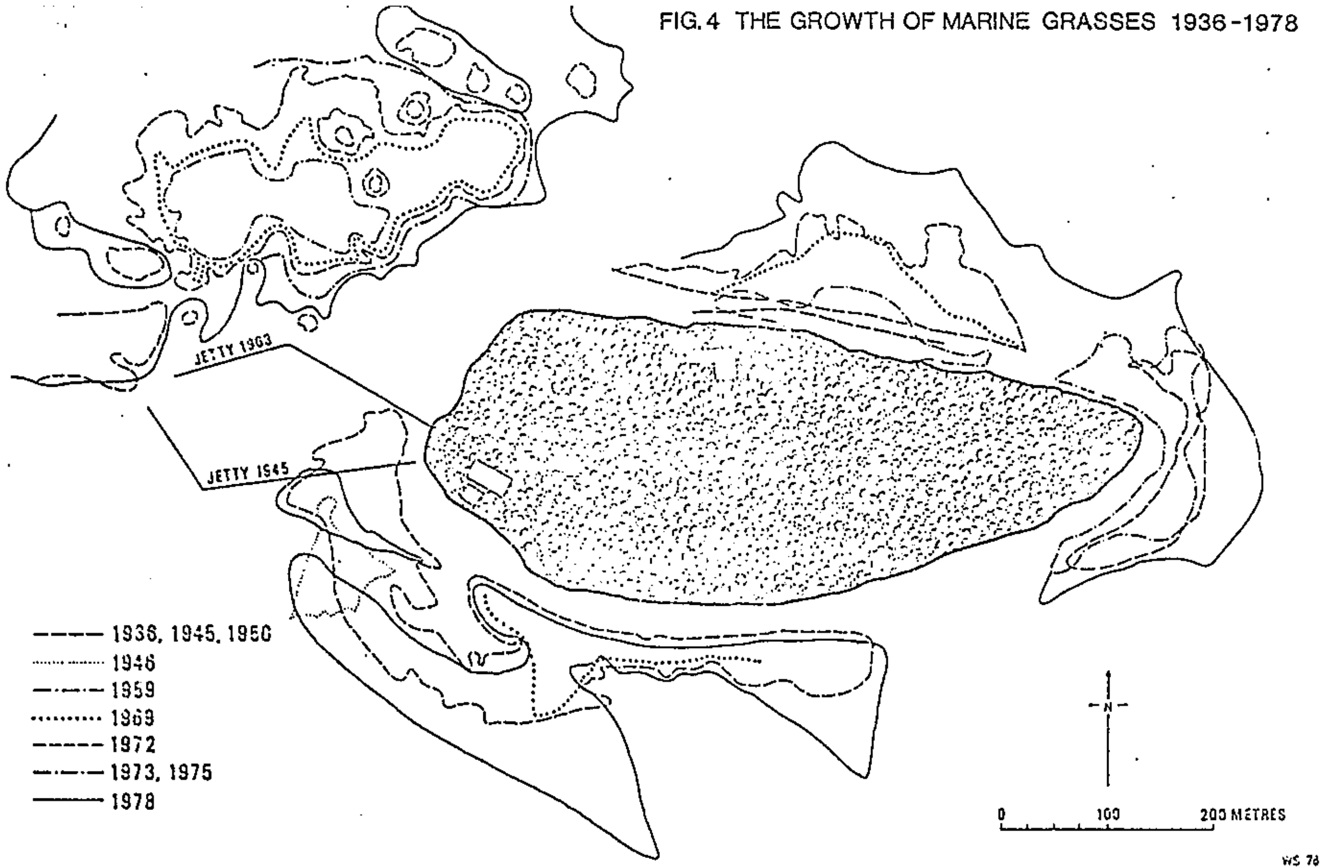


FIG. 5 BEACH/WATER INTERFACE - A FUNCTION OF TIDE HEIGHT

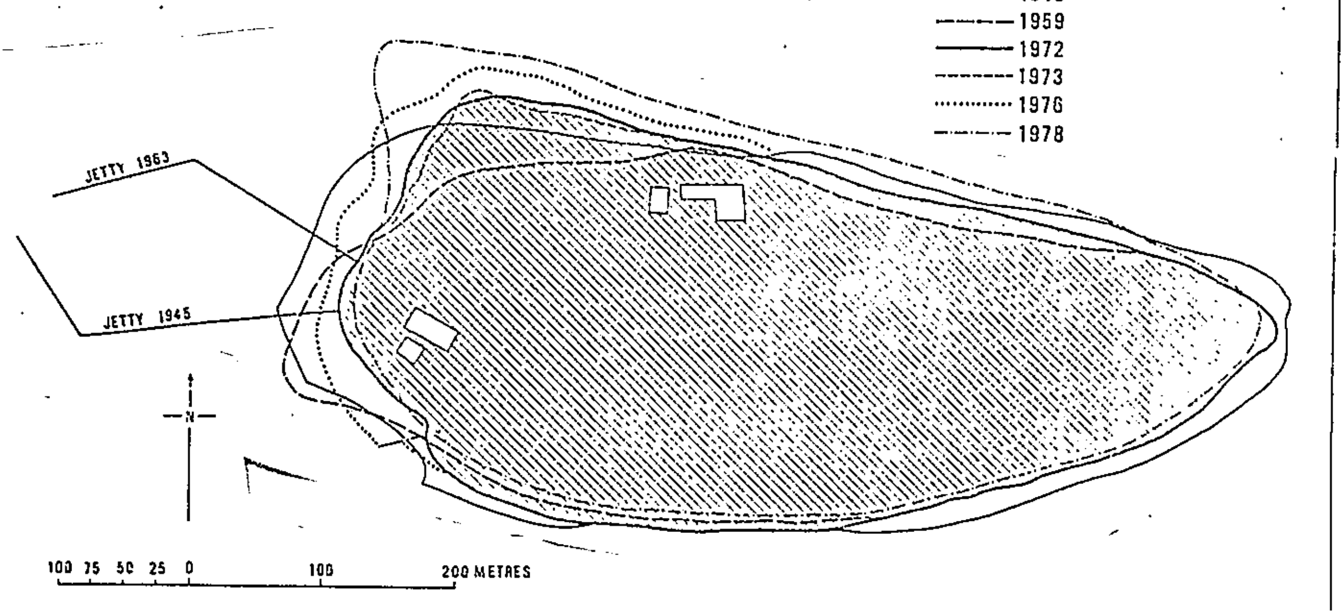
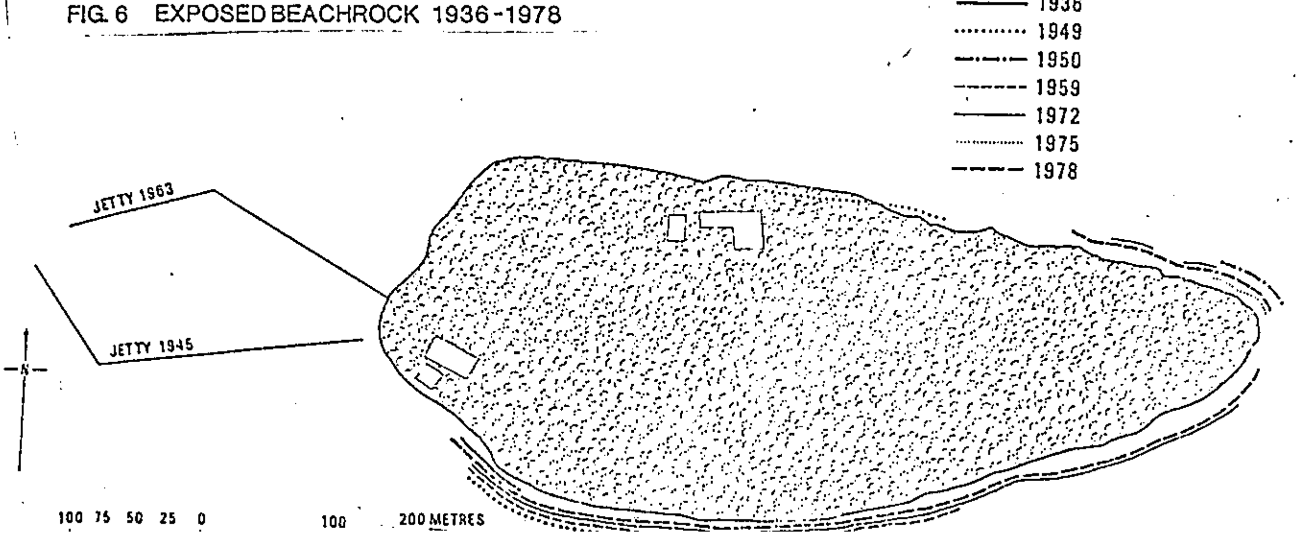
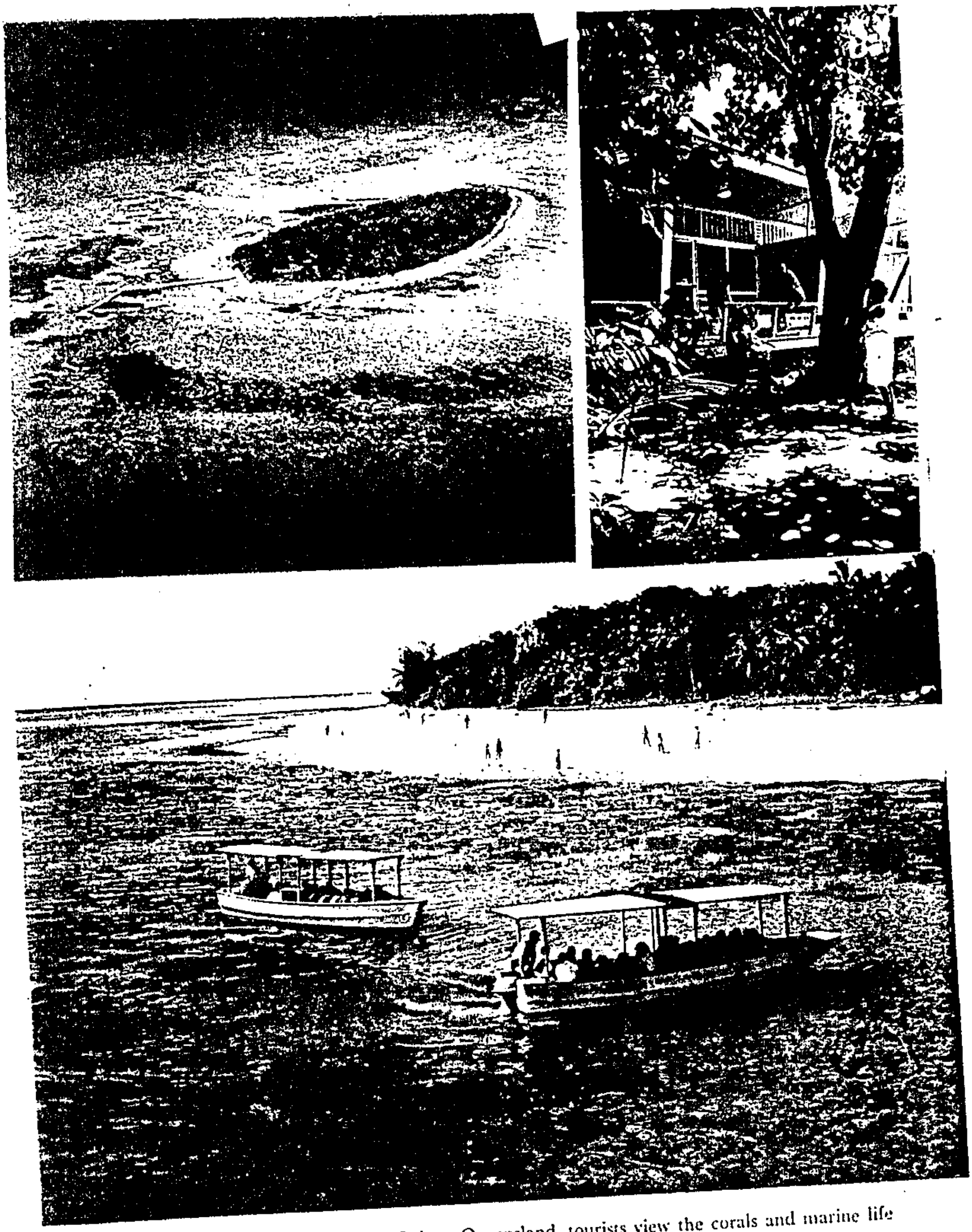


FIG. 6 EXPOSED BEACHROCK 1936-1978





At Green Island, a coral cay off Cairns, Queensland, tourists view the corals and marine life on the reef flat through glass-bottomed boats.

LIZARD ISLAND TO INNISFAIL

SPORTS AND OTHER FISHING

B. Goldman, Lizard Island Research Station

Although reef fishes were undoubtedly taken for local consumption, from the beginning of European settlements, no organised industry for that resource had developed before the turn of the century. In his report to Parliament in 1889 concerning the development of a fishing industry, Saville Kent wrote "one of the greatest impediments to such desirable progress has hitherto been the absence of any collated scientifically reliable data concerning the number and varieties of fish inhabiting Queensland waters". (This is still surprisingly true even today!).

Unlike our more 'primitive' neighbours, western man has habitually regarded the environment as a free supply of any resource he may wish to take, this applies especially so to the marine environment. Concepts of individual, or even corporate ownership of land and terrestrial animals, is only just being extended to include aquatic forms, these generally being of a fixed or sedentary nature such as oyster farms. Consequently, there are no feelings of individual or group responsibility for the rational exploitation of marine resources. With growing human populations and multiple demands for land, the average citizen no longer feels he has the 'right' to go and hunt on land for food. But the feeling is very widespread, almost universal, that man has the 'right' to fish, even if only for recreation. It is about time that this 'right' started to be challenged, especially the attitudes towards killing for sport (and not just for food or defence).

As discussed above, fishing disturbs the age structure of populations. This may have even greater consequences than previously imagined as we are now finding that the great majority of reef fishes are protogynous. In general, when a population is exploited, proportionately more larger fish are taken, which lowers the age structure. With fishes that are protogynous, the sex ratio is highly biassed with the larger fishes being predominantly, perhaps almost exclusively, males. Thus, lowering the age structure will severely disrupt the sex ratio and therefore have a drastic impact on the population's fecundity. We may have to alter our traditional approach to fisheries management, and instead of throwing back the little ones, we may be helping the population more if we throw back the big ones, i.e. the concept of 'minimum legal size' is not relevant to reef fishes.

Lastly, it has been estimated by Dr. G. Goeden of the Queensland Fisheries Service, that within a 50 mile radius of Cairns, coral trout populations have been reduced to one tenth of their normal abundance. This is due primarily to amateur anglers and fishing charter groups - not professional fishermen. Therefore, although coral reefs are the epitome of highly productive natural ecosystems, they may not be able to support anywhere near the level of exploitation (i.e. removal of energy and nutrients by fishing etc.) as we have been led to believe.

MARLIN FISHING: Big game fishing focuses international attention on Cairns and attracts considerable tourist revenue. Over the last two seasons, some 25 boats have fished the northern reefs. These boats would average $100,000 each, and together with maintenance at about $7-10,000 and salaries of $25-35,000 yearly, the industry must be considered significant.

There is no firm data as to the size, or geographical extent of the population of the black marlin *(Makaira indica)*, which is the principal fish caught. Tagged fish released off north Queensland, have been recaptured as far south as Sydney, as far east as New Zealand, and north around New Guinea and even in the Gilbert Islands. Some tagged fish have been at large for nearly two years. During the months September through December, the black marlin appear off the reefs north from Innisfail, and most abundantly between Cairns and Lizard Island.

Apart from the moral problem of killing for sport (Queensland Health Regulations prohibit the sale of marlin for human consumption) there are ecological problems which need attention:

1. Black marlin are most likely either sexually dimorphic or protandrous, as no males have been caught above about 150 kilos weight, while females above 500 kilos are now common (unless of course, large males do not take baits, or live elsewhere).

2. The fishes are in breeding condition when caught - those individ-

uals most sought after and most likely to win a competition, will be large gravid females (pers. obs.: gonads constitute approximately 5% body weight). This is obviously not the most sensible stage to exploit a population.

3. Many more fishes are caught than are weighed. Most of these are tagged and released but the trauma of capture is, apparently, generally fatal (some estimates put this mortality at 90%, but this is likely to be reduced with improved methods of capture - such as 'backing up').

4. After weighing, carcasses are generally dumped at sea, generally not far from the weigh station. When this is done near the islands (e.g. Green or Lizard) it appears to attract large sharks (e.g. 15 ft. hammerheads) which constitute a threat to other users in the area.

SHELL COLLECTING: General comments apply as per Capricorn-Bunker report. There is a shell club in Cairns with 40 members, one club in Innisfail with 35 members, and a small group in Port Douglas. Visitors are received from all over Australia, and overseas, and shell collecting trips are made to reefs on a roster-system (Cairns club). Apparently, there is one professional shell collector operating from Port Douglas.

AQUARIUM FISH COLLECTING: Many people in north Queensland keep marine aquaria and collect their own specimens. Their impact is virtually negligible. There is a variable number (one at present, sometimes 3 or 4) professionally catching reef fishes for southern markets (Sydney in particular) or overseas export (mostly northern Europe).

While not great, their activities may be locally destructive. However, it is a fishery which could easily be expanded but which will need careful management (e.g. rostering of reefs and catch limits). It is an activity which gives people long term satisfaction and helps to engender deeper appreciation in the public of the reef and its fauna.

BECHE-DE-MER

Malay fishermen have been exploiting beche-de-mer in Australia for about 1,000 years. However it is not known to what extent they reached and fished on the north eastern coast. The first record of European exploitation of beche-de-mer on the east coast of Queensland is in 1804 when the 'Marcia' under the command of Capt. Aickin returned to Wreck Reef where 'Cato' and 'Porpoise' had stranded in the previous year. While there Aickin noted the large numbers of beche de mer in the shallow waters around the reef and, being aware of their value, returned to Sydney with a trial sample. Much of the early fishery was confined to the reefs and islands of the Coral Sea and the first curing station was established on Lady Elliot Is. The potential of the more sheltered inner Barrier Reefs was soon recognized and the industry expanded rapidly into north Queensland waters. As early as 1827, ten tons of beche-de-mer were taken from Cooktown waters for export to the Chinese markets.

The early fishery was seriously troubled by Aborigines who resented the intrusion of the Europeans into their traditional territories. A group of fishermen who were operating on Green Island were massacred in 1858 (although another group was re-established there by 1868). In 1881 there was the tragic venture on Lizard Island, which resulted in the death of Mrs. Watson, her son and two Chinese servants. Nevertheless, the industry grew, no doubt stimulated by statements such as those of Percival (1881:5) who claimed "its very great extent of sea coast and wonderful wealth of adjacent seas indicate unsurpassable opportunities for people of maritime habits ..... the sea swarms with fish of innumerable varieties ..... the dugong abounds; beche de mer, pearl oysters and other shells, coral, turtle ..... waiting for someone to come and gather them ..... beneath a genial sky and in sheltered waters".

By 1890 there were 27 boats licenced out of Cooktown and six out of Townsville, Cairns and Ingham. The average take for a group of four boats carrying 24 men was around one ton of cured meat per month; top prices were £140 - 150 per ton. In the decade from 1880 an average of 200 tons per year of beche-de-mer with a value of around £19,000 were taken in north Queensland waters (Saville Kent, 1893).

Perhaps due to easier access to beche de mer in other parts of the South Pacific, that fishery later declined and has been non-existent in Queensland waters since World War II (except perhaps for a recent unproven venture in the waters off Townsville).

Moves to re-establish the beche-de-mer industry in North Queensland waters during 1977-78 prompted the Queensland Government to introduce amendments to the Fisheries Act 1976 to control the industry until such time as a detailed survey of stocks could be undertaken by the Queensland Fisheries Service. Restrictions introduced included the licensing of vessels and divers, limitations on the number of fishing units (motherships and dories) and the declaration of closed waters with respect to beche-de-mer fishing.

In the Lizard Island to Innisfail area, collection of beche-de-mer is only permitted between Lat. 15° and 16°S, i.e. approximately between Cape Flattery and Cape Tribulation, and is specifically prohibited in waters surrounding Pickersgill, Endeavour, and Boulder Reefs, and in waters in which are located any reef surrounding an island or coral cay (Gov. Gaz., 22nd April, 1978).

CORAL

The activities of the early fishermen were not solely confined to the collection of beche de mer. Small amounts of coral were collected for export as curios and it was suggested by Saville Kent (1893) that the antipatharian black coral would make a valuable export to India. Pearl shelling, already well established in the Torres Strait, was also practised on the east coast. In 1884 the total worth of this industry to Queensland was over £94,000 (Saville Kent, 1893).

TROCHUS SHELL FISHERIES for button manufacture first came into prominance in the 1920's. The industry reached peak production in 1927 (Moorhouse, 1933) then declined during the war.

A BRIEF HISTORY OF THE BECHE-DE-MER FISHERY IN AUSTRALIA

Howard Silver, Zoology Department, University of Queensland

I. INTRODUCTION

Holothurians, commonly called sea cucumbers, sea slugs, trepang, or beche-de-mer are a conspicuous and abundant portion of the fauna of the shallow water benthos of tropical Australia. Beche-de-mer and trepang are terms for the species of commercial value and occasionally refer to the dried product.

In the Pacific region sea cucumbers are consumed by Pacific Islanders, Japanese, and Chinese. The former two groups consume the product fresh. The Chinese are the only significant consumers of the dried product. Consumption of beche-de-mer by the Chinese is first recorded in the 1500's and records of importation of beche-de-mer date from the 1700's.

II. THE MACASSAN TREPANG FISHERY

When Matthew Flinders sailed through Torres Strait to northern Australia in 1803 he encountered a fleet of Malaysian fishing boats (praus). This fleet made yearly trips to northern Australia collecting and curing trepang and turtle shell.

The Macassan fishery began between 1650 and 1750. Between the 1700's and 1881, when European intervention began, the fleet averaged between 30-40 praus. Each prau carried a crew of 30. A voyage lasted 6 months. Each ship collected 8-10 tons of trepang. A fishery of 300-400 tons per year agrees with records of trepang export from Macassar to China.

In 1881 South Australia began taxing Macassan praus fishing in Australian waters. The statistics for the fishery are as follows: 1882-1894; 8-16 praus per year, a total catch of 82-250 tons; 1894-1907; 1-6 praus per year, catches of 30-100 tons. In 1907 the South Australian Government ceased issuing licences to Macassan praus.

Taxation of the praus reduced the profit margin of a voyage to a point where it was no longer profitable. As the industry declined crew size increased to nearly double and the catch per ship increased to 10-20 tons or more.

The trepang of northern Australia is of poor to average commercial quality receiving on average 1/3 the price of beche-de-mer from Torres Strait. It is present in large quantities and the Macassans relied on this and their skill in preparation to make a profit. The area was fished for approximately 200 years with no apparent diminution of the trepang stocks.

Concurrent with Australian regulation of the Macassans was the development of a small local trepang industry. This reached 20 tons in 1885 but declined until 1895 when it ceased. In 1899 9.5 tons were taken, 39.5 tons in 1903, and 32 tons in 1905. Sporadic production continued in the early 20th Century, carried out by local entepprenures. Fishing operations were run by both Europeans and Asians using local aborigines as crew. A primary obstacle to development of a local industry on a scale similar to the Macassan operation was a chronic labor shortage.

III. THE BECHE-DE-MER INDUSTRY IN QUEENSLAND

A. 1840's - 1890: Flinders was the first European to note the potential of beche-de-mer as a profitable fishery. Collecting began in the 1840's and a cargo was brought into Sydney in 1846. In the 1860's to 1870 a Captain Towns supplied the New South Wales Chinese community with beche-de-mer from the Great Barrier Reef. Export to Hong Kong and China began in 1874 and by 1880 the industry was flourishing.

An excellent account of the early decades of the fishery was submitted by W. Saville-Kent to the Queensland Parliament in 1890 and later published in a book on the Great Barrier Reef in 1893. By 1890 the backbone of the beche-de-mer fleet were small luggers of 5-6 tons. These made daily voyages from land based curing stations to local reefs coinciding with low tides, or the fleet would anchor at a reef with some ships ferrying supplies. In addition to the luggers were schooners of 20, to 40 and 50 tons. These ships carried small boats and had a processing plant and stores of supplies aboard. These ships made extended trips to isolated reefs.

The workforce consisted of aborigines, Torres Strait and South Pacific Islanders, and Manilla men. The operations were run by Europeans or Asians. Previously a large portion of the workforce had come from New Guinea but by 1890 this practice had been discontinued. The fleet was taxed as follows: small boat 10s, up to 10 tons 3, greater than 10 tons 10s per ton up to 20. An additional tax of 2s6d per crew member was levied. Crew wages were 5-20s per month and board. It was paid in goods or tobacco.

Although beche-de-mer was plentiful and accessible down to 20 meters most of the catch was collected from the top to the reef at low tide. Kent assumed that the reef tops were repopulated from one year to the next by migration of animals from deeper water. The average take for 1 station, employing 20-24 men and 4 boats would be 1 ton per month with 2 tons being the normal maximum.

Saville-Kent recommended that with the lack of knowledge of growth and reproduction in holothurians, size limit regulations would be inappropriate. He thought that research on these subjects was warranted.

In 1890 there were 62 licenced beche-de-mer boats operating out of Thursday Island, 27 from Cooktown, and others from Townsville, Cairns and Ingham. The statistics for the industry are presented in Table 1.

B. 1890-1908: In 1908 a Royal Commission was appointed to investigate the pearl-shell and beche-de-mer industries by the Queensland Parliament. By this time the industry had been in operation for nearly 30 years. The commission was equally concerned with overfishing and Asian dominance of both fisheries.

In 1907 there were 67 ships collecting beche-de-mer. Most of these were owned by Japanese who had been imported as divers for the pearl-shell industry and came to control both fisheries. Their range of operations extended from the Great Barrier Reef to the Coral Sea and from New Guinea to Lady Elliot Island. As the range of operations expanded the industry became dominated by ships 25 tons and larger.

Testimony was given at the Commission that the stocks of beche-de-mer were suffering from overfishing. While no quantitative evidence was offered and catch statistics showed no decline there is positive evidence for the decline. The majority of the catch was no collected in shallow water only.

The Commission recommended cessation of fishing for 2 years and elimination of Asian participants. Statistics for Torres Strait although incomplete give an indication of the value of the fishery and the number of boats involved.

C. 1913-1948: In 1913 "... the traffic with China in beche-de-mer was flourishing, and many thousands of pounds were exported annually from Thursday Island". (Clark, 1946). Clark (1921) mentions 25 years of exploitation prior to 1913. He proposed research on holothurians with a view towards developing sensible government regulation and restocking programmes. Clark (1946) remarks that the First World War disrupted the trade but following the war "... Chinese demand exhausted the supply that was easily accessible in the Torres Strait region".

Roughley (1951) gives some statistical information about the fishery between the World Wars. Between 1926-1935 the average catch was 213 tons, 139 tons in 1935 and 441 tons in 1932 being the maximum and minimum catches. Prices varied between 30-300 per ton depending on its grade, average price being 93 per ton. Average yearly gross was 12,688 with the maximum gross being 29,383 in 1927. He felt that available stocks showed little sign of depletion and output could be increased according to demand. An attempt to resume the trade in 1947 and 1948 failed due to lack of demand (see Table 1).

IV. OVERVIEW

Beche-de-mer fishing operated in Queensland as an industry for about 100 years. It was interrupted by the First and Second World Wars. It collapsed after the Second World War due to a lack of demand from China. In its time it was in terms of revenue and employment the second largest fishery in Queensland, pearl-shelling being the largest. Between the World Wars a trochus shell fishery developed which was operated in conjunction with beche-de-mer fishing and rivalled it as a source of income.

The fishery in Queensland differed from that in northern Australia in 2 respects. Firstly the beche-de-mer taken from the Great Barrier Reef is of higher quality and greater commercial value than that from northern Australia. The most valuable species fetched up to 300 per ton. Secondly the beche-de-mer stocks seem to be vulnerable to overfishing although the evidence for this is mixed. The Royal Commission of 1908 and Clark (1946) concluded that commercial holothurian stocks were seriously depleted. The catch statistics available do not support this conclusion although catch levels seem to have been maintained by more intensive fishing. Roughley felt if anything the fishery was under utilized although he includes the trepang grounds of northern Australia in this assessment.

Table VII

STATISTICS OF THE BECHE-DE-MER INDUSTRY IN QUEENSLAND: 1880-1948

Year	Boats	Catch in Tons	Value (£)	Catch/ Boat	Value/ Ton (£)	Source
1880	40	199	18,343		93.6	S-K & Bolton
1881		312	29,286		98.9	S-K
1882		317	30,914		97.5	S-K
1883		342	31,581		92.3	S-K
1884		285	24,867		87.3	S-K
1885		259	23,780		91.8	S-K
1886		252	19,510		77.4	S-K
1887		188 (86)	14,529 (6,207)		77.3 (72)	S-K & TSPSA
1888		242 (111)	20,048 (6,999)		82.8 (63)	S-K & TSPSA
1889	100+	282 (109)	22,740 (7,015)		80.8 (64)	S-K & TSPSA
1890	65	104	9,691	1.6	93	TSPSA
1891	57	70	6,910	1.2	99	TSPSA
1892		61	4,556		75	TSPSA
1893		50	3,881		78	TSPSA
1894		53	3,522		66	TSPSA
1895	41	22	1,624	.5	74	TSPSA
1896	47	30	2,421	.6	81	TSPSA
1897	18	17	1,125	.9	66	TSPSA
1898	11	15	1,282	1.4	85	TSPSA
1899	13	14	1,219	1.1	87	TSPSA
1900	11	13	1,255	1.2	97	TSPSA
1901	9	52	7,399	5.8	142	TSPSA
1902	26					TSPSA
1903	24					TSPSA
1904	23	45	5,865	2.0	130	TSPSA
1905	20	105	10,624	5.3	101	TSPSA
1906	79	131	13,938	1.7	106	TSPSA
1907	69	338	30,033	4.5	89	TSPSA
1908	55					TSPSA
1909-1925			no figures			
1926-1935		213	12,688		93	Roughley
1927			29,383			Roughley
1932		441				Roughley
1935		139				Roughley
1947		16				Roughley
1948		5	500		100	Roughley

S-K = Saville-Kent 1890 or 1893
TSPSA = Torres Strait Pearl-Shellers Association from Royal Comm. 1908

COMMERCIAL FISHERIES OF THE NORTH QUEENSLAND REGION

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1. INTRODUCTION

1.1 The Queensland Fish Board

The Queensland Fish Board, established in 1973, is responsible for the marketing of fishermen's catch in certain sections of Queensland which have been declared as "Fish Supply Districts". Prior to this date, and from 1966 onwards, the "North Queensland Fish Board" was responsible for the marketing of fish north of Rockhampton. Another body called the "Fish Board" established in 1936, was responsible for marketing south of Rockhampton. Owing to these administrative changes, there have been minor alterations in the period of recording monthly and annual data. This has been taken into account in the present analysis.

1.2 The data

This analysis is based on Queensland Fish Board data which record the total quantities of fish and shellfish received at various markets and agencies throughout the northern coastal areas of Queensland. Four main Queensland Fish Board markets - Bowen, Cairns, Innisfail and Townsville have been selected for this analysis. Analysis is confined to "total quantities of fish and other seafoods" in the case of monthly production data for individual species (section 2). Data on fish fillets are available but have not been dealt with here since whole fish, in terms of weights landed, are generally more important. Cairns, however, is the exception, where fillets of barramundi and mackerel in particular comprise a larger proportion of the catch than whole fish. In examining annual production data by species (section 3), "finned fish", "seafoods other than finned fish" and "fish fillets" were taken into consideration. Owing to differences in time scale for which these data were available, the different categories have been analysed separately for most of the period under consideration.

1.3 Data interpretation

In interpreting the data, it must be noted that it does not imply that all finned fish, fish fillets and seafoods other than finned fish received at the recording market or agency are sold exclusively in that locality. This is particularly so in the case of Barramundi and Mackerel. For example, in Townsville, 70% of Barramundi and 50% of Mackerel are sent to centres outside Townsville. However many of the species which comprise a somewhat lower proportion of the total catch are consumed locally. Analysis has been restricted to the more important species contributing to the total production of a particular part. In both the monthly and annual production data, the criterion of selection was those species which constitute at least 0.5% of the total catch for that market over the period of measurement.

2. ANALYSIS OF MONTHLY DATA

Monthly production data were plotted in time-series for the period January 1973 to April 1978 in order to observe regional and temporal variations in production which might occur in particular species. A number of species, chosen on the basis of the criterion given in Section 1.3 were examined in detail and are listed in Tables VIII (a)-(d).

2.1 Catch composition

In Cairns, Innisfail and Townsville, mackerel easily dominated the catch, occupying 50%, 44.9% and 38.8% respectively. The Bowen catch was only some 12% Mackerel, with School Mackerel (13.6%) the most dominant fish species.

Reef fish, especially Coral Trout, Emperor and Cod represent higher catch proportions in Cairns and Innisfail than in Townsville and Bowen. This is no doubt a reflection of the greater accessibility of Cairns and Innisfail to the Great Barrier Reef.

Some idea of the relative importance of each species at each market can be obtained from Table VIII(b)

2.2 Variation of monthly catch

All species analysed show considerable variation in their monthly catch. This variation may be split into two components - that due to seasonal influences and that due to influences other than seasonal (erratic variation). The coefficient of variation (CV) ie the ratio of standard deviation to mean, is a relative measure of the total monthly variation occurring for the production of a particular species. The coefficients listed in Table VIII(c) are generally very large. Catch variability is greatest for the Bowen market, apparently through erratic rather than seasonal factors. It should be emphasised here that figures given relate to quantities received from fishermen at the various markets. Their behaviour with respect to prices, weather conditions, harbour facilities, condition of the vessel etc, will undoubtedly influence the quantities of fish and shellfish received at a particular market. Therefore, the erratic component of the observed variation is considerably larger here than if a sophisticated sampling technique had been employed.

Despite masking by this erratic variation, obvious seasonal patterns emerge for a number of species.

BARRAMUNDI

Production peaked during May-July for the Townsville and Innisfail markets. Cairns and Bowen showed no distinct pattern.

MACKEREL

A production peak in October-November with virtually no erratic variation occurred at the Townsville and Innisfail markets. Cairns was characterised by a double peak at July-September and October-December. A less distinct June-July peak occurred at Bowen.

