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CONSERVATION AND USE
OF THE
CAPRICORN AND BUNKER
GROUPS OF ISLANDS
AND CORAL REEFS

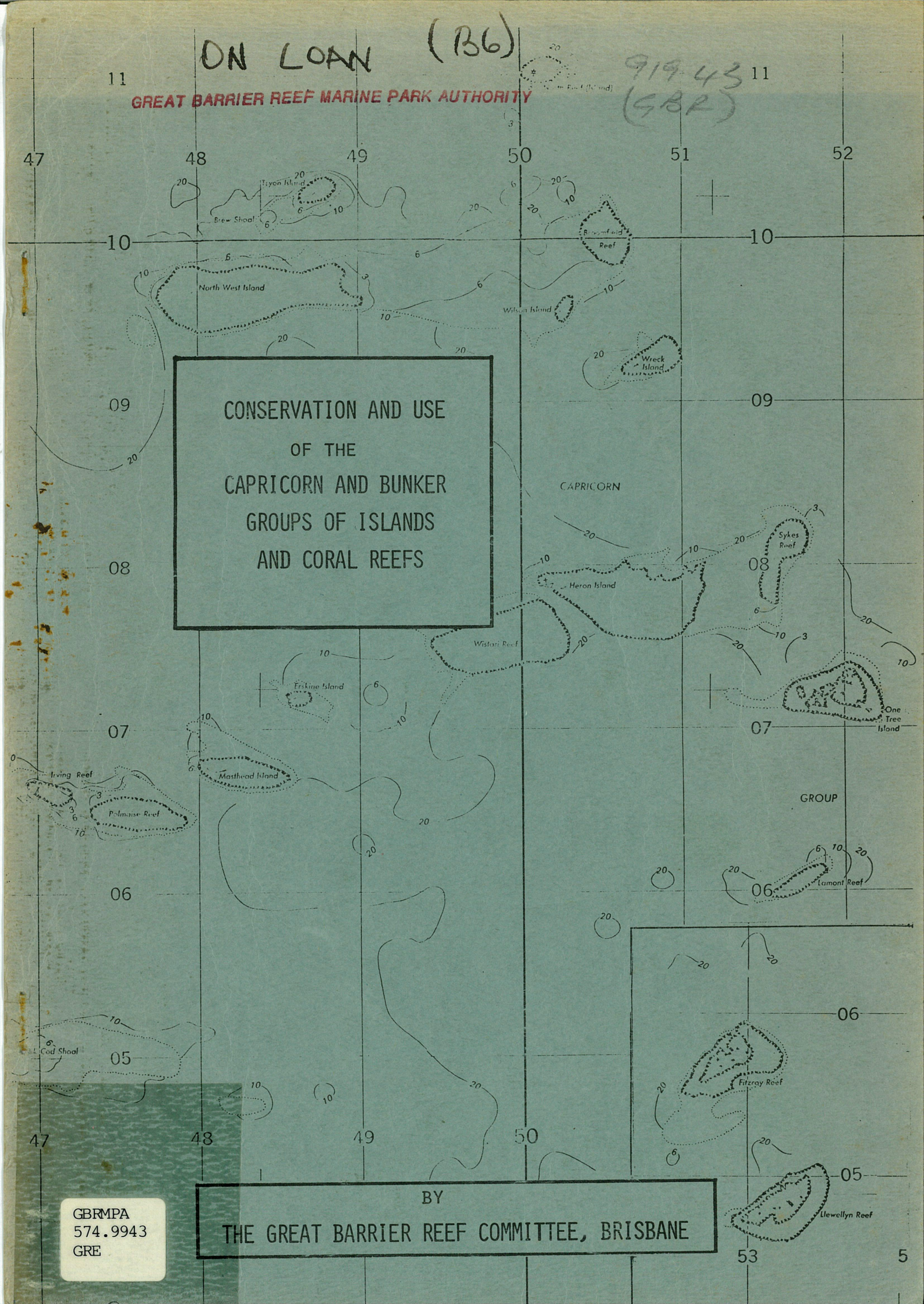
CAPRICORN

GROUP

BY

THE GREAT BARRIER REEF COMMITTEE, BRISBANE

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CONSERVATION AND USE

OF THE

CAPRICORN BUNKER GROUP OF ISLANDS

AND CORAL REEFS

An account of past uses and their impact, with
recommendations for future use and its regulation.

by

The Great Barrier Reef Committee

The individuals whose names are set out below have contributed directly to the preparation of this paper. It is largely based, however, on the accumulated knowledge of the area that has developed through the work of many, over many years

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CONTENTS AND SUMMARY

	<u>Pages</u>
I. INTRODUCTION - Purpose of submission - Wildlife values to be reconciled with traditional uses - Summary of historical uses - Ecological interdependence of the area	1-2
II. RESOURCES a. Vegetation - Scientific Resource - Shelter and food for fauna that is essential to cycle nutrients and fertilise sands; prevent erosion - Cycling of nutrients - Aesthetic, recreational, shelter for visitors b. Turtles - One of 3 most important world rookeries - Endangered species - Food resource - Observation and study of rare wild life phenomenon; relict breeding habit - Hatchlings form food for birds (merging of marine terrestrial components of ecosystem) c. Birds - 30% of known important breeding sites in the Great Barrier Reef - Transfer nutrients from the sea to fertilise land (merging of marine and terrestrial components of ecosystem) - Transfer seeds from island to island for colonisation and gene flow - Breeding behaviour and occurrence disturbed by man	3-8

Pages

II. RESOURCES (Continued)

3-8

- d. Coral Reefs
 - Diversity
 - Aesthetic properties
 - Scientific resource for studies on diversity, stability, evolution, etc.
 - Biologically active molecules of pharmaceutical interest
 - Fishes
- e. Commercial Fishery
 - Reef-related fish insignificant part of catch and not a major resource
- f. Recreation
 - Wildlife resources (vegetation, birds, turtles, coral reefs, fishes)
 - Beaches, waters

III. PRESENT USERS AND THEIR IMPACTS

9-17

- a. Private Boats
 - Anchoring damaging to corals
- b. Charter Boat Users
- c. Campers
 - Nutrient balance, diet and habitat of terrestrial fauna disturbed by garbage, body wastes, firewood
 - Reefs and biota affected by collecting, fishing, walking
 - People disturb nesting habits of birds
- d. Day Visitors
 - Garbage, use of firewood, shell collecting
- e. Hotel Tourists
 - All impacts of campers
 - Introduced fauna (rats, cockroaches, hens, peacocks, etc.) affecting native fauna, habitats and diet

Pages

e. Hotel Tourists (Continued)

- Vegetation removed for paths, roads, buildings, paved areas, rubbish dumps, freshwater and septic tanks affecting ground and tree nesting and increasing wind penetration and erosion
- Walking on dune areas causes erosion
- Walking around cays drives off migratory birds and waders
- Turtles and their nests and nesting areas disturbed, hatching disturbed by lights
- Garbage, scraps and promiscuous feeding alter feeding habits and species composition of populations both on the cay and in garbage dumping areas at sea
- Walking on reef and taking of live specimens disturbs localised areas
- Construction of harbour causing critical changes to reef drainage and sedimentation
- Desalination and septic tank effluent may affect reef

f. Research workers and students

- Impact includes that of hotel tourists where permanent dwellings are involved
- Importance of education
- Some disturbance to reefs from walking, turning over rocks in localised areas. Less disturbance from artificial reefs, pegging quadrats etc.

Pages

- g. Professional Fishermen
 - Principally pelagic fishery
- h. Sports Fishermen
 - 1. Line Fishermen
 - Reduction in size and in size/age structure of populations
 - Reduction predator pressure on prey of fished species and consequent reductions in diversity
 - Reduction in population size of other dependent fishes and invertebrates
 - 2. Spear Fishermen
 - All impact of line fishing
 - Introduction of human predator and consequent avoidance behaviour of certain species; selective fishing of those species that do not adopt such behaviour
 - Not recommended
- j. Amateur Shell Collectors
 - Affects populations in accessible areas
 - Not recommended
- k. Professional Shell Collectors
 - Possible effects of depletion of populations from certain areas by dredging, scuba diving
 - Not recommended
- l. Other Uses
 - Naturalists
 - Bird Watchers
 - Photography
- m. Recommended Uses

Pages

IV. CRITERIA AND CATEGORIES FOR ZONING

18-24

- a. Minimum Impact
 - Cays and reefs maintained in primitive condition for non-manipulative research and protection of flora and fauna
 - Regulation
- b. Controlled Impact
 - Cays and reefs maintained in near primitive condition for manipulative research and protection of flora and fauna
 - Regulation
- c. Moderate Impact
 - Cays and reefs no longer primitive but maintained in natural condition for visual enjoyment and recreational activities
 - Regulation
- d. Maximum Impact
 - Cays and reefs no longer primitive and with natural values impaired for visual enjoyment and recreational activities, research and education
 - Regulation
- e. Summary Guidelines for Regulations
 - Commercial activities; firewood, interference with vegetation; direct interference with terrestrial fauna; mechanical interference with reefs or cays; interference with reef fauna; anchorage; monitoring; education

Pages

V. REEF AND CAY ZONING - RECOMMENDATIONS 25-33

- a. Islands and Reefs with Suggested Usage - Tryon Island and Reef
North West Island
and Reef; Wilson
Island and Reef;
Wreck Island and
Reef; Erskine Island
and Reef; Heron Island
and Reef; One Tree
Island and Reef;
Hoskyn Islets and Reef;
Lady Musgrave Island
and Reef; North Reef &
Cay; Wistari Reef; other
Reefs without cays

b. Summary of Zoning

REFERENCES

APPENDIX I

- Geology of the Capricorn
Bunker Group by
P.J. Davies and
J.F. Marshall App.1-3

I. INTRODUCTION

Coral reefs are a long term and precious resource, and, paramount amongst coral reefs, the Great Barrier Reef is of World Heritage status. The most southerly islands and reefs of the Great Barrier Reef, the Bunker and Capricorn Groups, are one of its most important areas as they are more easily accessible than many others, and traditionally used.