SCHOOL MACKEREL

A pronounced August-September peak with very little erratic variation was seen in the case of the Bowen market. Townsville peaked later in October-November, while Cairns again exhibited the double peak in July-September and October-November.

SALMON

Only at the Townsville market did a distinct pattern (June-July peaks) emerge.

SWEETLIP

Distinct September-November peaks in production occurred at Bowen, Cairns and Townsville. No seasonal pattern was obvious at the Innisfail market.

CORAL TROUT

Pronounced October-November peaks were observed in all four markets.

PRAWNS

Bowen and Townsville were characterised by peaks in May and August-September. This correlates with the banana and tiger prawn seasons respectively. Cairns and Innisfail peaked in September and June-July respectively.

MUDCRABS

A distinct seasonal pattern (April-June peaks) only emerged for the Townsville data. Similar, but less distinct patterns were observed in the Bowen and Innisfail data.

LOBSTER

Strong August-September peaks in production occurred at the Bowen and Townsville markets.

SCALLOPS

Only at the Bowen market did any seasonal pattern (September peaks) occur.

2.3 Magnitude of catch

An impression of monthly catch magnitude of various species at different markets can be obtained from the mean monthly catch given in Table VIII(d) Catch magnitude will be treated in more detail on the basis of annual data in Section 3.

3. ANNUAL PRODUCTION

3.1 Introduction

The analysis of annual seafood (fish and shellfish) production data is undertaken here to illustrate certain short-term and long-term trends in the catches of major species of the north Queensland region, selected under the criterion given in Section 1.3. No attempt is made at an elaborate analysis since as in Section 2, information such as catch effort data is not available and even the data which is available have been recorded erratically; for instance, the annual totals during the periods 1977 and 1976 refer to the period May 1st to April 30th of the following year. Prior to that the period was July 1st to June 30th and during the year of transformation (1976) only a period of ten months was considered.

However, this data set gives some indication of the relative importance of certain species and periodic fluctuations, in the areas under consideration.

Trends in the production of finned fish only, are examined over a period of eleven years (1967-1977) since in all four market centres most species are brought by the fishermen in this form (Table IX(b)). Table IX(d) indicates those species where the filleted form is more important than the finned form. The latter analysis is over a period of five years (1973-1977).

For comparative purposes 'mean catch' is considered together with the 'minimum' and 'maximum' catch which give an indication of the range of the catch during the period covered.

3.2 Regional variations in total production

In the four market centres examined, total catch statistics indicate that Cairns and Townsville are the most important producers (Table IX(a)). Being more developed and larger than the other two centres, this trend is not surprising. Bowen which is located further south has the smallest recorded production. In all centres except Cairns, finned fish contribute more than 65% of the total catch. At Innisfail this figure is as high as 92% since the quantity of fish received in filleted form is minute. In contrast, Cairns records 56% of the total catch in filleted form, and it is largely due to this that it ranks above Townsville when both finned and filleted fish are considered.

In the production of shellfish, Townsville is the leading centre followed by Bowen. Townsville far exceeds all other centres in the production of prawns, mudcrabs, Moreton Bay lobsters and scallops. Cairns and Townsville have notably large catches of prawns recorded owing to their proximity to the Gulf of Carpentaria, and also in being two of the few towns in the north engaged in prawn processing for purposes of export (Table IX(d)). It is somewhat surprising that at Cairns, despite the large demand for products like squid and lobster during the past few years, that the quantity of shellfish received (excluding prawns) is negligible.

3.3 Regional variations in catch composition

For long-term planning purposes it is essential firstly, to identify the predominant species, and secondly, to find out whether the production of an individual species is stable or is widely fluctuating. This has an impact on management planning both in sea (catching) and land based operations (processing and distribution).

Mackerel is by far the most important species in the catch composition in all four centres (Tables IX(b), IX(d)). Prawns and Barramundi are next in importance. In Townsville and Cairns Salmon, Sweetlip, Mullet and Coral Trout are equally significant major contributors. On the other hand, in Bowen, the contribution of School Mackerel is noteworthy followed by reef fish such as Sweetlip, Coral Trout and Emperor. The relative importance of shellfish is far greater here than in any other centre. It is also relevant that Barramundi is relegated to the lower ranks of catch significance in Bowen. In the catch composition of Innisfail, once again Emperor, Sweetlip and Coral Trout are of secondary importance. Although its relative rank is low, it is necessary to mention that the Salmon catch, both at Bowen and Innisfail (not recorded here), is received largely in the form of fillets. This feature is also common to Townsville and Cairns

In the north Queensland waters the species referred to as 'Dart' is alternatively known as 'Queen Fish'. This species is of greatest importance in the catch composition of Townsville.

Some of the other species with regional concentrations are Jew fish which is abundant at Innisfail and Bowen, Whiting at Townsville and Bowen, and Gar fish at Cairns, Bowen and Innisfail.

The regional rank order of importance of each species has been indicated clearly on Tables IX(b) and IX(d). In terms of finned fish only, Townsville is marginally more important than Cairns. Bowen excels in the production of School Mackerel while Innisfail is regionally most important in the finfish production of Coral Trout, Sweetlip, Emperor and Cod (Table IX(b)), for reasons indicated in Section 2.1. When both finned and filleted fish are considered together, Cairns is the leading producer for most species (Table IX(d)). In shellfish production, Townsville is regionally the most important for a number of species including prawns, mudcrabs and scallops. Bowen ranks next to Townsville in the production of most species of shellfish.

3.4 Temporal variations in catch

Overall differences between the minimum and maximum catch for a number of species is most evident at Cairns and least at Bowen, probably because of differences in the magnitude of production.

The range is greatest in the more important species of the region such as Mackerel and Prawns. In addition, differencesbetween minimum and maximum production of finned fish are higher for Coral Trout generally, and individually for School Mackerel at Bowen, Barramundi at Townsville, Mullet at Cairns and Jew fish at Innisfail. For filleted fish these differences are most noteworthy for Mackerel, Barramundi and Sweetlip generally, and for Salmon and Coral Trout more specifically at Cairns, School Mackerel at Bowen, and Emperor at Innisfail. Once again these are the major contributors to total production in each of the centres. Besides prawns, large differences in the range of shellfish production is evident particularly in the production of scallops.

Together with minimum and maximum catches, it is interesting to find out whether there are particularly adverse or favourable years for a specific species or for an individual centre. This analysis is confined to the long-term data of finned fish only (Table IX(c)). However, this restriction does not alter the overall picture since the general trends are similar when both filleted and finned fish are considered together.

The odd peak in absolute terms of catch statistics is inevitable, but in general the trend in total production appears to be on the decline in the more important centres of Townsville and Cairns in particular. This trend is also reflected in the more important species of this region, such as Mackerel. The importance of Mackerel in this region is apparent in schemes such as the "Mackerel Price Stabilisation Scheme" introduced by the Queensland Fish Board in order to maintain stable prices for this product, throughout the year. Since the data recorded here give no indication of the quantity of fish entering the market from channels outside the Fish Board the decrease in the Mackerel catch may be attributed to one of two reasons (1) the catch has physically decreased owing to increased effort and subsequent overfishing; (2) due to substantial quantities of the catch entering the market through channels other than the Fish Board.* If the latter cause is true this trend could be further intensified with the introduction of the new payment scheme for Mackerel with effect from 1 October 1978. According to this scheme it is suggested that only 50% of the total

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* According to recent investigations carried out by fisheries biologists on the north Queensland waters it is highly unlikely that the mackerel catches have been depleted by overfishing.

value of the Mackerel will be paid on delivery and a balance of 25% on 1 February and the remainder on 31 March.

In contrast to Mackerel, Barramundi is one of the few species indicating an overall increasing trend. According to seafood consumption surveys conducted in these regions Barramundi is a highly demanded species. There is no doubt that the increasing trend in production should find a ready market in the local region as well as elsewhere in Australia.

Generally speaking, the years 1972/73 appear to be years of low production, with 1967/68 somewhat more favourable. In very broad terms a decreasing (-), increasing (+), stable (=), or oscillating (Λ) trend in the production of individual species has been noted in Table IX(c). It can be seen that Barramundi is the only species with an increasing trend which is consistent in all four centres. A similar downward trend in all the centres is conspicuous in Cod. In a number of species such as Salmon and Emperor no distinct production trend can be observed due to random oscillations. For Mackerel 1972/73 are two of the poorer years while 1968/69 is a better period for all centres excluding Innisfail. A similar trend throughout the study area may be seen for Coral Trout where 1967 appears to be a favourable year.

The relative contribution (percentage composition) of individual species to the total production of each centre is noted in Tables IX(b) and IX(d). This once again emphasises the importance of species such as Mackerel, Barramundi and prawns in particular, followed by some of the reef fishes such as Coral Trout and Sweetlip and, of the others, Mullet and Salmon.

4. CONCLUSIONS

There is a great deal of variation in catch magnitude in all species at all marketing centres out of which seasonal patterns emerge for some. In the more dominant species at least, these patterns may reflect the natural abundance of the species in fishing grounds adjacent to the towns in question. However, the importance of the Barramundi and prawn fisheries in the Gulf of Carpentaria must be considered (particularly with respect to Cairns) when drawing such conclusions. Concrete information relating to abundance of species will require the collection of detailed information on fishing effort as well as catch data.

TABLE VIII (a) SPECIES SHOWING SEASONALITY OF PRODUCTION

Species	Bowen			Cairns			Innisfail			Townsville		
	Peak	Max	Degree	Peak	Max	Degree	Peak	Max	Degree	Peak	Max	Degree
Barramundi	-	-	-	-	-	-	May	1636	2	May-Jul	3012	2
Cod	-	-	-	Nov-Feb	396	1	-	-	-	-	-	-
Coral Trout	Oct-Nov	734	2	Nov	1730	2	Oct-Nov	2652	2	Nov	679	2
Emperor	Sep-Nov	472	1	-	-	-	Nov-Jan	2316	1	-	-	-
Gar	Aug-Sep	548	1	-	-	-	Jul-Sep	521	1	-	-	-
Jew	Jul-Jan	197	1	Sep-Nov	1748	1	-	-	-	-	-	-
Mackerel	Jul-Aug	4982	1	Jul-Sep Oct-Dec	36443	2	Oct-Nov	25109	3	Nov	54860	3
School Mackerel	Aug-Sep	5979	3	Jul-Sep Oct-Nov	891	2	Jul-Aug	2083	1	Oct-Nov	1686	2
Mullet	Sep-Nov	534	1	-	-	-	-	-	-	-	-	-
Salmon	-	-	-	-	-	-	-	-	-	Jun-Jul	2298	2
Sweet Lip	Sep-Nov	1474	2	Sep-Nov	506	2	-	-	-	Sep-Nov	1857	2
Prawns	May Aug-Sep	6381	2	Sep	8967	2	Jun-Jul	5964	2	May Aug-Sep	32732	3
Mudcrabs	May-Jul	1324	1	Jun-Jul	521	1	-	-	-	Apr-Jun	1452	2
Lobster	Aug-Sep	482	2	-	-	-	Oct-Dec	1079	1	Sep	2915	2
Scallops	Sep	3113	2	-	-	-	-	-	-	-	-	-

Legend

Peak	Month(s) in which catch was consistantly high
Max	Magnitude of catch (Kg) during peak month(s)
Degree	Rank order indicating degree of seasonality where,

1 = seasonal pattern may be present but is overshadowed by erratic variation
2 = seasonal pattern present along with erratic variation
3 = seasonal pattern present with little or no erratic variation

\- indicates no seasonal pattern could be detected

TABLE VIII (b) CATCH COMPOSITION BY WEIGHT AS A % OF THE TOTAL

Species	Bowen %	Cairns %	Innisfail %	Townsville %
Barramundi	0.8	3.6	3.4	6.1
Bream	-*	-	0.7	0.6
Cod	-	0.5	0.8	-
Coral Trout	2.5	3.9	8.2	1.1
Emperor	1.1	1.3	4.0	-
Gar	0.6	0.5	0.6	-
Jew	0.7	0.9	3.3	-
Mackerel	12.2	50.0	44.9	38.8
School Mackerel	13.6	0.9	1.5	1.0
Mullet	1.5	4.8	0.7	2.4
Nannygai	-	-	1.3	-
Pike	-	0.6	-	-
Salmon	-	0.8	-	2.2
Sweet lip	5.4	1.2	8.7	2.7
Whiting	3.4	-	-	0.5
Total Whole Fish	47.3	73.6	84.3	61.2
Prawns	42.2	21.1	13.3	32.0
Mudcrabs	3.2	0.7	-	2.4
Sandcrabs	-	1.1	-	-
Squid	-	-	0.5	0.7
Lobster	1.8	1.6	1.2	2.1
Scallops	4.8	-	-	0.7

* Species forms insignificant part (less than 0.5%) of total catch

TABLE VIII (c) TOTAL MONTHLY VARIATION IN CATCH AS INDICATED BY THE COEFFICIENT OF VARIATION (CV)

Species	Bowen	Cairns	Innisfail	Townsvill
Barramundi	1.70	0.88	1.37	0.60
Bream	-*	-	2.49	0.84
Cod	-	1.28	1.13	-
Coral Trout	1.78	0.92	0.94	0.69
Emperor	1.92	0.87	1.47	-
Gar	4.22	2.13	1.90	-
Jew	1.90	2.58	1.41	-
Mackerel	2.13	1.20	1.59	2.03
School Mackerel	2.60	1.70	2.74	1.77
Mullet	1.80	0.59	1.04	0.68
Nannygai	-	-	2.26	-
Pike	-	1.10	-	-
Salmon	-	1.09	-	1.18
Sweetlip	1.60	0.84	0.72	1.07
Whiting	1.26	-	-	0.96
Total Whole Fish	1.18	0.92	0.97	1.34
Prawns	1.09	0.85	1.17	1.20
Mudcrabs	2.61	1.15	-	0.73
Sandcrabs	-	5.69	-	-
Squid	-	-	2.06	1.70
Lobster	1.78	1.64	1.88	1.32
Scallops	3.21	-	-	2.29
Total	0.95	0.68	0.83	0.81

* Species forms insignificant part (less than 0.5%) of total catch

TABLE VIII(d) MEAN MONTHLY CATCH (Kg)

Species	Bowen	Cairns	Innisfail	Townsville
Barramundi	31	441	303	1172
Bream	-*	-	60	109
Cod	-	60	73	-
Coral Trout	99	485	733	210
Emperor	41	156	356	-
Gar	22	67	58	-
Jew	25	113	296	-
Mackerel	476	6170	4013	7640
School Mackerel	529	114	135	193
Mullet	58	592	65	459
Nannygai	-	-	112	-
Pike	-	72	-	-
Salmon	-	101	-	417
Sweetlip	212	152	773	519
Whiting	131	-	-	96
Total Whole Fish	1846	9082	7533	11764
Prawns	1645	2609	1191	6150
Mudcrabs	125	88	-	456
Sandcrabs	-	131	-	-
Squid	-	-	44	125
Lobster	69	196	11	408
Scallops	186	-	-	128
Total	3905	12335	8933	19220

* Species forms insignificant part (less than 0.5%) of total catch

TABLE IX(a) RELATIVE IMPORTANCE OF BOWEN, CAIRNS INNISFAIL AND TOWNSVILLE IN THE TOTAL PRODUCTION OF FINNED AND FILLETED FISH, 1973-1977

	Bowen		Cairns		Innisfail		Townsville	
		%		%		%		%
Finned	125,627	68.2	506,580	43.5	453,092	91.8	698,187	67.8
Filleted	58,702	31.8	658,563	56.5	40,398	8.2	331,839	32.2
Both	184,329	100.0	1,165,143	100.0	493,490	100.0	1,030,026	100.0

TABLE IX(b) MEAN ANNUAL CATCH AND RELATIVE IMPORTANCE OF MAJOR FINNED FISH, 1967-1977

Species	Bowen			Cairns			Innisfail			Townsville		
	Mean Catch (kg)	Rank[1]	%[2]	Mean Catch (kg)	Rank	%	Mean Catch (kg)	Rank	%	Mean Catch (kg)	Rank	%
Barramundi	325	4	1.4	4,630	2	3.2	1,643	3	1.7	12,783	1	7.8
Bream	272	2	1.1	-	-	-	-	-	-	1,561	1	1.0
Cod	226	3	0.9	-	-	-	1,222	1	1.3	849	2	0.5
Coral Trout	1,254	4	5.2	5,085	3	3.5	11,141	1	11.6	5,582	2	3.4
Dart	-[3]	-	-	-	-	-	-	-	-	2,138	1	1.3
Emperor	1,032	3	4.3	2,380	2	1.6	6,377	1	6.6	-	-	-
Gar	208	3	0.9	1,194	1	0.8	917	2	1.0	-	-	-
Jew	555	2	2.3	-	-	-	4,360	1	4.5	-	-	-
Mackerel	7,998	4	33.5	105,184	1	72.8	50,912	3	53.0	101,485	2	62.2
School Mackerel	3,082	1	12.9	1,437	2	1.0	1,350	4	1.4	1,371	3	0.8
Mullet	606	4	2.5	6,785	1	4.7	1,368	3	1.4	5,378	2	3.3
Salmon	-	-	-	794	2	0.5	-	-	-	5,695	1	3.5
Sweetlip	2,109	3	8.8	1,187	4	0.8	9,524	1	9.9	7,055	2	4.3
Whiting	991	1	4.1	-	-	-	-	-	-	830	2	6.5
Total[4]	23,908	4	(77.9)[5]	144,399	2	(88.9)	95,997	3	(92.4)	163,168	1	(88.6)

1. Regional rank order of importance for individual species
2. Approximate percentage composition of total catch for individual species
3. Production does not qualify under given criterion of selection (sections 1.3)
4. Refers to the total for all species at this market, averaged over the given period
5. Indicates the total percentage contribution of the major species selected here

TABLE IX(c) SPATIO-TEMPORAL VARIATIONS AND TRENDS OF MAJOR FINNED FISH, 1967-1977

Species	Bowen			Cairns			Innisfail			Townsville		
	Minimum (kg/yr)	Maximum (kg/yr)	Trend[1]	Minimum (kg/yr)	Maximum (kg/yr)	Trend	Minimum (kg/yr)	Maximum (kg/yr)	Trend	Minimum (kg/yr)	Maximum (kg/yr)	Trend
Barramundi	23 (1967)	736 (1973)	+	2,626 (1976)	7,168 (1977)	+	635 (1970)	4,796 (1977)	+	8,126 (1968)	26,118 (1970)	+
Bream	38 (1972)	905 (1973)	Λ	51	-		-	-		580 (1971)	2,913 (1967)	-
Cod	58 (1967, 1969)	647 (1974)	-	10	-		312 (1973)	2,980 (1968)	-	211 (1976)	1,436 (1972)	-
Coral Trout	229 (1972)	2,525 (1976)	+	685 (1973)	10,883 (1967)	Λ	3,127 (1973)	22,008 (1967)	-	2,207 (1976)	11,208 (1967)	-
Dart	-[2]	-		-	-		-	-		937 (1977)	3,504 (1973)	-
Emperor	65 (1969)	3,875 (1975)	=	99 (1973)	5,476 (1968)	Λ	4,118 (1967)	9,306 (1974)	Λ	-	-	
Gar	18 (1969)	799 (1977)	+	81 (1976)	2,510 (1968)	-	148 (1975)	2,305 (1971)	Λ	-	-	
Jew	28 (1969)	1,014 (1974)	Λ	-	-		1,240 (1976)	11,422 (1974)	Λ	-	-	
Mackerel	1,434 (1972)	15,878 (1968)	-	27,586 (1973)	198,678 (1968)	-	9,724 (1973)	79,599 (1975)	=	4,136 (1973)	147,032 (1969)	=
School Mackerel	8 (1967)	11,665 (1977)	+	208 (1973)	3,735 (1971)	+	170 (1969)	3,814 (1972)	Λ	13 (1975)	2,904 (1977)	+
Mullet	140 (1972)	1,137 (1977)	+	3,768 (1968)	11,293 (1973)	Λ	404 (1976)	4,319 (1970)	-	1,504 (1968)	7,413 (1973)	=
Salmon	-	-		33 (1967)	1,280 (1970)	Λ	-	-		3,601 (1975)	9,243 (1971)	Λ
Sweetlip	400 (1972)	5,143 (1976)	+	460 (1968)	2,011 (1975)	+	5,618 (1973)	15,491 (1968)	Λ	4,378 (1970)	11,022 (1968)	Λ
Whiting	17 (1973)	2,535 (1968)	-	-	-		-	-		0 (1968)	1,724 (1971)	=
Total[3]	5,072 (1972)	33,145 (1968)	Λ	51,603 (1973)	290,890 (1968)	-	42,575 (1973)	121,722 (1974)	Λ	58,203 (1973)	230,980 (1967)	-

1. Indicates the overall trend in production, where + increasing trend, - decreasing trend, = stable, Λ random oscillations
2. Production does not qualify under given criterion of selection (sections 1.3)
3. Refers to the minimum and maximum calculated for all species at this market, averaged over the given period

TABLE IX(d) MEAN ANNUAL CATCH AND RELATIVE IMPORTANCE OF MAJOR SPECIES OF FISH (FINNED AND FILLETED) AND SHELLFISH 1973-1977

Species	Bowen			Cairns			Innisfail			Townsville		
	Mean Catch (kg)	Rank[1]	%[2]	Mean Catch (kg)	Rank[1]	%[2]	Mean Catch (kg)	Rank[1]	%[2]	Mean Catch (kg)	Rank[1]	%[2]
Barramundi	1,091	4	3.0	46,150	1	19.8	3,259	3	3.3	25,270	2	12.3
Cod	345	4	0.9	3,253	1	1.4	599	3	0.6	1,360	2	0.7
Coral Trout	2,049	4	5.6	6,589	1	2.8	6,200	2	6.3	6,135	3	3.0
Dart	-[3]			-			-			2,856	1	1.4
Emperor	1,680	3	4.6	2,523	2	1.1	7,317	1	7.4	1,120	4	0.5
Mackerel	12,276	4	33.5	130,346	1	55.9	57,180	3	57.9	118,058	2	57.3
School Mackerel	6,773	1	18.5	2,820	2	1.2	1,129	4	1.1	2,784	3	1.4
Mullet	660	4	1.8	8,163	1	3.5	844	3	0.9	7,085	2	3.4
Salmon	1,493	3	4.1	9,270	2	4.0	-			10,091	1	4.9
Sweetlip	3,234	3	8.8	1.739	4	0.7	8,624	2	8.7	10,087	1	4.9
Total (Fish)[4]	366,666	4	(80.8)[5]	233,028	1	(90.4)	98,698	3	(86.2)	206,005	2	(89.8)
Prawns	31,143	3		36,966	2		12,343	4		53,094	1	
Mud Crabs	1,455	2		896	3		51	4		6,002	1	
Sand Crabs (Bodies)	592	1		34	3		-			149	2	
Squid	507	2		102	4		195	3		702	1	
Moreton Bay Lobsters	1,864	2		816	3		403	4		3,685	1	
Lobster Meat	-			166	1		41	3		141	2	
Scallops	1,975	2		460	3		-			4,039	1	

1. Regional rank order of importance for individual species
2. Approximate percentage composition of total catch for individual species. Note this cannot be given for shellfish because the unit of measurement varies from kg to bodies (Sandcrabs) to bottles (Oysters)
3. Production does not qualify under given criterion of selection (sections 1.3)
4. Refers to the total for all species at this market, arranged over the given period
5. Indicates the total percentage contribution of the major species selected here.

TABLE IX(e) SPATIAL VARIATIONS IN MINIMUM AND MAXIMUM CATCHES FOR MAJOR SPECIES OF FISH (FINNED AND FILLETED) AND SHELLFISH, 1973-1977

Species	Bowen		Cairns		Innisfail		Townsville	
	Minimum (kg)	Maximum (kg)	Minimum (kg)	Maximum (kg)	Minimum (kg)	Maximum (kg)	Minimum (kg)	Maximum (kg)
Barramundi	582	1,854	37,536	65,652	1,651	6,644	14,800	35,904
Cod	103	647	307	7,631	325	995	756	2,882
Coral Trout	1,037	3,419	1,513	13,080	3,127	9,043	4,048	10,277
Dart	-[1]	-	-	-	-	-	1,665	4,130
Emperor	200	4,469	132	4,389	4,392	9,308	254	1,523
Mackerel	3,649	20,728	37,173	175,183	10,849	81,699	6,222	169,544
School Mackerel	182	13,733	844	8,691	252	2,420	32	5,418
Mullet	271	1,137	4,511	12,071	404	1,337	3,926	10,665
Salmon	12	1,704	6,395	17,188	89	1,164	7,349	14,753
Sweetlip	1,240	6,061	1,519	2,011	5,630	10,901	6,545	14,524
Total (Fish)	16,324	48,265	122,380	303,602	45,561	127,420	74,841	278,337
Prawns	12,675	54,206	22,712	68,807	6,125	15,800	23,425	97,353
Mud Crabs	283	4,438	100	1,418	0	113	4,133	8,358
Sand Crabs (Bodies)	24	2,211	0	85	-	-	51	367
Squid	78	1,341	0	388	0	883	0	2,913
Moreton Bay Lobsters	668	4,659	96	2,735	47	1,273	1,053	6,142
Lobster Meat	-	-	0	774	0	203	0	707
Scallops	0	6,829	0	2,303	-	-	444	13,792

1. Production does not qualify under given criterion of selection (section 1.3)

SHIPPING CHANNELS

LIZARD - INNISFAIL

H.G. Chesterman, Department Transport
(formerly Captain of the Light House Supply Vessel, Cape Moreton)

Outside the regular shipping lanes, navigation in the Great Barrier Reef is restricted by inadequate modern surveys, and charts and where the reefs are far off the coast, by the absence of features that can be used for navigation marks. Further tidal currents are strong and are not well documented, creating further hazards to those unfamiliar with the area. It should be noted that, although the Federal Department of National Mapping are presently engaged in bathymetric charting of Australia's Continental Shelf, there are not at present hydrographic charts available for most of the area.

The shipping lanes themselves are heavily used and mariners of the Queensland coast and Torres Strait Pilots Service, and of the Dept. of Transport Lighthouse Service, skilfully negotiate these waters and are familiar with them. Local fishermen and charterboat operators are usually familiar with the features and have a personal knowledge of the navigable channels within a radius of the port from which they operate. The Australian Commonwealth Department of Transport now maintains a series of lights and channel markers along the entire Barrier Reef. Vessels of unlimited displacement, but drawing no more than 11.9 metres, now regularly use this inner route, with 1410 vessels being piloted through in 1977 (Whiteman, 1978). The following account of navigable channels emphasises some of the problems of navigation in these waters. In the vicinity of Lizard Island, where the edge of the Continental Shelf with its ribbon reefs lying right on the edge of the 200 m line, are close to the coast, there are prominent continental and high island features to aid navigation. There are several good navigable channels, clear of dangers, and well known, through the outer reefs. The continental slope in this region is steep and soundings drop away very rapidly into very deep water. To the south of Lizard the reefs are small, often close to one another, with few navigable channels between them. There is, however a reasonably wide navigational channel between the coast and the reefs. Lark Pass (south of Cape Flattery) is charted but seldom used nowadays, most navigators prefer to proceed further south, to use either Cruiser or Papuan Pass, both south of Cooktown and south of the characteristic ribbon reefs of the northern section.

To the south west of Lizard I., the first of the sandy cays that are to be seen on this route, Eagle Islet, was once used as a navigation mark for ships using Cook's Passage. Further south on Low Wooded Isle, there is the remains of a twin engine U.S. Air Force bomber which force landed during the war. It is now almost completely covered by sand. On the opposite side of the shipping channel Three Isles sand cay can be seen. The three apparent isles comprise two sets of coral ramparts with mangrove parks and a sand islet, which has a lattice tower lighthouse and at low tide is contiguous with one of the other islets. Mosquitoes abound in the mangroves and good mud crabs have been caught there.

In the vicinity of Cooktown the reefs come fairly close to the coast, Dawson Reef being a matter of only a few miles off the coast. They remain fairly close together south to Trinity Opening. In the vicinity of Trinity Opening the continental slope is not so steep as it was further to the north and this has been taken advantage of in the laying of the Compac (Commonwealth Pacific, Australia to Canada) submarine telephone cable which runs out from the coast just north of Cairns and through Trinity Opening, down the reasonably gentle continental slope, well protected in the muddy sediments that accumulate there.

Just off Cairns, Grafton Passage is at the moment the only passage lighted for night navigation of ships. Before the passage was lighted the distinctive Arlington Reef was used as a marker. It was well known to sailors and could not be mistaken. South from Cairns there is again a fairly wide danger-free area of water between the coast and the main areas of reef formation. The reefs in this area have been particularly well surveyed and there are good expanses of water between them. However many of these reefs do not have the usual sand cays at the north west corner and there is foul water around and between them. The passages through these reefs are Flora, Noggin, Geranium, but these are rarely used nowadays, Grafton Passage being the main one for shipping.

For shipping proceeding southwards along the inner channel the next passage out of the reefs is by Palm Passage off Great Palm Island.

From Cruiser Pass to Palm Pass it should be noted that the reefs are not right on the edge of the Continental Shelf, that is, on the 200 m line, as they are further to the north and there is from 6 to 8 miles between the outer line of reefs to the edge of the Continental Shelf. However although the Continental slope is gradual at the Trinity Opening, it becomes steep again until the vicinity of the Palm Passage. The actual position of the edge of the Continental Shelf (the 200 m line) however is not accurately known in the area out from Innisfail to the Palm Passage.

The channels of this section of the so called 'inner route' (which begins at Gubbins Reef and traverses over 400 n miles of reef) are often narrow, some only 3/4 of a mile in width, with many sharp turns. Vessels using the route may continue all the way to Torres Strait or pass through the reef using one of the various openings near Lizard Island or Raine Island. Approximately 1,500 vessels use the inner route each year. They are all required to carry pilots but around 10% fail to do so. Coastal vessels are not required to carry pilots. The route is limited to vessels with a draft of less than 11.9 m but it is possible for vessels up to 250,000 tons in ballast to use the route safely provided their draft does not exceed 11.9 m.

Although the inner route is now well charted it is still potentially dangerous for large vessels that must adhere closely to tidal schedules to be sure of a safe passage through the various shallow points. This is a particular problem during summer months when severe rain squalls may render radar navigation systems inoperative.

Currently available admiralty charts of the region still do not clearly define the position of the outer edge of the Barrier Reef.

SHIPWRECKS

Under *The Historic Shipwrecks Act 1976* the Federal Minister is empowered to proclaim any wrecks in these waters a historic or protected zone. Following declaration of such zones there will be opportunities for discussions with relevant Queensland authorities with an interest in marine archaeology. In the area under consideration there are not known to be any historically important wrecks.

NOMENCLATURE OF COASTAL FEATURES, REEFS AND ISLANDS

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NAMES OF REEFAL FEATURES

Many of the names of the features of the Queensland coast and offshore reefs and islands were originally applied by early explorers and surveyors and were subsequently incorporated into the charts that were originally produced by the British Admiralty. In 1938 these names were reviewed, and many revised to remove the possibility of confusion and to ensure easier identification of reefs. Names were changed only after careful research. The reviewers acknowledged the considerable contribution that Captain Cook had made both to hydrography in Australian waters and also in conferring appropriate names on new discoveries. Most of the names that had been conferred by Captain Cook remain to this day.

The Queensland Place Names Board Act 1957 now establishes that Board, with its Advisory Council, as the statutory authority for naming features of the territory of the State of Queensland. Accordingly, the names of all islands and the names of subtidal features within Queensland territorial waters (3 miles from Low Tide on Queensland territories) are the responsibility of the Board.

There is no International Convention under which Australia has rights to other than the resources of the sea bed outside territorial waters (Geneva Convention on the Continental Shelf 1958). Consequently, those reefs which are not territories of the State of Queensland (reefs outside territorial waters which are not above the water at high tide and do not have islands) are subject to Australian legislation only in respect of their resources.

There is therefore no statutory body responsible for the naming of subtidal features of the Continental Shelf outside State territory. However, the National Mapping Council was set up by agreement between the Prime Minister and Premier of the States to co-ordinate mapping at Federal and State level. State and Federal representatives of corresponding agencies and departments, the Australian Surveyor General, the Director Military Mapping and the Hydrographer RAN, are members of the Council. This Council ensures that there is consistency in the names that will be used on all charts that are published by the respective Federal and State Departments.

It should be noted, however, that there is still a degree of duplication in the names that are being used. The status of many of the names are uncertain and in many cases, where charts are based on surveys of 70 or more years ago their location as shown on the charts is often far from accurate. Further reconnaissance charts prepared with the aid of Earth Resources Technology Satellite imagery have indicated that there are about 2,000 drying reefs in the GBR. Many more may exist at depths greater than the satellite imagery has detected. The Great majority of these features have no names at all. There is a great need for a thorough review of this matter, to accurately determine co-ordinates, and to regularise the status of all the names that are in use.

The following names and their origins of coastal features represent not a complete list of all features, but rather a list of those about which some historical facts are known. Much of Part A: "Lizard Island to Innisfail" is contained in "Reefs and Islands of the GBR between14° and 17°S, an unpublished report to the Great Barrier Reef Marine Park Authority by N. Harvey, P.J. Isdale and D.G. Backshall, Dept of Geography, James Cook University of North Queensland, and the chart which accompanies it.

FEATURE NAME (from N to S)	ORIGIN OR NOTES
Turtle Islets	Cook's chart 1770
Wilson Reef	Lt W.T.P. Wilson, HMS Waterwitch 1897
Red Pt	appearance
Fly Reef	HMS Fly (1844-5)
Miles Reef	Lt I.B. Miles, HMS Dart 1901 - was Ar Reef (R)
Beatrice Reef	formerly 'rr' reef
Two mile opening	approximate width of passage
One and half mile opening	approximate width of passage
One mile opening	approximate width of passage
Half mile opening	approximate width of passage
Hilder Reef	Commodore, Burns Philp

Hicks Reef	Petty Officer, Surveyor RAN
Yonge Reef	Sir Maurice Yonge, Sci leader GBR Expedition 1928-9 - formerly named June Reef (c 1900)
No Name Reef	local name
Macgillivray Reef	J. Macgillivray, naturalist, HMS Rattlesnake 1845-50
Lizard Island	named by Cook 1770 after reptile inhabitants
South Island	formerly Newt Island
Palfrey Island	formerly Iguana Island, then Saddle Island
Bird Islet	formerly Seabird Islet
Petricola Shoal	discovered 1928 by S.S. 'Petricola'
Gunga Shoal	S.S. Gunga A.S.N. Line ship c 1880's
Nymph Island	was En (N) Reef
Eagle Island	named Cook 1770 (sea eagles *Haliaeetus leucogaster* still present on W side)
Eyrie Reef	as above
Petherbridge Islets	Sec Qld Marine Board (was Kew Islets)
Rocky Ledges	appearance
Sim Reef	formerly Nares Reef
Maxwell Reef	formerly Covered Reef
Linnet Reef	formerly El Reef (L)
Martin Reef	formerly EM Reef (M)
Lookout Point	named Cook 1770, vantage point
N Direction Island	named Cook 1770, Cook's chart: 'Isles of direction'
S Direction Island	named Cook 1770; Cook's chart: 'Isles of direction
Kedge Reef	formerly Keh Reef (K)
Ribbon Reef	locally called No. 10 Ribbon - appearance
Rocky Islets	physiography
Eye Reef	Eye (I) Reef
C. Flattery	named Cook 1770
Helsdon Reef	was Aitch Reef (H)
C. Bedford	after John, Duke of Bedford 1st Lord Admiralty

Two Isles	from Cook's Journal
Gull Reef	was Gee Reef (G)
Pasco Reef	Lt F.C. Pasco, HMS 'Paluma' 1889
Three Isles	Cook's account
Low Wooded Isle	Cook's account
Harrier Reef	'Harrier' L.M. Schooner lost here July 1891
Forrester Reef	formerly Eff Reef (F) - Qld Port Master
Conical Rock	shape
Lark Reef (Pass)	HMS 'Lark'
Cape Bedford	named Cook 1770
Williamson Reef	Lt A.C. Williamson, HMS 'Paluma' 1889
Cooktown	Captain James Cook 1770
Endeavour River	Cook's ship 'Endeavour'
Grassy Hill	Cook's account
Monkhouse Pt	Surgeon on HMS bark 'Endeavour' 1770
Mt Cook	named after Cook by P.P. King - formerly Gore's Mt named by Cook
Boulder Reef	called Turtle Reef in Parkinson's account 1770
Dawson Reef	formerly Dee Reef (D)
Cowlishaw Reef	formerly Cee Reef (C)
Osterland Reef	Cooktown Harbour Master 1907
Cairns Reef	Qld Governor W.W. Cairns
Bee Reef	Bee Reef (B)
Gubbins Reef	Lt G.W. Gubbins, MHS 'Paluma' 1889 - was Eh Reef (A)
Hope Islands	named Captain Cook
Endeavour Reef	Cook's ship 'Endeavour'
Rattlesnake Pt	HMS Rattlesnake 1847
Weary Bay	Cook's account
C Tribulation	named Cook 1770
Pickersgill Reef	Mate, HMS 'Endeavour' 1770
Pearl Reef	HMS 'Pearl' Hydro survey ship 1873
Spitfire Reef	Govt Schooner 'Spitfire' (retrieved Watson's bodies from Howicks)
Trinity Bay	n Cook on Trinity Sunday 1770
Trinity Opening	'as above'
Low Isles	Cook's account

Penguin Channel	HMS Penguin 1905 Hydrographic survey
Pt Douglas	Qld Premier, John Douglas
Yule Reef	Lt C.B. Yule, HMS 'Bramble'
Middle Cay	local name
Upolu Cay	ship 'Upolu', iron schooner wrecked April 25 1886
Raaf Shoals	RAAF
Noggin Passage	beer mug
Hedley Reef	scientific director GBRC
Jackson Patches	Lt J.M. Jackson, HMS 'Fantome' 1907-8 survey
McCulloch Reef	A.R. McCulloch, Aust'n Museum, surveyed sponge fishing 1918
Howie Reef	Lt J.H. Howie, RN survey (HMS 'Sealark')
Cayley Reef	Rear Admiral?
Mt Maria/Pt	Brig wrecked Bramble Reef 25-2-1872
Nathan Reef	Qld Governor 1920s
Gilbey Reef	gin distiller
Green Island	named and charted Cook 1770
Haycock Island	unusual appearance (locally 'Scout Hat Island')
Flora Pass	'Flora' wrecked Great Detached Reef 1834
False Cape	west of C Grafton, resembles it
Rocky Island	Cook's account
Cairns	Qld Governor W.W. Cairns
Cape Grafton	A.H. Fitzroy, 3rd Duke Grafton
Fitzroy Island	'as above'
Hervey Shoals	Lt Commander RN HMS 'Fantome' 1922 survey
Scott Reef	Lt C.M.L. Scott, HMS 'Fantome' 1907 survey
Flora Reef	HM warship (wrecked near C. Grenville 1-6-1832)
Coates Reef	gin distiller

TABLE X ISLANDS AND PERMANENT CAYS - LIZARD ISLAND TO INNISFAIL

Further sand cays, not identifiable from satellite imagery may be present. Reconnaissance charts show many unnamed and uncharted reefs to be present (see Fig. 1)

NAME	GROUP	LOCATION	ELEVATION (m)	AREA (ha)	GENERAL FEATURES & VEGETATION	TENURE	DEVELOPMENT
Lizard		14°40'S 145°28'E	359	1012	High and rocky with well developed fringing reefs; mainly grassed with bushes and trees over much of S end of island	National Park; Leasehold	Resort, airstrip, research station
Palfrey		14°42' 145°27'	136	6	Both islands are high and rocky and lie on a drying reef connected to the SE tip of Lizard Is; mainly grassed with trees and bushes in sheltered parts	Commonwealth leasehold	Lighthouse
South		14°42' 145°27'	123	15		Crown Land	
Eagle		14°42' 145°23'	-	3	Vegetated sand cay lying on the NW end of Eyrie Reef; grass and bushes	Crown Land	
Turtle Is.	Turtle Group	14°43' 145°12'	9	91	Six, low, tree-covered islets with well developed fringing reefs	National Park	
Pethebridge Is.		14°45' 145°06'	6	8	Two, low, wooded islets with fringing reefs	Crown Land	Lighthouse
North Direction		14°45' 145°31'	188	26	High, steep and rocky with fringing reefs	Crown Land	
South Direction		14°50' 145°32'	177	61	High, steep and rocky with a drying reef at the N end; a few trees lie at the N extremity of the island	Crown Land	
Rocky		14°52' 145°29'	46	32	Three rocky islets lying on a drying reef; only the largest islet is wooded	National Park	
Two Is.		15°01' 145°26'	17	14	Two low, wooded islets lying on a drying reef	National Park	

Low Wooded		$15^{\circ}06'$S $145^{\circ}23'$E	18	-	A low, wooded island fringed by a drying reef	Crown Land	
Three Is.		$15^{\circ}07'$ $145^{\circ}25'$	10	40	Three, low wooded islets on a drying reef; all are covered with trees, grass and mangroves	National Park; Commonwealth leasehold	Lighthouse
Rocky		$15^{\circ}36'$ $145^{\circ}20'$	50	6	-	Lighthouse Reserve	Lighthouse
Hope Is.		$15^{\circ}45'$ $145^{\circ}27'$	9	174	Two sand cays lying on the N and S ends of a drying reef; both cays are covered with bushes	National Park	
Pickersgill		$15^{\circ}51'$ $145^{\circ}34'$	1	-	A sand cay on the NW end of Pickersgill Reef	Crown Land	
Snapper		$16^{\circ}18'$ $145^{\circ}30'$	115	56	A high island with a narrow fringing reef in places; E part grassed, W part thickly wooded	National Park	
Woody	Low Islands	$16^{\circ}23'$ $145^{\circ}35'$	20	5	Mangrove covered cay on the E side of the Low Isles drying reef	Crown Land	
Low	"	$16^{\circ}23'$ $145^{\circ}35'$	18	20	Wooded cay on the W side of the Low Isles drying reef	Commonwealth Land	Lighthouse
Michaelmas		$16^{\circ}36'$ $145^{\circ}59'$	2	1	Low, vegetated cay lying at the SW end of Michaelmas Reef	National Park	
Upolo		$16^{\circ}40'$ $145^{\circ}56'$	2	1	Low, vegetated cay lying on the WNW end of Arlington Reef	National Park	
Double		$16^{\circ}43'$ $145^{\circ}41'$	83	36	High, rocky island lying on the N end of a drying reef	Recreation Reserve	Defunct Resort
Haycock		$16^{\circ}44'$ $145^{\circ}42'$	34	2	Rocky islet lying to the SE of Double Is. on the same drying reef	Crown Land	

NAME	GROUP	LOCATION	ELEVATION (m)	AREA (ha)	GENERAL FEATURES & VEGETATION	TENURE	DEVELOPMENT
Green		16°45'S 145°59'E	20	12	Low, tree-covered cay lying on an extensive drying reef	National Park; Leasehold	Tourist Resort
Rocky		16°53' 145°54'	42	12	High, rocky island joined to Cape Grafton at low water by a drying sand and mudflat	Aboriginal Reserve	
Little Fitzroy		16°55' 146°00'	57	1	Small, rocky island lying on a spit of foul ground close NE of Fitzroy Is.	Freehold	Lighthouse
Fitzroy		16°55' 146°00'	269	259	High, rocky island; wooded almost to its summit	Crown Land: Leasehold	
Sudbury		16°57' 146°08'	2	-	Low sand cay on NW extremity of Sudbury Reef	Crown Land ?	
High	Frankland Islands	17°09' 146°01'	168	69	High, rocky island; wooded, open eucalypt and small pockets of rainforest	National Park	
Mabel	"	17°12' 146°05'	26	2	Rocky island lying on the S end of a drying reef; covered with dense scrub	National Park	
Normanby	"	17°12' 146°05'	34	6	Rocky island lying on the N end of the above drying reef; dense scrub	National Park	
Round	"	17°14' 146°06'	36	1	Small, rocky islet lying to the north of Russell Is.	National Park	
Russell	"q	17°14' 146°06'	59	20	High, steep and rocky; wooded at its S end	Freehold	Lighthouse

THE GREAT BARRIER REEF BETWEEN LIZARD ISLAND AND INNISFAIL

SUMMARY AND RECOMMENDATIONS FOR MANAGEMENT

SUMMARY

The biological and commercial importance of the area arises from its geographic location close to the narrow coastal plain, on the edge of a narrow continental shelf, and in the centre of the latitudinal extent of the Great Barrier Reef:

1. The reefs lie close to the coast and are easily accessible from Cairns, Cooktown and Innisfail. The importance of this area to tourists arises from its ready accessibility. It is an area where the Great Barrier Reef may be observed and enjoyed.

2. There are continental islands in the area that can be used to accommodate tourists without using the more vulnerable coral cays for the purpose. These continental islands also provide alternate attractions that bring tourists into the area.

3. Here where the reefs lie close to the coast and the mainland is visible from the deep safe waters of the Coral Sea, early explorers made landfall. The area includes historic locations associated with early European contact with the reef, viz. pre 18th Century Portuguese exploration, British exploration and subsequent settlement. Thus Endeavour Reef and the Endeavour River are monuments to the early discoverers of Australia, especially Captain Cook. These are historic locations of importance to the tourist industry and to the people of Australia for they contribute to the nation's sense of identity.

4. The reefal area is narrow and close to the edge of the continental shelf. Deep oceanic waters of the Coral Sea are present within a few hundred metres of the reef (over 1,000 m deep within one km of the reefs). This may account partly for the fact that the area is a centre of an international sports fishing industry of pelagic oceanic species. This has also enhanced its importance to the tourist industry.

5. Its importance to the tourist industry is associated with the health and diversity of its growing coral and associated organisms both aquatic and terrestrial.

6. The adjacent continent is not very industrialised, and, with the close proximity of the Great Divide to the coast in this region, the hinterland has scenic and landscape values that also enhance the tourist importance of the area.

7. Cyclone and storm surge frequency is not high on this part of the coast.

8. Low Isles is the site of the 1928 Expedition on which much of our knowledge of coral reefs is based and there were earlier visits to the region by HMS ships "Beagle", "Fly" and "Rattlesnake" with the naturalists Stokes, Beet Jukes, Huxley and MacGillivray. Further, Michaelmas Cay was the site of the first drill hole to investigate the structure of the reefs.

9. There is a diversity of reef types and ages in the area (outer ribbon reefs, mid shelf, crescentic reefs with varying orientation and varying morphology); sand cays are of variable size and are vegetated to varying degrees and coral ramparts and mangroves may be present. Thus the area has a particular importance for the study of the geology, dynamics and the biology of reefs and cays.

10. A broad range of island types and sizes are present in the area. This provides an ideal situation for studying the effect of such variables on the numbers of species and their interactions on islands. Here a sufficient sample can be available from a given latitude to make comparisons independently of the effect of the latitude and other regional aspects. It is also possible to identify the effects of latitude on situations since the source of the biota (the Australian mainland) is common to the islands along the whole latitudinal extent of the Great Barrier Reef.

11. The area contains a large number of coral cays with important breeding colonies of seabirds.

12. The close proximity of the deep oceanic waters so close to the reefs that lie on the edge of the continental shelf in this region, undoubtedly confer some particular property to the reefs and their biota, albeit this is not yet identified.

13. The biological importance of this area to the overall reef ecosystem, assuming an interrelationship between the reefs, arises from its location more or less in the middle of the latitudinal extent of the Great Barrier Reef. It lies between regions to the north and south that are further offshore, not so easily accessible and not so subject to pollution from continental watersheds. Consequently, these are not as vulnerable as this central area. Nevertheless it is an essential link in the chain of recruitment from reef to reef that maintains gene flow through the length of the Great Barrier Reef. The maintenance of its populations of organisms is therefore of paramount importance.

PART II

THE GREAT BARRIER REEF
INNISFAIL - BOWEN

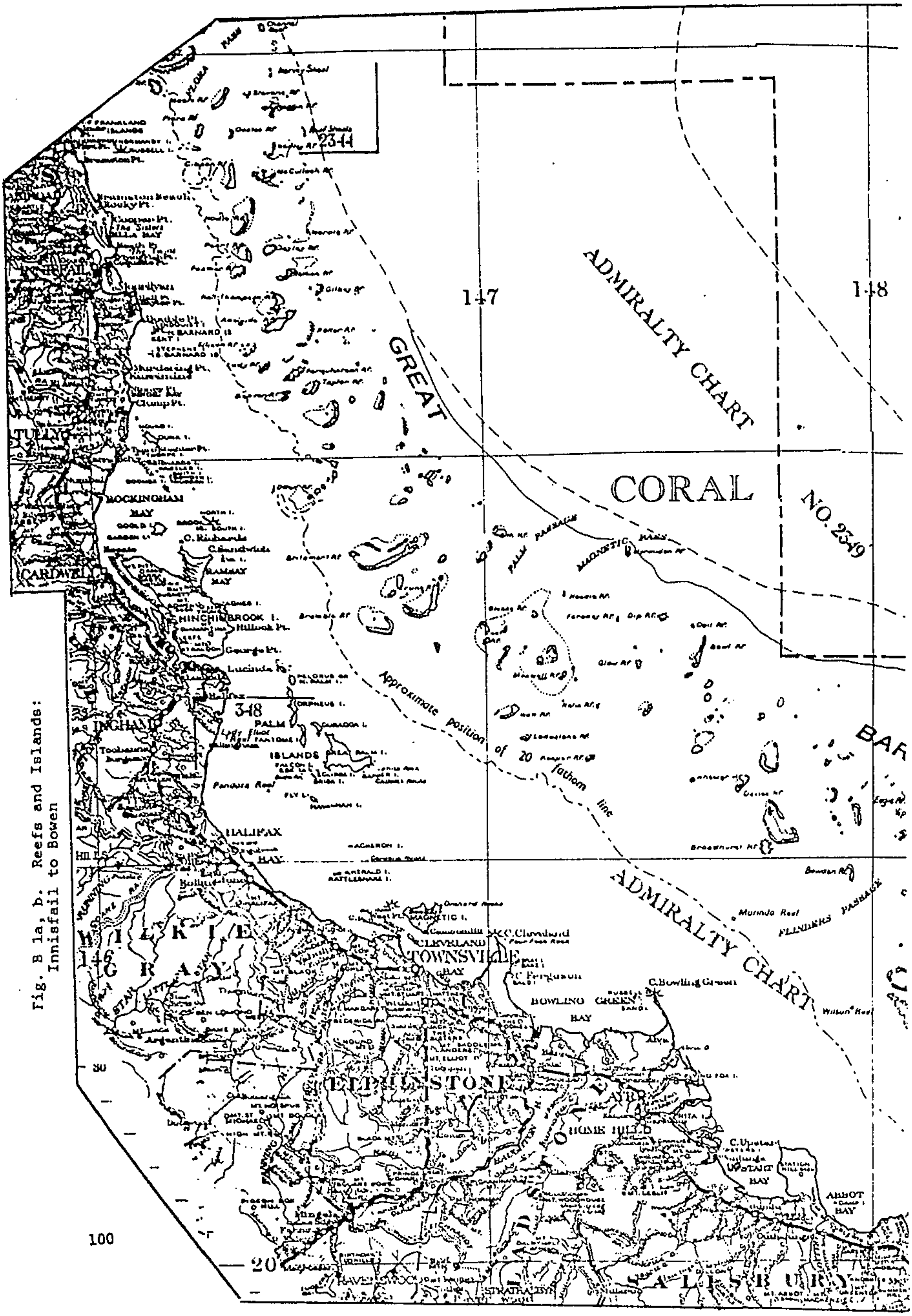
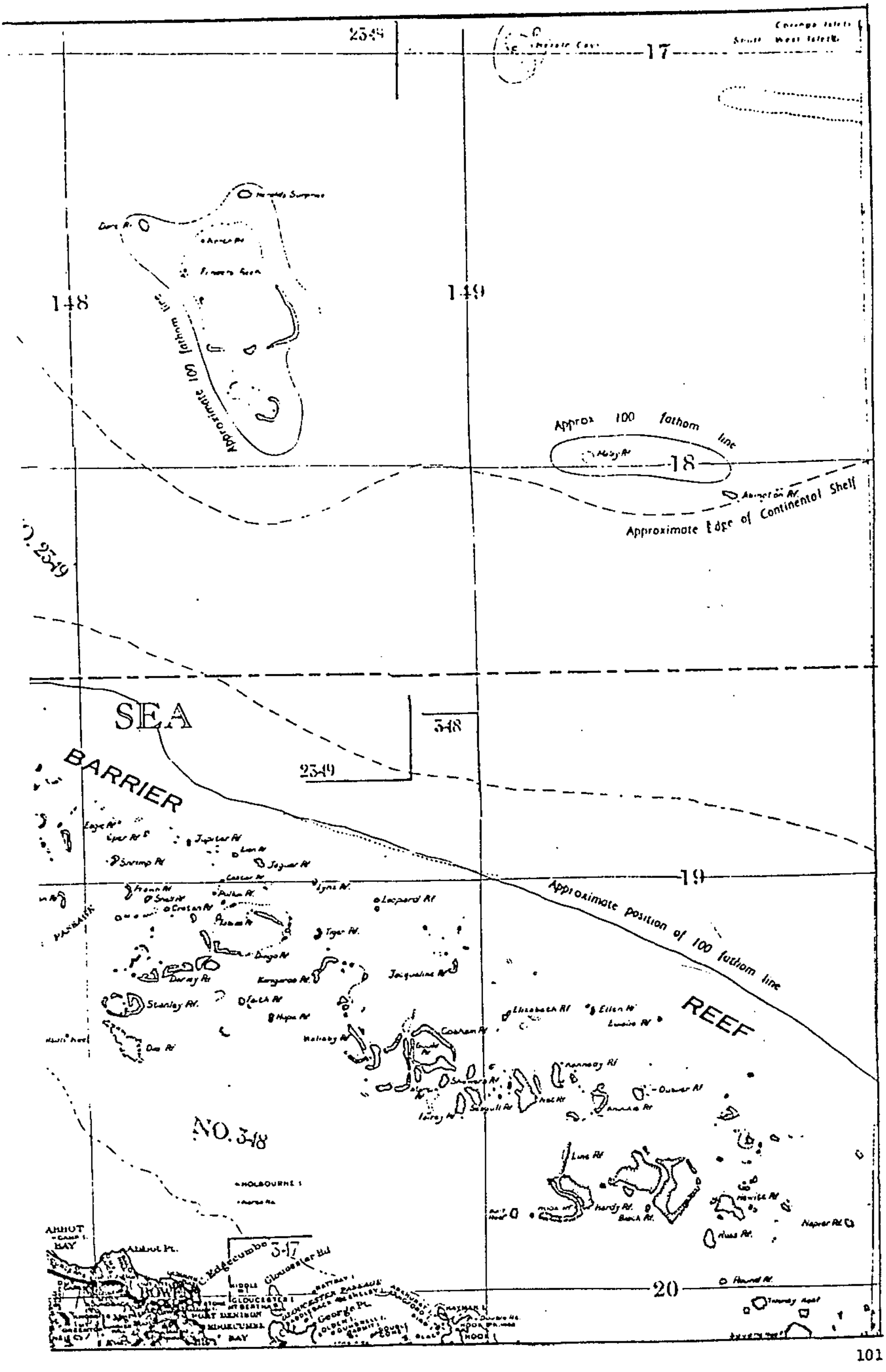


Fig. B la, b. Reefs and Islands: Innisfail to Bowen


2348
17
148
149
Approximate 100 fathom line
Approx 100 fathom line
18
Approximate Edge of Continental Shelf
2349
SEA
348
BARRIER
19
Approximate position of 100 fathom line
REEF
Jupiter Rf
Shrimp Rf
Jaguar Rf
Lynx Rf.
Leopard Rf
Tiger Rf.
Dingo Rf
Darley Rf
Kangaroo Rf.
Jacqueline Rf
Stanley Rf.
Hope Rf
Cobham Rf
Elizabeth Rf
Ellen Rf
Lucille Rf
Dingo Rf
Kennedy Rf
Ouswer Rf
Line Rf
Hardy Rf.
Beach Rf.
Hewitt Rf
Napier Rf.
Hook Rf.
Hound Rf.
Tancredy Reef
NO.348
HOLBOURNE I.
ABBOT BAY
Abbot Pt.
C. Edgecumbe
Gloucester Hd
347
GLOUCESTER PASSAGE
George Pt.
BOWEN
PORT DENISON
HAYMAN I.
HOOK
20

THE ENVIRONMENT - INNISFAIL TO BOWEN

COASTAL PHYSIOGRAPHY, METEOROLOGY AND HYDROLOGY

A. PHYSIOGRAPHY

The coastline between Innisfail and Bowen extends from 17°50'S to 20°S and lies between 145°13'E and 148°15'E. Its length, based on 1:250,000 charts, is approximately 500 km and it borders a quite varied landmass, the essential features of which are set out in Maxwell (1968). While the Great Dividing Range approached the coast closely in the northern part of the region between Innisfail and Cooktown, it swings away in the south, the coast at the same time running south east to produce a substantially broadening watershed and extensive coastal plain that comprises recently elevated marine deposits and widespread alluvia. The coastal ranges extending through the region are discontinuous and directly influence the character of the coastline and the patterns of run-off to the sea.

Drainage patterns are dominated by the Burdekin River and its tributaries which have a total catchment area of 130,000 km^2 and drain all the land lying between the coastal ranges and the Great Divide as far north as the Herbert River. East of the coastal ranges smaller drainage basins are associated with the Don, Haughton and Ross Rivers but their combined catchment area is less than 3,500 km^2 (Table XIa).

North from Bowen, almost the entire coastline as far as the Hull River is of low relief with the exceptions of Cape Upstart, Cape Cleveland and one or two lesser bluffs which are largely rocky igneous formations. Although dune formation has influenced much of the low lying coastal margin, the underlying sediments, exposed both intertidally and extending subtidally, are moderately to strongly muddy. In estuaries and sheltered bays, these fine sediments totally determine coastal character.

Seaward from the coast between Bowen and Townsville the edge of the continental shelf lies from 125 to 150 km offshore but gradually narrows further north. On the inner shelf, continental (high) islands of rugged topography and surrounded, at least in part, by fringing coral reefs are common throughout the area. The majority of these islands are small with only Magnetic, Hinchinbrook, the Palm Islands, Gold, and Dunk exceeding 800 ha.

With the exception of these fringing reefs, coral reef development throughout the region is largely restricted to the marginal shelf east of the 36 m (20 fathom) line. South of 18°S, the zone of reef development is between 50 and 60 km wide and lies from 65 to 80 km offshore. Reefs in this region are small, widely spaced and seldom approach close to the outer edge of the continental shelf.

B. CLIMATE

The Commonwealth Bureau of Meteorology is the basic source of climatological data for the region. Detailed information and general accounts of climatic conditions prevailing in coastal areas are published by the Royal Australian Air Force (1942), the Royal Netherlands Meteorological Institute (1949) and the Department of National Development (1970, 1971). It should be noted that much of the information contained in these sources comes from land stations and its applicability to offshore areas remains uncertain. Pickard (1977) has reviewed climatic factors relevant to the physical oceanography of the Great Barrier Reef region.

WIND. The area south of 15°S comes under the influence of the south east trade winds and wind direction for much of the year is from between south and east. The easterly component prevails from August through to January or February with southerly winds prevailing for the remainder of the year. North of 15°S the north west monsoon invades the region during the summer months and may extend its influence as far south as 16°S (Pickard, 1977). A notable feature in the region between 17° and 19°S is the tendency of the wind to back by 45° to 90° (SE to NE) between 0900 and 1500 hrs. Wind speeds are seldom high, except during the passage of tropical cyclones, but calm days are rare. Average wind speed is usually higher during the winter months.

CYCLONES. The majority of cyclones that affect the Queensland coast originate in the Intertropical Convergence Zone between 8° and 18°S in the north Coral Sea. Their subsequent paths are highly variable but most either curve south east to parallel the coast or track south west and cross the coast at some point north of Brisbane. Conditions associated with tropical cyclones include high winds, rough seas, torrential rain and coastal flooding. Wind gusts may approach 200 km/hr and storm surges in coastal areas may add more than 6 m to predicted tide heights (May, 1976).

From 1909 to 1975 a total of 75 cyclones entered the 5° square area extending from 15°S to 20°S and lying between 145°E and 150°E (Laurenz, 1977). All occurred in the six months from December to May with most (83%) during January, February and March. Of the 42 cyclones that crossed the coast between Bowen and Lizard Island, 15 made land fall between Cairns and Cooktown and most of the remainder between Cairns and Ayr. Figures indicate that in addition to those which make landfall, a high proportion of cyclones that approach the coast are likely to affect offshore reef areas, especially in the region south of Townsville where the reefs lie 100 to 150 km offshore. (Table XIb)

AIR TEMPERATURE. Monthly mean air temperature cycles for coastal centres north of Bowen show a maximum in December or January and a minimum in June or July. The monthly mean maximum temperature shows little variation (30°-32°C) north of 20°S while the monthly mean minimum declines steadily (19° to 14°C) from north to south. Highest and lowest recorded temperatures for Townsville (up to 1966) is 38°/1°C. The few data available suggest that temperature ranges offshore are comparable with those observed on the adjacent coast. (See *Australia Pilot;* Pickard, *loc. cit.;* Royal Netherlands Meteorological Inst, 1949).

RAINFALL. Coastal areas of tropical Queensland are characterized by a distinct wet season with about 70% of the total annual rainfall occurring in the three months from January to March. Mean annual rainfall for the coast from Bowen to Cooktown is between 1,000 and 2,200 mm except in the Tully - Babinda area (17°21' to 18°S) where annual totals average 3,600 to 4,400 mm. Large year to year variations in rainfall are typical of the whole area with individual annual registrations ranging from around 40 to 190% of mean annual totals. Monthly rainfall registrations show even larger variations. For example, the January range for Innisfail is 6 to 294% of the mean monthly value, and that for Bowen, 2 to 491%. Tropical cyclones cause local heavy falls which often result in 24 hr totals in excess of 250 mm; 800 mm have been recorded in a single 24 hr period further north at Port Douglas. Rainfall observations for offshore islands are limited but indicate that, with the possible exception of area around 17°40'S, precipitation over reef areas is comparable with that on the adjacent coast (Dept. National Development 1970, 1972; Pickard, 1977; Brandon, 1973).

RIVER RUNOFF. Information on runoff is available for only a limited number of the rivers in the region, the main source being publications of the Australian Water Resources Council (1976) from which Table 1 was extracted. Note that the Burdekin River has by far the largest mean annual discharge and that its minimum and maximum recorded flows are 2 and 290% of the mean value. Similar large annual variations are shown by the other smaller rivers in the dryer southern region. River discharges in the north show a narrower range of variation which can probably be attributed to fewer dry years.

Pickard *(loc. cit.)* has estimated that rain falling directly over the sea contributes almost twice as much freshwater to the Great Barrier Reef lagoon than does river runoff. The latter, however, being more localized, is likely to have a significant influence on near shore salinity regimes.

C. TIDES

Information on tidal heights and times are to be found in tables published by the Australian Department of Defence (1977) and the Department of Harbours and Marine (1977). Easton (1970) has described tidal patterns around Australia. Tides are semi-diurnal with consideral neap-spring variation and pronounced diurnal inequalities. The mean spring range varies from 2.5 m at Bowen to 1.6 m at Lizard Island. Charts given by Maxwell (1968) indicate that tidal ranges on the reef are similar to those on the adjacent coast but tides are approximately 10-20 mins earlier. Recent studies (Cresswell and Grieg, 1978) suggest, however, that the tidal maxima at Low Isles and Trinity Opening occur 2-3 hrs earlier than that at Cairns.

Information on the direction and strength of tidal currents is given in the *Australia Pilot*. This indicates that the tide floods to the north or north west, north of North Barnard Island (17°41'S), and to the south, south of the island. Near the inner edge of the Barrier Reefs the direction of the set is modified by the proximity of openings through the reef, the set being towards the openings during the ebb and away during the flood. In open waters inside the reef, flow rates average 0.25 to 0.5 m/sec with speeds of up to 2 m/sec occurring in narrow passages and channels.

D. HYDROGRAPHY

The only systematic study of the water column in Barrier Reef waters is that undertaken by Orr (1933) at Low Is. during the Great Barrier Reef Expedition in 1928-29. Much of the remaining data are scattered covering limited areas and/or restricted time periods. An account of the general properties of the waters of the region was given by Brandon (1973) and this and other studies up to 1975 have been reviewed by Pickard (*loc. cit.*). This review draws heavily on this latter work.

TEMPERATURE AND SALINITY. Between 14.6° and 19.5°S, the temperature of near shore waters average 29.1° to 22.2°C, the temperature range increasing from 6°C in the north to 7.4°C in the south (Pickard, *loc. cit.*). The only time series data on sea temperatures for specific localities are those given by Orr (*loc. cit.*) for Low Is, and by Kenny (1974) for Townsville. Low Isles temperatures showed a range of 8.4°C with a maximum of 29.9°C in February and a minimum of 21.5°C in August. The Townsville data cover four years and showed a mean range of 9.4°C and varied from a mean maximum of 31.2°C in January to a mean minimum of 21.8°C in July. The monthly range varied from 2° to 4.4°C indicating that considerable variation can be expected in surface temperatures in near shore waters.

Near shore surface salinities range from 35^{o}/00 in October to less than 32^{o}/00 in February (Pickard, *loc. cit.*). The low value in February results from freshwater input from rain and river runoff during the wet season. Below 10 m and at greater distances from the shore the water column is more stable. For most of the year mixing within the lagoon is sufficient to prevent stratification of the water column (Pickard, *loc. cit*). Temperature/salinity time plots given by Pickard show that changes in density of the surface waters result from changes in salinity from January to March and from changes in temperature from April to December. This contrasts with conditions outside the reef where changes in density can be almost solely attributed to variations in temperature. There is almost no data to indicate the level of interchange between lagoon waters and those outside the reef.

CURRENTS. Information relating to water movements within reef waters is scant and to some extent contradictory. The *Australia Pilot* states that during January the current is to the southeast and for the remainder of the year the set is to the north or northwest under the influence of the southeast trades. March and November are reported to be 'transitional' with the direction of the set described as highly variable. Notes on Admiralty charts (2349, 2923 and 2924) state that from April to November currents run northward and during December to March the current is irregular but more frequently sets south. The monthly charts of current vectors given by the Royal Netherlands Meteorological Institute (1949), indicate a net northward flow for most of the year and a southward set from October to December. Current roses for 19°S provided in the same source indicate a west to north flow for the first six months of the year and a south to east flow during the remainder of the year. Current speeds are reported to average 0.1 to 0.4 m/sec (Royal Netherlands Meteorological Institute, 1949; *Australia Pilot*), however, Admiralty charts note currents as high as 1.3 m/sec running north during the south-east trades. Semi-diurnal variations in current speeds occur as a result of changes in the direction of the tidal stream (Easton, 1970). Little information exists concerning currents immediately seaward of the Barrier Reefs. Admiralty charts record a current setting south at 0.25 to 0.5 m/sec along the outer edge of the reefs from May to December.

TABLE XIa Watersheds and stream flow

	km^2 Catchment area	Annual discharge 10^6m^3		
Tully River Basin				
Tully R.	1,470			
Herbert River Basin				
Herbert R.	8,810	3,468	(498- 7947)	14 -229
Ross River Basin				
Ross R.	790	281	(1- 1155)	0.4-411
Haughton River Basin				
Haughton R.	1,750	310	(39- 905)	12 -283
Burdekin River Basin				
Burdekin R.	130,000	9,046	(188-26271)	2 -290
Don River Basin				
Don R.	712	56	(0- 223)	-398

TABLE XIb. Cyclone landfalls and approaches to within 50, 100 and 150 km of the coast for 100 km units of coastline between Cairns and Bowen. Note: Cyclones are not recorded as approaches for the unit in which they make landfall (Data from Laurenz, 1977).