They are also important as the most southerly group of islands of the Indo-Pacific coralline region. Accordingly they may support very many of those biologically important populations that usually occur at the limits of the geographical range of a species where stringent selective pressures confer important genetic characteristics that affect the species over its whole range.

They are extremely high in terms of natural values, including fauna and flora (both terrestrial and marine), recreational (including wilderness) experience, and visual beauty of land and seascape (including underwater). They are under threat by their very accessibility to growing coastal towns, and their closeness to the high population density of the southern Australian east coast.

There is a developing feeling among those who are concerned about our Great Barrier Reef heritage that the Capricorn and Bunker group of islands and reefs need some overall plan for protection and use, as there are signs of deterioration of the area as increasing use is made of it.

This has led the Great Barrier Reef Committee to develop a philosophy and outline plan to aid those many Government Departments, State and Federal that bear direct responsibility for the control of the islands and reefs and the waters that surround them. The following is offered after much thought and co-operative effort by the Great Barrier Reef Committee.

Although some of its resources have been, and continue to be, used commercially, its wild life values first attracted the attention of visiting naturalists. These wildlife values remain high, and represent the basic resource of the area, both for visual and recreational pursuits and also as a scientific resource and a source of protein and pharmaceutical products. The criteria and guidelines that follow are based on the management requirements that would reconcile the protection of its wildlife values with these traditional uses.

The early history of the Southern Great Barrier Reef includes early references by Cook and Banks in their journals, and then a series of important visits by early naturalists on H.M.S. survey vessels. MacGillivray (1852) and Jukes (1847) were together on the H.M.S. 'Fly', accompanied by the cutter H.M.S. 'Bramble', and One Tree Island, Heron Island and Wreck Island were named on this trip (1842-1845) among other cays and reefs (Ogilvie, 1977). Jukes landed on One Tree Island, and was singularly impressed with the consolidated dead coral flat on his first 'coral' island. The 'Beagle' visited the area in 1839 and 'Masthead Island' was named. The 'Rattlesnake' also passed by with T.H. Huxley on board.

Ornithologists (Austin, Cornwall, Le Soueff) began visiting in the early 1900's, and their visits culminated in an expedition to the Capricorns in October 1910, by the Royal Australasian Ornithologists' Union (See Kikkawa, 1976, for ornithological historical references). Masthead Island was used for the base of this expedition and this island and North West, rather than Heron, were used up to 1930 by ornithologists.

One of the earlier uses made of the area was guano mining, and North West Island was mined from 1898-1900. A lease for a turtle soup factory was also granted on North West Island in 1904 to Captain Thomas Owens and taken over by Captain Christian Poulson in 1923 although it was not in operation between about 1914 and 1923. On Heron Island a request for a lease for fishing turtles was refused to Mr. William H. Wilson in 1923, and granted to Mr. L. Marsh in the mid-nineteen twenties. This concern was taken over by Mr. Percy Friend in 1928.

In 1932 the Heron Island operation was sub-leased to Captain Poulson and he converted the turtle factory to a resort. In 1936 this lease was transferred to him, and although it expired in 1942, and no further lease was made because of the war, the resort remained, and has slowly grown to its present size.

In 1950 the early and continuing scientific use of the area culminated in the application by the Great Barrier Reef Committee for a lease of 5 acres for research, and the station has operated continuously since 1951 and become internationally known. Scientific activities spread to One Tree Island when a field research station was established there by the Australian Museum in 1966.

Marine areas have a number of fundamental ecological characteristics which affect management. In the case of coral reefs, a majority of the fauna have a floating larval stage, and an area like the Bunkers and Capricorns cannot be subdivided for such species. Nor is the extent of its interdependence with the remainder of the Great Barrier Reef to the north and east known. Larvae, floating for days or weeks, well may be drifted around all the reefs in such an area and beyond, with tidal and wind derived currents. A significant portion of the fauna has attached eggs, or parental care or viviparous development that often reduce the length of time that juveniles are free to drift. These species exist in populations that are more isolated from those on even nearby reefs, with little genetic mixing between them. Under these circumstances the careful management of each reef becomes critical since each may be a necessary link in the chain of recruitment that maintains genetic vigour of the species along the whole length of the Great Barrier Reef.

The Bunker/Capricorn Groups are, however, geographically separated from the remainder of the Great Barrier Reef by the Capricorn Channel. This makes their management as a unit appropriate from the administrative point of view. It is appropriate also from an ecological point of view as

long as its biological links with the remainder of the Reef are recognised. Marine management, with its associated monitoring, must be of the area as a whole, whatever zones, permanent or periodic, are determined for its control.

II. RESOURCES

Vegetation on Cays

The vegetation includes: grasses (Thuarea, Cenchrus, Stenotaphrum, Lepturus), vines (Vigna, Ipomea), succulents (Sesuvium, Portulaca), herbs (Cakile), shrubs (Messerschmidia, Scaevola) and forest (Pisonia trees up to 60 ft., Pandanus, Casuarina) (From Heatwole, 1976).

As pointed out by Heatwole, "coral cays can be logically considered not only as a product of the reef, but as an extension of the reef ecosystem." The vegetation of each cay is of intrinsic interest, and there are transitions from the smaller to the larger cays. It is better studied than in most areas. The dynamics of the flora (recruitments and losses) have been studied over a long period (e.g. Longman, 1914; MacGillivray & Rodway, 1931; White & MacGillivray, 1926; Cribb, 1965-1972; Heatwole, 1971, 1976). The work of Heatwole and his associates has yielded significant information on island biogeography. The vegetation is, therefore, an important scientific resource.

The vegetation is also essential to the conservation of the islands, since without it, the sands of which they are formed would quickly erode. There is an intimate relationship between the vegetation and the sea birds (which it shelters and protects) that rest, roost or live on the island. Its maintenance is vital to their continued existence on the islands, and their existence there is vital in transferring nutrients from the sea to fertilise the vegetation, to colonise the cays with plants and maintain gene flow between otherwise isolated populations. The vegetation, together with the other animals that live on the island, and for which it provides shelter and food, also plays its part in cycling the nutrients. In a recreational sense the vegetation is important. The cool deep green interior of the Pisonia forests, the wild low shrubs of the smaller cays, the succulent mat around One Tree Island pool - all these are an integral part of the beauty of the islands, and are one of the reasons why they are used.

Turtles

Four species of turtles occur in the Capricorn/Bunker area, the Green Turtle, the Loggerhead Turtle, the Hawksbill Turtle, and the Leatherback Turtle. Of these the first three are particularly associated with the reef system (Bustard, 1974), and the Green and Loggerhead Turtles have major nesting sites in the area.

The Green Turtle is circumtropical in nesting distribution and populations have declined in most countries this century. The Great Barrier Reef supports the largest breeding stocks of Green Turtles in the world today, and the Capricorn/Bunker groups constitute one of the four major breeding grounds for the species in northern and eastern Australia. In the Capricorn/Bunker area North West Island supports the largest breeding aggregation of Green Turtles (several thousand females per season). Heron Island has about 500-700 Green Turtles breeding each summer, but numbers vary considerably (1100 in 1974/75, 21 in 1975/76) (Heatwole, Cogger and Limpus, unpublished).

Bustard (1970) considers there are only 15 Green Turtle rookeries left in the world, five of which are in Queensland, and the Capricorn/Bunkers form one of these.

The Loggerhead Turtle is a more temperate nesting species and occurs in all tropical and warm temperate oceans. In eastern Australia its breeding is almost entirely confined to the southern Great Barrier Reef and the adjacent mainland coast between Bustard Head and Bundaberg. The Capricorn and Bunker groups are the most important breeding ground for the species in eastern Australia, and there is a small mainland site at Mon Repos, near Bundaberg. Wreck Island is the most important breeding ground (over 1000 females some seasons) followed in importance by Masthead Island. Heron has a few Loggerheads each year (Heatwole, Cogger, Limpus, op. cit.). Bustard (1970) considers the Capricorn Bunkers to be one of the three most important world nesting sites.

It is clear from known work that the Capricorn/Bunker groups are of the utmost importance as feeding and nesting areas for the Green and Loggerhead Turtles. They are essential for the maintenance of adequate populations of these species. If these species should be lost in this area, this would be a significant loss to both species in a world sense. Turtles are part of the marine ecosystem. Their existence on these islands provides man with an opportunity to study and observe this unique wildlife phenomenon. Turtles are an important part of the diet of local communities in many parts of the world. Their hatchlings at certain times of the year comprise the prey for certain sea birds and this, too, is one of the means by which the sea and land merge in this ecosystem.