	Cairns		Townsville		Bowen
Landfalls	5	7	7	6	1
50 km	5	1	3	4	9
100 km	7	3	5	7	10
150 km	10	6	3	8	12
Total	27	17	18	25	32

GEOMORPHOLOGY OF THE GREAT BARRIER REEF BETWEEN BOWEN AND INNISFAIL

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Although one of the most utilised areas of the Great Barrier Reef, the reefs between Bowen and Innisfail have had little geomorphological or geological research carried out on them. The area has been discussed in a general sense by Fairbridge (1950, 1967) and by Maxwell (1968, 1973) whose statement on the sediments and bathymetry of the area is still the most authoritative. Only two papers have dealt with this area specifically, Sugden (1972) and Hopley (1978a). Sugden's work was essentially on the sediments of the region, but most of the results have not been published. Hopley has worked on the age and structure of individual reefs of the area and on sediment movement on reef tops, mainly on Wheeler Reef. Harvey has carried out geophysical investigations of a number of reefs in the area and recently, in co-operation with the Queensland Geological Survey the present authors carried out over 300 km of continuous seismic profiling over the continental shelf of the region. Preliminary results only are available and are incorporated in this review. Although some work on the off-shore islands was carried out and published in the early reports of the Great Barrier Reef Committee and by Steers (1929, 1937, 1938) more recent reviews incorporating radiometric dating have been made by Hopley (1968, 1971, 1975). Similarly mainland work carried out by Hedley (1925), Jardine (1928a,b) and Stanley (1928) has been updated by soils (Murtha 1975) and geomorphological survey (Hopley 1970a,b, 1978, Hopley and Murtha 1975). This review is essentially extracted from these earlier publications.

MAINLAND GEOMORPHOLOGY

The eastern coastal zone of north-eastern Australia is backed by a nearly continuous main scarp varying in altitude up to 1000 m with numerous residual or fault block coastal hills and ranges, the majority of which are aligned parallel to the regional NNW-SSE structural trend. The coastline is generally parallel to this trend and is separated from the main escarpment by a coastal plain of essentially Quaternary sediments, varying in width up to 50 km. Where the coastline cuts across the regional structural trend, wider coastal plains are associated with indented coastlines, as for example, in the Townsville to Bowen area.

Quaternary deposits of the coastal plain and adjacent continental shelf are the result of two contrasting processes: erosion of the main escarpment and coastal ranges in response to fluctuating climatic and eustatic conditions; and the pulsatory production of carbonate sediments on the outer shelf in the area of the Great Barrier Reefs in response to fluctuating sea levels. Terrigenous and carbonate sediments thus interdigitate over the inner shelf as a consequence of the marine transgressions and regressions of the Quaternary. Much sediment transport during the late Cainozoic has produced extensive deltaic and estuarine sequences where major rivers reach the coast. Their total thicknesses are unknown over many parts of the coastal plain but the available information suggests that 30 m to over 150 m of sediment has accumulated in the major deltas. Most are assumed to be of Quaternary age.

TERRIGENOUS DEPOSITS

By far the largest proportion of coast plain sediments are alluvial or colluvial in origin. In the Townsville area, where they have been studied in greatest detail (Hopley and Murtha 1975) the surface deposits are considered to be no older than the last interglacial (c 125,000 years BP) and it is likely that the underlying deposits are all of Quaternary age. They overlie a bedrock surface eroded during periods of low sea level.

Murtha (1975) has divided the Quaternary deposits of the Townsville coastal plain into four units: older alluvium, younger alluvium, piedmont slope deposits, and coastal deposits. The older alluvium is the major component of the plain and consists dominantly of gently sloping alluvial fans and plains with some infilled stream channels; the sediments are often more than 40 m thick and carry strongly differentiated soils. The younger alluvium consists dominantly of elongated alluvial terraces, levees, and channel infills that usually rise 1-4 m above stream beds; they carry weakly differentiated soils. The narrow zone of piedmont slopes is underlain by alluvial fan and colluvial deposits that fringe the coastal hills and ranges. The coastal deposits are dominantly sandy, stranded beach ridges occurring along most of the coastline with mangrove muds and salt pans adjacent to tidal inlets.

Riverine silcrete (Grant and Aitchison 1970) is associated with many of the older stream channel deposits; at a number of localities it dips beneath Holocene beach ridges and outcrops on the lower beach where it may be confused with carbonate-cemented beach rock.

There is little lateral continuity in the subsurface deposits. Hopley and Murtha (1975) suggest they have accumulated in a similar way to the present surface deposits. The oldest recognised are iron-cemented fans at the base of the main escarpment. Similar materials on the coastline at Mount Douglas overlie a boulder beach that is assumed to be of last interglacial age. Their age is tentatively correlated with the drier period 116,000 to 86,000 years BP of Kershaw (1978) but in the piedmont zone the fans may be considerably older.

Subsequently the Townsville coastal plain suffered a period of severe weathering, decomposition and mobility of sesquioxides during which the older fans were cemented and fine grained fluvial floodplain deposits laid down over much of the coastal plain. Climatically Kershaw (1978) suggests that the period 86,000-79,000 years BP have provided the wetter conditions necessary, but it is a relatively short period; the degree of weathering may thus be as much a function of time as of higher rainfall. However, there has been a period of more recent fan accumulation and increased drainage density which has left features such as fans and channel infills morphologically similar to those of the earlier drier phase, though uncemented and with minimal weathering modification. The accumulation of carbonate nodules in soil profiles of the area may also date from this period. Two such nodules produced radiocarbon dates of 14,680 and 15,100 years BP (Hopley and Murtha 1975) which probably represent the later phases of the desiccation. If so, then the later fans and fluvial deposits may correlate with the maximum glacial drier periods of Kershaw (1978), 38,000 to 8,000 years BP.

The major process operating along the eastern seaboard during the Quaternary has apparently been scarp retreat, which, during variable climatic conditions, resulted in the accumulation of talus, alluvial fans and plains. Along the river valleys incised into the main escarpment, major terrace sequences have developed although none have been studied in detail. De Keyser and Lucas (1968) describe 3 major and 3 minor terraces along the Russell River, and south of Gordonvale on the Mulgrave River. Three terraces cut into older alluvial fans occur at about 22 m, 9 m and 6 m above river level and the thickness of sediments beneath the upper terrace is estimated at over 30 m hence the lower beds are now below sea level (Jardine 1925; de Keyser 1964). A major terrace has been described on the lower Burdekin near Dalbeg approximately 10 m above the level of the present floodplain (Hopley 1970b). Although minor terraces on the lower reaches of many streams may be the result of eustatic changes of sea level, the majority appear related to climatic change, and its associated sediment yield and hydrological variations. Tectonism may also have contributed to the development of some of the sequences by minor uplift of the land.

Tectonism has also been suggested as a cause of many drainage modifications. Some stream diversions such as the deflection of west flowing rivers towards the east coast by upwarping have been described by many authors (eg Taylor 1911; de Keyser and Lucas 1968; Heidecker 1973). Other drainage diversions may be related to volcanic activity and basalt flows particularly in the lower Mulgrave, Russell and Johnstone Rivers; in the valley of the Little Mulgrave River a travertinous limestone 9 m thick and containing some plant remains and gastropods were deposited in a lake dammed by basalt (de Keyser and Lucas 1968). More recent drainage diversions are related to sedimentation and sea level changes (eg Jardine 1928b; Hopley and Murtha 1975).

DELTAIC DEPOSITS

A tropical climate with intense seasonal rainfall and a deeply weathered, uplifted hinterland is ideally suited to produce large fluvial sediment yields. Not surprisingly, therefore, the major rivers are associated with extensive deltaic or estuarine infill deposits. Greatest stratigraphic detail is available for the extensively drilled Burdekin delta, Australia's largest cuspate delta draining a basin of over 129,000 km^2 (Hopley 1970b). Here the deltaic deposits reach over 150 m thick at the base of Cape Bowling Green and generally have a depth of over 70 m. Weathered bedrock up to 10 m in thickness is overlain by clays, sands and gravels which have little lateral continuity. However, a number of weathering horizons can be identified, the uppermost of which, usually characterized by a compact red oxidized or ferruginized clay, is directly overlain by unconsolidated Holocene sediments, and is thus regarded as late Pleistocene in age (Hopley 1970b). Carbonate nodules from 23 m deep, at the top of the Pleistocene surface, were dated at 15,000 years BP (Hopley and Murtha 1975). A wedge of unweathered and uncompacted Holocene deposits overlying the Pleistocene strata attains a maximum thickness of 38 m on the eastern side of the delta, 22 m on the northern shores of the delta, and thinning to little more than 5 m around the delta margins. Because of a rock bar at Kelly Mount the Burdekin at all low sea level stages of the Pleistocene has discharged northwards into Bowling Green Bay and not eastwards in the area of the present distributaries.

Less stratigraphic detail is known for the Herbert delta (basin area 8800 km^2). Deltaic morphology is simpler than that of the Burdekin: deposits over 93 m thick occupy a relatively simple, funnel-shaped bedrock estuary. At least 12 m of Holocene sediments are present as a veneer over the older weathered deltaic deposits.

LITTORAL DEPOSITS

Depositional shorelines dominate the coast of north-eastern Australia. Three types of deposits have been recognized: beach ridges, coastal dunes and cheniers.

BEACH RIDGES: A narrow fringe of beach ridges consisting of quartz sands up to 5 m high occurs along all coastlines exposed to the prevailing south-easterly or easterly winds. The ridges are usually less than 400 m wide except close to river mouths where wider ridge sequences may be found. Major barrier systems are associated with the larger rivers; north of the Burdekin for example a sequence of over 100 ridges forms a sand barrier up to 7 km wide near Cape Cleveland (Hopley 1970b). The majority of beach ridge systems overlie older Pleistocene coastal plain sediments and are of Holocene age. The earliest of the Holocene ridges appear to have been deposited between 5000 and 6000 years BP, the time at which modern sea level was first achieved in the Holocene in this area.A Belperio (pers comm) provided a date of 5960 ± 230 years for mangrove deposits below the oldest ridges near Townsville. In the wider Holocene barriers younger ridges frequently truncate the older ones indicating periods of recession in the barrier formation.

Inner barriers of presumed Pleistocene age are much less continuous than elsewhere in eastern Australia. However small remnants of such shorelines do exist along the entire coastline. Most are low sandy ridges with podzol soil profiles. One such ridge near Townsville contains calcareous cemented deposits dated at 14,680 years BP

(Hopley and Murtha 1975). Another, to the south of the Burdekin is more calcareous and contains a dune calcarenite and a coquina minimally dated between 25,150 and 28,900 years BP (Hopley 1970b). A similar deposit near Bowen, but in a very early stage of consolidation and within a Holocene sequence, was described by Frankel (1976). In general, carbonates are not a major constituent of either Pleistocene or Holocene mainland beaches.

Multiple barrier systems such as those described from southern Australia (eg Cook *et al*, 1977) are not found along the north-eastern coast of Australia with one exception. Behind Cowley Beach near Innisfail and multiple beach ridge sequence is 12 km wide; the innermost ridges consist of red sands with groundwater podzol soils, the central sequence consists of heavy textured sandy clays, and the outer ridges of siliceous sands with weakly developed podzols. At least three barrier systems appear to have survived here and warrant further attention.

COASTAL DUNES: Coastal dunes form wherever there is a local abundance of sand and exposure to strong onshore winds, but large dunes tend to be the exception rather than the rule on the coast of tropical Queensland south of Cooktown. Beach ridges, with or without small aeolian cappings, tend to be the dominant barrier forms on lowland coasts except towards the northern ends of arcuate bays where there is greater exposure to prevailing south-easterly winds (Bird and Hopley 1969). This lack of dune development is the combined result of the reduced incidence of sand-moving winds in comparison with temperate coasts (Jennings 1965) and, perhaps more importantly, the lack of an abundant sand supply away from river mouths.

On the coast south of Cooktown dunes generally take the form of a narrow littoral fringe of low, flat foredunes seldom exceeding 8 m in height and typically much less. A low rate of sand supply and the growth characteristics of the *Ipomoea-Canavalia-Spinifex* vegetation community give rise to low platform or dome-like dunes. Higher fossil foredunes up to 20 m, now vegetated and located well inland, occur south of Cape Upstart and in the Burdekin Delta (Hopley 1970b), and suggest that sand movement may have been greater than at present at certain times during the Quaternary.

In exposed locations foredunes have been disrupted by blowouts to form a series of parabolic dunes with active noses moving inland. Presently active parabolic dunes 8-10 m high occur along virtually the entire length of Cape Bowling Green spit. Elsewhere, as at Ramsay Bay on Hinchinbrook Island where they attain heights of over 60 m, parabolic dunes of Holocene age are now largely stabilised by scrub and forest vegetation.

CHENIERS AND MANGROVE DEPOSITS: On sheltered coastlines particularly on the lee of headlands, fine grained deposition dominates, coasts are fringed by mangroves and chenier plains have been deposited during the Holocene. Typically the plains consist of narrow chenier ridges of sands, fine gravels, and shell grit up to 2 m above the surrounding plain which consists of grassland (mainly *Sporobolus virginicus*) towards the land and bare salt pan to seawards. Stratigraphy in the Broad Sound area (Burgis 1974) which may be typical of most sequences of the area, shows about 3 m of Holocene sediments, the basal deposits being shallow water marine muds, overlain by intertidal muds and sands, mangrove deposits, and finally high tidal muds which postdate the deposition of the cheniers. The deposits represent coastal progradation from the maximum of the Holocene transgression about 5000 years ago. The oldest chenier ridges in the area are older than 5000 years (Cook and Polach 1973). According to Cook and Polach they formed during periods of low sediment supply leading to erosion of mangrove deposits and development of a ridge from the coarser lag materials. However, cheniers are also developed during low frequency, high energy events such as tropical cyclones: Hopley (1973) has reported the emplacement of a chenier in Bowling Green Bay during cyclone Althea in 1971.

The sequence described at Broad Sound, although of wide horizontal extent because of the large tidal range, appears typical of Holocene low energy depositional environments elsewhere in north Queensland. However, bare salt flats are very restricted on the wetter coast between Ingham and Cooktown and due to lower salinity levels, mangroves survive on high tidal flats that are only occasionally inundated. Radiocarbon dates for mangrove materials beneath intertidal silts and clays are 7230 ± 550 years BP (GaK-6265) from a depth of 3.1 m on Magnetic Island (A.P. Spenceley, pers comm) and 7130 ± 150 years BP (GaK-4898) from a depth of 6.0 m on Hinchinbrook Island (A.L. Bloom, pers comm).

GEOMORPHOLOGY OF THE HIGH ISLANDS

Many of the high continental islands have areas of Quaternary deposits. The majority of islands have fringing coral reefs that are narrow on the exposed windward side but widen to 500 m or more on the leeward western or north-western sides. The reefs themselves have developed during the Holocene transgression but, like the Great Barrier Reefs, may have Pleistocene foundations. Only one reef, that of Hayman Island just south of the area under review, has been drilled and dated. Here the Holocene reef has developed over a Pleistocene reef at a depth of 15-20 m; the younger reef commenced development during the Holocene transgression at about 9300 years BP and grew upwards at a rate slightly slower than the rate of the transgression (Hopley et al, 1978). Further drilling was carried out on a fringing reef in Cockle Bay, Magnetic Island, but had poor recovery. One borehole sunk to 7.6 m encountered mostly soft sediment whereas the second recovered reef material to a depth of 1.2 m before encountering soft sediment. On two islands, Pleistocene deposits, probably of last interglacial age, outcrop at the surface. On Camp Island near Cape Upstart cemented coral shingle, resembling modern intertidal beachrock but with both corals and cement extensively recrystalised to calcite, yielded a minimal date of 20,200 years BP (Hopley 1971). On Cockermouth Island, near Mackay and south of the review area, remnants of a Pleistocene dune calcarenite dated at 15,640 years BP (Hopley 1975) forms isolated islands on the reef flat. Solution piping within the reef flat suggests that it was eroded during a period of low sea level and implies that much of it may also be of Pleistocene age.

Elsewhere the oldest Holocene deposits of the high islands are generally coarse boulder beaches formed from the reworked corestones of the Pleistocene regolith around the islands slopes (Hopley 1968, 1971,1975). These beaches may rise to over 6 m above MHWS and frequently have their basal portions cemented. Both cyclonic events and higher Holocene sea levels have been suggested for their emplacement. Later Holocene deposits are richer in carbonates derived from the fringing reefs. Emerged reefs approximately 1-1.5 m above the upper limit of modern reef growth have been described from islands of the Bowen-Whitsunday area (Hopley 1975) and the Palm Islands (Hopley 1971). An emerged reef on Middle Island, near Bowen was dated by Hopley (1975) at 5210 and 5290 years BP. On the same islands overlying or associated with the raised reefs are cemented terraces, usually consisting of coral shingle with an aragonitic cement, which have been equated with mo-ern intertidal beachrocks. They have yielded radiocarbon dates of between 5000 and 3500 years BP and are related to sea levels 3-4 m higher than present (Hopley 1971, 1975). Phosphatic sandstones are also incorporated in the spits of a number of islands as well as the cays of the Great Barrier Reef. They are probably derived from guano, but only on Holbourne Island have they been mined (Saint-Smith 1919).

Sediments of the fringing reefs have been examined by Smith (1975, 1978) who has shown by multivariate statistical techniques that reef sediment characteristics vary closely with morphological zone:

i) Upper beach: medium to coarse sands, poorly sorted, symmetrical distribution and mesokurtic. Carbonate percent is generally less than 50%.

ii) Lower beach: fine to medium sands, moderate sorting, negatively skewed and pronounced leptokurtosis Carbonate percent within the range 40-75%.

iii) Reef flat: coarse biogenic sediments, poorly sorted, positively skewed and with a great range of kurtosis values. Carbonate percent within the range 60-95%.

iv) Subaqueous delta: on reef flat adjacent to stream mouths are areas of medium sands, poorly sorted, negatively skewed and platykurtic or mesokurtic. Carbonate percent is low, generally less than 10%.

v) Reef margin or fore-reef: medium to coarse sands of moderate sorting, negatively skewed and mesokurtic or leptokurtic. Carbonate percent about 50%.

THE OUTER REEFS OF THE GREAT BARRIER REEF (Fig. 1)

Off Bowen the continental shelf has a width of between 125 and 150 km but north from latitude 18°S where the coastline changes from a NW-SE to N-S alignment the shelf narrows to between 50 and 100 km. Shelf depths between the reefs are generally within the range 50 to 60 m. Reefs in the southern part of the area occupy the outer 35% of the shelf and nowhere approach within 50 km of the mainland coast. Further north they occupy up to 50% of the outer shelf and come within 20 km of the mainland. In many ways this is not a distinctive region of the Great Barrier Reef. To the south massive reef complexes with deep narrow intervening channels are found. This region extends northwards only to the Darley-Dingo Reef complex, a mass of reefs 40 km long immediately north of Bowen. To the north of the region and particularly northwards from Cairns where the shelf narrows to only 50 km, the distinctive northern province of the Great Barrier Reef commences, with a continuous line of narrow ribbon reefs with confined passages between them, a zone of mid-shelf patch reefs and a distinctive inner zone of low wooded island reefs with shingle ramparts, platforms, cays and reef flat mangroves.

Nonetheless it is an important area in terms of reef evolution and possibly also in terms of its biological diversity. During the maxima of Pleistocene glaciations, when sea level was lowered by approximately 135 m, it has been estimated that oceanic water temperatures off the Queensland coast were lowered by c.2°C (CLIMAP 1976; Shackleton 1978). This may have been sufficient to have moved the southern limit of coral growth as far north as the Mackay to Bowen area. The Bowen to Innisfail area of the Reef would have remained an area of prolific coral growth as sea levels of the last glacial period (125,000 years to the present), apart from the glacial maximum period of about 25,000 to 17,000 years ago, would have been lower than 50 m for only comparatively short periods, coral reefs would have survived on this area of the shelf throughout most of this glacial cycle. They were most likely in the form of fringing reefs around the cores of the older emerged reefs of the last interglacial period. In contrast, on the shallower shelf to the north of Cairns, the continental shelf would have been emerged for up to 70% of the last 125,000 years. As the continental margin in the northern reef area has an extremely steep slope, reef development over most of this period would have been limited to a very narrow outer fringe. In this light the Bowen to Innisfail region of the reef may have acted as a refuge area during each Pleistocene glaciation and may help towards explanation of the great biological diversity and complexity of the reef in this region.

The reefs between Bowen and Innisfail consist essentially of irregular patch reefs, generally much smaller than reefs to both south and north (Fig. 1). Even the largest reefs of the area, Broadhurst and Trunk Reefs are less than 15 km long. The majority of reefs are between 5 and 10 km in length and up to 5 km in width, though smaller reefs less than 1 km in size are found mainly on the outer edge of the shelf. The long axis of most reefs lies normal to the coastline (ie north-east to south-west). The majority have a "hard line", or relatively straight edge on the windward south-eastern margin and a less regular leeward side made up of scattered "bombies" or isolated coral colonies. The most continuous reef flat development is on the windward side but the central part of the reefs is frequently made up of a lagoonal area with isolated coral colonies though on no reef off Townsville is there a true lagoon enclosed by reef flat margins as, for example, in the Bunker-Capricorn group of reefs at the southern end of the Great Barrier Reef. Vegetated reef islands are completely absent on this part of the reef. There are no permanently vegetated cays between Bushy Island, opposite Mackay, to Green Island near Cairns, a distance of 600 km. This is in part due to the lack of extensive reef flat development. Only three reefs (Wheeler Reef described below, Beaver and an unnamed reef at 18°03'S, 146°53'E) have even unvegetated sand cays the former two of which are inundated on high spring tides. The mobility of these cays is illustrated by changes at Wheeler Cay documented by Hopley (1978c) from which figure 2 is derived.

The nature of the continental shelf and its sediments in this area has been extensively described by Maxwell (1968, 1973). The shelf is of box morphology having depths of about 80 m on its outer edge. Although the shelf slope is gentler than elsewhere along the Reef, depths in excess of 300 m are found within 10 km of the edge. The reefs rise from depths varying from 40 m on the inner margins of the reef province to 80 m on the outer edge. Sediments are highly carbonate (>80%) around the reefs but terrigenous sediments extend for a greater distance out across the shelf than along most other stretches of the Queensland coastline. A distinctive extension of terrigenous sediments extends out across the shelf between Cape Cleveland and Cape Bowling Green, significantly the line of the Burdekin River during low sea level phases of the Pleistocene (Hopley 1970b). This differs from Maxwell's (1968) location of the Pleistocene Burdekin. Recent seismic traverses have indicated a major channel, now infilled south of Keeper Reef which may be the low sea level extension of the Burdekin.

Understanding of reef morphology has increased significantly over the last 10 years, from work carried out elsewhere in the world and on the Great Barrier Reef (eg see the Proceedings of International Coral Reef Symposia in Brisbane, 1973 and Miami, 1977). In most areas, present reefs have developed as veneers of Holocene growth over older Pleistocene foundations which were exposed to subaerial processes during the low sea levels of the late Pleistocene. The morphology of the Pleistocene foundation is dependent on both the original morphology of the earlier reef and the modifications during exposure which may develop a karst relief. In turn the degree to which this Pleistocene morphology influences modern reef morphology is a reflection of the depth of the antecedent platform, the nature of the rise of sea level over it, the response of reef building organisms to this transgression and, finally, the response of the reef organisms and the sediments they produce to the prevailing environmental conditons including wave and tidal regimes.

Apart from Wheeler Reef (Fig. 3), described by Harvey (1978) where the Holocene-Pleistocene contact lies at a depth between 15.5 and 20 m and Viper, Darley and Keeper Reefs reported below, little information is available as yet for the depth of the Pleistocene unconformity in the Bowen to Innisfail area, but results elsewhere on the Reef suggest it lies from 4 to 20 m below the present surface. If the sea level curve of Thom and Chappell (1975) is taken as applicable to this part of the north Queensland shelf, then the deepest antecedent platforms would have been inundated approximately 9500 years ago, when the transgression was at its maximum (about 10 mm per year). Studies of present day calcification rates and of dated Holocene reef sequences suggest that maximum accretion of calcium carbonate occurs at windward perimeter locations at rates of 4 Kg/m^2/year, giving vertical growth rates of 3 mm per year (Davies *et al* 1977). Thus reefs developed on deeper platforms would not be able to maintain upward growth rates equal to the rise in sea. Based on the figures given and the Thom and Chappell sea level curve a reef developing from a 20 m platform would have reached modern sea level by 2600 years BP. However, reefs developing from higher platforms would have been inundated at a time when the sea level rise was slowing down. Thus a reef growing from a 10 m platform would have reached modern sea level by 4500 years BP and a 5 m platform by 5500 years BP giving progressively longer times for lateral reef development from perimeter locations, the formation of reef flats and the infilling of lagoons which would have been formed by the upward growth from the perimeters of the former platform. In some cases it is considered that this platform itself may have contained a central depression, as the result of solution processes.

This scheme of Holocene reef development from Pleistocene foundations provides a basis for understanding the age and degree of development of present reef flats. It is confirmed by recent drilling and seismic investigations on the Great Barrier Reef (Harvey 1977; Davies *et al* 1977; Hopley *et al* 1978). However, the picture is complicated by a further variable, the nature of the sea level rise. This for long has been a matter of controversy in eastern Australia, but hydroisostatic models such as those of Bloom (1967), Walcott (1972) and Chappell (1974) provide for regional variations in transgression rates. In particular Chappell suggests that marginal shelf subsidence and compensatory inner shelf emergence may take place. Modern sea level may thus have been achieved earlier on the inner shelf where evidence for emergence may be found. This is certainly the case in the Townsville region, though some tectonic movement may also be involved (see Hopley 1974). On the outer shelf modern sea level may have been achieved much later, and, whatever the depth to the Pleistocene unconformity, reef surfaces will be younger than on the inner shelf.

Although hydroisostatic warping on the narrow shelf north of Cairns proved minimal (Hopley 1977) the pattern in the Townsville region may provide evidence for marginal shelf subsidence. Material from drill cores from the upper 2 m of the outer shelf Viper Reef is no older than 2660 years BP (Fig. 4) even though the Pleistocene unconformity is located at only -11 m. On mid-shelf Darley Reef dates for similarly located materials are as great as 6210 years BP (Fig. 5) whilst the Pleistocene unconformity is only 2 m higher. The comparative youthfulness of reef surfaces in the Bowen-Innisfail area is also borne out by cores from Keeper Reef. The oldest radiocarbon date obtained from the upper 4 m was 2610 years ± 90 years BP (GaK-7275). The Pleistocene unconformity has been tentatively identified at 15 m beneath the reef and appears to correlate with a seismic reflector beneath back reef sediments which rises to less than 20 m. On inner continental islands in the Bowen area sea level was as much as 2.5 m above present by 6020 years (Hopley 1975) and on the mainland, mangrove and shell material within 2 m of modern sea level has been dated at between 5960 and 7230 years BP.

The variation in morphology of reefs in the Townsville area may be explained in terms of the variation in depths of Pleistocene unconformities and nature of the sea level rise. Where the unconformity is deep and/or modern sea level has been reached comparatively recently, reef flat development will be limited to the other perimeter and will not be continuous.

At the other extreme, with progressively shallower foundations, and/or with modern sea level reached at earlier dates, reef flat development will be more extensive, lagoons will be infilled and sediments will accumulate.

Once the reefs have reached modern sea level they have grown largely in response to the southeasterly wind pattern. Although the windward edge may be the most productive, material is swept back towards the lee side of the reef, ie the reef grows leewards, as suggested by Davies (1977). Calcareous algae develop on the windward side over the corals and shingle banks (as indicated by Viper and Darley Reefs) further helping to produce the "hard line" of the reef margin. Coarser shingles may accumulate as sediment tongues and large reef blocks are thrown onto the reef margin during cyclones. As the reef flat extends, finer sediments accumulate on the leeside at the point of wave convergence initially as an unvegetated and highly mobile cay. Later, with increasing size and stability plant life may become established, further stabilising the cay. At a further stage still, formation of beach rock gives the cay even greater permanence.

Apart from the innermost, more massive reefs north of Bowen (Darley-Dingo Reef complex) the reef surfaces of the Great Barrier Reef in the Townsville region appear to be young. Reef flats are best developed on the inner reefs, and here development of even unvegetated sand cays is limited. Older reef flat surfaces with low wooded islands or cays, shingle ramparts, cemented platforms and emerged reefs as displayed north of Cairns are absent from this area, though in many respects the high continental islands of the inner shelf, with similar emerged reefs and beach rock platforms, appear to be parallel features to the low wooded island reef further north. Flat algal surfaces so typical of windward reef flats of both northern and southern reefs, are lacking or only minimally developed on reefs between Bowen and Innisfail.

The youthfulness of the reef tops in the region has some notable implications for management. The veneer of living corals makes these reefs extremely attractive for tourism, although the distance of the reef from the coast makes access difficult. Where the reefs are closer to the mainland, near Innisfail, high annual rainfall totals and massive freshwater run-off from the mainland has inhibited reef top coral growth on at least the nearshore reefs. The veneer of living corals makes these reefs particularly vulnerable to outside influences. Oil spillage or pollutants from the mainland, if carried out in surface waters to the reefs of this area would have an even more drastic impact than on reefs to north or south where dense coral growth is limited to reef margins or lagoons. It may be more than coincidental that the area of the Great Barrier Reef where *Acanthaster planci* congregations were most noticed and apparently caused greatest damage was also the area where youthful reefs with luxuriant reef top coral growth occur.

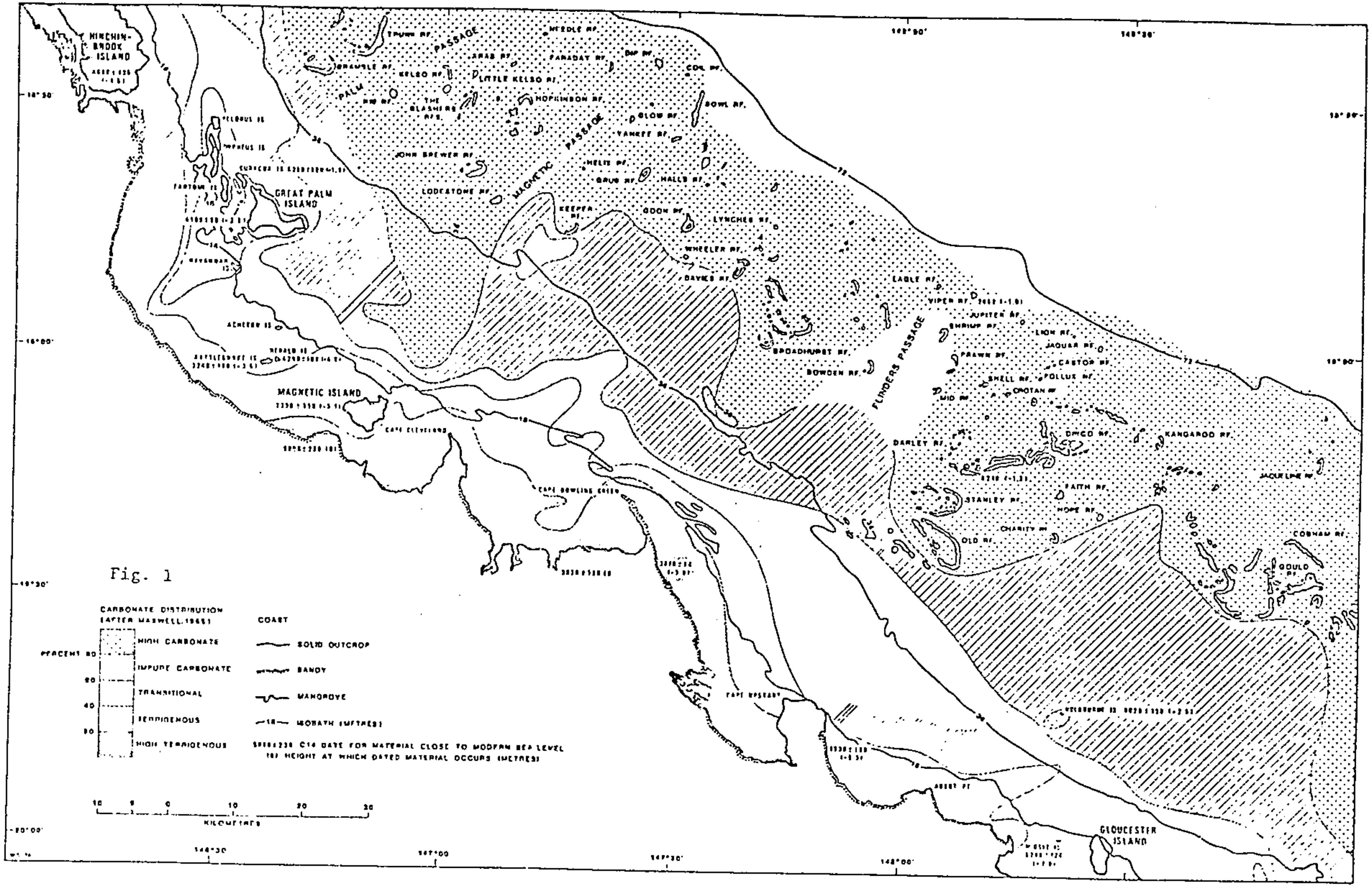

HINCHINBROOK ISLAND
GREAT PALM ISLAND
MAGNETIC ISLAND
GLOUCESTER ISLAND
PALM PASSAGE
MAGNETIC PASSAGE
FLINDERS PASSAGE
CAPE CLEVELAND
CAPE BOWLING GREEN
CAPE UPSTART
PELORUS IS
ORPHEUS IS
CURACOA IS
FANTOME IS
HAVANNAH IS
ACHERON IS
RATTLESNAKE IS
HERALD IS
TRUNK RF.
NEEDLE RF.
BRAMBLE RF.
ARAB RF.
FARADAY RF.
KELSO RF.
LITTLE KELSO RF.
RIB RF.
THE BLASHFORD RFS.
HOPKINSON RF.
COIL RF.
BOWL RF.
GLOW RF.
YANKEE RF.
JOHN BREWER RF.
HELIX RF.
GRUB RF.
HALLS RF.
LODESTONE RF.
KEEPER RF.
DOON RF.
LYNCHES RF.
WHEELER RF.
DAVIES RF.
EAGLE RF.
VIPER RF.
JUPITER RF.
SHRIMP RF.
LION RF.
JAGUAR RF.
BROADHURST RF.
BOWDEN RF.
PRAWN RF.
CASTOR RF.
POLLUX RF.
SHELL RF.
CROTAN RF.
MID RF.
DARLEY RF.
DIPCO RF.
KANGAROO RF.
FAITH RF.
STANLEY RF.
HOPE RF.
CHARITY RF.
OLD RF.
JACQUELINE RF.
COBHAM RF.
GOULD RF.
ABBOT PT.
18°30'
19°00'
19°30'
20°00'
146°30'
147°00'
147°30'
148°00'
148°30'
10
36
72
CARBONATE DISTRIBUTION (AFTER MAXWELL,1968)
HIGH CARBONATE
IMPURE CARBONATE
TRANSITIONAL
TERRIGENOUS
HIGH TERRIGENOUS
PERCENT 80
60
40
20
COAST
SOLID OUTCROP
SANDY
MANGROVE
—18— ISOBATH (METRES)
5850±230 C14 DATE FOR MATERIAL CLOSE TO MODERN SEA LEVEL
(8) HEIGHT AT WHICH DATED MATERIAL OCCURS (METRES)
10
5
0
10
20
30
KILOMETRES

Fig. 1

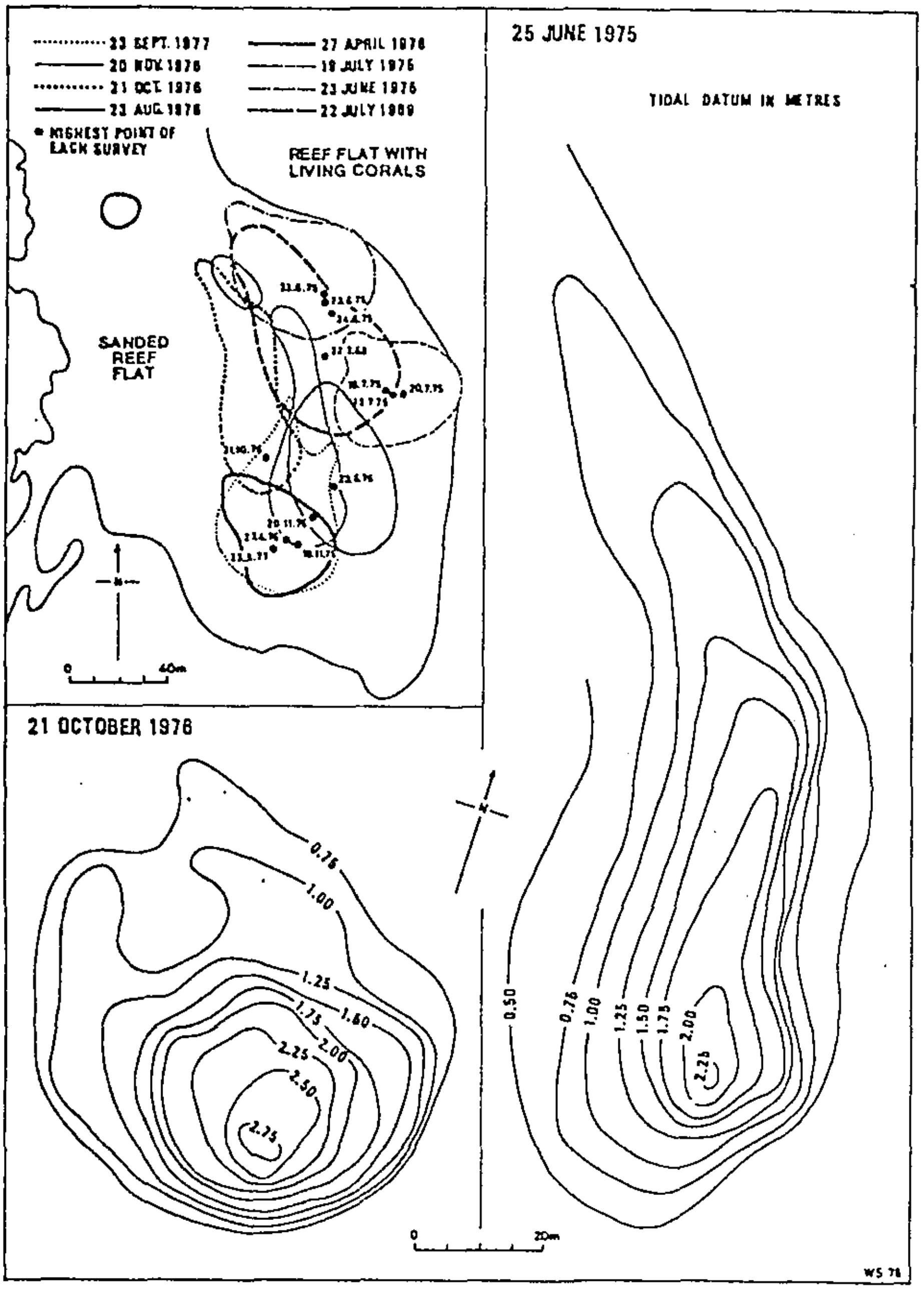
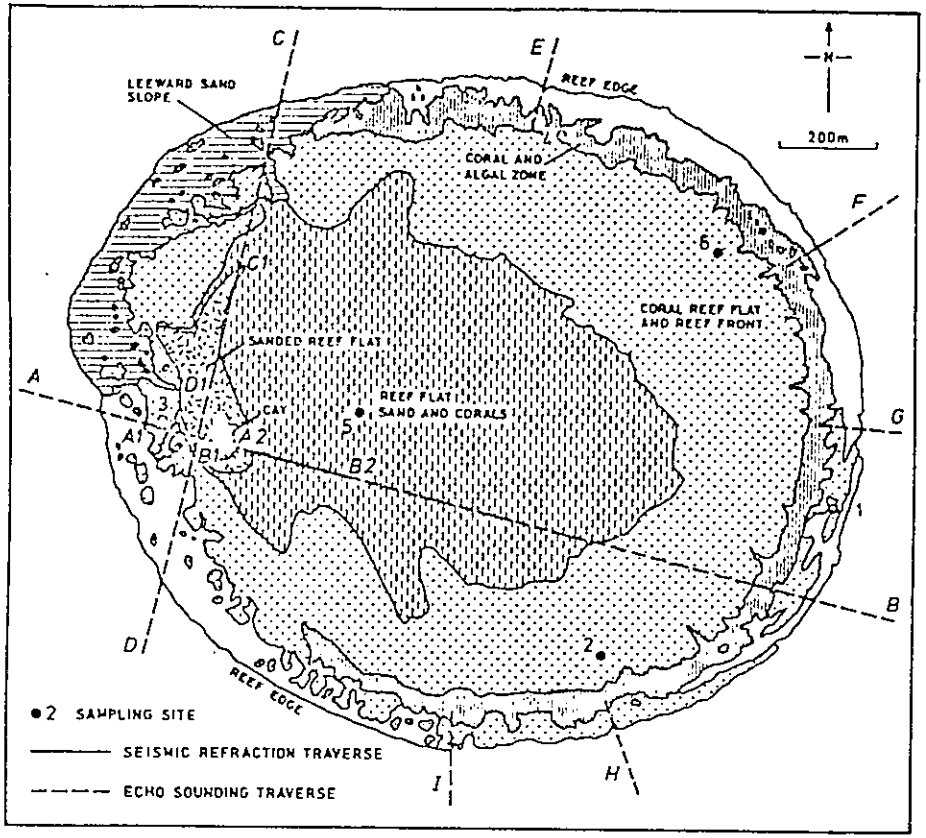


Fig. 2 Changes in cay location and morphology, Wheeler Reef

Fig. 3a Wheeler Reef, morphology and location of transects and sampling sites



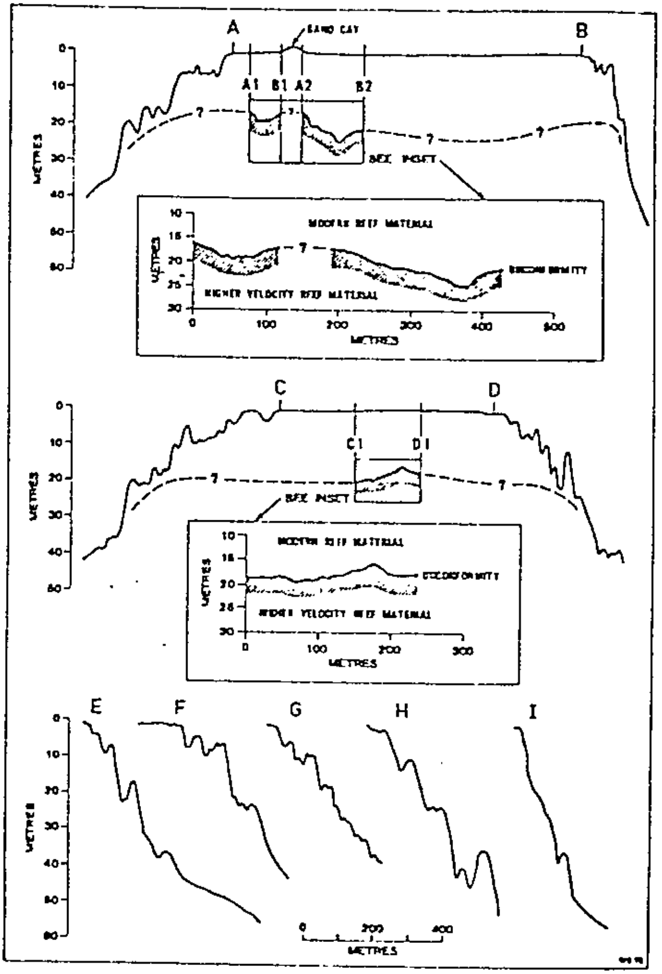


Fig. 3b Seismic and echo sounding transects, Wheeler Reef

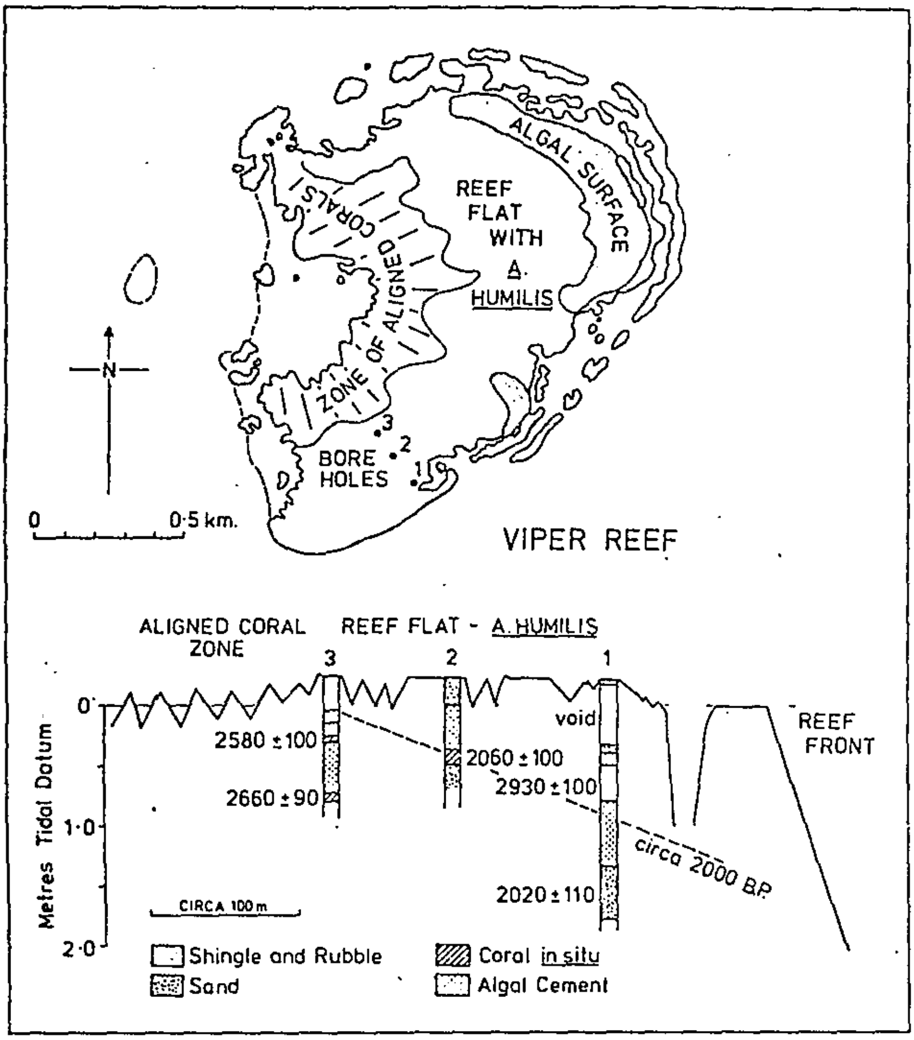


Fig. 4 Viper Reef drill cores and radio carbon dates

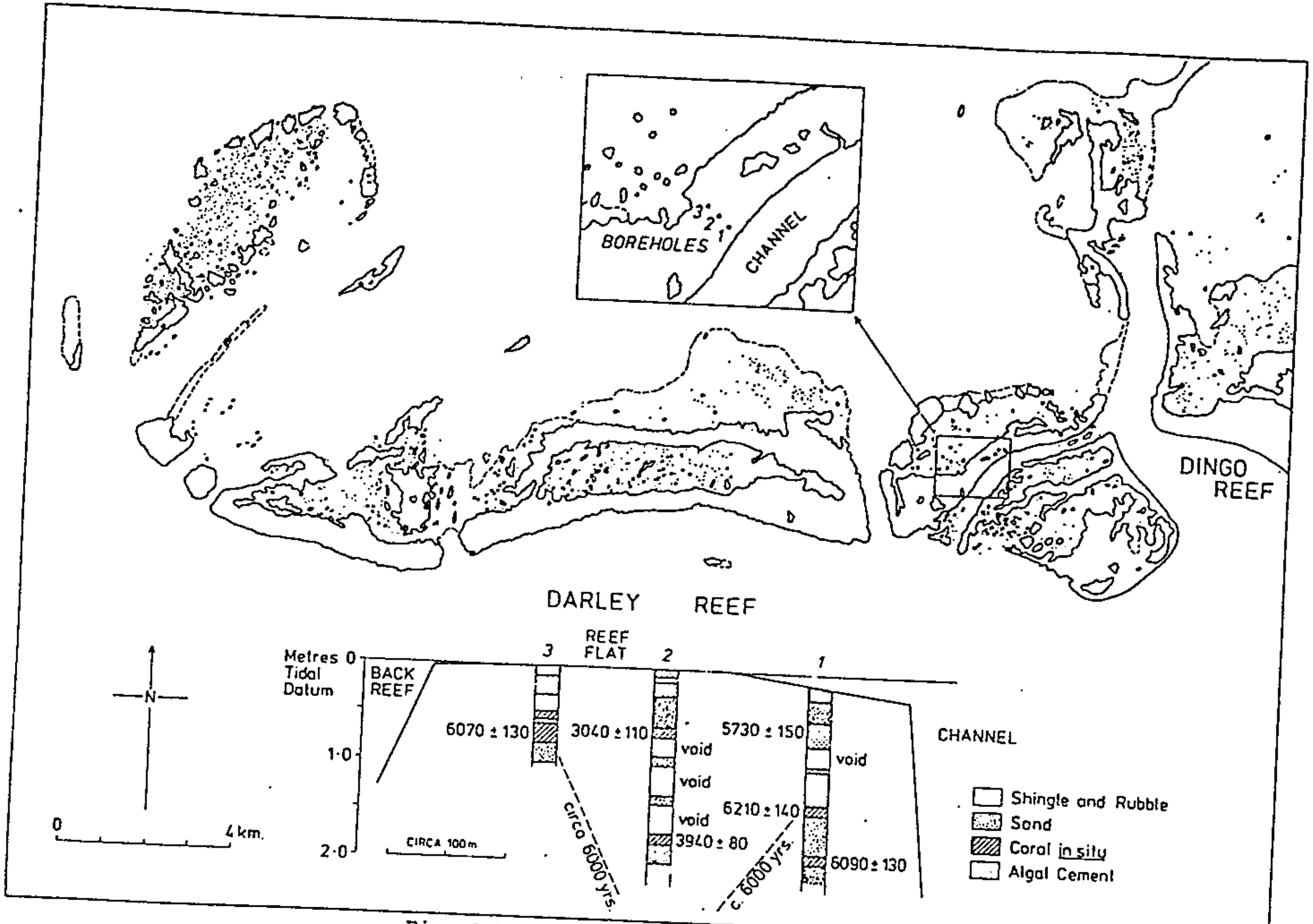


Fig. 5 Darley Reef drill cores and radio carbon dates

THE BIOTA OF THE LAND/SEA INTERFACE
INNISFAIL TO BOWEN

A concise account of land forms, geology vegetation and land use of the Townsville-Burdekin Section is available in a Resource Series from the Geographic Section of the Department of National Development.

THE TERRESTRIAL MARGIN

Eucalypt forest or woodland reaches the coast in the vicinity of the Tully River and extends southwards to Townsville (see Specht, Boughton and Roe, 1974).

Beyond Townsville, and with the exception of Capes Cleveland and Upstart, the coastal fringe is dominated by salt marsh and sparsely vegetated salt mud flats (see Saenger, Specht, Specht and Chapman, 1977).

THE MANGROVES

(For checklists see Saenger *et al., loc. cit.*).

TABLE XII INNISFAIL TO BOWEN

	km^2
Tully R.	13
Murray R., Rockingham Bay	89
Hinchinbrook Is., Channel	233
Halifax Bay	65
Cleveland Bay	32
Bowling Green Bay	135
Ayr to C. Upstart	86
Abbott Bay	7

THE BIOTA OF THE ISLANDS OF THE GREAT BARRIER REEF REGION FROM BOWEN NORTH TO INNISFAIL

H. Heatwole, University of New England

INTRODUCTION

Between the years 1967 and 1978 a total of 73 islands and coral cays of the Great Barrier Reef region have been examined and surveyed for various groups of plants and animals. Some of the islands sampled were continental islands, others were sand cays; distances from the mainland and size of island varied greatly. Many of the visits to the islands were opportunistic and consequently not all of the taxa included in the survey could be studied on every island. An attempt was made on most islands to make as complete a collection of the vascular plants as possible and to collect a representative of each species of the herpeto-fauna. If sufficient time were available ants were also collected and then a variety of the other terrestrial arthropods. In this report the islands are described in a general way and then discuss the results of the biotic survey. In the region under consideration in the present report, only three islands were examined. They were Holbourne Island, Eshelby Island and Bay Rock. They will be treated in turn.

Species lists for terrestrial plants, invertebrates, reptiles and birds are set out in the Appendices

GENERAL DESCRIPTION OF THE ISLANDS

HOLBOURNE ISLAND

This island was visited on 5th June 1969 and 2nd March 1971. Holbourne Island is located at 19°43.8' S; 148° 21.7' E and can be located on chart number AUS825. It has an elevation of 366 feet. It is a mainland type island. It is a hilly, irregularly shaped island with rather steep sides around the north-western, northern, eastern and south-eastern edges. There is a beach on the south-western and part of the southern coasts. The beach contains strand vegetation merging into a herb flat along the southern edge; there is also a herb flat on the north central coast but which is surrounded by a thicket of gum trees and shrubs. A thicket of *Pisonia* trees occurs on the south-western part of the island

and there are several *Pandanus* near the beach. The upland part is saddle-shaped with a western and an eastern peak and a valley in between. There are rocks strewn about the hills, and shrubs and low trees occur on the raised flats and in sheltered gulleys on sides of hills. On the western hilltop there are thick grasses inter-mixed with herbs and saplings with a small thicket of gum trees at one end. The eastern hilltop has shrubs clustered into dense scrub on the summit sloping into grass-covered hillsides; there is scrub on rocky outcrops all over the island.

The soil was a chocolate colored, fine-textured loam. There was an area of beach rock on the southern edge.

Human effect on the island has arisen from a number of sources. There is a permanent gas light as a navigational aid. The cylinders are at the base of the hill and a pipe-line goes to the top to the light. There is a pathway up the hill. In the past the island was mined for guano, and coral was used for a cement works. Japanese lived on the island on the southern flat although there are no traces of houses remaining. There are flat slabs of coral cement on the northern beach. A male goat was present in 1969 and in 1971.

ESHELBY ISLAND

Eshelby Island was visited on 2nd March 1971. It is located at 20° 01.0' S; 148° 37.6' E and appears on chart number AUS825. It has an elevation of approximately 154 feet. It is a mainland type island. The island is roughly dumbell shaped with the long axis running north and south. Most of the island is surrounded by rather steep sides, although at the constricted part in the centre there is a coral rubble beach on both the eastern and western sides of the constriction. The southern part of the island was covered with trees and shrubs which form thickets at times. This gave way towards the constricted part of the island to an almost continuous cover of grass. Many rocks were present and they formed an almost continuous area of boulders behind the light-house located on the summit of the northern portion of the island. Other parts of the northern part of the island were covered with thickets of trees and some grassy areas. Only one of the species of plants was collected; it was *Ipomoea brasiliense*. However, *Tribulus cistoides*, *Ipomoea* sp. and *Vigna marina* were recognised while on the island. The soil was a reddish-colour and consisted to a large extent of gravels.

Human influence seemed to be primarily the presence of the lighthouse.

BAY ROCK

This island was visited on 8th June 1969 and on 4th March 1971. It is located at 19° 07.15' E; · 146° 45.4' S. It is a continental type of island with an elevation of about 80 feet. The island is irregularly rectangular in shape and is covered mainly by tall herbs and grasses with scattered low shrubs, and one tree at the base of the eastern cliff. There were several mangrove saplings amongst the rocks on the beach. On the steeper slopes there were vines and prostrate herbs down to the rocky shore. There were several gulleys which contained a tangle of vines. Most of the island is surrounded by steep-sided slopes although there is a beach on the eastern edge.

There was once a house on Bay Rock although now there is merely an unmanned light. A rock-walled path leads from the eastern edge of the island up to the lighthouse on the south-western corner.

CONCLUSIONS

The terrestrial vegetation consists of 2 basic elements (1) strand species or insular species widespread on islands in the Australasian archipelago and/or along coasts in that region and (2) species characteristic of equivalent habits on the adjacent mainland.

The reptiles can be categorized in the same 2 categories, the first category containing *Cyrtodactylus* and *Cryptoblepharis* and the second the remaining species. It is too early to generalize about the invertebrates.

These islands did not seem to be major nesting rookeries for sea birds although some nesting did occur; a complete assessment in this regard would require more extensive observations at different times of year.

BIRDS

1. SEA BIRDS

Kikkawa (1976) records a total of 11 species from the reefs and Islands of the region. Six species are reported to have breeding colonies in the area. These include the Common Noddy, Silver Gull, Bridled Tern, Lesser-crested Tern, Crested Tern and Black-naped Tern.

Islands with breeding colonies are as follows (from Kikkawa (1976) and Lavery and Grimes (1971)):

NORTH BARNARD (KENT) ISLAND - 5(3). One of four major breeding sites for the Lesser-crested Tern on the GBR.

SOUTH BARNARD ISLAND - 1(1). One of four major breeding sites for the Lesser-crested Tern.

DUNK ISLAND - 9(2). Minor breeding colonies of the Bridled and Black-naped Terns.

WHITE ROCK - 4(2). Minor breeding colonies of the Silver Gull and Crested Tern.

HOLBOURNE ISLAND - 1(1). A minor breeding site for the Silver Gull.

OCEAN CREEK BANK - Listed by Lavery and Grimes (1971) as a major breeding site for the Silver Gull.

2. OTHER BIRDS

The larger continental islands of the region support a quite varied land and water bird fauna, e.g. North Barnard Island 13(8), Palm Island 11(0), Magnetic Island 60(33) and Dunk Island 99(55). Distinctive maritime species breeding in the region include the Reef Heron (Dunk and Magnetic Islands), White-faced and Mangrove Herons (Dunk Island), White-breasted Sea Eagle (Magnetic Island), Red-backed Sea Eagle (Dunk and Magnetic Island) and Osprey (Dunk Island and White Rock), (Kikkawa 1976).

TABLE XIII

NUMBER OF BIRD SPECIES RECORDED FROM REEFS AND ISLANDS OF THE GBR (Kikkawa, 1976)

INNISFAIL TO BOWEN

	SEA BIRDS		LAND AND WATER BIRDS	
	Total No.	No. breeding	Total No.	No. breeding
Nth. Barnard Is.	5	3	13	8
Sth. Barnard Is.	1	1	2	1
Dunk Is.	9	2	99	55
South Brook Is.	-	-	9	5
Goold Is.	-	-	7	-
Palm Is.	-	-	11	-
White Rk.	4	2	2	2
Magnetic Is.	-	-	60	33
Holbourne Is.	1	1	-	-

USE AND IMPACT

HUMAN OCCUPATION AND ACTIVITIES ON THE MAINLAND

INNISFAIL TO BOWEN

This report covers the area contained within the Northern Queensland Statistical Division and includes the shires of Hinchinbrook, Thuringowa, Ayr, Bowen and Dalrymple. Although the shire of Dalrymple lies wholly to the west of the coastal ranges it is included here as it contains much of the catchment for the Burdekin River and its tributaries.

The main sources of information used were "Resources Series, Burdekin-Townsville Region, Queensland", specifically, "Land Use" (Department of Minerals and Energy, 1973) and "Geology and Minerals" (Department of National Development, 1972), and various publications of the Australian Bureau of Statistics, Queensland Office.

POPULATION DISTRIBUTION AND DENSITY

At 30th June, 1978, the population of the Northern Queensland Statistical Division was estimated to stand at around 153,800 of which 151,130 (93%) were located in the coastal shires and 92,520 (60%) in the cities of Townsville and Charters Towers. With the exception of the two city areas, population density is low throughout the region and particularly so in the inland shire of Dalrymple.

Population distribution and density, Northern Queensland Statistical Division, 30 June, 1977

Local Authority Area	Population	Density
Ayr	19,300	$3.8/km^2$
Bowen	11,710	0.6
Charters Towers (city)	8,070	196.8
Dalrymple	2,670	0.04
Hinchinbrook	14,700	5.4
Thuringowa	12,900	3.1
Townsville (city)	84,450	224.6
Total	153,800	Mean 1.5

LAND USE

Most of the non-arable land on the coastal plains and all the plains and tablelands west of the coastal highlands are devoted to livestock production. This is almost exclusively beef cattle with a small number of pig farms concentrated mainly in the coastal shires. On the coastal plains cattle are frequently associated with crops, especially sugar cane, and holdings devoted mainly to beef production average around 4,300 ha. Rural holdings west of the coastal highlands average around 26,300 ha and stocking rates are substantially lower than on the coast. There is no dairy industry in the region.

The growing of crops is mainly confined to the delta and levee soils of the lower Burdekin and Herbert Rivers. Although the area under crops amounts to less than 1% of that devoted to livestock production the total value derived from crops is over seven times that derived from livestock. Sugar cane is by far the most important crop accounting for over 80% of the total value of crop production from the region. Fruit, vegetables, cereals (maize, grain, sorghum and rice) and tobacco are the other major crops grown on the coastal plains. Rainfall is highly seasonal and 45% of all land under crops is irrigated. Fertilizer is used on approximately 33% of land under crops and sown pastures.

The major forest areas in the region are confined to the coastal ranges and high country north of Townsville and most are contained within state forests and national parks. National parks throughout the region cover over 100,000 ha and some 6,400 ha of land in the Townsville and Hervey Range areas are designated as military reserves. Most of the limited industrial development in the region has occurred in the Townsville area.

HISTORY AND CURRENT STATUS OF THE MAJOR INDUSTRIES

1. PASTORAL INDUSTRY

Settlement of the region by pastoralists began in the early 1860's and by 1863 all of the Burdekin basin had been taken up primarily for sheep raising. For a variety of reasons sheep numbers declined and by the late 1860's wool production had become uneconomical. As sheep flocks declined cattle increased in importance and beef from the interior of the region supplied both local and coastal markets. The increase in demand for beef during the gold rush led to a rapid increase in herd sizes in the 1880's, and the establishment of the Townsville to Charters Towers railway in 1882 facilitated transport of livestock to export orientated facilities on the coast. Freezing works were opened at Townsville in 1892 and at Merinda in 1895.

Crops and livestock, area and gross value of production (1976-77)

Shire	Area of Rural Holdings ('000 ha)		Gross Value of Production ($'000)	
	Crops	Live-stock	Crops	Live-stock
Hinchinbrook	38.8	185.7	44,015	838
Thuringowa	3.4	236.6	1,075	1,877
Ayr	41.1	293.2	77,749	1,775
Bowen	4.2	2,237.1	12,690	5,452
Dalrymple	0.7	6,101.2	370	8,836
Regional total	88.1	9,053.8	140,819	18,778

Invasion of the region by cattle tick in 1895 followed by drought in 1902 led to a drastic reduction in herd size. Recovery was slow and the profitability of the industry fluctuated widely up to the war years. Some stability was achieved with the signing of the 15 year beef agreement with the U.K. in 1952. With the termination of this agreement in 1967 beef exports to the U.K. declined but this was largely offset by expanding markets in the U.S.A. and Japan.

In 1976-77 the gross value of livestock production was $18,778,000.00, approximately 12% of the total value of rural production from the region. Livestock production contributed approximately 1.3% to the state total. Most beef produced in the region is exported to the USA or Japan either in chilled or frozen form. Freezing works are established at Townsville and at Bowen.

2. SUGAR CANE

Sugar cane was first grown in the region around the ports of Bowen and Townsville in the 1860's but both areas proved to be unsuitable and were abandoned in the early 1870's. Between 1869 and 1872 the industry was established along the lower Herbert River near Ingham and by 1874 over 200 ha were under cane. High prices for sugar and the availability of cheap Polynesian labour (Kanakas) led to a rapid increase in cane area during the early 1880's. During this period the lower Burdekin was first planted and irrigation from ground water sources used to supplement rainfall. In the years between 1895 and 1906 the industry was drastically restructured with large estates giving way to small shareholdings, Kanaka labour being replaced by Australian labour and central cooperative mills replacing small private mills.

Sugar cane growing is restricted to the lower Herbert and Burdekin Rivers in the shires of Hinchinbrook and Ayr and along the lower Haughton River near Giru in the Thuringowa shire. Irrigation is used on over 90% of land under cane in the Ayr and Thuringowa shires and on a little over 1% of land in the Ingham region. In the region as a whole, 45% of all land under cane is irrigated. Fertilizer use averages 1 tonne/ha and a total of around 18 tonnes of pesticide (mainly lindane) are used annually in Herbert and Burdekin growing regions. There are six mills operating in the region, two near Ingham, three in the Ayr/Home Hill district and one at Giru. Sugar produced in the region is shipped from the ports of Townsville and Lucinda, both having bulk storage and handling facilities.

In 1975-76 the region produced over 25% of the total cane crushed in the state. The total value of production for the region was over $108 million.

3. OTHER CROPS

Horticultural Crops - The region produces appreciable quantities of fruit and vegetables mainly on irrigated land along the coastal margin in the Bowen area. Approximately 50% of the state's tomatoes and capsicums, and over 70% of the state's mango crop is produced in the area around Bowen.

Cereals - Maize and grain sorghum are grown mainly in the shires of Ayr and Bowen. Rice has been grown commercially in the region since 1967 and in 1975-76, 7864 tonnes were produced mainly in the Ayr shire.

Tobacco - 145 tonnes of tobacco were produced in the Hinchinbrook shire in 1975-76.

4. EXTRACTIVE INDUSTRIES

Minerals - Gold, tin, silver, lead and copper mineralization is widespread throughout the region and substantial amounts of these minerals have been recovered in the past. Gold was first discovered in the region at Cape River in 1867 and further discoveries followed at Ravenswood (1868) and Charters Towers (1871). Up to 1902, the Charters Towers Gold and Mineral Field was Queensland's major producer of gold and had a substantial influence on the development of the region. The area is considered to offer little incentive for further mining even if there is a significant increase in the price of gold.

Since 1875, tin production in the region has come mainly from the Kangaroo Hills Mineral Field and neighbouring areas. A number of tin batteries are still in operation in the area west of Ewan but recoveries are small and production highly variable.

Silver-lead mines opened at Ravenswood in the 1880's were an important source of both these minerals for several years. Silver and lead were also obtained from the Charters Towers Field as a bi-product of gold mining. No significant production of either mineral has occurred in the region in recent years.

The most significant mining venture in the region at the present time is that at Greenvale, 193 km west of Townsville. Reserves are estimated at 45,000,000 tonnes averaging 1.55% nickel and 0.11% cobalt. The mine is connected by rail to a refinery 24 km north of Townsville. Low world nickel prices have greatly reduced the profitability of this venture and its continued operation is in some doubt.

Copper was frequently recovered as a bi-product of mining for other minerals, notably gold and silver, but no significant production has occurred in the region since the early 1960's. In 1959, Copper Refineries Pty. Ltd. opened a plant at Townsville to refine blister copper railed from Mt. Isa.

Coal has been mined continuously in the Collinsville area since 1919. Coal production has risen steadily in recent years and, in addition to meeting local requirements, the Collinsville mines produce high grade coking coal for export to Japan.

5. FORESTRY

During early settlement timber was cut to provide fuel and building materials and to clear land for crops and grazing. In mining areas local timber was used for shoring up shafts and to provide fuel for crushing batteries. Large quantities of timber were cut to provide railway sleepers. In coastal areas prime cabinet woods such as red cedar were cut in large quantities from the rainforests and little now remains.

Although the Department of Forestry has established plantations of exotic pine on the coast north of Townsville, native forests currently provide all the timber cut in the region. Cabinet woods (65%) and forest hardwoods (26%) account for the bulk of that taken. During 1977-78 the 12 licensed mills in the region produced a little over 3% of the total timber cut in the state.

THE IMPACT OF HUMAN ACTIVITY ON THE COASTAL MARGIN

At the present time, it is not possible to make a general assessment of the effects of human activity on the coastal region between Bowen and Innisfail. A superficial analysis of the patterns of land use however, suggest three areas where significant land/sea interactions are likely to occur. These are the regions of intensive agricultural activity on the Burdekin and Herbert Rivers and the urban-industrial region around Townsville. Two recent studies give support to this view. Olafson (in press) has reported significantly higher lindane levels in animals from reefs adjacent to the major sugar cane growing regions on the Queensland coast. Reefs in the region between Innisfail and Bowen lie some 60 to 80 km offshore and residue levels are low by world standards. No data are yet available for lindane levels in near shore environments. In the Townsville region, Knauer (1976, 1977) has recorded significantly increased heavy metal concentrations in sediments surrounding the nickel refinery outflow in Halifax Bay.

These examples illustrate two points. Firstly that the most important land/sea interactions probably land/sea interactions probably occur via river and stream outflows and secondly that terrestrial influences on near shore and reef environments will most likely have low level and long term effects. Given the topographic and climatic diversity over this coastline and the variability in character and intensity of land use, programs designed to monitor and evaluate terrestrial influences on the marine environment will of necessity, therefore, cover long time intervals and a number of watersheds.

INNISFAIL TO BOWEN

TOURISM

Tourist facilities are located on Dunk Island, Hinchinbrook Island, Orpheus Island and Magnetic Island. Until recently a resort was in operation on Richards Island in the Family Group.