Birds

The birds of the Capricorns and Bunkers form one of their most characteristic features. Visitors to the islands can live close to nesting White-capped Noddy Terns and Wedge-tailed Shearwaters, and (together with nesting turtles) this may add greatly to the satisfactions they derive from a visit to the cays. These two bird species nest in abundance in the area (17,000 Noddy Terns and 16,600 Shearwaters estimated to nest on Heron Island by Shipway, 1969). The birds are also critical to the conservation of the cays since they are the agency by which the nutrients are transferred from the sea to the land. They are the means by

which the sands are fertilised to support the vegetation which binds them together. They are also the agents which transport seeds from island and island, to maintain the gene flow and genetic vigour of otherwise isolated populations and to colonise newly developed sandcays with stabilising vegetation.

Lavery and Grimes (1971) investigated 78 islands, and listed Masthead, One Tree, North West, and Wilson Islands as four of the nine islands known to be most important for breeding seabirds on the Great Barrier Reef. Of the other 14 important islands they include Lady Musgrave, Fairfax, Hoskyn, Tryon and Heron Islands.

The Capricorn/Bunker group include over 30% of known important breeding islands on the Great Barrier Reef.

Six tern species commonly breed on the Capricorn/Bunker cays, and Table I shows the importance of these islands over the whole Great Barrier Reef.

TABLE I: Number of nesting colonies of terns on the Great Barrier Reef and the number of these that occur in the Capricorn/Bunker Group. Number of the major colonies of each species of tern that occur in the Capricorn/Bunker Group. Percentages are in parentheses.

SPECIES	Number of Colonies		Number of Major Colonies	
	On G.B.R.	In C/B Grp.	On G.B.R.	In C/B Grp.
Black-naped	28	6 (21%)	7	2 (29%)
Roseate	11	5 (45%)	3	1 (33%)
Bridled	34	8 (24%)	15	5 (33%)
Lesser Crested	11	3 (20%)	4	0
Crested	23	6 (26%)	6	3 (50%)
White-capped Noddy	18	6 (33%)	4	4 (100%)

(from Kikkawa, Elvish, Grimes, pers. comm.)

From the Table it can be seen that all major White-capped Noddy breeding sites are in the group, 50% of all major sites of the Crested Tern, and 45% of all colonies of the Roseate Tern. For all six species the area is important.

Many other birds are found on the cays including, sometimes, Sea Eagles and Ospreys. One nest on One Tree Island described by J. Beete Jukes, naturalist on the 'Fly' is now some 10 ft. high, and Sea Eagles have been seen on it, though not nesting, in the last decade. Over 50 species of birds have been found on Heron Island, 30 of which occur regularly. Kikkawa (1976) has given a full account of the birds.

The reason for the great importance of the Capricorn/Bunker Groups is that of all the many high islands on the Great Barrier Reef only three are chosen as major nesting sites for sea birds, all the remainder are coral cays. Thus 30% of the 33 important breeding sites on the Great Barrier Reef lie in the Capricorn/Bunker Groups. Therefore for the continuance of this rich and varied avifauna in its present state on the Great Barrier Reef, the breeding activities on Masthead, One Tree, North West, Wilson, Lady Musgrave, Fairfax, Hoskyn, Tryon and Heron Island must be protected.

The birds of these cays have a critical role and are a most important resource, which (for many species) is affected by the mere presence of man in numbers - a fact of primary importance in their management.

Coral Reefs

The coral reefs of the area are diverse in species, rich in underwater shape and form the primary structure and recreational resource of the area. The fauna and flora is a true coral reef fauna with all that the statement implies - in every pool, under every dead coral boulder, often lying on the open reef flat are shellfish, echinoderms, fan worms, corals and other living forms of varying hues and shapes, to delight the eye and provide interest for the child or adult. The fish fauna is bizarre and colourful, with 870 species known from the area (Talbot et al, unpublished). Underwater are rich beds of coral visually as fine as found anywhere in the world. Cliffs, gutters (spurs and grooves), caves, holes, huge coral bombies - the underwater scenery is of high quality. It is probably true to say that the majority of all photographs of underwater scenery and underwater life published in the recent spate of books on the Great Barrier Reef are taken from this area. The reefs of the Capricorns and Bunkers are the southernmost limit (apart from Lord Howe Island) of the great Indo-West Pacific centre of marine faunal diversity - by far the world's richest. There are an even greater number of species as one moves northwards. This species diversity is the property of the coral reef zone rather than the latitude, since these great assemblages of species do not occur on the rocky outcrops of nearby Fraser Island.

This diversity resulting in the diversity of shapes, colours and movement that provides satisfactions for the viewer represents a traditional resource, that is most important at this southern limit, owing to the accessibility of the area. There is only one other place on the Great Barrier Reef (Green Island) where visitors may live in a hotel on a true coral cay, formed solely by its surrounding coral reef.

The diversity of biota associated with a coral reef is also important as a scientific resource. Scientists are far from understanding the relationships between the components, the dynamics of the ecosystem and the strategies that have evolved to enable this density and diversity of species to co-exist. The solution to many problems regarding stability in natural ecosystems and how they must be managed in order to maintain their productivity must be solved here in one of the most complex that is known. Again, the accessibility of the area confers it with a paramount importance as a resource.

The coral reef biota is also an important scientific resource for studies that will improve the understanding of living processes and of the chemical and physical devices that have evolved. The biologically active molecules that exist in coral reef organisms have already attracted the attention of pharmacologists because of their clinical properties and are an example of the ways in which scientific understanding of coral reefs have a direct application.

Commercial Fishery

Line fishing (See section III, h(1) below) seems to be the major reason for chartering boats, and is also an important activity for many who visit Heron Island, or camp on islands in the group. From what personal observations and discussions we have had, the Capricorn and Bunker reefs themselves are not important for commercial fishes although some line fishing is done there.

Gladstone handles 94,000 kg. of fish in the round, which is 2.3% of the Queensland catch, but the commonest species (Mackerel, Kingfish, Mullet, Estuary Salmon, Barramundi) are pelagic fish, or not fish taken on coral reefs. Thirteen fishing boats are registered, and although many visiting boats land catches, this is chiefly for prawns, scallops and mackerel and not for benthic reef fish. These Gladstone registered fishing boats do fish the reefs of the Capricorn Bunker groups, but also range beyond. We have no indication of the percentage of catch taken from the reefs in question. Yeppoon has much the same size catch (81,000 kg.) and Bundaberg lands 264,000 kg. Some of the fishing effort of these two centres may be spent in the area. Reef fish are however a small part of the catch, and the effort is apparently low on the Capricorn/Bunkers. Coral reef fish from the area do not seem to constitute a major commercial resource.

Recreation

The wildlife resources described above (vegetation, birds, turtles, coral reefs, fishes) are used primarily in a recreational way, and form the basis for the human interest in the area. To these must be added beaches for sun baking, clear water for swimming, and a moderate climate

whose fine weather period (October-January) coincides with the major long summer vacation. In the rest of the year winds are usually fresh, but the climate is still excellent, but less safe for small boats. There is little commercial activity clashing with recreational. The long term future of the reefs and cays is clearly recreational, and this pattern has already been set.

III. PRESENT USERS AND THEIR IMPACT

a. Private Boats

An increasing number of families, either from Gladstone, or with trailed boats from elsewhere, are using their craft to go into the Capricorn/Bunker groups for camping and fishing. About 1.5 thousand boats are registered at Gladstone. The impact of these boats is primarily transport (and the uses of their occupants are listed below) but anchoring in shallow restricted areas has considerable impact and damages the reef, especially in much-used locations, adjacent to settlements and near islands where safe and accessible anchorage is available. Davis (1977) working at Dry Tortugas has estimated that 50% of the coral cover in a 220 ha. area has been damaged by anchors dragging across the corals.

b. Charter Boat Users

The charter boat is now an established business in Gladstone and Bundaberg, and these craft take groups, chiefly amateur line fishermen and divers (including spear fishermen), but also campers, shellers, sports fishermen and others, to the islands and reefs of the Bunkers and Capricorns. Such boats would make 200-400 2 - 5 day trips/year (fide Harbour staff at Gladstone, Bundaberg and Yeppoon). Their impact is considered under the groups they transport (listed below).

c. Campers

It has been traditional for campers to be taken by fishermen and charter boats, and more recently for many to go in their own boats, to a number of islands. These islands are chiefly used; Masthead and North West Island in the Capricorns, and Lady Musgrave in the Bunkers. We have also known of camping on Wreck Island, and on most other islands.

The impact of these campers, who may number many scores at holiday periods, is considerable, particular problems being garbage, body wastes, and burning of firewood. This latter can rapidly reduce lizard and insect refuges (the lizard population on Wilson Island would disappear if dead wood was removed, and this is the only island with a lizard population not associated with human habitation), removes a source of natural nutrient, and if carried to living trees can drastically damage an island. There is little doubt that the reefs have also been affected by spear fishing and line fishing and shell collecting and that there has been coral damage, owing to boat anchorage and reef walking (see under Hotel tourists, below) but there are no data, either baseline or later monitoring, for assessment.

Campers have also undoubtedly caused introduction of exotic plant species, by seeds associated with food and gear and also introduced insects.

The impact of campers on Masthead Island, North West Island and Lady Musgrave Island, may have another serious result. Masthead Island, for example, is one of ten islands in the whole Great Barrier Reef where Lesser Crested Terns nest (Kikkawa, Elvish and Hulsman, pers. comm). In both the nesting and non-nesting period the effect of people on birds is disturbing, and terns are particularly susceptible to disturbance by humans. The Masthead Island population of Lesser Crested Terns must therefore be considered at risk. Lavery and Grimes (1971) list Masthead Island and North West Island among the nine most important islands for breeding birds in the Great Barrier Reef, and include Lady Musgrave among the fourteen other important breeding islands. Thus all three camping islands are 'important' or 'most important' breeding sites. (See separate section on birds, II.)

Camping is an important activity in the area, making the satisfactions that are available through direct contact with the wildlife and recreational values of the area available to a wide range of individuals in the community.

d. Day Visitors

Day visitors picnic on most of the cays. Their impact is not as great as that of campers, garbage, some body waste, use of firewood and collection of shells being their principal impact. More often, however, day visitors will remove their garbage with them. It is an important activity, making direct contact with the wildlife and recreational values of the area available to a wide range of people from all sections of the community. It is also a use that causes a minimum of impact on the ecosystem.

e. Hotel Tourists

At present only Heron Island has a hotel business in the Capricorn and Bunker Islands. This can cater for approximately 180 guests and staff may number up to 50. This is an important resort on the Great Barrier Reef, having been in operation continuously since 1932. It is also one of the two resorts on a coral cay, as opposed to mainland type high island.

The impact of the Hotel and its guests on Heron Island has been considerable (but see also Research Activity). A portion of the island has been affected by tree removal and building activity. Dumps of tins and old building material have also made inroads into the forest area.

Peacocks, wild chickens, ducks, parrots, rats and cockroaches have been introduced. Pet dogs have been permitted on the island, as well as, at various times, an Emu and Wallabies.

Introduction of insects, other small fauna, as well as plants, increases with human habitation. For example, an African ant, Pheidole megacephala has been inadvertently introduced to Heron Island and is the only ant on the cay. It has ousted the native ants in the view of Heatwole (1976). Erskine Island, for example, has five native species of ant.

It is the view of Kikkawa, Elvish and Hulsman (pers. comm.) that the absence of surface nesting birds (as opposed to tree nesting White-capped Noddy Terns and Reef Herons and burrowing Wedge-tailed Shearwaters) is due to human impact. The area that has been concreted and the portions of the forest removed for building, paths, roads, fresh water and septic tanks, recreation areas (including tennis courts) have, however, reduced the amount of space available for burrowing nests of Wedge-tailed Shearwaters, and buildings and lights have interrupted their flight paths and disturbed their behaviour.

Tree-nesting birds are also directly affected by removal of the trees in certain areas and by the altered wind penetration that selectively affects those segments of the population that nest in the vicinity of the settlement.

Although human impact is least on the White-capped Noddy Terns, and Wedge-tailed Shearwaters, it is very great and can be disastrous for the rest of the terns (Black-naped, Roseate, Bridled, Lesser Crested and Crested). Excessive walking around cays also sends off local and migratory waders and is important at non-breeding times also. This is considered to be the reason for the lower number of terns and waders at Heron Island.

The Capricorn/Bunker Groups form one of the fifteen major Green Turtle rookeries left in the world (see Turtles, II, above). The Loggerhead Turtle breeds on only two sites in eastern Australia of which the Bunker/Capricorn cays are one. The turtles may be affected by direct interference with nests, by reduction of space available for nesting, and by loss of hatchlings that are attracted toward lights at night. Thus the larger hotel-type tourist operation with its large number of visitors and extensive and well lighted buildings and paved areas may affect the turtle populations. The turtles of both species may have been affected by these and other human induced factors. On Heron Island their primary laying area is now at Sharks Bay, the furthest point away from the resort and the research station. The impact on these populations has not been determined, however.

Garbage and scraps have attracted silver gulls in the non-breeding season, and are likely to have affected the number of gulls there. This would increase predation by gulls on eggs and chicks of sea birds at the nesting period. It is considered that this has occurred (Kikkawa, Elfish and Hulsman, pers. comm.). Increased predation on eggs and chicks also occurs when parent birds are temporarily or

permanently disturbed from their nests by people. Scraps of food left around and promiscuous feeding of birds by people also change dietary habits of the birds and directly and indirectly can affect other reef and terrestrial species (e.g. rails, silver-eyes and herons).

The area of underwater garbage dumping is also affected and the species composition is also likely to have been affected. Sharks are said to be more common where garbage is habitually dumped.

Construction of a harbour has had an appreciable affect on the reef where the deep channel has changed the flow over the reef and altered its drainage pattern and the sedimentation pattern in the immediate vicinity of the harbour and channel. Erosion of the island has also been caused by pedestrian traffic over dunes; and by removal of parts of the forest (changing wind flow patterns over the island).

Other possible effects of the tourist hotel on Heron Island are from septic tank and desalination plant effluents released onto the reef. Where these are onto well irrigated sections of the reef it is possible that the effect is minimal, but this should be investigated.

Walking on the reef is at present unregulated. This will have an impact on the shallow water corals of the reef flat, especially in the area where tourists are regularly taken on "reef walks". Woodland and Hooper (1977) working at Wistari, assessed the damage in an area subjected to traffic as a drop in live coral cover from 41% to 8%. Although the taking of live shells is strictly prohibited at Heron Island, it has been observed that the diversity of molluscs in those parts of the reef that are easily accessible is reduced (P. Frank, pers. comm).

A point that must be made strongly is that the impact of people on the Heron Island reef and cay is not confined to the resort and research station area. It affects the whole of the island, much of its fish and other reef fauna, and also affects Wistari Reef, Wilson Island and its reef and other nearby cays and reefs where tourists from Heron Island are taken on fishing trips and for picnics.

f. Research Workers

One marine research station (Heron Island) and one field station (One Tree Island) are in the area. In addition scientists have studied on other islands (University of New England). The area is now the best known of any in the Great Barrier Reef. Heron Island Research Station has been functioning for 26 years, and One Tree Island has been operated by the Australian Museum from 1966 and by Sydney University from 1975 (11 years). The resultant work of these two stations has made this area one of the

world's significant sources of base-line scientific data on coral reefs. Bench line data is available from only two other locations on the Great Barrier Reef, viz from Low Isles (1927-28 and 1954 expeditions) and Lizard Island (Research Station operated by the Australian Museum). Both of these locations are toward the northern extent of the Great Barrier Reef.

Associated with its research role, the educational importance of the Heron Island Research Station is also considerable. The direct experience of a coral reef as one of the most complex ecosystems that is known is important in the training of students of both biology and geology. Further, "During the last two decades much of the basic research on the reef has been done at Heron Island and more recently at One Tree Island by Australian and foreign post-graduate students attached to Australian Universities. For many of these graduates the inspiration for much of this research has undoubtedly stemmed from their participation in undergraduate field activities in reef waters at Heron Island. The present and projected role of these stations is therefore of paramount importance to the vitality and growth of science education in this country, and for the training of the future custodians of the Great Barrier Reef." (Mather and Talbot, 1975).

The impact of these Research Stations includes the results of merely living at the Stations, and at present 10 people live at Heron Island Research Station permanently with an equivalent of 17 additional people (850 man-weeks in 1976). At One Tree Island there are 2 permanent and equivalent of two additional people (80 man-weeks in 1976).

But in addition the work undertaken has some impact. This impact is likely to be most marked on the reef flat directly in front of the Heron Island laboratory, but as collecting is limited in the Marine Park (Queensland State) area, which includes Heron Reef and Wistari Reef, this impact does not seem to be great. There is visual impact from pegs and quadrats used for marking study areas, and not always removed, and on the section of the reef adjacent to the research station each boulder of convenient size behind the reef crest is probably turned over to observe the encrusting fauna at least once every year by successive parties of students. The reef flat in this area is also subjected to heavy traffic. One Tree Island, with its larger reef area/scientific ratio would show some underwater impact but this would, as in the case of Heron Island reef, be slight and unmeasurable. At One Tree Reef some 1.6m x .6m x .6m concrete block artificial 'reefs' have been placed in the lagoon, and are being used for fish counts.

g. Professional Fishermen

Current fishing boats registered in Gladstone area number 13. Present Gladstone fish landings (1976) amount to 94,000 kg. (We have no boat data on Yeppoon or Bundaberg.) Of these fish landings some species can be said to be reef related, but not much over 15% are resident reef dwellers.

Other fishermen use the area, and fishermen landing fish at Gladstone may fish further afield. But if we assume broadly that each registered boat supports two families, some 50-80 people are directly dependent on fishing in Gladstone.

Where reef-dwelling fishes are involved the impact of this fishery is the same as that of line fishing (below).

h. Sports Fishermen

1. Line Fishing

This has traditionally been the commonest reason for going to the reefs and islands, and still likely to be so. Line fishermen as a user group may be said to have traditional rights. They also are users of Heron Island tourist resort, hirers of charter boats, campers, and owners of visiting boats. In fact this is probably the principal use of the area generally, and exceeds the use by professional fishermen.

It is the use that most affects the reefs without cays, and very often, where charter and private boats are involved the activity may not even involve landing on an island. It does affect the reefs, however, in that anchoring damages coral. Garbage and other effluent released from boats associated with sports fishing are also likely to affect the area. There is also the direct impact on the fish populations.

Anglers talk of some of the nearer reefs as yielding no longer the same size or number of fish. They remove the largest fish, generally carnivores, predators on smaller fishes and also invertebrate predators. There is little doubt that they have an effect on the whole reef fauna.

Recent scientific evidence suggests that line fishing is likely to have a number of effects on a coral reef, and some of these are listed below:

- i. Reduction in population size of the fished species. This would be particularly the case in reef-dwelling species (e.g. coral trout, red emperor). Wide ranging pelagic species with large population sizes would be resistant for longer.
- ii. Shifts in size and age structure of the fished species to smaller and younger fish.
- iii. Reduction in predation on the fished species prey. This could have far-reaching consequences on the composition and diversity of the varied and colourful fish fauna of a typical coral reef. High predation seems important in the maintenance of diversity right through the food chain. Thus

the dynamics of this ecosystem is affected, and population and community structure changed.