Dunk Island is a continental island of some 890 ha surrounded by a well developed fringing reef. The recently completed hotel is located on the extreme north western tip of the island at Brammo Bay. Developments associated with the resort include tennis courts, swimming pool, a six hole golf course and airstrip. Access to the island is by air or daily launch service from Clump Pt.

The resort on Hinchinbrook Island is located at Point Richards at the northern tip of the island. Accommodation is provided for approximately 60 guests in 15 separate units. There is a central dining area and a fresh water swimming pool. Access to the island is by launch from Cardwell.

Orpheus Island is a continental island of 1,376 ha surrounded by well developed fringing reefs. The small resort located at Hazard Bay on the western side of the island provides accommodation for only 24 guests in cabin type facilities. Access to the island is by launch from Townsville or Lucinda.

Resort development on both Hinchinbrook Island and Orpheus Island covers only a small part of the total area of the islands. On Dunk, however, the resort and its associated facilities extend over more than 100 ha. On all three islands the areas not covered by resort leases are national parks, and on Hinchinbrook Island and Dunk Island camping is allowed in the park areas subject to the granting of permits.

Relative to the more northern island, development on Magnetic Island is much more extensive. In addition to a wide range of tourist facilities, the island supports a substantial resident population. At the present time the development is mainly confined to the eastern side of the island between Horseshoe Bay and Picnic Bay. Much of the remainder of the island is national park (2,533 ha). There is an extensive road system connecting the settlements on the eastern side of the island and a regular ferry service operates between Picnic Bay and Townsville.

The "Visitor Plan" recommended that Townsville become a major entry point for international tourists and that the bulk of the necessary hotel facilities be established on Magnetic Island. In addition to upgrading the existing facilities this would involve the establishment of resort complexes at Florence Bay and Cockle Bay, the development of a major residential area on the unoccupied western side of the island and a new road to link this settlement with those on the eastern side. The report stressed the importance of having a co-ordinated development plan so as to preserve the "fragile charm" of the island and limit uncontrolled expansion of roads and roadside developments.

FISHERIES

SPORTS FISHERIES

The reefs are far out from the coast and not generally accessible to other than charter and private launch. The continental islands on which the resort activities of the area are based, are also close to the coast and do not result directly in over-use of the fishing resources of the reefal area.

Charter and especially private launch use can create impacts on specific areas where use is made of one particular reef or cay over a continuous period, or even for repeated visits. There are many small, pristine and very attractive cays with safe anchorages. It is known that for a single launch party fishing off one of these cays over a three day period their catch of mature reef fishes fell by approximately one half on the third day. In the long term, this type of exploitation of climax organisms could have a very detrimental effect on the biota. An education campaign amongst charter boat and private owners could help to alleviate this problem, which can, at the present time be managed under existing fisheries legislation.

COMMERCIAL FISHERIES (see Part I, Section B: Commercial Fisheries, above).

It is known that Townsville and Innisfail are important producers of commercial finned fishes and Salmon, Sweetlip, Mullet, Red Emperor, Coral Trout and Cod are all significant components of the catch. The pressure on the fish resources of sections of the reefs emanates principally from these centres, as Bowen catch is small and has a higher component of school mackerel. The fact that the catch is declining at Townsville and Cairns has serious implications for the management of this reef resource.

BECHE-DE-MER

Collection of beche-de-mer in the Innisfail to Bowen area is limited to waters between lat. 18° and 20°S, i.e. approximately between Tully and Bowen. Within this area beche-de-mer fishing is prohibited in waters surrounding Otter, Bramble, John Brewer, Lodestone, Keeper, Grub, Yankee, Coil, Bowl, Coon, Centipede, Wheeler, Davies, the unnamed reef immediately to the north east of Davies, Big and Little Broadhurst Reefs and in waters in which is located any reef surrounding an island or coral cay (Gov. Gaz., 22nd April, 1978).

Although no recent venture has proceeded far to date, the existence of a well established market for beche-de-mer in Asia virtually assures the economic viability of the industry provided that export health requirements can be met. What is not clear at this stage is whether Barrier Reef beche-de-mer populations can support long term exploitation. Information on abundance, size structure and stability of reef populations is urgently needed before attempts are made to establish the industry on a large scale. It is hoped that studies now being undertaken by the Queensland Fisheries Service will provide much of this information.

SHIPPING CHANNELS

INNISFAIL - BOWEN

H.G. Chesterman, Department Transport
(formerly Captain of the Light House Supply Vessel, Cape Moreton)

The principal passage out of the reefs south of the Grafton Passage (just out from Cairns) is Palm Passage off Great Palm Island. It has two towers built, one on Pith Reef at the outer end of the passage and one on Rib Reef at the inner end, but unlike the Grafton Passage these towers have not been lighted. The passage is wide and fairly free of dangers, passing between two coral studded areas.

Further to the south Magnetic Passage lies on the opposite side of the Slashers group of reefs. The outer edge of the Magnetic Passage is marked by a wreck on Myrmidon Reef. Although further to the north (from the Trinity Opening) the coral bearing area lies considerably (6-8 miles) to the west of the Continental Shelf, the 200 m line comes close to the outer reefs again in the vicinity of Magnetic Passage.

South of the Magnetic Passage the reefs have not been thoroughly surveyed and most of the hundreds of reefs in this area are incorrectly charted. Because of the lack of survey it has been found that aerial reconnaissance maps are far more accurate than the navigational charts. Generally it is 70 or 80 years since there was any concentrated survey work done in any part of this area and since instruments were not then as accurate as they are today the results of those surveys are often unreliable. Further, in this region the reefs are virtually out of sight of land and there are no features to fix on. A further consideration relating to the inaccuracy of the surveys is that it was all done in sailing ships operating close in to coral. It was dangerous work and the manoeuvreability of a ship, relying on "backing the topsails" to move away from coral when it was sighted close ahead was a difficult operation. The early surveys done by Cook, Flinders, Blackwood, Oldham and Co. were done in this way and their achievements are all the more creditable in view of these difficulties that had to be overcome.

In this region the reefs are a considerable distance from the coast and there is a great lagoonal area in which are located the Continental High Islands of the Whitsunday group, the centre of a considerable tourist industry. The main shipping channel runs through the inner passage, there being no passage out through the reefs south of the Magnetic Passage off Townsville. In addition to the lack of survey of the outer barrier it can be seen from the air that reefs are located close together with narrow and obviously shallow passages between them. The tides in the vicinity have a very extensive range and on the ebb tide there are a series of rapids where masses of white water tumble out over and between the reefs. It is unlikely that hydrographic surveys of this area will be undertaken in the immediate future, as there appears to be no commercial interest in the area (other than commercial fishing) and the reefs are too far off the coast to be under immediate pressure from a tourist industry. There are the first of two automatic weather stations to be found in this area (on Creal Reef, about 70 nautical miles N.E. of Mackay). It consists of four heavy steel piles driven down through the sand cay supporting stainless steel hut in which the instrumentation and transmission equipment are installed. Aerial reconnaissance has demonstrated that there is considerable movement of the sand cays in this area, which move around on the reef flat over as much as 300 m.

Pilot facilities are available at all the major ports in the region. All vessels leaving the Port of Bowen are required to carry pilots, but those leaving Townsville and passing directly through the Palm Passage are not required to do so.

The new bulk sugar loading facility at Lucinda Pt. will provide north Queensland with its first deep water port. The wharf extends 3 miles out to sea and will accept vessels up to 60,000 tons approximately every 3 weeks. These ships will leave reef waters directly through the Palm Passage. It is possible that further deep water facilities will be developed here in the future.

SHIPWRECKS

The following historically important wrecks occur in the area and should be declared Historic or Protected zones under the Historic Shipwrecks Act 1976.

Yongala: 23 March, 1911, wrecked in a cyclone off the Queensland coast. A coastal steamer belonging to the Adelaide Steamship Company, the 3864 ton Yongala was carrying 120 crew and passengers when she sank in what has been described as Queensland's worst shipping disaster.

Prince Regent: December 1827, wrecked on the Great Barrier Reef. A ship of 527 tons, she had been engaged in transporting convicts to Sydney.

Stirling Castle: 21 May 1836, at The Swain Reefs. The crew, after sailing in one of the ship's boats to one of the islands of the Bunker group, mutinied. The remainder sailed to the Sandy Cape, where Captain Fraser, his wife Elizabeth, and two mates began the walk to Moreton Bay. Captured by Aborigines, Fraser and one mate died, Mrs. Fraser and the remaining mate eventually being rescued. Of the 18 people aboard, only 8 survived. The Stirling Castle was a brig of 351 tons.

NOMENCLATURE OF COASTAL FEATURES, REEFS AND ISLANDS

P. Isdale, James Cook University of North Queensland

FEATURE NAME (from N to S)	ORIGIN OR NOTES
Hall-Thompson Reef	Lt, HMAS 'Geranium' 1924 survey, later Admiral
Adelaide Reef	RAN warship
Geranium Passage	HM survey ship 1924
Eddy Reef	naval surveyor
Farquharson Reef	RN surveyor Lt W.I. HMS 'Fantome', 1922 survey
Taylor Reef	Lt T. HMS 'Herald', 1924 survey
Beaver Reef)	'tied' names
Otter Reef)	
Dunk Island	n Cook for G.M. Dunk, First Lord Admiralty on June 8 1770
Tam O'Shanter Pt	barque with Kennedy's expedition-landed here 21-6-1848
Family Islands	n Cook 1770
Richards Island)	RN surveyors on HMS 'Paluma', 1880s
Wheeler Island)	
Combe Island)	
Smith Island)	RN surveyrs on HMS 'Paluma' 1880s
Bowden Island)	
Duncan Reef	local name
Barnett Patches	local name
Goold Island	n by Captain king, HMS 'Mermaid' on 19-6-1819
Cape Richards	Lt G.E. Richards, HMS 'Paluma' 1887 survey
Cardwell	after Rt Hon E. Cardwell, Sec State Colonies 1865
Mt Hinchinbrook/Island	n by King 1819
Britomart Reef	HM brig 1837
Bramble Reef	HM cutler 1843-5
Myrmidon Reef	HM survey ship 1885-8
Thread Reef)	'tied' names
Needle Reef)	
Thimble Reef)	
The Slasher's Complex)	ships grounded here June 1842 while carrying the "slashers'" Regiment
Kelso Reef)	
Arab Reef)	
John Brewer Reef)	

FEATURE NAME (from N to S)	ORIGIN OR NOTES
Hopkinson Reef)	'tied' names - Faraday/scientist
Faraday Reef)	
Dip Reef)	
Coil Reef)	
Arc Reef)	
Glow Reef)	
Keeper Reef	probably reef hit by 'Uncle Tom' (11-8-1865) - ship saved
Halls Reefs - Knife, Fork, Spoon, Cup and Saucer	local 'tied' names
Palm Island	named for Cook's mistake re vegetation thereon
Pelorus Island	HMS 'Pelorus' 1830s survey ship
Fantome Island	HMS 'Fantome', RN survey ship 1907-1923
Curacoa Island	HM warship 1860s
Falcon Island	HM warship 1860s
Esk Island	HMS warship 1860s
Brisk Island	HM warship 1860s
Eclipse Island	HM warship 1860s
Pandora Reef	HM survey ship 1850-54
Fly Island	HMS 'Fly' 1843-45 surveys
Albino Rock	formerly White Rock
Halifax Bay	after Dunk, Earl of Halifax
Acheron Island	HM survey ship 1830s, 1840s
Herald Island	HM survey ship 1845-61
Magnetic Island	n Cook 1770
Middle Reef	location
Cape Cleveland	n Cook 1770 for Henry, 2nd Duke of Cleveland
Salamander Reef	HMS 'Salamander' 1867 survey
C Bowling Green	n Cook 1770
Wheeler Reef	Lt F.S. Wheeler, HMS 'Paluma' 1887 survey
Shrimp Reef)	'tied' names
Prawn Reef)	

FEATURE NAME (from N to S)	ORIGIN OR NOTES
Bowden Reef	Lt F. Bowden-Smith, HMS 'Paluma' 1888
Stanley Reef	either GBRC scientist or Capt O. Stanley, HMS 'Rattlesnake'
Old Reef	probable site wreck of 'Gothenburg' 1875, also hit by 'Percy' 1865
Morinda Shoal	SS Morinda
Flinders Passage	Flinders' route (found 20-10-1802)
Castor Reef Pollux Reef	'tied' names
Lion Reef Jaguar Reef Tiger Reef Lynx Reef Dingo Reef Kangaroo Reef	'tied' names
Faith Reef Hope Reef Charity Reef	Three small patch reefs in close proximity to each other - 'tied'
Pakhoi Bank	steamer

FEATURE NAME (from N to S)	ORIGIN OR NOTES
Cape Upstart	n Cook 1770, appearance
Cape/Edgecumbe/ Bay	n Cook 1770 for 'Endeavour's' Sgt of Marines
Chyebassa Shoal	warship
Middle Island	position in Edgecumbe Bay
Stone Island	after Henry Stone (Dalrymple Expedition 1860)
Nares Reef	after Commander G.S. Nares, HMS 'Salamander', inner route 1865-67
Holbourne Island	n Cook for Admiral Holborn in Cook's N American campaigns
Gloucester Island	n Cook for Wm Henry, Duke Gloucester, 3rd son Frederick, Prince of Wales
Pt Denison	discovered Captain Sinclair 1859
Bowen	after Governor G.F. Bowen 1859

TABLE XIV ISLANDS AND PERMANENT CAYS - INNISFAIL TO BOWEN

Further sand cays, not identifiable from satellite imagery may be present. Reconnaissance charts show many unnamed and uncharted reefs to be present (see Fig. 2).

NAME	GROUP	LOCATION	ELEVATION (m)	AREA (ha)	GENERAL FEATURES & VEGETATION	TENURE	DEVELOPMENT
Lindquist		17°39'S 146°10'E	39	13	Low, rocky island lying close SE of Double Pt.	Crown Land	
Breshnahan	North Barnard	17°40' 146°11'	19	2	Low, rocky island lying close N of Hutchinson Is.	Crown Land	
Hutchinson	"	17°41' 146°11'	85	19	Both islands lie on a bank of foul ground and are high and rocky. Vegetation includes rainforest, melaluca, eucalypt and mangrove forest	National Park	
Jessie	"	17°41' 146°11'	58	6		National Park	
Kent	"	17°41' 146°11'	95	24	High and rocky; largely bare of vegetation	Lighthouse Reserve	Lighthouse
Stephens	South Barnard	17°44' 146°10'	49	24	Both islands are high and rocky and lie on the outer edge of a drying reef. Vegetation includes rainforest, melaluca, eucalypt and mangrove forest	National Park	
Sisters	"	17°45' 146°10'	30	5		National Park	
Mound (Purtaboi)		17°55' 146°08'	19	6	Rocky island lying on a bank extending north from Brammo Bay	National Park	
Dunk		17°56' 146°09'	271	891	High, steep and rocky with well developed fringing reefs along the SW and W sides. Vegetation includes rainforest	National Park; Leasehold	Tourist resort and airstrip
Kumboola		17°57' 146°08'	61	12	Rocky islet at the W extremity of Dunk Island	National Park	
Mung-um-Gnackum		17°57' 146°08'	-	2		National Park	

NAME	GROUP	LOCATION		ELEVATION (m)	AREA (ha)	GENERAL FEATURES & VEGETATION	TENURE	DEVELOPMENT
Woln-Garin		17°58'S	146°11'E	12	3	Low, rocky island at SE extremity of Dunk Island	Crown Land	
Thorpe	Family Group	17°59'	146°08'	85	16	High, rocky and reef fringed; wooded	Freehold	
Richards	"	18°00'	146°09'	107	86	High, rocky and wooded	Freehold	Defunct resort
*Pee-Rahm-Ah	"	18°00'	146°09'	14	2	Low island lying on a spit of foul ground extending from the SE extremity of Richards Island	Crown Land	
Wheeler	Family Group	18°02'	146°10'	94	31	High, rocky and reef fringed. Vegetation includes hoop pine, casuarina and open eucalypt forest	National Park	
Coombe	"	18°03'	146°11'	113	49	High, rocky and reef fringed. Vegetation similar to Wheeler Is.	National Park	
Smith	"	18°02'	146°12'	64	10	Both islands are high and rocky and lie on the same drying reef. Vegetation similar to Wheeler Is.	National Park	
Bowden	"	18°03'	146°12'	61	10		National Park	
Hudson	"	18°03'	146°12'	270	20	Rocky Island with high cliffs and fringing reefs. Vegetation similar to Wheeler Is.	National Park	
North	Brook Group	18°09'	146°17'	76	65	High and rocky with small fringing reefs. Vegetation includes dense rainforest	National Park	
Middle	"	18°09'	146°17'	15	16	Rocky with small fringing reefs	National Park	

Tween	"	18°10'	146°18'	-	6	Rocky with small fringing reefs	National Park	
South	"	18°10'	146°18'	46	8	Rocky and reef fringed	Freehold	Lighthouse
Goold		18°10'S	146°10'E	418	830	High and rocky with poorly developed rainforest	National Park	
Garden		18°11'	146°09'	40	20	Rocky and sparsely wooded	Recreation Reserve	
Eva		18°14'	146°19'	35	2	Rocky and wooded	Crown Land	
Mangrove		18°19'	146°08'	-	3	Low, swampy island in the Hinchinbrook Channel	Crown Land	
Agnes		18°21'	146°20'	55	16	Rocky island connected to Hinchinbrook Channel by a drying reef	Crown Land	
Hinchinbrook		18°21'	146°13'	1142	39350	Steep, rocky island. Dense rainforest and tall eucalypt forest with extensive mangroves along the W side	National Park	Tourist Resort
*Benjamin Flat		18°25'	146°11'(?)	-	778	Low, swampy island in Hinchinbrook Channel	Crown Land	
Haycock		18°28'	146°13'	58	6	Small island in Hinchinbrook Channel	Crown Land	
North Palm (Pelorus)	Palm Group	18°33'	146°30'	282	410	High, rocky and wooded	Crown Land	
Orpheus	Palm Group	18°37'	146°30'	172	1377	Rocky and reef fringed; grass, low rainforest and open eucalypt forest	National Park, Leasehold	Research station and tourist resort
Curacoa	"	18°41'	146°33'	296	433	Rocky, reef fringed island. Summits grassed. Narrow fringing reef on E side	Aboriginal reserve	
Fantome	"	18°41'	146°31'	221	770	Rocky island with two wooded summits	Quarantine Reserve	Hospital

NAME	GROUP	LOCATION	ELEVATION (m)	AREA (ha)	GENERAL FEATURES & VEGETATION	TENURE	DEVELOPMENT
Great Palm	Palm Group	18°44'S 146°37'E	554	5670	Rocky, thickly wooded and for the most part surrounded by drying reefs	Aboriginal Reserve; Leasehold	Aboriginal settlement (Pencil Bay)
Falcon	"	18°46' 146°32'	59	16	Rocky and wooded, lies on the N end of a drying reef	Aboriginal Reserve	
Esk	"	18°46' 146°31'	50	26	Rocky, wooded and reef fringed	Aboriginal Reserve	
Eclipse	"	18°46' 146°33'	63	15	High and flat topped; drying reef on the N side	Aboriginal Reserve	
White (Albino) Rock	"	18°46' 146°43'	23	1	Rocky	Leasehold	Lighthouse
Barber	"	18°47' 146°40'	26	2	Rocky islet near the southern extremity of Great Palm Island	Crown Land	
Brisk	"	18°47' 146°33'	70	45	Rocky with a wooded and grassy summit. Lies on the S end of the same drying reef as Falcon Island	Aboriginal Reserve	
Fly	"	18°50' 146°32'	35	3	Rocky and covered with low scrub. A drying reef extends from the WNW side	Crown Land	
Havannah		18°50' 146°32'	154	130	Rocky with two summits. Drying coral reefs extend from the NE and SW sides	Aboriginal Reserve	
Acheron		18°58' 146°38'	57	5	Rocky and grassed	Leasehold	Formerly RAAF bombing and gunnery range
Cordelia Rocks		19°00' 146°41'	24	5	Two rocky islets joined by a drying coral reef	Leasehold	Formerly RAAF bombing and gunnery range

Herald	$19^{\circ}02'$	$146^{\circ}38'$	53	65	Rocky with two rounded, grassy hills. A drying reef extends along the W side	Leasehold	Formerly RAAF bombing and gunnery range
Rattlesnake	$19^{\circ}02'$S	$146^{\circ}37'$E	121	182	Rocky and grassed	Freehold; Leasehold	Formerly RAAF bombing and gunnery range
Magnetic	$19^{\circ}08'$	$146^{\circ}50'$	495	5184	Rocky and rugged with fringing reefs. Vegetation includes hoop pine, eucalypt forest and mangroves	National Park, Leasehold and Freehold	Tourist and residential development
Bray	$19^{\circ}15'$	$147^{\circ}04'$	12	2	Rocky	Crown Land	
Bare	$19^{\circ}15'$	$147^{\circ}04'$	9	2	Rocky	Crown Land	
Bald	$19^{\circ}16'$	$147^{\circ}04'$	3	2	Rocky	Crown Land	
Russell	$19^{\circ}19'$	$147^{\circ}25'$	12	2	Connected to mainland by a drying sand spit. Tree-covered	Crown Land	Lighthouse
Sand	$19^{\circ}19'$	$147^{\circ}23'$(?)	-	65	Drying sand island	Crown Land	
Holbourne	$19^{\circ}44'$	$148^{\circ}22'$	112	20	Rocky with drying reefs extending from the S side. S side covered with grass and bushes	Crown Land	Lighthouse
Camp	$19^{\circ}51'$	$147^{\circ}54'$	40	11	Rocky and grasses. Below water coral reef extends from the ESE side	Crown Land	
Middle	$19^{\circ}59'$	$148^{\circ}22'$	55	57	Rocky and sparsely wooded. A drying reef extends from the S side of the island	Crown Land	
Rattray	$20^{\circ}00'$	$148^{\circ}33'$	111	23		Crown Land	

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* Listed in "Leasing and Development of Queensland Islands, 1966" but not located on navigational charts.

PART III

APPENDICES

APPENDIX I FIELD GUIDES - LOW ISLES

GEOLOGY

Geological excursion notes compiled by R.F. McLean, Department Biogeography & Geomorphology, Australian National University, Canberra.

These notes are based on work done at Low Isles by Fairbridge and Teichert (1947, 1948), Marshall and Orr (1931), Moorhouse (1933, 1936), Otter (1937), Steers (1937), Spencer (1930), Stephenson (1931) and Stephenson, Endean and Bennett (1958). More recent surveys done during the course of the 1973 Expedition have demonstrated some changes. (See Gibbs, 1978; Flood and Scoffin 1978; Stoddart, McLean, Scoffin, and Gibbs, 1978; and Stoddart, McLean and Hopley, 1978).

In these notes, emphasis is placed on the areas most likely to be visited - the sand cay and shingle ramparts - both of which are of considerable geomorphological interest and are accessible at all stages of the tide.

INTRODUCTION

Low Isles is located in the shipping channel, 7-8 miles NE of Port Douglas and about 20 miles shoreward of the outer Barrier Reefs. It is the southernmost example of a specialized class of coral islands called *island-reefs* by Spender or *low-wooded islands* by Steers. (Three Isles, south of Lizard Island is another well known example). All island-reefs or low-wooded islands show similar ground plans although clearly there are differences in detail. They comprise two islets built on isolated reefs: (1) a sand cay to leeward, and (2) a mangrove swamp and shingle cay or ridges to windward. Normally the two islets are separated by a shallow water area of reef flat, although in some cases they coalesce and no bare reef flat is left between them. Outside the shingle cay the usual sequence of features is a platform of coral conglomerate, a moat, an outer shingle rampart, algal terrace zone and seaward reef slope.

Although there is a striking similarity in structure of all island-reefs or low-wooded islands, Steers believes it would be unfortunate to regard Low Isles as the 'type' or 'standard' example because at Low Isles there is scarcely any shingle cay, a true platform is absent and the anchorage is more pronounced than elsewhere

ISLAND ENVIRONMENTS

> "Low Isles...is simply a coral reef on whose surface certain configurations of debris have accumulated"
>
> \- Spender, 1930.

A number of distinctive ecological, geomorphological and sedimentological environments have been recognized on Low Isles including (1) Sand cay; (2) Shingle ramparts; (3) Boulder tract; (4) Seaward shelves; (5) Seaward slopes; (6) Anchorage and adjacent sea floor; (7) Reef flat. The reef flat comprises five units: (a) Sand flat; (b) *Thalamita* flat; (c) Mangrove park; (d) Mangrove swamp; (e) Moats. These will be briefly described in turn. Reference should be made to the accompanying sketch map.

1. THE SAND CAY

This is an oval shaped islet occupying about 3½ acres, measuring 250 m by 100 m at low tide, situated near the NW end of the reef platform. Its long axis runs E-W, that is at 45° to the prevailing SE trade winds. Its highest parts are about 6 ft above HWL.

The sand is exclusively of biogenic origin - coralline, molluscan and foraminiferal in roughly equal parts - and can be sized classed as medium to very coarse sand. A hand-boring carried out by Marshall and Orr penetrated 14.5 ft of similar sand without reaching bottom.

The periphery of the sand cay consists of areas of steeply sloping sand and areas where beachrock predominates. Considerable mobility of the beach sands is reported with temporary sand-spits developing to the S on the E and W sides of the cay during northerly gales in winter. These are reduced when the SE Trades are dominant. During the 1934 cyclone all the E end of the cay was laid bare exposing beachrock, while large quantities of sand were added at the W end encroaching on to the boulder zone. (Observations in October 1972 showed the S shore to be considerably depleted of sand. A distinct erosional scarp 0.5 - 1.0 m high was developed at the vegetation line. Small sticks of coral shingle were present at the swash limit). At the edge of the vegetation line high on the beach small pumice lumps (1-3 ins in diameter) were observed by Fairbridge and Teichert in 1945. The Moorhouse cyclone map of 1934 shows the pumice line on the NE side of the cay surface itself. The pumice may come from volcanoes in the New Britain-Solomons-New Hebrides area.

Beachrock forms a conspicuous part of the shore. It probably surrounds the whole cay although it has not all been exposed at any one time. In 1929 outcrops along the N shore predominated while in 1945 it was well developed on the S shore as well. In 1972 the S outcrops were more noticeable than the N ones, most of the latter being covered by a thin veneer of sand. Outcrops at the E end were temporarily exposed by the 1934 cyclone. During the 1928-29 Expedition a borehole was put down in the centre of the sand cay to settle the question whether there was cemented sand-rock under the middle of the cay continuous with the outcrops on the beach. Nothing but sand similar to that at the surface was encountered. "It was interesting to find that in all probability there is not cementation in the interior of the cay". (Spender, 1930, p. 288).

The beachrock is composed of material similar to the adjacent sands. It typically dips 5-7° seaward, though the strike in places is divergent to the beach-line, indicating slight shifts in position of the cay. It is fissured by rectangular jointing parallel to the strike and dip, erosion tending to separate it into blocks a few feet square. Mobile sands passing across the surface undoubtedly cause some erosion of the surface, while solution pits are indicative of chemical erosion. A number of organisms inhabiting the beachrock are capable of erosion. For an account of rock destroying organisms at Low Isles reference should be made to Otter (1937). Grazing species include littorinids, *Planaxis* and *Acanthozostera,* and the dominant boring form is *Lithophaga*. Stephenson, Endean and Bennett recognized four fairly distinct zones on the NE beachrock surfaces: (1) 'bare' *(Nodolittorina, Planaxis)* at HWN; (2) Oyster *(Crassostrea)* at MSL; (3) algal *(Enteromorpha)* at LWN; and (4) *Chama* at moat level.

Fairbridge and Teichert provide evidence that cementation of sands into beachrock is still proceeding. As Spender noted in 1930 the formation of beachrock "provides an interesting problem in calcium chemistry".

2. SHINGLE RAMPARTS

These interesting geomorphic features encircle the reef platform like a horseshoe open to the NW. They are ridges of shingle made up of coral fragments (mostly sticks of *Acropora*) and other calcareous debris broken off the seaward living reef and cast up by waves to their swash limit. The ramparts are highest and best developed to the E and SE, the direction of the heaviest prevailing seas, and become narrower and lower away from the SE apex. At the extremities the horseshoe is hooked inwards by two long shingle tongues known as *Tripneustes* spit (north) and *Asterina* spit (west). These are mobile features: between 1928-45 the former swung inwards another 50 yards while the latter had extended another 200 yards. In 1954 the S extension of *Tripneustes* spit was even more marked. On the *inner* side of the ramparts in the SE, the apex is bisected by another low shingle tongue (known as 'Long tongue'). Fairbridge and Teichert (1948) suggest that it represents former rampart material which is gradually being dissolved and drawn into the mangrove swamp. It cannot be associated with any specific rampart, but must be older than the oldest of the four ramparts they recognized. The main ramparts have a well marked inner edge which is in places cuspate in plan. In cross-section the rampart is normally asymmetric, having a short steep inner slope dropping 2-4 ft at a gradient of 45° and a long gentle outer slope at 2-5°. The outer edge is observed beneath the inner edge of the succeeding rampart, except for the outermost ridge which merges with the reef margin. Most of the ramparts are well elevated reaching 5, 8 and even 10 ft above low water spring datum. There are lower gaps in the ridge where water pours in at flood tides and out during ebb tides. At high tide the long narrow strip between ramparts fills with water which does not drain completely at low tide but remains as an elongate 'moat'.

Spender and others in the 1928-29 Expedition described an 'Inner' and 'Outer' rampart. The outer was described as loose and somewhat unstable, tending to advance over the inner which was grey or black with age, firmly cemented and extremely hard. In the most highly developed area in the E and SE, Fairbridge and Teichert identified *four rampart lines*.

(a) FIRST RAMPART - the oldest and innermost clearly defined rampart consisting of the sand-crowned spit ('Green Ant Island') and certain 'glades' to the E of the mangrove swamp. Made up of black, firmly cemented coral fragments, severely corroded in places. Is heavily overgrown with *Bruguiera* a mangrove found only in this area. Forms steep inner slope to mangrove swamp. Outer slope gradual towards steep inner edge of second rampart.

(b) SECOND RAMPART - ('Inner rampart'). 2-4 ft thick and except near 'Green Ant Island' forms the innermost rampart extending from S of Mangrove Park to N of Mangrove swamp. Consists of blackened and corroded coral 'breccia'. Dominant vegetation is *Avicennia*. Rampart did not move at all between 1928-45, although in places fresh material has accumulated on it.

(c) THIRD RAMPART - ('Outer rampart'). Most complete and best developed. Encircles greater part of reef platform. Mostly loose or partly cemented, 2-4 ft thick, overlaps Second Rampart. Consists partly of fresh and partly blackened and corroded coral. 1934 cyclone from NE drove whole of the 'Outer rampart' inwards along the N and E sides of the Isles, thus destroying the parallelism of the old 'Outer' and 'Inner' ramparts and partly filling in the moat. Inward movement continued after 1934. *Tripneustes* and *Asterina* spits are included in the third rampart.

(d) FOURTH RAMPART - Formed since 1928 or 1934. Overrides and rests upon Third rampart as new "breastworks". Is discontinuous. Three sections most notable: (a) Inverted U-shaped ridge at extreme NE end; (b) Eastern breastwork, 250 yds long with incurved horn in central area; (c) in SE, straight ridge 270 yds long with incurving hooks at each end. Built of fresh coral debris and weathered fragments from older Third rampart. Inner and outer edges steep. Top narrow (2 ft).

The ramparts represent successive periods of accumulation of debris continually being provided as a result of wave attack on the growing edge of the reef fringe. This debris can be carried only a certain distance before wave force is dissipated. Storms and cyclones gradually cause rampart to move inwards until a critical point is reached when a new rampart will begin to form overlapping the first. As the living coral fringe grows out, a second, third and fourth rampart will follow the first. It is not suggested that any one of the ramparts is precisely contemporaneous along its whole extent, or that succeeding ramparts represent specific time stages. It is likely that while the fourth rampart is forming in exposed parts, the third rampart is still accumulating debris along more protected parts of the shore. It is not necessary to postulate any oscillation of sea-level or geological movement to account for this outward growth (Fairbridge and Teichert, 1948).

3. THE BOULDER TRACT

Between the sand cay and NW extremity of the ramparts there is another shingle ridge of coral debris, the Boulder Tract. Being protected from the SE trades its structure is quite different from the shingle ramparts. It is lower, but is made up of large massive coral boulders (as well as smaller ones) crowned by scattered 'coral-heads'. Spender has accounted for this boulder tract by the fact that in the normally protected water on the NW, massive corals grow on slender pinnacles and during rare storms from the NW these become broken off and cast up on to the edge of the reef platform.

Biological zonation on the Boulder tract includes: oyster, 'bare' and *Tridacna* zones. In 1954 the 'bare' zone was dominated by *Acanthopleura*. Abrasion by this chiton may delimit the lower border of the oyster zone and seems responsible for the removal of rock from the boulders, which were deeply incurved to form a central waist. It seems likely that many boulders noted in 1928-29 have subsequently been cut through at their central waists, the top portions having then fallen (Stephenson, Endean and Bennett, 1958).

4. SEAWARD SHELVES

Seaward of the outermost rampart the loose shingle passes into a bared surface of partly lithified debris and hard cemented coral 'breccia' which occupies a zone up to 200 ft wide ranging from 4 ft above to a little below LWS. This lithified coral shingle ("honeycomb rock") is pitted and etched by chemical solution and presents a very jagged surface. In places a dense algal (including 'lithothamnion') and mussel cover is evident. Fresh loose calcareous material (sand, grit and coral) is delivered to the shelf from breakdown of the reef edge. The shelf itself may be a former rampart, now slightly raised, consolidated and suffering erosion, (Steers, 1937) or may be due to cyclone removal of calm-water aggregations of shingle (Stephenson, Endean and Bennett, 1958).

5. SEAWARD SLOPES

These environments occur round the perimeter of the island lying below MLW. The slope is covered with dead and living coral and associated biota. In the anchorage and north of the cay dead hemispherical corals and rubble are typical. Hard corals are sparse but soft corals abundant. Moving N and then down the E side of the isle, with an increase in exposure, the number of soft corals declines and hard corals increases. Along the S and SW slopes hard corals are common or very common and soft corals absent. *Acropora, Goniastrea* and *Porites* are the most significant large corals. During the 1934 cyclone great damage was done to the reef with branching corals being smashed, mutilated or destroyed particularly in the N areas. The 1950 cyclone evidently had similar effects. Massive corals were less severely affected.