- iv. Species which work over unconsolidated sandy areas seeking buried molluscs (e.g. some trevally, spangled emperor) are associated with many smaller fish species who derive food from the disturbed sand areas. Reduction in population size, changes in size structure, and losses of local population in easily accessible areas will affect these associated species adversely.
- v. Faeces of fish droppings on a reef are re-cycled - ingested by corals and eaten by other invertebrates and fishes. The rate of droppings per unit area is high. Bardach (1961) has estimated that 2,300 kgm/ha/year of calcareous material passes through fishes guts. Piscivores, the largest of the fishes and those that are most often caught, are an important source of rich faeces.

The above effects suggest that certain areas must be kept free from line fishing if such reefs are to form natural assemblages or be used for basic data.

2. Spear Fishermen

In the past few decades spearfishing has been a moderately important activity, perhaps getting less so. We reluctantly come to the conclusion that there are strong reasons why this form of activity is incompatible with many other recreational activities.

- i. Spearfishing primarily takes shallow-water reef species, including resident species with home ranges or territories.
- ii. Spearfishing selectively affects those species which remain. There is a marked difference in fish behaviour between places where there is reasonably heavy spearfishing, and where there is none. Humans become predators, and are avoided.

The impact of spearfishing therefore includes both the kind of impacts resulting from line fishing, but it also directly affects those areas where other users might wish to view or photograph, by causing certain fishes to avoid humans and it removes those which remain.

j. Amateur Shell Collecting

Many tourists enjoy exploring shallow water areas and exposed coral reefs for the very great diversity of underwater life. Echinoderms and molluscs, in particular, are picked up and often dried and cleaned and taken home. Some shell collectors almost reach professional status, others have

collections to exchange and discuss with other collectors in clubs. Many tourists enjoy (even if the material is later discarded) the collecting and handling of such natural history material, and this adds to the enjoyment of a reef visit. Living molluscs collected for the purpose of obtaining the shell are killed and very often a large number of specimens are taken.

It has an impact difficult to assess, but is considered to have affected the population of some species, e.g. the Heron Island Volute, the Trumpet shell. Bennett (1971) considers that shellers are able to cause severe damage to a reef flat. Certainly in easily accessible locations much frequented by people, the populations of the more conspicuous molluscs are seriously depleted as indicated above (section 'Hotel Tourists'), many gastropod species are depleted in the vicinity of the Heron Island Research Station and Resort, even though collecting is strictly regulated at Heron Island.

It is possible, even though most gastropod molluscs have larvae that drift in the plankton, and are available for recruitment onto a wide range of reefs, that this type of random recruitment is not sufficient to balance the rate of predation once the adult breeding stock is too much reduced.

Taking of live molluscs, except under permit for scientific purposes, is not an activity that we think should proceed in the Bunker/Capricorn groups, where there is already so much stress imposed on the biota by the other uses of the area that must be accommodated.

There need to be no restriction on collection of shells of dead molluscs.

k. Professional Shell Collecting

We are aware that in some cases very great numbers of shells have been removed from reefs for sale. Collecting techniques have included dredging, as well as large-scale hand collecting, both on exposed reefs and in deeper water with scuba gear.

There are no data that would indicate the present intensity of this use, or its impact. Nevertheless, we believe it is not an activity that should proceed in these waters.

l. Other Uses

Bird watching and naturalists' clubs make occasional use of the Capricorn and Bunker groups. It might be expected that these more sophisticated types of recreation, as well as photography above and below water, will increase. Certainly, literature on these subjects is increasing rapidly, presumable in response to demand.

m. Recommended Uses

The following uses should be accommodated in future plans for the area. They include all traditional and present uses except spearfishing (which is not recommended). Professional or amateur collecting of live molluscs for their shells is not recommended, nor is it recommended that licenses for commercial collecting of coral in the area be available. Where visual enjoyment is referred to it includes swimming, photography, scuba diving and bird watching and any other activity that is passive and has no affect on the environment. The groupings of uses are considered compatible or historical (Heron Island)

1. Cays and Reefs in primitive condition for non-manipulative research only and protection of fauna and flora (including birds and turtles).
2. Cays and Reefs for manipulative research (one only recommended - One Tree Island and reef).
3. Cays and Reefs for camping, line fishing (some areas protected), boating and visual enjoyment.
4. Cays and Reefs for day visiting, line fishing (some areas protected), boating and visual enjoyment.
5. Cays and Reefs for hotels and resident visitors, research and education, line fishing, boating, visual enjoyment (including glass bottom boat viewing), other recreational activities (e.g. tennis), commercial activities (boat hire, shop). (One only recommended - Heron Island and reef).

IV. CRITERIA AND CATEGORIES FOR ZONING

Any concept of zoning should attempt the following three things:

1. Protect the traditional 'rights' of current users and reconcile these with those attributes of the reefs and cays that are relevant.
2. Protect the wildlife values, above and below water, of the area.
3. Leave as many options open for future generations as possible, i.e. make as few irreversible decisions as possible.

We believe present relatively unregulated uses are overpressing the cays, and in particular their vegetation, bird life and delicate nutrient balance (through disturbance of populations, garbage input and dead wood losses) are being permanently damaged. Underwater and between the tides damage is difficult to measure, but it is likely that some shellfish, reef-surface corals and fish populations are affected. Regulation is therefore urgently needed.

The following are important criteria in the conservation of the area:

a. Minimum Impact

Cays and/or Reefs maintained in near primitive condition for non manipulative research and protection of fauna and flora.

Some reef area or areas should remain in a primitive condition, where man has minimum impact. Such an area or areas will serve as reference points for our understanding of the coral reef ecosystem, and are important both for understanding impact on other areas (and to aid maximum sustainable yield) and to permit baseline studies to aid reef management. On largest islands and outside breeding seasons some day visiting could be allowed.

Regulation

Activity restricted to scientific research that does not affect living or non-living components of the reefs or islands. Visits should be carefully regulated to minimise impact. No forest clearing or permanent buildings should be allowed, no firewood to be burnt, garbage and body wastes to be removed, no visitors in nesting seasons or on small cays. Notice that this is the highest protective category.

b. Controlled Impact

Cays and/or Reefs maintained in near primitive condition for manipulative research and protection of fauna and flora.

Areas which are close to primitive but where research activity is permitted with some impact on the environment. In some research it is essential to experiment with the reef to understand it. Examples are: geological drilling to learn its history; collection of animals to undertake taxonomic work; or removal of a community from a reef area to understand the recruitment process. The impact on the environment that is caused by the research should be strictly controlled to maximise the value of the observations that are made here. Impact on a resource that is of high value should be avoided.

Regulation

Activity restricted to research of the kind described, no major constructional work (restricted to accommodation necessary for scientific monitoring), no forest clearing to be allowed, no firewood to be burned and body wastes and garbage to be removed, no live biota to be taken except for designated experiments, no visitors. Fishing is not permissible.

c. Moderate Impact

Cays and/or Reefs no longer primitive but maintained in a natural condition; for visual enjoyment, recreational activities.

Areas include those in which the past uses have caused impacts which have affected the primitive values. Secondary growth and generation, however, preserves their 'natural' condition. Such areas can accommodate uses that cause impact but do not affect these 'natural' values. The use of these locations as a recreational resource is important. Research is not a primary use to which they should be put, since this would also impair their natural condition that contributes to the satisfactions available to those that visit them. Impact on any resource that is of high value should be avoided including restrictions during nesting seasons. Where a cay is small and camping could cause pressure on the island and its vegetation, day visiting only should be allowed. It is also these reefs and islands that provide shelter for private and charter boats and their occupants that use the area for fishing and other recreational activities. Access to these reefs and islands is a factor that should be taken into account in determining the use to which they should be put.

Regulation

Day visitors and camping. Line fishing to be allowed outside restricted protected locations, no permanent buildings, no major constructional work, no forest clearing, no firewood to be removed, garbage to be removed, generally no taking of living biota other than fish by line and for food. Camping should be by permit and in restricted locations and arrangements made for removal of body wastes. Anchorage should be controlled and moorings should be provided.

Islands and reefs that are zoned in this category will require supervision and for this reason should not be remote or widely separated.

d. Maximum Impact

Cays and/or Reefs no longer primitive, and with natural values impaired; for visual enjoyment, recreational activities.

Areas in which past uses have impaired the primitive condition, and where constructional work on the island and the reef (including the erection of permanent buildings) have impaired the natural values have an important recreational function.

Certain types of research can proceed from these locations, but since they are principally for people, certain manipulative work could not easily proceed under controlled conditions. Further, such manipulative research that would be likely to affect the diversity that may be seen on parts of the island and on the reef and that would impair its aesthetic qualities should not proceed except in localised areas and under strict regulation. Impact on any resource that is of high value should be minimised.

Since the primitive values are alienated by the operation of a hotel, it is economic in terms of wildlife and other resources, to confine residential development to the same island. Under these circumstances a larger resident scientific establishment is possible than it would be if primitive values had to be preserved.

Educational activities and interpretive facilities for tourists are both important activities that can proceed with the operation of a research facility with resident staff.

There is radical interference with animal and plant life in certain parts of those islands and reefs that are subjected to maximum impact. Efforts must therefore be made to regulate this impact, and to protect other parts of these areas in order that:

1. Any characteristics of the populations or communities that are endemic to the island or reef can be preserved;
2. The role of the island or reef in the dynamics of the whole area can be maintained and factors relating to the interdependence between it and other units of the system are preserved;
3. That populations of the biota remain viable and play their part in the dynamics and conservation of the cay and reef;
4. The diversity of biota that provides for visual enjoyment is available to those who visit the island;
5. The wildlife values of the area are preserved for the satisfaction of those visiting.

Regulation

Activities include Hotel tourists and research, education, and recreational activities. Line fishing should be allowed, although it should be prohibited in special areas where fishes can be tamed and viewed at close quarters. Removal of forest, building of accommodation, service and recreational facilities should be allowed. Parts of the island and reef must be set aside and left in their natural state. Removal of biota allowed only under license for research.

e. Summary Guidelines for Regulations

A study of past use and its impact suggests that regulation of the following activities will need to be implemented to satisfy the criteria for zoning (set out above). The regulations of these practices will concern State Authorities where land above the low tide mark is involved (1-6, 13), and the Great Barrier Reef Marine Park Authority where they relate to reefs and surrounding waters below the low tide mark (7-13).

1. Commercial activities - since the hiring of boats, shops etc. do affect the natural values of an area, these should be allowed in maximum impact areas only.
2. Firewood - since removal of wood from islands results in loss of habitat and nutrients, this should not be removed from, nor moved in, any location at which primitive and natural values are to be maintained, except in controlled impact areas for designated experiments under the strictest control.
3. Interference with vegetation - since clearing or felling of trees, shrubs and cutting of grass destroys habitats, food, and causes erosion, this should not be allowed in any areas where primitive or

natural values are to be maintained, except in controlled impact areas for designated experiment, under the strictest control.

4. Direct interference with terrestrial fauna - since collection or removal of fauna for any purpose can result in reduction in population size or composition of the organisms directly affected and of other organisms indirectly associated, this should be prohibited in all areas except where introduced species are involved, and for specific research experiments under strictest control (but not in minimum impact areas). Special provisions protecting fauna must be available in breeding seasons.

5. Indirect interference with terrestrial living biota - since this can occur, merely by presence of people, it is difficult to control. However regulations for management must include:

Moderate Impact Areas:

- i. camping by permit only; in restricted locations.
- ii. building of fires in restricted locations (preferably in fireplaces, and on beaches).
- iii. no electric lights.

Maximum Impact Areas:

- i. pedestrian traffic should be restricted to pathways.
- ii. forest removal and buildings and their location should be carefully planned to minimise impact on fauna and reduce dangers of erosion.

In all areas arrangements for removal of garbage and body wastes should be stringently supervised, and promiscuous feeding of native fauna or the introduction of non-endemic plants or animals should constitute an offence.

Seasonal management of islands during turtle and bird nesting periods is also important and on minimum and controlled impact areas access should be restricted during the nesting season. Some restriction of access to specially protected locations may be necessary in maximum and moderate impact areas to protect parts of the breeding populations and maintain the wildlife values of these islands.

6. Mechanical interference to cays and other activities that cause mechanical damage should be prohibited except in maximum impact areas where it can be shown that there is a need and that permanent damage will not be caused (e.g. harbour construction). Beach rock should never be removed, pedestrian traffic on sand dunes should be avoided as should the removal of trees from dunes (even in maximum impact areas).

7. Destruction of parts of the reef for any purpose is a dangerous practice, and can in some instances result in escalating damage. It should be prohibited at all locations except in maximum impact areas where access at all states of tide becomes essential. Where channel and harbour or other construction does become necessary, it should only be done after full investigation of the hydrological and sedimentological regime in the area has been completed (Appendix I, p.2 (a), perturbation of sediment transport system). The construction of the Heron Island access channel and harbour without regard for the sediment transport across the reef is causing sediment choking of reef flat and localised changes in the fauna.

8. Anchorage - since damage to reefs can result from anchoring boats on reef flats, lagoons and slopes, especially where safe and accessible locations result in heavy use, moorings should be provided and their use made obligatory. Moorings and anchorage on the windward side of reefs is especially destructive (see Appendix I).

9. Interference with reef fauna - use of the reef should be regulated in such a way to avoid depleting populations. At some locations on all reefs with cays, line fishing should be prohibited. One of these locations should be close to the cay for visual enjoyment. In minimum impact areas no line fishing should be allowed. In controlled impact areas manipulative research that involves direct interference with populations should only be done under permit. Walking on reefs should also be regulated in places where such use is heavy (e.g. all maximum impact reefs). Tracks for this purpose should be indicated.

10. Disposal of garbage and other waste materials at sea - is at present done without any regulation. It causes some impact on the marine environment in the vicinity of cays and consequently may also, indirectly and possibly also directly, affect the cay. It is essential that this practice be stringently regulated in regard to the material that is dumped and when and where it is dumped. These regulations must apply to vessels, including charter and private craft and to disposal of waste from cays.

11. Disposal of effluent from septic tanks, desalination plants or other sources should be carefully controllled. Investigations on impact of this operation are required.

12. It is possible that monitoring of sites to assess the impact of the permitted use on them may suggest modifications in the regulations and their administrative provisions that will better effect the purpose for which they have been developed. This could even affect the zoning and the use of an area temporarily or permanently; or could result in a periodic change in the use of an area. In view of these possibilities, we suggest that monitoring of populations is an obligatory procedure associated with the regulation of use of the area.

13. Education of users is essential in ensuring their co-operation and goodwill. To this end literature should be available through the resort and tourist offices that sets out the relevant regulations and the reasons for them (including information in the biology, geology and history of the area), together with relevant maps. A public relations officer should desirably be available to co-ordinate the communication of this information.

V. REEF AND CAY ZONING - RECOMMENDATIONS

An account of the cays and reefs together with suggestions for their use (according to the criteria discussed above (Chapter IV)).

Geological characteristics of the islands and reefs are documented in Maxwell (1968) and Flood (1977). Information on soil, beach rock and dominant vegetation is contained in Steers (1938), although there well could have been some changes since that time. Vegetation for the area is also discussed by MacGillivray and Rodway (1931). Domm (1971) has discussed all the cays with the exception of Heron Island. Other works on vegetation of each island are indicated. Fairfax, Lady Musgrave and Hoskyn Islands and part of Heron Island are National Parks although permits to camp have been available (except on Heron Island). Most of the other cays are Crown Land. The vegetation has been protected, however, under the Native Plants Protection Act.

A naturalist interested in turtles, fish and birds, Ms. Julie Booth, has lived for various periods over the sixties and seventies alone on Fairfax, Wilson and Wreck Islands, and still does so on the latter. She is fiercely protective of the natural values, and has been an effective warden of each island while she is resident on it.

We believe that the protection of all the flora and fauna, according to the criteria set out above is essential for its proper management.

Tryon Island and Reef

Tryon Reef is a small platform reef, without lagoon, and with linear growth of coral (windrows, or coral alignments) well marked, resulting from strong wave action across the entire reef flat (Maxwell, 1968).

The elongate sand cay (14 ha) is to the southwest, and has some small development of beach rock on the southeast. The cay is thickly vegetated with many vines and creepers. The island is of sand with coral and shell fragments.

The island is used for camping. The reef is small and access to the island relatively simple. However, it is an important bird breeding island.

Ornithologists consider that Tryon Island should be retained as a nature island, with the cay primarily for breeding birds (Kikkawa, Elvish, Hulsman, 1977).

Tryon Reef is used for line fishing, and it is suggested this activity should continue.

North West Island and Reef

A large elongate platform reef running almost east-west with a large sand cay (153 ha) at its western end. The reef has irregular (not markedly linear) coral growth, and has sand bank development on its northern side. It is slightly centrally depressed forming a lagoon, and has prolific coral growth at and behind its rim with good grooves and spurs development (Maxwell, 1968). Beach rock is developed at the southwest end of the cay. The island is almost entirely sand and there are some low dunes on the southwest. It has attractive thick luxuriant vegetation with high Pisonia forest (Cribb, 1969b).

North West Island was mined for guano from 1898 to 1900 (Cribb, 1969c). The turtle soup factory was operating in 1910 and probably terminated with the First World War. It was opened again in 1924 and operated until activity shifted to Heron Island. The remains of buildings and machinery are still present, and the water tanks for many years encouraged campers. The area directly affected by these activities is small, but caused introduction of feral cats, domestic fowl, and mice, as well as plants and insects.

Its prime values are its forest, breeding Green Turtle, and its importance as a bird nesting area (one of the nine most important on the Great Barrier Reef).

Its present use is chiefly as a camping island. We believe this use should be regulated and retained. But control must protect breeding birds and turtles, and prevent further wood being used as fuel. It is suggested also that line fishing be permitted, with some monitoring of impact, but that a portion of reef of the order of a kilometre and close to the cay be protected from fishing, to be used for viewing only.

Wilson Island and Reef

A small outer platform reef almost round in shape with a sand cay (7 ha) at its southwestern corner. The vegetation of the cay is thick, and with Pandanus and creepers (Cribb, 1965). The island is of sand with soil forming and coarse shingles.

The island is used for camping, and day parties go there for picnics as it is close to high tourist population at Heron Island. It is accessible at all states of the tide as the island is on the edge of the reef and boat access from relatively deep water straight onto the beach is possible.