6. THE ANCHORAGE AND ADJACENT SEA FLOOR

In the N between the sand cay and NE point of the isle, there is a pronounced indentation which serves as an anchorage. T.A. Stephenson has suggested that Low Isles may consist of two reefs joined together and this may account for the indentation which is more pronounced here than on other low wooded island reefs. It is floored with clean calcareous sand which shelves from the sand flat down to 15 ft in the centre. Patches of coral heads dot the sand carpet. The sea floor round the island is quite different, being composed of soft grey mud. Depths of 60 ft are reached 200-300 yards from the reef edge except in the NW where there is a shallower bank.

7. REEF FLAT

All the area within the ramparts, boulder tract and cay can be included. Superficial sediments are mostly sands, dead coral and debris and 'honeycomb-rock'. The last occurs in slabs and pavements, severely rotted and overgrown with algae. It consists of cemented reef debris, coral, algal and molluscan fragments. Bores put down in 1928-29 at various points on the reef platform to 15 ft showed grey coralline mud with no dead *in situ* coral. The reef flat can be subdivided into 5 areas:

(a) Sand flat. S of the cay. Average level 3 ft above LWS. Comprises a small area of surface rubble and stones and large sandy area, higher parts of which form sandbanks and lower parts dominated by 'sea grasses' and algae. Surface fauna mainly carnivorous gastropods and crabs. A bore in the sand flat showed 5 ft of sand like at surface, then soft clean grey mud to 15 ft.

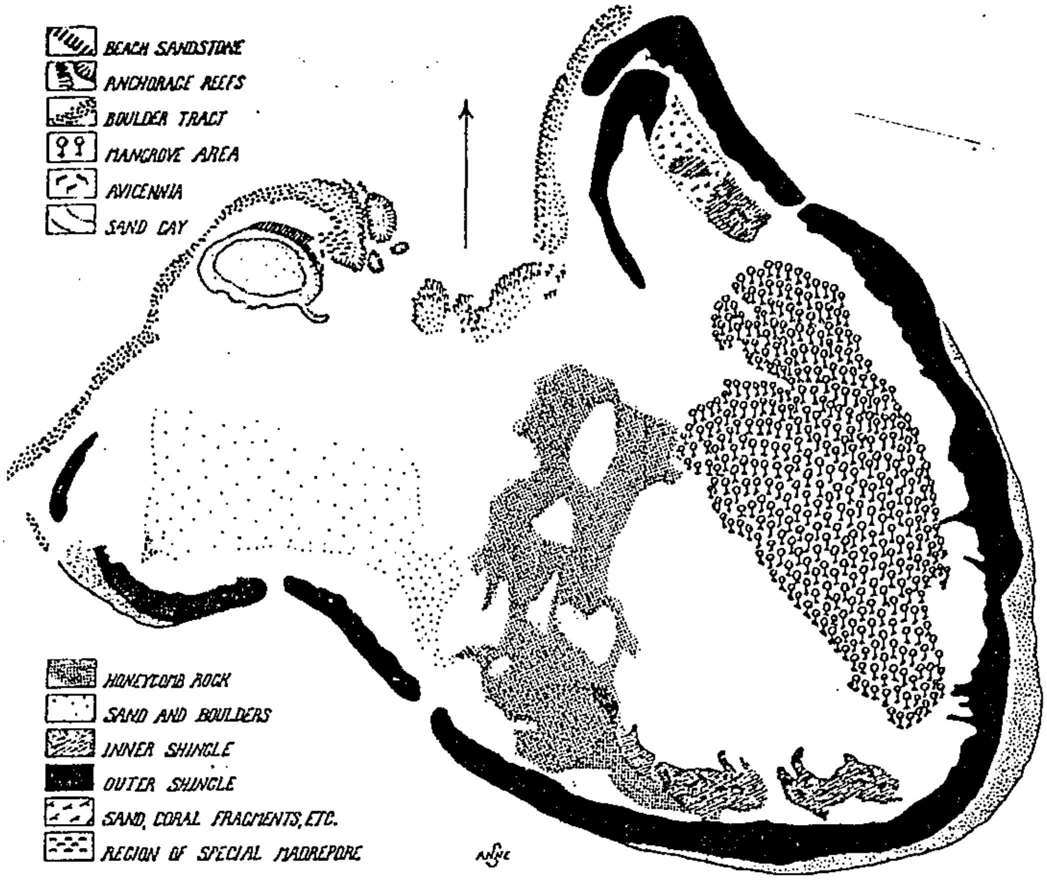
(b) *Thalamita* (Crab) Flat. Slightly deeper area S of Sand flat. Consists of sand littered by flat slabs of dead coral *(Acropora)* interspersed with horseshoe clams *(Hippopus)* and occasional coral boulders. Coral rubble carries dense algal cover, with 'sea grasses' on the sand, and living coral in deeper pools.

(c) Mangrove Park. Higher than previous two areas. Floor consists mostly of 'honeycomb rock' with extensive algal incrustation and sand. 'Sea grass' (strap-like seaweed *Thalassia*) cover and clumps of mangrove *(Rhizophora)* give park-like appearance. In parts deep pools with mud floors may indicate sites of former mangrove clumps. Considerable extension of mangroves since 1928-29 is indicated.

(d) Mangrove Swamp. Cover 50 acres. Forms the second of the two 'islets' of Low Isles which show at HW, but floor of swamp is covered with water much of the time (2-4 ft above LWS). There is no distinct cay, but several patches of shingle rise slightly above general swamp level. A bore in the swamp showed 18 ins soft brown 'mangrove' mud; 6 ins 'mangrove' peat; 2 ft sand; and clean grey sandy mud to 15 ft. The flora is tall *Rhizophora*, part of which was destroyed by cyclones but has since recovered and extended into smaller glades. The existence of the mangrove swamp is dependent on protection given by the ramparts.

(e) Moats. Series of water channels forming deep marginal parts of reef flat, and areas within ramparts retaining water at LW. Moat areas have been greatly reduced since 1928-29. The cyclone of 1934 had catastrophic effects on the moats and their fauna in the N and E with encroachment of rampart shingle and breaching of 'dams'. These processes have continued. 'Acropora moat' in the SW is the only one still intact. Previously extensive *Acropora* beds have been reduced to small areas, while the more massive corals (e.g. *Porites*) appear to have survived in most places. Great floristic and faunistic variety is apparent. Sediment is mainly coral rubble and sand.

Fig. 1. Low Isles (from Stephenson *et al.*, 1931).



VEGETATION OF LOW ISLES REEF

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MAP VEGETATION OF LOW ISLES REEF

Low Isles lie 7 miles east of P. Douglas on the mainland and approximately 20 miles west of the outer part of the Great Barrier Reef. There is a shingle reef platform, approximately 1 mile long, supporting two wooded areas, a small sand cay near the NW edge of the platform and a much larger mangrove area occupying much of the eastern part of the platform. At highwater there is thus an impression of two separate islands.

From below LWS there is, in most places, a gradual slope upwards to a crest of coral rubble which encloses the reef flat. In the western parts this crest exceeds the height of the reef flat it borders by only about 30 cm or less; eastwards it increases in height, finally rising above EHWS and forming the ramparts which drop steeply to the reef flat. Behind the outer rampart occurs a somewhat broken line of older ramparts.

In conformity with the terminology used in the notes on Heron I. four main regions are recognised as follows: Beach, Reef Flat, Reef Rock Rim, Seaward Platform. The mangrove area, although occupying part of the reef flat, and its associated ramparts are treated separately.

1. BEACH

Beach rock occurs on both the northern and southern sides of the sand cay. The algal vegetation it supports is, in its main features, similar to that on beach rock at Heron I. Three main algal bands may be seen, at least in some parts.

(a) *Entophysalis deusta* band: The uppermost band, yellow-brown to almost black, dominated by *Entophysalis deusta* and *Calothrix crustacea*.

(b) Mixed cyanophyte band: A very pale pink layer produced by various blue-green algae binding fine calcareous sediment.

(c) *Gelidiella bornetii* band: The lowermost band, with many of the small algae obscured by loose sediment. *Gelidiella bornetii* is usually common. Other constituents are *Enteromorpha clathrata*, black discs of *Rivularia atra* and red-brown domes of *Schizothrix arenaria*.

Oysters may occur in both the Mixed Cyanophyte band and the *Gelidiella bonnetii* band.

II. REEF FLAT (other than the mangrove area)

The Reef Flat, enclosed by a Rubble Crest, occupies the greater part of the reef platform. Its substratum may be of sand or reef rock either of which may be partly overlaid by calcareous rubble of varying size. At low water it may be submerged to a depth seldom exceeding 40 cm or shortly emergent as sand flat, reef rock or an irregular mosaic of emergent substrata and shallowly submerged intervening areas. Compared with the Heron I. Reef Flat there is little living coral.

(As at Heron I., a deeper, outer area, the Moat, can be distinguished in some areas although it is less marked than at the time of the 1920-29 Expedition. Its vegetation is not sufficiently distinctive to justify separate description in this brief summary).

The commonest plant of the Reef Flat if the sea grass *Thalassia hemprechii* which, in some places near the mangrove area, forms an almost complete cover. Other, smaller, seagrasses which reach to higher levels than *Thalassia* and are particularly common in the sandy area south of the cay, are *Halophila ovalis, Halodule uninervis* and *H. pinifolia*. In this sandy area also occur the dark green, spongy, deeply "rooting" clumps of *Avrainvillea erecta*.

Macroscopic algae of the Reef Flat include *Halimeda opu tra, H. cylindracea, Boodlea composita, Caulerps racemosa, Dictyophacria cavernosa, Padina australis, Cystoseria trinodis, Sargassum* sp., *Turbinaria ornata, Laurencia papillosa, Gelidiella acerosa, Hypnea nidulans, Ceratodictyon spongiosum, Spyridia filamentosa* and *Tolypiocladia glomerulata*.

III. REEF ROCK RIM

From the edge of the Reef Flat a pavement of reef rock slopes gently seawards. Rubble of varying size is deposited on its upper part to form the Rubble Crest enclosing the Reef Flat. Rubble, either compacted or loose, also covers much of the slope so that a distinction into an upper Rubble Crest and a lower Reef

Rock Slope is less appropriate than at Heron I.

Over this desolate expanse of rubble three main algal bands may be distinguished as follows:

(a) *Entophysalis deusta* band: This appears as a yellow-brown to grey-brown stain, in upper parts almost black. Particularly where the shingle is stabilised in a sand-mud matrix, other cyanophytes occur and include *Calothrix crustacea, Kyrtuthrix maculans, Microcoleus lyngbyaceus* and *Rivularia atra*.

(b) Lithothammian band: The thin encrustation of lithothammia seldom covers more than half the available surface. When dry, the band is distinguishable in distant view as a pale, sometimes almost white strip which changes to pale pink on being moistened by a shower of rain.

(c) Fleshy algae band: The band could probably be subdivided. Its upper part is constituted by a yellow-brown fur of small algae, principally *Gelidiella bornetii, Gelidium pusillum* and *Polysiphonia howei*. At a lower level these are joined or replaced by a dull yellow-brown to fawn mat of numerous small species in which *Laurencia* usually predominates. It is, in general, similar to the turf of small algae occurring in comparable positions at Heron I. except that, particularly in its lower part, many of the constituents reach greater size, being several centimetres in length.

IV. SEAWARD PLATFORM

Occupying the lowermost intertidal region is a band of rich coral growth and encrusting lithothammia, emergent for up to 40 cm at ELWS. This is less platform like than the comparable area at Heron I. and descends gradually rather than precipitously to deep water. It differs further in the presence among the coral of several macroscopic, fleshy algal species including *Laurencia papillosa*.

VEGETATION OF THE RAMPARTS AND ASSOCIATED MANGROVE FOREST

The supralittoral ramparts are stained a dark sooty grey by the blue-green alga *Amacystis montana* with smaller quantities of *Scytonema hofmanni*. In positions of heavy shade *Pseudendoclonium submarinum* forms a green stain.

Numerous species of vascular plants occur on the inhospitable ramparts and include *Ipomoea pes-caprae, Wedelia biflora, Sophora tomentosa, Scaevola taccada, Calophyllum inophyllum, Ticus* spp., *Linociera ramiflora* and *Brassaia actinophylla*. Some of the species occurring here appear to be derived from seeds brought from the mainland by the Torres Strait Pigeon which nests among the mangroves in its thousands during summer. Many of the plants so derived do not appear to pass the seedling stage.

The highest patch of rampart (the so-called Green Ant Island) has a well developed terrestrial vegetation which includes *Thespesia populnea, Linociera ramiflora, Micromelum pubescens, Mimusops elongi, Vitex negundo, Diospyros ferrea* var. *reticulata, Flagellaria indica, Caesalpinia bonduc* and *Lepturus repens*.

Below EHWS shingle is stained brown to yellow-brown by *Entophysalis deusta* which is partly replaced by the green *Pseudendoclonium submarinum* in heavy shade.

The prostrate succulent *Sesuvium portulacastrum*, with which are mixed the algae *Rhizoclonium capillare* and *Calothrix pilosa*, occurs in some areas of gentle slope in the uppermost intertidal area. The lower limit of *Sesuvium* marks approximately the uppermost limit of mangroves.

The mangrove forest occupies the eastern area of the reef flat, most of the plants occurring within the protection of the ramparts (occasional windsheared specimens of *Avicennia* occur outside the ramparts on the most exposed eastern shore). *Rhizophora stylosa* is the dominant species, and over much of the area it forms a dense forest broken here and there by open muddy glades and by small "streams" floored with *Thalassia hemprichii*. However, particularly round the margins of the mangrove area, there occur several other species the most common of which are *Avicennia eucalyptifolia, Aegialitis annulata, Ceriops tagal* and *Osbornia octodonta*. The last mentioned forms a dense band along part of the northeastern edge of the mangrove area, the bases of many of the trunks being enveloped in a shingle rampart.

Mangrove trunks, prop roots and adjacent shaded shingle support small algae of several species including *Rhizoclonium capillare, Cladophora socialis* prox., *Monostroma* sp., *Bostrychia tenella* and *B. binderi*.

KEY TO THE MANGROVES OF LOW ISLES

A.B. Cribb

LEAVES OPPOSITE

Under surface of leaf with a pale, felted layer of hairs; with numerous pencil-like roots protruding from substratum .... *Avicennia eucalyptifolia*

Under surface without hairs; no protruding pencil-like roots

- Oil dots present in leaf; no conical stipular sheath at stem apex .... *Osbornea octodonta*
- Oil dots absent in leaf; conical stipular sheath present at stem apex
- Leaves with small black or brown dots on underside; calyx lobes 4; prop roots present.. *Rhizophora stylosa*
- Leaves without small black or brown dots on underside; calyx lobes more than 4; prop roots absent
- Calyx with 5 lobes, not bell-shaped; stem base often with prominent plank buttresses ... *Ceriops tagal*
- Calyx with 11-13 lobes, bell-shaped; stem base often broadened and fluted but usually without plank buttresses; with irregular knee roots .... *Bruguiera gymnorhiza*

LEAVES ALTERNATE

With pinnate leaves.. *Xylocarpus granatum*

With simple leaves

- Twigs prominently annulate; leaves with stem-clasping leaf base .... *Aegialitis annulata*
- Twigs not prominently annulate; leaf base not stem-clasping
- Latex present; a pair of small glands at base of leaf blade .... *Excaecaria agallocha*
- Latex absent; a small gland at apex of midrib on lower side .... *Lumnitzera racemosa*

FIELD GUIDE TO THE SEA GRASSES OF LOW ISLES

A.B. Cribb

Halophila ovalis (R. Br.) Hook. f. Long-petiolate leaves in pairs along the prostrate rhizome; blade 8-15 mm long, with midrib and 10-14 lateral veins on each side.

Halodule uninervis (Forsk.) Aschers. Leaves 1.7-2.5 mm diam., mostly 4-10 cm long; central vein often forked at apex and sometimes ending in a triangular hyaline tooth; submarginal vein on each side not obvious; apex with a prominent lateral tooth on each side.

Halodule pinifolia (Miki) den Hartog. Similar to *H. uninervis* but with narrower leaves 0.7-1.2 mm diam., and with the apical margin fimbriate rather than with an obvious lateral tooth on each side.

Thalassia hemprichii (Ehrenb.) Aschers. Leaves 10-13 mm diam., mostly 8-26 cm long, usually falcate; midrib with 6-7 longitudinal veins on each side, linked by cross veins. The most common sea grass at Low Isles.

Enhalus acoroides (L.f.) Royle. Rhizome clothed with long black bristles to 10 cm long; leaves 9-13 mm wide, up to 100 cm long, with numerous indistinct, longitudinal veins linked by cross veins.

BRIEF NOTES ON THE INVERTEBRATES, LOW ISLES

Isobel Bennett

The map (Fig. 1, p. 44) shows the main structures superimposed on the reef flat, and the relationship of the sand cay with its lighthouse, to the extensive mangrove complex to the east and south-east.

The second Great Barrier Reef Expedition to Low Isles (organized by the Great Barrier Reef Committee in 1954) gave a detailed survey of the various reef habitats and noted changes in the fauna (W. Stephenson *et al.*, 1958), based on the survey by T.A. Stephenson *et al.* (1931) during the 1928-29 Expedition.

After almost twenty years, it should be interesting for those familiar with the above papers to note further changes to the reef flat as a whole.

Increased shipping, tourist activity and shell collecting have all played their part, but there has also been considerable silting of some moat areas where both the above expeditions recorded flourishing coral growths. Mangrove seedlings have also become established in areas beyond those previously noted.

SANDY BEACH OF THE CAY

The most obvious features are the burrows of Ghost crabs (*Ocypode* spp.).

Talitrid amphipods may be found and olive shells (*Oliva* spp.) may be found beneath the sand at about the level where it merges into the sand flat of the reef.

BEACH ROCK

A few mollusc species are the most commonly occurring animals of the beach rock area to the north of the cay, with the gastropod *Planaxis sulcatus* the dominant form, followed seawards by *Crassostrea amasa* and *Chama fibula* (= *jukesi* olim).

Under and among the stones and broken slabs of beach rock a number of different species annelids Crustacea, Mollusca and echinoderms have been listed, the most obvious being the small isopod, *Ligia*, and the hermit crabs *Petrolisthes lamarcki* and *Clibanarius virescens*.

BOULDER TRACT

This area of broken boulders and rubble occupies most of the western edge of the reef and here again molluscs are the most obvious faunal element with the oyster *Crassostrea amasa* at the highest levels. The large chiton *Acanthopleura gemmata* will be found in crevices on the boulders and at the lowest levels the burrowing clam, *Tridacna crocea*, will be seen. The barnacle, *Tetraclita vitiata*, occurs sporadically on the sides of boulders.

At lower levels there are patches of various species of Alcyonarians.

THE REEF FLAT

To the south of the Cay, there is a considerable area of reef flat, bounded by various "moat" regions. The near shore sandy region has an infauna of species such as the enteropneust, *Ptychodera*, and the burrowing anemone, *Edwardsia*. On the surface the foram, *Marginopora vertebralis*, the starfish, *Archaster typicus*, and the purple-mouthed *Strombus gibberulus* are among the more obvious species, with the bristle worm, *Eurythoe complanata*, under stones.

Seawards, the flat merges into an area of rubble, boulders and stones on a sandy substrate (the *Thalamita* Flat of T.A.S. *et al.*) where molluscs again play a major role. *Siphonaria zanda* and the slug *Onchidium verruculatum*, are common on the higher boulders, with the chiton, *Acanthopleura gemmata*, in the crevices, and the burrowing *Tridacna crocea* at low tidal levels.

The cryptic fauna includes several species of ophiuroids and holothurians, with the burrowing echinoid, *Echinometra mathaei*, in boulders and occasional needle-spined *Diadema setosum* in pools. Attached to the undersides of boulders are numerous encrusting sponges, hydroids and Polyzoa. Among the mobile species, several species of crabs, hermit crabs and the stomatopod, *Gonodactylus chiragra*, are common.

THE MANGROVE COMPLEX

There are two fairly clearly defined regions among the mangroves - the more open sand and shingle areas, and the dense growths where the roots of *Rhizophora* form an almost impenetrable barrier. Between these two there is a gradation from clean sand to dense, sticky mangrove mud.

On the mangroves themselves, particularly on the prop roots of the tall *Rhizophora stylosa*, the most obvious animals are the oyster, *Crassostrea amasa*. In some places the barnacles *Tetraclita vitiata* and *Chthamalus caudatus* are common. Crabs, anemones, molluscs such as *Siphonaria, Nerita* spp. and *Clypeomorus* also occur.

High up on the branches of mangroves, there is a littorinid zone, with the species *Littorina scabra.*

In deeper areas such as drainage channels through the mangroves, the sea urchin, *Diadema setosum* occurs and colonies of corals such as *Leptastrea purpurea* and *Pocillopora damicornis* were common attached to the roots of the *Rhizophora*. Other corals in this area include species of *Montipora* and *Goniastrea.*

In the more muddy areas molluscs such as *Telescopium telescopium* and *Terebralia palustris,* and the crabs *Metapograpsus* and *Sesarma,* are among the more obvious species.

THE "MOAT"

Several different areas where water is retained on the reef flat at low tide, have been designated as "moats" by the two expeditions, and although the fauna differs to a certain extent in each locality, and the species increase in numbers in the deeper and more extensive moats, there is an overall uniformity in the kinds of animals to be found there.

Up to forty species of corals have been listed from the various moats but only a few of these, such as species of *Montipora, Goniastrea, Pocillopora,* and the micro-atoll forming *Porites lutea,* were noticeably common.

In the previously extensive north-eastern moat (the *Porites* Pond of T.A.S. *et al),* it will be seen that there has been very considerable silting and there are no longer flourishing colonies of *Porites lutea,* such as those noted in 1954. The sea grass, *Thalassia,* dominated the sandy areas of this moat carrying a large population of the black *Holothuria* spp.

Whilst the needle spined urchin, *Diadema setosum,* and the clam, *Hippopus hippopus,* are still to be found, they no longer occur in the large numbers which previously existed.

Other animals found sporadically in the moat areas include the molluscs, *Lambis lambis* and *Strombus luhuanus* (the Red-mouthed Stromb, which is the most commonly found mollusc on rubble areas throughout the reef flat generally) starfish such as *Nardoa* and the pincushion *Culcita novaeguineae,* and colonies of the soft corals, mainly of the genera *Sarcophyton, Sinularia* and *Lobophyton.*

THE SHINGLE RAMPARTS

As in the moat regions, the fauna of the various shingle habitats on the reef varies from place to place and, as would be expected, increases in species numbers at the lower tidal levels.

At the higher levels, the crab, *Petrolisthes lararcki,* and the molluscs, *Onchidium, Nerita* spp. and *Clypeomorus* and *Planaxis* commonly occur.

On the eastern side of the island where the shingle rampart merges into a more consolidated rock platform, the Ring Cowrie, *Monetaria annulus* was extremely common in the more "honeycombed" rock, with beds of the small mussel, *Modiolus agripeta* on the smoother rock surfaces.

THE ANCHORAGE AND THE SEAWARD SLOPES

These are the coral dominated areas of the reef and here again the coral fauna varies with the different aspects of the reef face and with descending depth.

It will be noted that species of *Acropora* and *Montipora* dominate in some areas such as the south-western edge of the reef, whilst species such as *Symphyllia nobilis* and *Goniastrea* spp. are more abundant on the eastern exposed side of the reef.

On the western side of the Anchorage soft corals are the dominant species occurring on dead corals.

APPENDIX 2 - FIELD GUIDE - LIZARD I.

GEOLOGICAL EXCURSION NOTES TO LIZARD ISLAND

1. INTRODUCTION

Lizard Island is situated at latitude 14°40'S and longitude 145°26'E in the northern region of the Great Barrier Reef Province (Maxwell, 1968, Fig. 17b). It is a high rocky island, south-westward of Cook's Passage, situated about 24 km from the mainland and 16 km from the Outer Barrier. The island has an area of approximately 10 km^2 and a maximum N-S length of 4 km; the E-W width is 3 km. Two NNW-SSE trending ridges cross the island separated by a low grassy valley; the highest point of the island is in the middle of the eastern ridge at 360 m (Australian Pilot, 1962).

Two smaller rocky islets, South Islet and Palfrey Islet (= Iguana Island, Stephenson, Stephenson, Tandy and Spender, 1931; Saddle Island, Fairbridge, 1950; Cape Melville 1:250,000 sheet) lie 2 km SW and 2½ km WSW of the southeastern extremity of Lizard Island respectively. South Islet is 123.4 m high and Palfrey Islet 136.5 m.

Lizard Island is bordered by narrow, steep fringing reefs on its eastern and western sides. To the south side the reefs are more extensive and join with the reefs fringing the southern islets to enclose a small lagoon up to 9 m in depth (Fairbridge, 1950).

Sandy beaches occur in the bays and inlets of the islands.

2. GEOLOGY OF THE ISLANDS

The islands consist of granites mapped as the Finlayson Granite (Lucas and deKeyser, 1965). They describe it as a cream to grey, massive, fairly even, medium to coarse grained, locally porphyritic, tourmaline-bearing, biotite - muscovite granite, in which both potash feldspar (microcline perthite) and quartz exceed piagiociase. Pegmatic bands occur through the granite and consist of quartz, cream feldspar, muscovite, and variable amounts of tourmaline. Jones and Jones (1956) report the presence of ignimbrite as well as granite on Palfrey Islet.

The granites are considered Permian by Lucas and deKeyser (1965) as all isotopic age determinations on similar granites to the south have yielded Permian ages.

The beaches in the bays are of quartz sands.

3. FRINGING REEFS

"These are narrow band-like reefs adjacent to the coast. They are seen to advantage from the slopes of the mountain, their form, extent and abrupt seaward edges being clearly defined against the white sandy bottom. One of these reefs was examined. Inshore were a few granite boulders, with some coral debris and shingle partly masked by a dense growth of *Sarcophytum, Lobophytum* and *Sinularia*. The water even inshore was about a foot deep at this tide (9th June), many of the Alcyonaria projecting. Proceeding towards the edge of the reef the water deepens, and about 10-15 yards from the shore there are large masses of living *Porites,* frequently a couple of yards in diameter, with pools and channels between. These masses continue to the edge of the reef, which lies some 50 yards from the shore, and descends rapidly to deep water, in irregular steps; and towards the margin the pools and crevices are of considerable depth. Outside the reef-edge the bottom is clean sand. On and between the larger coral masses flourishes a rich and varied growth of other corals and alcyonaria, including fields of *Sinularia flexibilis*. This fauna resembles that described below for one of the isolated reef-patches, and includes, in addition to the forms there mentioned, species of *Culophyllia, Tridacophyllia, Pachyseria, Pavona, Echinopora, Galaxea, Peconnocora,* Icbed and follose *Porites; Stichopus chloronotus* and *Gyrostoma ramsayi*.

This reef, which is probably typical of the fringing reefs of the island, appears to be a young reef, with no reef-flat, still narrow, and consisting mainly of living coral, with a predominance of massive *Porites*. The escarpment which forms the seaward face is made of tiers of living colonies of this coral," (Stephenson, Stephenson, Tandy and Spender, 1931).

4. REEF PATCHES TO SOUTH OF LIZARD ISLAND

"Between Palfrey and South Islets, and between the latter and Lizard Island, this reef-system has a distinct edge and constitutes a sort of miniature barrier-reef upon which there is surf in ordinary south-easterly weather. This barrier encloses a deep pool (to the left of the figure), a practicable anchorage for small craft, with an entry which lies just outside the picture. Westward of the pool, between Palfrey and Lizard Islands, lies a sandy shoal of complicated outline and very variable in level. Upon this occur numerous reef-patches, some of them adjacent to the shore of one or other of the islands, others quite isolated.

Three of the isolated reef-patches were examined, and one of these (lying to the west of Palfrey Islet) will be described. It is a reef separated by some distance from any shore, and surrounded on all sides by sand. The shape is roughly triangular, the apex to windward (SE). The reef is made of dead boulders and masses of coral with sand between, and the surface is very irregular and full of complex holes and crevices. The edges are abrupt, about 6 ft. deep on the windward side. The general surface of the reef (apart from exceptional prominances) was about a foot below the level of low water; at an extreme tide there would be some exposure.

The whole reef is covered with a rich and healthy growth of coral and Alcyonaria, resembling that of the Low Isles anchorage, but including some elements characteristic of more exposed situations. Fleshy Alcyonaria are plentiful; *Acropora* is represented by about twelve species, including *A. palifera* and cyathiform, stagshorn, and bush-like species; and *Montipora* by both branched and foliose forms. Among the corals are other creatures, especially giant clams, some of them 3 ft. long or more. The largest species is apparently identical with *T. derasa,* the other with *T. elongata*. Smaller species are also present. Further details of the fauna are given in the list at the foot of this page.

The interest of the reef lies in the picture which it presents of the structure and fauna of an isolated reef-patch growing up from a sandy floor. The conditions described probably resemble those which prevail on any comparable reef before it has acquired a reef-flat or a modified surface which restricts or abolishes the growth of coral on top of it. A second reef-patch which we examined, a little to westward of the one described, seemed to have reached a slightly more advanced condition, since it had a sort of embryonic reef-flat of boulders, sand and shingle, with a slight stony bank at one side, exposed at low water. Here the growth of living coral was restricted on top of the reef, but was very rich down the steep sides. Connected with this reef was a notable mass of coral many feet deep, square yards of which were covered by a living colony of *Diplostrea heliopora.*" (Stephenson, Stephenson, Tandy and Spendart 1931).

APPENDIX 3 - SPECIES LISTS - INNISFAIL-LIZARD ISLAND

VASCULAR PLANTS OF LOW ISLES

A.B. Cribb

(Introduced plants are preceded by an asterisk)

1. CORAL CAY

MONOCOTYLEDONS

Pandanaceae
  Pandanus sp. (Three Isles)
Arecaceae
  **Cocos nucifera*

DICOTYLEDONS

Casuarinaceae
  Casuarina equisetifolia
Lauraceae
  Cassytha filiformis
Fabaceae
  Vigna marina
Euphorbiaceae
  Euphorbia eremophila
Passifloraceae
  **Passiflora foetida*
Lythraceae
  Pemphis acidula (Third Island)
Combretaceae
  Terminalia catappa
Myrtaceae
  Osbornia octodonta (Third Island)
Oleaceae
  Jasminum simplicifolium
Convolvulaceae
  Ipomoea pes-caprae
Boraginaceae
  Tournefortia argentea
Verbenaceae
  Premna obtusifolia
  Vitex trifolia
Pedaliaceae
  Josephinia grandiflora (Three Isles)
Goodeniaceae
  Scaevola sericea (syn. *S. koenigii*)

II. SHINGLE TONGUE

MONOCOTYLEDONS

Poaceae
  Lepturus repens
Flagellariaceae
  Flagellaria indica
Commelinaceae
  Commelina cyanea

DICOTYLEDONS

Amaranthaceae
  Achyranthes aspera
Aizoaceae
  Sesuvium portulacastrum
Malvaceae
  Thespedia populnea

III. MANGROVE COMMUNITY

DICOTYLEDONS

Euphorbiaceae
  Excaecaria agallocha
Rhizophoraceae
  Bruguiera gymnorhiza
  Ceriops tagal
  Rhizophora stylosa
Plumbaginaceae
  Aegialitis annulata
Verbenaceae
  Avicennia marina

IV. SEA GRASSES

MONOCOTYLEDONS

Hydrocharitaceae
  Halophila ovalis
  Thalassia hemprichii
Zannichelliaceae
  Cymodocea sp.
  Diplanthera uninervis

V. REFERENCE

Stephenson, T.A., Stephenson, Anne, Tandy, G., and Spender, M., 1913: The structure and ecology of Low Isles and other reefs. Great Barrier Reef Expedition 1928-29. Scientific Reports Vol. 3: 17-112.

Macnae, W., 1966: Mangroves in eastern and southern Australia. *Aust. J. Bot.* 14: 67-104.

BIRDS VISITING LOW ISLES

(* breeding)

- Megapodiidae
  - Scrub Fowl (*Megapodius freycinet duperryii*)*
- Columbidae
  - Bar-shouldered Dove (*Geopelia humeralis*)*
  - Torres Strait Pigeon (*Ducula spilorrhoa spilorrhoa*)*
  - Green-winged Pigeon (*Chalcophaps indica chrysochlora*)
  - Purple-crowned Pigeon (*Ptilinopus superbus superbus*)
- Sulidae
  - Brown Gannet (*Sula leucogaster plotus*)
- Laridae
  - Crested Tern (*Sterna bergii*)
  - Lesser Crested Tern (*Sterna bengalensis*)
  - Caspian Tern (*Sterna caspia*)
  - Little Tern (*Sterna sinensis*)
  - Common Tern (*Sterna hirundo longipennis*)
  - Black-naped Tern (*Sterna sumatrana*)*
  - Silver Gull (*Larus novaehollandiae*)*
  - Bridled Tern (*Sterna anaethetus anaethetus*)*
  - Sooty Tern (*Sterna fuscata nubilosa*)*
- Charadriidae
  - Mongolian Sand-dotteral (*Charadrius mongolus mongolus*)
  - Eastern Golden Plover (*Pluvialis dominica fulva*)
  - Double-banded Dotteral (*Charadrius bicinctus*)
- Scolopacidae
  - Turnstone (*Arenaria interpres interpres*)
  - Grey-tailed Tattler (*Tringa brevipes*)
  - Eastern Curlew (*Numenius madagascariensis*)
  - Bar-tailed Godwit (*Limosa lapponica baueri*)
- Ardeidae
  - Reef Heron (*Egretta sacra*)*
- Accipitridae
  - White-breasted Sea-Eagle (*Haliaeetus leucogaster*)*
  - Osprey (*Pandion haliaetus cristatus*)*
- Alcedinidae
  - Sacred Kingfisher (*Halcyon sancta leucorhynchus sancta*)
  - Mangrove Kingfisher (*Halcyon chloris sordida*)*
- Zosteropidae
  - Silvereye (*Zosterops lateralis* sub sp.)*
- Meliphagidae
  - Varied Honeyeater (*Meliphaga versicolor versicolor*)*
- Campephagidae
  - White-breasted Cuckoo-shrike (*Coracina papuensis hypoleuca*)
- Grallinidae
  - Magpie-lark (*Grallina cyanoleuca*)
- Artamidae
  - White-breasted Wood-swallow (*Artamus leucorhynchus*)

VASCULAR PLANTS OF LIZARD ISLAND, PALFREY ISLAND, NYMPH ISLAND, PETHEBRIDGE ISLAND AND THREE ISLES

H. Heatwole

LIZARD ISLAND

Schizaeaceae
Lygodium microphyllum

Adiantaceae
Adiantum aethiopicum

Casuarinaceae
Casuarina equisetifolia var. *incana*

Opiliaceae
Opilia amentacea

Lauraceae
Cassytha filiformis
Cassytha glabella

Fabaceae
Alysicarpus bupleurifolius
Crotalaria linifolia
Jacksonia thesioides
Tephrosia filipes
Vigna marina
Vigna vexillata

Mimosaceae
Acacia anlacocarpa var. *macrocarpa*
Acacia crassicarpa

Euphorbiaceae
Breynia stipitata
Euphorbia atoto
Euphorbia macgilliarayi
Euphorbia micradenia

Simaurobaceae
Suriana maritima

Anacardiaceae
Semecarpus australiensis

Sapindaceae
Dodonaea lanceolata
Dodonaea viscosa

Passifloraceae
Passiflora foetida

Lythraceae
Pemphis acidula

Myrtaceae
Eucalyptus papuana
Eugenia grandis
Melaleuca leucodendron
Thryptomene oligandra

Barringtoniaceae
Barringtonia calyptrata

Rhizophoraceae
Ceriops tagal var. *tagal*
Rhizophora stylosa

Combretaceae
Lumnitzera racemosa

Onagraceae
Ludwigia octovalvis

Araliaceae
Brassaia actinophylla

Asclepiadaceae
Sarcostemma australe

Convolvulaceae
Evolvulus alsinoides var. *decumbens*
Ipomoea brasiliense
Operculina turpethrum

Boraginaceae
Cordia subcordata

Verbenaceae
Clerodendrum floribundum
Clerodendrum inerme
Premna corymbosa

Lamiaceae
Plectranthus sp.