However, its wildlife value as a bird nesting area (one of the nine most important islands on the Great Barrier Reef) is high. Suggested uses are for line fishing (with some areas protected for viewing only) and the cay to be protected for its bird populations.

Wreck Island and Reef

A triangular platform reef with a sand cay (7 ha) at its southwest corner. The beaches are of sand and fine shingle, with some beach rock along the southeast shore. The vegetation is relatively low with Messerschmidia and Scaevola.

Wreck Island has been used for camping, but this is not common at present (except for one person). Day parties have used the island from Heron Island, but do not do so at present.

The chief wildlife values of the island are as the major nesting site for Loggerhead Turtles (the most important in eastern Australia).

Its importance as a turtle rookery and its small size preclude its use for overnight camping, although day visits could be a non-damaging use. This use would fulfil a particular need since it is recommended that nearby Wilson Island (at present used for day visiting) be completely protected for its important bird populations. Line fishing could be permitted and a non-fishing area protected for viewing only.

Masthead Island and Reef

Masthead reef is a moderately large platform reef, $3\frac{1}{2}$ sea miles long, closer to Gladstone than the other islands. It has slight dishing, and strongly developed spurs and grooves at its edges. The island (49 ha) is rather similar in size to Heron Island. The vegetation is attractive, luxuriant and diverse, with tall Pisonia forest, and Casuarina fringes (Longman, 1914). The island is almost entirely of sand and there are dunes on its exposed side.

It has commonly been used for camping because of its closeness to Port Curtis.

The wildlife values of the island are great. Its flora is diverse and it has much the same number of species as the larger North West Island (Heatwole, pers. comm.) It is the only island in the group, other than Wreck Island, where the Loggerhead Turtle is known to breed. It is an important bird breeding island (one of the nine most important on the Great Barrier Reef), and has large nesting populations of Wedge-tailed Shearwaters, Noddy Terns, and is one of the ten islands on the Great Barrier Reef where the Lesser Crested Tern breeds (one of the two in the Bunker and Capricorn groups). It has much less human impact, particularly with regard to the introduction of exotic plants and animals than most of the other islands and certainly less than the larger forested islands (Heron and North West). Opuntia (prickly pear) was introduced as early as 1927 (Heatwole, 1971), but has not done much damage.

Since it is the only one of the larger cays with a well developed Pisonia forest in these groups of islands that has not been seriously affected by introduced plants and animals, and since it also has important breeding birds and turtles, its wildlife value should be retained. No building, nor overnight camping should be permitted or those values will be lost. The reef could be used for fishing. Possibly day visitors, carefully regulated and not visiting when the terns were breeding, would be the least damaging use to which it should be put. In view of its traditional use and closeness to Port Curtis it seems appropriate that people should be allowed to use it. Again a viewing, non-fishing zone should be declared for such day visitors, while line fishing could be allowed around the rest of the reef.

Erskine Island and Reef

A small oval platform reef just over a mile long, with small sand cay (2 ha) at its western edge. Coral is well developed, and there is no lagoon. The cay is vegetated with Messerschmidtia and Scaevola. There is beach rock development and the cay is of shingle and shell. The cay does not have important wildlife values.

It has been used for camping and day parties. It is really too small to be used for overnight camping, and day picnicing would seem a reasonable use. Line fishing could be permitted.

Heron Island and Reef

A platform reef some six miles long, with 16 ha. sand cay at its eastern end. The reef has a true lagoon (up to 3.5m deep), surrounded by rich coral but this is not accessible from the sea. There is good development of beach rock along south and northern shores. The cay has still extensive Pisonia forest, although this has been reduced by the tourist resort and the Research Station.

The vegetation is thick and luxuriant (Gilham, 1963; Fosberg, Thorne, Moulton, 1961). There are large populations of birds, chiefly Noddy Terns and Wedge-tailed Shearwaters, and it is a most important nesting site for the Green Turtle.

The Island was first leased for a turtle soup factory in 1923. This use was changed to a tourist operation in 1932 (Ogilvie, 1977). The Great Barrier Reef Committee applied for, and was granted a lease for a research station in 1951. That facility was operated by the Committee until 1970, when the University of Queensland became a partner in the venture.

The fauna and flora of the reef were protected under the Queensland Fisheries Act 1957 from 1963. More recently the reef became part of the marine National Park proclaimed for the Heron Island and Wistari Reefs. That part of the island outside the tourist resort was gazetted as a National Park in 1960. The research station lease is within the boundary of the National Park.

Tourism, research, line fishing, glass-bottomed boat viewing, diving with or without scuba are all current uses.

More research has been undertaken on Heron Island than anywhere else on the Great Barrier Reef. The area is of the highest scientific value, and is one of the most significant world scientific data and bench mark areas in coral reefs. The operation of the research station is a major facility and is also important in providing logistic and other support to the more remote One Tree Island Field Station, the only other location in the southern part of the Great Barrier Reef where significant scientific work is being pursued. The Heron Island Station is also an important educational facility for biology, geology and high school students.

Recreation, education and scientific research do not seem to be clashing, except in regard to the number of people causing impact on the island and reef (including forest clearing, building, harbour construction, fishing) and affecting its wildlife and scientific values. Certain types of manipulative research (including the collection of specimens for taxonomic and experimental work) should continue to be allowed, under licence, but these activities should be excluded from certain locations that are protected for their wildlife values. There are already certain areas so protected. However they should be added to and selected rationally on the basis of biological, physical and recreational value.

Owing to its heavy use and scientific significance, we believe that ideally Heron Island Reef should not be fished at all. However, there has been a traditional use of it by visitors and residents for this purpose. Since it would cause hardship for that use to be withdrawn, we suggest that line (sports) fishing, from the reef or from small dinghies be prohibited from specified locations that are available only for visual enjoyment and non-manipulative scientific work. Commercial fishing should not be allowed at Heron Island.

Adjacent Wistari Reef is recommended for complete protection for non-manipulative scientific work only.

The main use of the Wistari/Heron Reefs should be the enjoyment of, research into, and education about a natural system.

One Tree Island and Reef

A six kilometre long platform reef with a central lagoon averaging about 3-4 metres in depth. Maxwell (1968) describes this as a lagoonal platform reef. The cay is of coral shingle; a shingle bank thrown up by wave action at the windward, southeast, edge of the reef, which having reached above sea level has become vegetated. The reef, particularly on the south and east, has strongly aligned coral, and the lagoon has many patch reefs and reticulate reefs. The cay, of some 24 hectares, is vegetated with pandanus, clumps of low Pisonia trees, Messerschmidia shrubs up to 10 feet, and low herbs, climbers and succulents. There is a central saline pool (McNeill, 1955). There is coarse coral shingle and some finer sediments.

One Tree Island attracted the attention of Australian Museum scientists in 1965, although naturalist parties had previously visited on many occasions, including Australian Museum parties. Field work was first carried out by expedition, but in 1968-69 huts were built and a permanent manager installed. Two simple laboratory and living huts and a cottage have been built, and the island is occupied by a maintenance officer and his wife. The station is now run by Sydney University (since 1975) and Sydney University staff and postgraduates, as well as other scientists, use the facility.

The island has had as its main use day picnics, an occasional camping party, and increasingly, since 1966, research.

Its wildlife values are high (it has Bridled, Lesser Crested, Crested, Roseate and Black-naped Terns breeding) and the island and its reef now has added value as a scientific bench mark, significant work having been done there, including studies on fishes, some invertebrates and on some aspects of geology (including calcification processes). This island and reef should be primarily for research with some areas of lagoon and reef for manipulative research. No fishing should be permitted.

Hoskyn Islets and Reef

A small platform reef about a mile long with strong radially aligned pattern of reef growth, typical of the smaller platforms. It has two vegetated islets and is slightly depressed forming a very shallow 'lagoon'. The islets are quite thickly vegetated (Cribb, 1972). The Eastern Islet (3 ha) has a rocky platform round the north and east, and the Western (9 ha) has beach rock and beach conglomerate. There is a coarse sand and shingle, often in ridges and some rich soil with guano. It was gazetted as a National Park in 1937.

The Islets are jointly considered as one of the 14 important bird nesting sites on the Great Barrier Reef.

We would recommend that controlled day picnicing in non-breeding periods and line fishing be permitted, but no overnight camping.

Fairfax Islets and Reefs

A platform reef some two miles long, depressed to form a shallow lagoon. The reef has two sandy cays (16 ha). Vegetation is fairly dense, dominated by Casuarina. In the early 1960's the Royal Australian Navy used a target range nearby. It is possible that some shells exploded on the island, although this has never been positively established. Certainly no great damage appeared to have occurred.

Fairfax has been used for camping, and one person lived on the island for a few years. Wildlife values include vegetation and birds. The islets are considered as one of the fourteen important bird breeding areas in the Great Barrier Reef. It had been a National Park since 1937.

We would recommend that this island be protected for its bird populations and that the reef also be protected as primitive. Fairfax Islets and reef, therefore, comprise the one unit of reef and cay for which complete protection is recommended.

Lady Musgrave Island and Reef

A closed-ring platform reef just under 3 miles long. There is a true lagoon with an opening to the sea, the depth being up to 7 metres. The reef growth is radial. The sand cay (19 ha) is at the southeastern end of the reef, and is thickly wooded. Beaches are sand and shingle with some beach rock on the northeast end. There is a central pool similar to One Tree and Fairfax. The island has been a National Park since 1967.

Its use has been as a camping, fishing and shell collecting area. Because of its entrance it has a higher number of visiting boats than most of the reefs and provides a protected anchorage for boats using the area.