Scrophulariaceae
Buchnera tetragona
Buchnera urticifolia
Lindernia alsinoides

Acanthaceae
Justicia procumbens

Pedaliaceae
Josephinia imperatricis

Goodeniaceae
Scaevola taccada

Asteraceae
Epaltes australis
Glossogyne tenuifolia
Wedelia biflora

Liliaceae
Dianella sp.
Lomandra banksi

Flagellariaceae
Flagellaria indica

Poaceae
Alloteropsis semialata
Elyonurus citreus
Heteropogon triticeus
Setaria surgens
Spinifex hirsutus
Sporobolus virginicus
Themeda australis

Arecaceae
Cocos nucifera
Ptychosperma elegans

Pandanaceae
Pandanus sp.

Cyperoceae
Cyperus aquatilis
Cyperus polystachyus
Fibristylis acularis
Fimbristylis dichotoma
Fimbristylis ferruginea
Fimbristylis pauciflora

Orchidaceae
Dendrobium discolor

PALFREY ISLAND

Schizaeaceae
Lygodium japonicum

Sinopteridaceae
Cheilanthes distans

Thelypteridaceae
Cyclosorus goggilodus

Casuarinaceae
Casuarina equisetifolia var. *incana*

Moraceae
Ficus drupacea
Ficus sp. (probably *F. scobina)*

Aizoaceae
Sesuvium portulacastrum

Myristicacaceae
Myristica insipida

Lauraceae
Cassytha filiformis

Fabaceae
Canavalia maritima
Crotalaria linifolia
Derris trifoliata
Desmodium sp.
Galactia muelleri
Indigofera hirsuta
Indigofera pratensis
Jacksonia thesioides
Vigna marina

Mimosaceae
Acacia crassicarpa
Desmanthus virgatus (introduced)

Caesalpiniaceae
Cynometra ramiflora

Euphorbiaceae
Euphorbia atoto
Euphorbia serrulata
Phyllanthus urinaria?
Securiaega virosa

Simaurobaceae
Suriana maritima

Anacardiaceae
Buchanania arborescens

Vitidaceae
Cayratia trifolia

Tiliaceae
Triumfetta repens

Malvaceae
Abutilon indicum
Thespesia populnea

Passifloraceae
Passiflora foetida

Myrtaceae
Eugenia sp. (probably *E. hemilampra)*
Philidiostigma rhytispermum?
Thryptomene oligandra

Araliaceae
Brassaia actinophylla

Asclepiadaceae
Gymnanthera nitida
Hoya australis
Sarcostemma australe

Rubiaceae
Psychotria nesophila

Convolvulaceae
Evolvulus alsinoides
Ipomoea brasiliense
Merremia tridentata ssp. *hastata*

Lamiaceae
Plectranthus diversus

Scrophulariaceae
Striga curviflora

Asteraceae
Emilia sanchifolia
Glossogyne tenuifolia
Wedelia biflora

Hypoxidaceae
Curculigo ensifolia

Commelinaceae
Commelina undulata

Poaceae
Cymbopogon refractus
Imperata cylindrica var. *major*
Ischaemum villosum
Spinifex hirsutus
Themeda australis

NYMPH ISLAND

Casuarinaceae
Casuarina equisetifolia var. *incana*

Moraceae
Ficus opposita

Nyctaginaceae
Boerhavia diffusa

Aizoaceae
Sesuvium portulacastrum

Chenopodiaceae
Arthrocnemum sp.
Pachycornia cinerea
Salsola kali

Lauraceae
Cassytha glabella

Fabaceae
Crotalaria linifolia

Euphorbiaceae
Euphorbia eremophila

Zygophyllaceae
Tribulus cistoides

Rutaceae
Micromelum minutum

Simaurobaceae
Suriana maritima

Celastraceae
Elaeodendron melanocarpum

Rhamnaceae
Colubrina asiatica

Vitidaceae
Cayratia trifolia

Passifloraceae
Passiflora foetida

Lythraceae
Pemphis acidula

Rhizophoraceae
Rhizophora stylosa

Plumbaginaceae
Aegialitis annulatum

Sapotaceae
Manilkaria kanki
Mimusops elengi
Planchonella obovata

Asclepiadaceae
Sarcostemma australe

Rubiaceae
Ixora klanderana

Convolvulaceae
Operculina turpethrum

Boraginaceae
Tournefortia argentea

Asteraceae
Vernonia cinerea

Flagellariaceae
Flagellaria indica

Poaceae
Lepturus repens
Sporobolus virginicus

Pandanaceae
Pandanus sp.

PETHEBRIDGE ISLAND

Nyctaginaceae
Boerhavia diffusa

Aizoaceae
Sesuvium portulacastrum

Chenopodiaceae
Arthrocnemum halocnemoides var. *pergrannlatum*

Capparidaceae
Capparis lucida

Euphorbiaceae
Excaecaria agallocha

Zygophyllaceae
Tribulus cistoides

Lythraceae
Pemphis acidula

Rhizophoraceae
Ceriops tagal var. *tagal*
Rhizophora sp.?

Convolvulaceae
Ipomoea tuba

Verbenaceae
Avicennia marina var. *australasica*

Poaceae
Lepturus repens
Sporobolus virginicus

THREE ISLES

Casuarinaceae
Casuarina equisetifolia var. *incana*

Moraceae
Ficus coronata
Ficus opposita

Nyctaginaceae
Boerhavia diffusa

Aizoaceae
Sesuvium portulacastrum

Chenopodiaceae
Salsola kali
Suaeda australis

Amaranthaceae
Amaranthus interruptus

Lauraceae
Cassytha filiformis

Capparidaceae
Cleome viscosa

Fabaceae
Vigna marina

Euphorbiaceae
Euphorbia atoto
Euphorbia hirta
Euphorbia tannensis
Macaranga tanarius

Zygophyllaceae
Tribulus cistoides

Simaurobaceae
Suriana maritima

Rhamnaceae
Colubrina asiatica

Vitidaceae
Cayratia trifolia

Passifloraceae
Passiflora foetida

Cucurbitaceae
Bryonopsis laciniosa
Citrullus vulgaris

Lythraceae
Pemphis acidula

Rhizophoraceae
Rhizophora stylosa

Sapotaceae
Planchonella obovata

Ebenaceae
Diospyros ferrea var. *geminata*

Rubiaceae
Morinda citrifolia

Convolvulaceae
Ipomoea brasiliense
Merremia tridentata spp. *hastata*

Boraginaceae
Tournefortia argentea

Verbenaceae
Avicennia marina var. *australasica*
Clerodendrum sp.?
Premna corymbosa
Stachytarpheta urticifolia
Vitex ovata

Asteraceae
Pterocaulon sphacelatum
Vernonia cinerea
Wedelia biflora

Commelinaceae
Commelina sp.

Poaceae
Heteropogon contortus
Imperata cylindrica var. *major*
Lepturus repens
Panicum antidotale
Sporobolus virginicus

Cyperaceae
Remirea maritima

TERRESTRIAL INVERTEBRATES ON LIZARD ISLAND, PALFREY ISLAND NYMPH ISLAND AND THREE ISLES

H. Heatwole

ARACHNIDS

PHALANGIDA

LIZARD ISLAND

1 unidentified species

PSEUDOSCORPIONS

PALFREY ISLAND

Anagarypus sp.

NYMPH ISLAND

Garypidae
  Anagarypus sp.

SPIDERS

LIZARD ISLAND

Diaea stiata
Nephila plumipes (Latr.)
Argyope aetherea (Walck)
Diaea limbata
Cyclosa camelodes (Thor.)
Cyrtophora moluccensis
Argyope protensa L. Koch.
Thomisus spectabilis Dol.
Argyrodes argentatus Combr.
Tetragnatha heatwolei
Theridion sp.

LYCOSID, SALTICID, OXYOPID, CLUBIONID

Unidentified species

PALFREY ISLAND

Diaea stricta

NYMPH ISLAND

Cyclosa camelodes
Thomisus spectabilis
Diaea limbata
Archaeranea mundula
Theridion sp.
Storeia sp.
SALTICID, LYCOSID
Unidentified species

MILLIPEDES

LIZARD ISLAND

1 unidentified species

CENTIPEDES

LIZARD ISLAND

2 unidentified species

INSECTS

ODONATA

LIZARD ISLAND

Neurothemis stigmatizens stigmatizens

BLATTODEA (roaches)

LIZARD ISLAND

Blattidae
  Cosmozosteria lateralis
  Platyzosteria sp.

Blattellidae

2 spp.

ISOPTERA

LIZARD ISLAND

2 spp.

DERMAPTERA

LIZARD ISLAND

Pygidicranidae
  Eubarellia annulipis

NYMPH ISLAND

Eubarellia annulipes

MANTODEA

LIZARD ISLAND

Amorphoscelidae
  Paraoxypilinae
  1 unidentified species

Mantidae
  Orthodera ministralis
  Mantinae
  1 unidentified species

PALFREY ISLAND

Mantidae
  Orthodera ministralis

NYMPH ISLAND

Mantidae
  Orthodera ministralis

ORTHOPTERA

LIZARD ISLAND

Eumastacidae
  Morabinae
  1 unidentified species

Acrididae
Acrida conica
Locusta migratoria
Pycnostictus seriatus
Valanga sp.
Austracris guttulosa
Xypechtia sp.
Rectitropis sp.

Gryllacrididae
1 unidentified species

Tettigonidae
Conocephalus sp.
Phancropterinae, 1 unidentified species

Gryllidae
Gryllinae, 2 unidentified species
? Ornebius sp.
Trigonidiinae, 1 unidentified species

PALFREY ISLAND

Eumastacidae
Morabinae, 1 unidentified species

Acrididae
Stenacatantaps angustifrons
Pycnostictus seriatus

NYMPH ISLAND

Acrididae
Acrida conica
Pycnostictus seriatus
Valanga sp.

Gryllacrididae
1 unidentified species

Tettigonidae
Conocephalus sp.

Gryllidae
? Ornebius sp.
Oecanthus sp.

PHASMATODEA

LIZARD ISLAND

Phasmatidae
1 unidentified species

NYMPH ISLAND

Phasmatidae
1 unidentified species

NEUROPTERA

PALFREY ISLAND

Chrysopidae
Chrysopa otalatis

NYMPH ISLAND

Chrysopa sp.

COLEOPTERA

LIZARD ISLAND

Scarabaeidae
Melolonthinae
Colpochila sp.

Chrysomelidae
Chrysomelinae
Paropsis bovilli Blackburn
Paropsis sp.

Halticinae
Nisotra breweri Baly

Galerucinae
Monolepta germari Lacordaire

Hispinae
Monochirus multispinosus Germar

Tenebrionidae
Opatrinae
Gonocephalum torridum Champion
Caedius sp.

Cerambycidae
Cerambycinae
Phoracantha quinaria Newman

Carabidae
Harpalinae
Gnathaphanus vulneripennis Macleay

Pterostichinae
Abacetus sp.

Scarabaeidae
Dynastinae
Metanastes vulgivagus Olliff

Melolonthinae
Lepidiota sp. n.

Bruchidae
Bruchus sp. *diversipes* Lea

Coccinellidae
Stethorus sp.
Stethorus notescens Blackburn
Rhizobius ventralis Erichson
Scmnodes lividigaster Mulsant
Cisseis sp.

Anobiidae
Dryphilodes obscuripennis Lea

Melyridae
Laius cinctus Redtenbacher

Phalacridae
Phalacrus fimetarius Fab.

Pelodidae genus sp. 1
Pelodidae genus sp. 2

Staphylinidae
2 unidentified species

Cleridae
Tenerus sp.

Curculionidae
Otioorhynochinae
Myllocerus nivens Lea

Baridinae
Baris sororia Lea

Lathrididae
Corticaria adelaidae Blackburn

DIPTERA

LIZARD ISLAND

Tipulidae
2 unidentified species

Cecidomyiidae
1 unidentified species

Stratiomyidae
Odontomyia or *Hedriodiscus* sp.

Rhagionidae
Chrysopilus sp.

Bombyliidae
Geron sp.

Dolichopodidae
Sciapus sp.
Chrysosoma sp.

Syrphidae
Eristalis sp.
Syritta sp.

Platystomatidae
Duomyia sp.
Rivellia sp.
Plagiostenopterina enderleini

Lauxaniidae
Homoneura signatifrons
Homoneura sp. nov.

Agromyzidae
Melanagromyza dianellye

Chloropidae
Oscinus sp.
Prionoscelus femoralis

Muscidae
Orchisia sp.

Calliphoridae
Chrysomyia megacephala

Sarcophagidae
1 unidentified species

PALFREY ISLAND

Tachinidae
1 unidentified species

Calliphoridae
Calliphora sp.

Pipunculidae
Tomasvaryella sp.

Lauxaniidae
Sapromyza sp. A.

Ephydridae
Discomyza maculipennis (Wied.)

Tephritidae
Trupanea sp.

Chloropidae
Oscinis aff. *seriata* Mall.
Botanobia sp.
2 unidentified species

Agromyzidae
Melanagromyza specifica

NYMPH ISLAND

Chironomidae
Cheronomus magnivalva

Cecidomyiidae
1 sp.

Bombyliidae
?Anthrax sp.

Dolichopodidae
Hereostomus sp.

Platystomatidae
Elassogaster terraereginae

Chloropidae
?Oscinis sp.

Tachinidae
1 sp.

LEPIDOPTERA

LIZARD ISLAND

Noctuidae
2 unidentified species

Arctiidae
Utetheisa sp. cf. *pullchelloides*

Lycaenidae
Lampides boeticus dainoctes
Zizurea alsulus alsulus

Pieridae
Elodina parthia

Satridae
Hypocysta sp.

Hesperiidae
Drybadystes sp.

PALFREY ISLAND

Hesperiidae
Ocybadistes walkeri sothis

Lycaenidae
Zizuria otis labradus (Godt.)

Amatidae
Amata sp.

Arctiidae
Uretheisa sp.

NYMPH ISLAND

Lycaenidae
Lampides boeticus dainotes

Pieridae
Elodina sp.

THREE ISLES

Pieridae
Anaphaeis java teutonia

HYMENOPTERA (excluding ants)

LIZARD ISLAND

Meteorus sp.
Bracon sp.
Phanerotoma sp.

PALFREY ISLAND

Phanerotoma sp.

NYMPH ISLAND

Phanerotoma sp.
Agathiella sp.
Rogas sp.
Iphiaular sp.
Myosoma sp.
? *Campyloneurus* sp.

HYMENOPTERA (ants; family Formicidae)

LIZARD ISLAND

Ponerinae
Brachyponera lutea (Mayr)
Rhytidoponera sp.
Rhytidoponera metallica (Smith)

Pseudomyrmecinae
Tetraponera sp.

Myrmicinae
Pheidole sp.
Meranoplus sp.
Crematogaster sp. a.
Tetramorium quineense

Dolichoderinae
Leidomyrmex sp. a.
Leidomyrmex sp. b.
Leidomyrmex sp. c.
Leidomyrmex sp. d.

Formicinae
Opisthopsis haddoni
Oecophylla smaragdina
Camponotus sp. B.
Camponotus sp. C.
Camponotus sp. D.
Polyrhachis sp. C.
Polyrhachis sp. D.
Polyrhachis sp. E.

NYMPH ISLAND

Pseudomyrmecinae
Tetraponera sp.

Myrmicinae
Crematogaster sp. A.
Crematogaster sp. B.
Triglyphothrix sp.

Dolichoderinae
Iridomyrmex sp. A.

Formicinae
Oecophylla smaragdina
Camponotus sp. A.
Camponotus sp. B.
Polyrhachis sp. A
Polyrhachis sp. B
Paratrechina longicornis

TERRESTRIAL REPTILES OF LIZARD ISLAND, PALFREY ISLAND, NYMPH ISLAND, PETHEBRIDGE ISLAND, THREE ISLES AND LOW WOODED ISLE

H. Heatwole

LIZARD ISLAND

LIZARDS

Carlia sp.?
Carlia dogare
Carlia fusca
Cryptoblepharis boutoni
Gehyra ? oceanica
Cyrtodactylus pelagicus
Varanus gouldii
Heternotus binoei
Sphenomorphus crassicaudus

SNAKES

Boiga irregularis
  Brown tree snake
Liasis childreni
  Childrens python
Dendrelaphus punctulatus
  Green tree snake
Glyphodon tristis
  Brown headed snake
Typhlina sp.?
  Blind snake

PALFREY ISLAND

Gehyra australis
Cryptoblepharis boutoni
Cyrtodactylus pelagicus

NYMPH ISLAND

Cyrtodactylus pelagicus
Gehyra sp.
Sphenomorphus sp.
Carlia fusca

PETHEBRIDGE ISLAND

Cryptoblepharis boutoni

THREE ISLES

Cyrtodactylus pelagicus
Gehyra variegata
Gehyra australis
Sphenomorphus pardalis

LOW WOODED ISLE

None found

APPENDIX 4 - SPECIES LISTS - INNISFAIL-BOWEN

H. Heatwole

FLOWERING PLANTS ON HOLBOURNE ISLAND

Moraceae
  Ficus microcarpa var. *latifolia*
  Ficus opposita
  Ficus platypoda

Nyctaginaceae
  Pisonia grandis

Aizoaceae
  Sesuvium portulacastrum

Portulacaceae
  Portulaca oleracea

Amaranthaceae
  Achyranthes aspera

Capperidaceae
  Capparis lucida

Fabaceae
  Abrus precatorius
  Canavalia maritima
  Sophora tomentosa?
  Tephrosia astragaloides

Caesalpiniaceae
  Cassia retusa

Euphorbiaceae
  Croton arnhemicus
  Dryptetes australasica
  Euphorbia atoto
  Euphorbia hirta
  Euphorbia tannensis
  Phyllanthus albiflorus
  Phyllanthus reticulatus

Zygophyllaceae
  Tribulus cistoides

Rutaceae
  Achronychia laevis

Sapindaceae
  Cupaniopsis anacardioides

Rhamnaceae
  Colubrina asiatica

Vitidaceae
  Cissus opaca

Malvaceae
  Abutilon indicum
  Sida acuta
  Sida cordifolia
  Thespesia populneoides

Passifloraceae
  Passiflora aurantia
  Passiflora foetida

Cucurbitaceae
  Melothria maderaspatana

Myrtaceae
  Eucalyptus papuana

Combretaceae
  Terminalia melanocarpa

Ebenaceae
  Diospyros ferrea var. *geminata*

Oleaceae
  Jasminum didymum

Apocynaceae
  Alyxia ruscifolia
  Ervatamia orientalis
  Parsonsia plaesiophylla

Asclepiadaceae
  Sarcostemma australe

Rubiaceae
  Guettarda speciosa
  Morinda citrifolia

Convolvulaceae
  Ipomoea nil
  Ipomoea pes-caprae

Boraginaceae
  Tournefortia argentea

Verbenaceae
  Clerodendrum floribundum
  Clerodendrum inerme
  Lantana camara
  Premna corymbosa?
  Stachytarpheta urticifolia

Lamiaceae
  Plectranthus diversus

Goodeniaceae
  Scaevola taccada

Asteraceae
  Gynura pseudochina
  Tridax procumbens
  Vernonia cinerea
  Wedelia biflora

Liliaceae
  Dianella caerulea

Commelinaceae
  Commelina sp. (probably *C. undulata)*

Poaceae
  Brachiaria milliformis
  Cenchrus echinatus
  Chloris virgata
  Cynodon dactylon
  Digitaria ciliaris
  Digitaria ramularis
  Heteropogon contortus
  Imperata cylindrica var. *major*
  Lepturus repens
  Rhynchelytrum repens
  Setaria sp.
  Sporobolus virginicus

Themeda arguens
Thuarea involuta

Pandanaceae
Pandanus sp.

Cyperaceae
Cyperus conicus
Cyperus tetracarpus
Fimbristylis sp. (probably *F. depauperata)*
Schoenus falcatus

Orchidaceae
Dendrobium discolor

FLOWERING PLANTS ON BAY ROCK

Moraceae
Ficus opposita

Nyctaginaceae
Boerhavia diffusa
Commicarpus chinensis

Portulacaceae
Portulaca filifolia
Portulaca oleracea

Chenopodiaceae
Salsola kali

Menispermaceae
Tinospora smilacina

Fabaceae
Canavalia maritima
Galactia muelleri
Indigofera hirsuta

Euphorbiaceae
Euphorbia hirta
Phyllanthus albiflorus

Anacardiaceae
Pleiogynium cerasiferum

Malvaceae
Abutilon indicum
Sida cordifolia

Passifloraceae
Passiflora foetida

Sapotaceae
Mimusops elengi

Oleaceae
Jasminum didymum

Apocynaceae
Catharanthus rosea

Convulvulaceae
Evolvulus alsinoides
Ipomoea brasiliense
Ipomoea nil
Jacquemontia paniculata

Verbenaceae
Avicennia marina var. *australasica*
Clerodendrum inerme
Premna corymbosa
Vitex ovata
Vitex trifolia

Asteraceae
Epaltes australis
Pterocaulon serrulatum
Tridax procumbens

Commelinaceae
Commelina undulata

Poaceae
Cenchrus echinatus
Chloris barbata
Chloris virgata
Cymbopogon ambiguus
Cymbopogon bombycinus
Digitaria leucostachya
Heteropogon contortus
Imperata cylindrica var. *major*
Paspalidium gracile
Rhynchelytrum repens
Sporobolus virginicus

Cyperaceae
Bulbostylis barbata
Cyperus perangustus
Fimbristylis polytrichoides

INVERTEBRATES

The invertebrates arising from the 1969 trip were sent to specialists but no identifications have been received yet. The kinds of animals collected were as follows.

HOLBOURNE ISLAND

Terrestrial snails, beetles, hymenopterans (including ants), termites, spiders, lepidopterans, roaches, flies, grasshoppers, bugs, slaters, centipedes and millipedes.

ESHELBY ISLAND

No notes on invertebrates except that some ants were collected.

BAY ROCK

Hymenopterans, grasshoppers, roaches, mantids, beetles, flies, bugs, spiders, slaters, termites, and centipedes. The island had a very dense population of large brown locusts, nearly in plague proportions in 1969; they were not mentioned in 1971.

AVIFAUNA

HOLBOURNE ISLAND

The birds collectively seen in June 1969 and March 1971 were the following:

White-breasted sea eagle *(Haliaetus leucogaster)*
Reef Heron *(Egretta sacra)*
Silver gull *(Larus novaehollandiae)*
Pied oystercatcher *(Haematopus ostralegus)*
Sooty oystercatcher *(Haematopus fuliginosus)*
Brown quail *(Synoicus australis)?*
Bar-shouldered dove *(Geopilia humeralis)*
Scaly-breasted lorikeet *(Trichoglossus chlorolepidatus)?*
Pheasant coucal *(Centropus phasianus)?*
Pied currawong *(Strepera graculina)*
Grey-crowned babbler *(Pomatostomus temporalis)*
Willy-wagtail *(Rhipidura leucophrys)*

There were also 4 other species, which were not identified to species including a swallow, a kite, a kestrel and a gannet.

ESHELBY ISLAND

There were several species observed nesting on this island in March 1971. They were as follows:

Bridled terns *(Sterna anaetheta)* were fledging under shrubs and trees near the lighthouse and among the *Vigna* and herb low vegetation on the saddle and western slope. There were more than 20 pairs.
Crested terns *(Sterna bergii)* fledging on edge of western beach. There were more than 20 pairs.

In addition to the species known to be nesting the following species were seen:

White-breasted sea eagle *(Haliaetus leucogaster)*
Silvereye *(Zosterops lateralis)*
Bar-shouldered dove *(Geopilia humeralis)*
Golden whistler *(Pachycephala pectoralis)*

BAY ROCK

No notes on the birds of this island were recorded in 1971. In June 1969 the following species were observed:

White-breasted sea eagle *(Haliaetus leucogaster)*
Silver gull *(Larus novaehollandiae)*
An unidentified swallow

REPTILES

HOLBOURNE

The known herpetofauna of Holbourne Island consists of 4 species of gecko, 2 species of skinks and 1 snake. The geckoes and most skinks were collected from beneath rocks and logs on the beach. The snake was found under a coral rock on the beach. Although many rocks were turned on the hillside and top of hill, only 1 skink was found there. The species collected, were as follows:

Gekkonidae
  Cyrtodactylus pelagicus
  Gehyra australis
  Gehyra sp.
  Heteronotia binoei

Scincidae
  Ctenotus robustus
  Sphenomorphus nigricaudis

Boidae
  Liasis childreni

ESHELBY ISLAND

The herpetofauna known from Eshelby Island consists of 4 species of geckoes and 4 species of skinks. They are as follows:

Gekkonidae
  Cyrtodactylus pelagicus
  Gehyra australis
  Gehyra sp.
  Heteronotia binoei

Scincidae
  Sphenomorphus brachysoma
  Sphenomorphus punctulatus
  Sphenomorphus tennuis
  Sphenomorphus sp.

BAY ROCK

Only 3 species of reptiles are known from Bay Rock. They are the skinks *Cryptoblepharis* sp. and *Sphenomorphus nigricaudis*, and a python. The last was reported seen by crew members of the Cape Moreton but was not collected.

APPENDIX 5 - BIBLIOGRAPHIES

LIZARD ISLAND BIBLIOGRAPHY

B. Goldman

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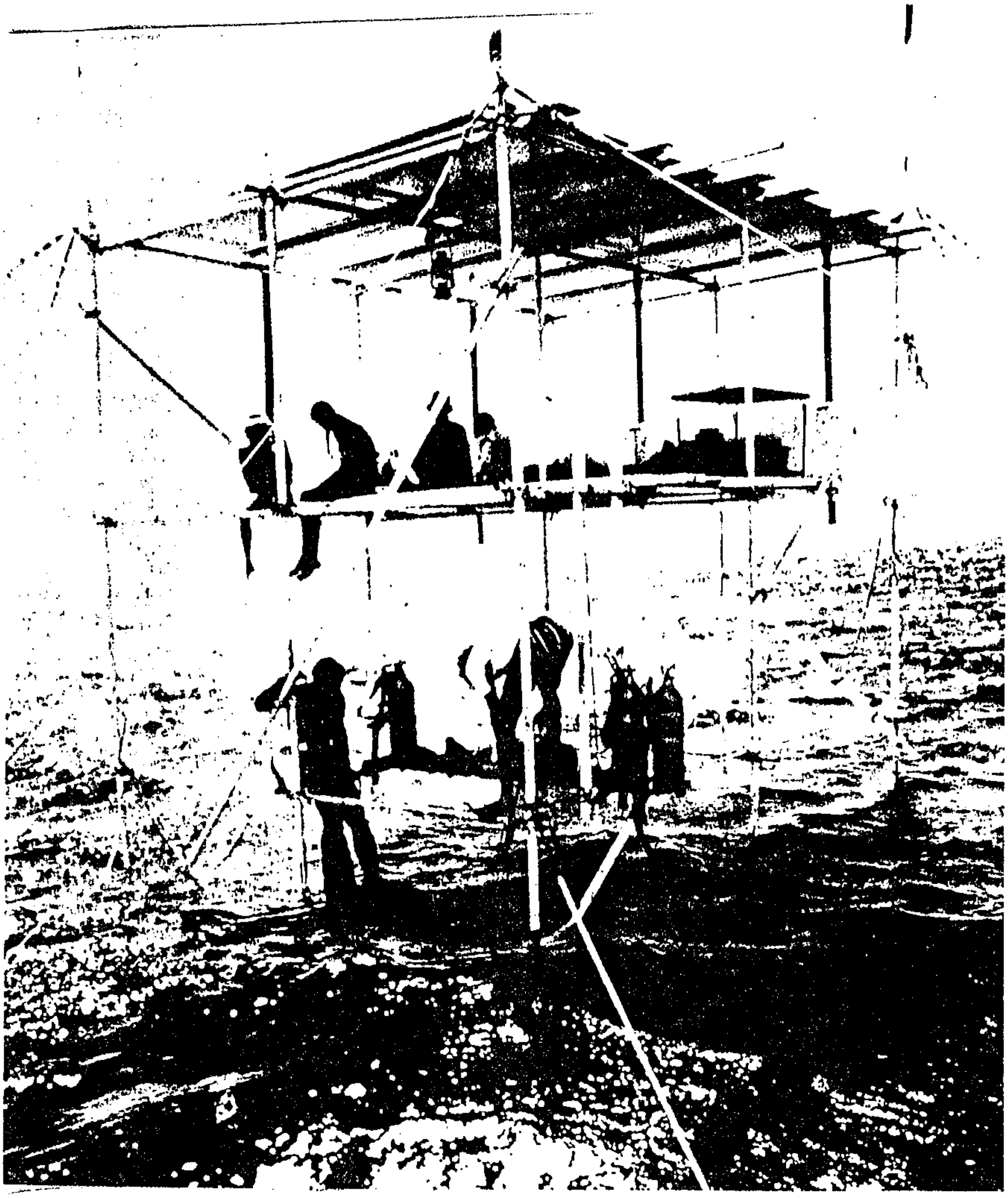

Research platform on the outer Great Barrier Reef erected by the Australian Museum and Macquarie University. The platform is 13 km from the Lizard Island Research Station and it facilitates continuous day and night work without the necessity for a large boat.
(Photo: F.H. Talbot, Macquarie University).

APPENDIX 6 - LEGISLATION RELATING TO THE GREAT BARRIER REEF

	STATE LEGISLATION		FEDERAL LEGISLATION	
Convention etc.	Islands (to low tide)	Territorial Sea and Seabed (3ml)	To 12 mls from low water	Continental Shelf
Imperial Letters Patent 1872	Mining Fisheries, 1957-76[1] Fauna Conservation, 1952-76[2] Native Plants Protection 1930 Forestry 1959-76 Acts Beach Protection Act 1968-72 National Parks and Wildlife Act 1975			
Australian Constitution			Fisheries Act 1952[5]	______
International Conventions on: (a) Territorial Sea and Contiguous zone 1958, and earlier conventions.		Fisheries Act 1957-76[1]		
(b) Fishing and Conservation of Living Resources 1967		Forestry Act Amendment Act 1971[4]		
		Petroleum Submerged Lands Act 1967	Petroleum Submerged Lands Act 1967	
(c) Whaling, 1948		Whaling Act, 1960		
(d) Continental Shelf 1968		Continental Shelf (Living Natural Resources) Act 1968		
		Seas and Submerged Lands Act 1973		
		Great Barrier Reef Marine Park Act 1975		
		National Parks and Wildlife Service Act 1975		
		Australian Heritage Commission Act 1975		
		Historic Shipwrecks Act 1976		

ADDITIONAL LEGISLATION, NOT DIRECTLY RELEVANT TO THE WORK OF THE AUTHORITY

FEDERAL

Lands Acquisition Act 1955
Customs Act
Immigration Act
Quarantine Act
Merchant Shipping Act
Lighthouses Act 1911-73
Navigation Act 1912-73
Marine Pollution Convention
Quarantine Act
Pollution of the Sea by Oil Act 1960-73
Pollution (Shipping Levy) Act 1972
Pollution (Shipping Levy Collection) Act 1972
Beaches Fishing Ground and Sea Routes Protection Act 1932-66
Submarine Cables and Pipelines Act 1963-73

STATE

Queensland Marine Act 1958-75
Torres Strait Islanders Act 1971-75
Aboriginal Relics Preservation Act 1967-76
Aborigines Act 1971-75
Harbours Act 1955-76

FOOTNOTES

1. The State Fisheries Act protects: Marine mammals, fishes, turtles, crabs, prawns, crustaceans, molluscs, sponges and corals; and by Order-in-Council all fauna in certain protected areas, and shell grit.

2. The State Fauna Conservation Act protects: butterflies, mammals, reptiles, birds; and all fauna in declared Fauna Sanctuaries, Refuges and Reserves.

3. The State Forestry Act protects: All fauna in National Parks; and all State Forests are Fauna Sanctuaries; frogs are also protected in Timber Reserves and State Forests as a Forest Product.

4. The State Forestry Act Amendment Act: Makes provision for proclamation of Marine National Parks in which fish are defined as a forest product, etc. The Fisheries Act operate notwithstanding any provisions of the Forestry Act, i.e. where fishing is allowed in National Parks.

5. The Commonwealth Fisheries Act regulates exploitation of: "fish" including turtles, dugongs, crustaceans, molluscs (except those proclaimed under the Commonwealth Continental Shelf (Living Natural Resources) Act 1968).

6. The Commonwealth Continental Shelf (Living Natural Resources) Act - in the Queensland Division of the Australian continental shelf, regulates exploitation of: corals (living only), holothurians, sea urchins, bivalve molluscs, gastropod molluscs belonging to sedentary species. Tridacnids, tritons and helmet shells are completely protected against exploitation by all persons for any purpose.

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