Wildlife values include vegetation and birds (among the 14 important islands in the Great Barrier Reef).

Controlled camping (to minimise impact on nesting and roosting birds) and line fishing could be permissible uses. Anon-fishing viewing area could be created.

North Reef and Cay

The reef has a very small vegetated cay and has a light house. It has no particular wildlife values and, little recreational value, owing to its small size. It could be useful for day visits and line fishing.

Wistari Reef

The reef does not have a vegetated sand cay. It has not been subjected to any heavy pressure and has been protected under the Queensland Fisheries Act, and now under the National Parks Act. Its location, close to the research station at Heron Island confers on it a scientific value, which is enhanced by the legislative protection it has received.

We recommend that it be used as a reef for scientific research and underwater viewing, receiving minimum impact and no fishing (National Park status has not previously precluded line fishing).

Other Reefs without Cays

There are eight reefs without cays in the Capricorns and Bunkers. These are: Broomfield, Polmaise, Wistari, Sykes, Lamonte, Fitzroy, Llewellyn, and Boulton reefs. One of these, Wistari Reef close to Heron Reef, is a marine park area under Queensland law. Except for Wistari Reef, we do not feel that the traditional uses of fishermen over these reefs need be changed. But we do not believe the public interest, nor the interests of the fishermen themselves, are properly served unless some areas are not fished. Of the eight reefs without cays we recommend no fishing for Wistari Reef and, another reef to be determined in consultation with user groups.

Summary of Zoning (see Table II)

The suggested zoning is summarised in Table II and in Appendix I. The main points are:

1. Traditional fishing is encouraged in the whole area except for locations on each of the reefs where sections are to be retained for the purpose of exclusive visual enjoyment; and on the Reefs to be set aside for maximum protection, Fairfax and Wistari Reefs and possibly a second reef without a cay; and the One Tree Island Reef which is recommended for protection for manipulative scientific research. Commercial as well as sports line fishing is allowed at all other locations except at Heron Island where no commercial fishing should be allowed (3-4 out of 20 reefs not available for line fishing).

2. Overnight camping is suggested on North West Island and Lady Musgrave Island, but not on Masthead Island. Bird populations and vegetation should be protected on Masthead, and only regulated day trips and no overnight camping is recommended. No development is recommended for Masthead as this is incompatible with the retention of its most important wildlife values.

3. Bird and turtle population protection. Apart from Lady Musgrave and North West (camping); Masthead (which may be large enough to permit day visiting without losing the more fragile birds); Heron and One Tree (where there are permanent residents); there are Tryon, Wilson, Wreck, Erskine, Hoskyn and Fairfax which should not become "camping" islands, or the wildlife values will be lost. Wreck and Erskine Islands can be used for day visiting - the latter is a small and lovely cay but not a major bird nesting site, and the former is not included within the 14 important breeding islands, and its value is primarily its vegetation and its Loggerhead Turtle nesting, which could be compatible with day visits. Ornithologists would like to see the remainder, i.e. Tryon, Wilson, Hoskyn and Fairfax completely protected. Whether some day visiting in the non-breeding season is possible concomittant with the protection of these important bird populations is a judgement we have not made. Suffice it to say that Wilson is included in the nine most important islands for bird breeding. More work is needed on these four islands for a decision. Tentatively we have only suggested Hoskyn for day picnicing of these four. This gives a spread, throughout the Capricorns and Bunkers, where such activity can be accommodated, and gives restriction of entry to only three cays (Tryon, Wilson and Fairfax) of 12.

4. Reefs for protection. Of all the reefs without cays Wistari is the only reef for which we recommend maximum protection. A second reef should be so designated but there is no information on which to base a recommendation. At all other reefs commercial and sports fishing (line) is recommended.

TABLE II : SUMMARY OF VALUES AND RECOMMENDED USE OF CAYS AND REEFS

	Area of cay (ha)	Vegetation	Nesting Turtles	Nesting Birds	Scientific	Traditional Use	Recommended Use	Impact Type
*Heron Island	16	<u>/XXXX/</u>	² XXX	XX	XXX	hotel scientific education	hotel scientific education	Maximum
Reef					XXX	harbour fishing education scientific	harbour scientific sports fishing only	Maximum
One Tree Island	24	XXX	X	XXX	XX	scientific camping	scientific	controlled
Reef					XX	scientific	scientific	controlled
*Lady Musgrave Island	19	XXX	X	XX		camping	camping	moderate
Reef						fishing shelling	fishing	moderate
North West Island	153	<u>/XXXX/</u>	² XXXX	XXX		camping	camping	moderate
Reef						fishing	fishing	moderate
Masthead Island	49	XXXX	¹ XXX	XXXX		camping	primitive day visits	minimum
Reef						fishing	fishing	moderate
Wreck Island	7	X	¹ XXXX	X		camping day visits	primitive day visits	minimum
Reef						fishing shelling	fishing	moderate

* - National Parks

Wilson Island	7	XX	X	XXX	camping, day visits	primitive	minimum
Reef					fishing shelling	fishing	moderate
Fairfax Islets	16	XXX	X	XX	camping	primitive	minimum
Reef					line fishing	primitive	moderate
Tryon Island	7	XX	X	XX	camping	primitive	minimum
Reef					line fishing	line fishing	moderate
Hoskyn Islets	12	XX	X	XX	camping	primitive day visits	minimum
Reef					fishing	fishing	moderate
ERskine Island	2	X			camping, day visits	day visits	moderate
Reef					fishing	fishing	moderate
North Island	?				light house	day visits	moderate
Reef					fishing	fishing	moderate
Wistari Reef					National Park	primitive	minimum
Other Reefs without Island					fishing	fishing	moderate

<u>Vegetation:</u>	X grasses	<u>Birds:</u>	X significant	<u>Turtles:</u>	1 X significant
	XX shrubs, vines		XX one of 14 important islands		1 XXX important island for Loggerheads
	XXX trees		XXX one of 9 very important islands		2 XXX important island for Greens
	XXXX forest		XXXX one of 9 very important islands		1 XXXX v. imp. island for Loggerheads
	 many introduced species		with a unique nesting population		2 XXXX v. imp. island for Greens

APPENDIX I

by

P.J. Davies and J.B. Marshall

GEOLOGY OF THE CAPRICORN/BUNKER REEFS

A detailed submission is being prepared for the Great Barrier Reef Marine Park Authority. The following is a summary:

The Pre-Holocene Growth Surface

During the last glacial sea-level low (pre-15,000 yrs BP) the Queensland continental shelf was above sea level, much of it for over 100,000 years. During this time, subaerial erosion of the exposed surface occurred. The morphology of the surface on which Holocene reefs later grew was therefore a combination of original topography modified by subaerial erosion. In the region of the Capricorn/Bunker reefs this surface varied from 7 to 57 m below present sea level. Steep-sided knolls rising 20-30 m from a gently sloping plain represented the sites of previous reefs. The knolls were roughly triangular in shape with their apexes pointing southeast. They were steepest on their southeast margins, and their tops varied from 7 to 20 m below present sea level.

Growth on the Pre-Holocene Surface

Reef growth on the pre-Holocene surface began 8-9,000 yrs BP on the tops of the steep-sided knolls. The exact timing of the start of reef growth depended on the time at which the tops of the knolls were covered by the rising sea level, a function of the depth of their summits. Reef growth first occurred around the perimeter of the knolls at a vertical rate of 3-4 mm/yr. Sea level was rising at a rate of 6-10 mm/yr. The ultimate fate of the coral reefs was therefore related to the Holocene history of sea level changes.

Sea-level Changes in the Holocene

Two important features of Holocene sea-level change have had a profound effect on the morphology of present-day reefs:

1. The rate of sea-level rise was twice as fast as the rate of reef growth, the result of which was that the reefs grew vertically.
2. Sea level stabilised in eastern Australia at about its present level approximately 6,000 yrs BP. Potential growth platforms for coral reef growth varied from 7 to 20 m below present sea level. As a result of sea level stabilisation at about 6,000 BP, a reef growing from a -5m platform would have reached stabilised sea level by 5,500 years BP, whereas a reef growing from a -20 m platform would have reached sea level by 2,000 years BP; reefs growing from depths greater than - 25 m, would either be about to reach sea level, or would do so in the near future. The reefs of the Capricorn and Bunker Groups have all reached sea level at different times in the last 5,000 years. This has had a profound effect on their morphology.

Reef Growth in the Modern Hydrologic Regime

The extent of growth in the modern hydrologic regime depends primarily on the growth rate and the length of time for which the growth rate has operated. Windward margins are the principal growth areas, calcifying at a rate of $4 \text{ kg.m}^{-2}.\text{yr}^{-1}$. The time over which this has occurred is different for different reefs. Wreck and Fairfax have existed in the modern wave regime for 5,000 years, compared with 1-2,000 years for Fitzroy and Llewellyn. Many of the reefs of the Capricorn/Bunker Groups are roughly triangular in shape. The windward margins are steep, in some places precipitous. The leeward margins are more gently sloping. Coral growth is sparse on windward slopes and profuse on leeward slopes. Little sediment is accumulating on windward slopes; abundant sediment is accumulating on leeward slopes. Lagoons are either relatively deep (10 m) or very shallow (0.5 - 1 m). They are either densely populated with patch reefs, or sparsely populated. Islands are predominantly sandy on leeward margins, or composed of coarse rubble on windward margins. At Fairfax Reef, a sequential development of reef and windward and leeward islands is visible. $\text{Cl}4$ data is available from three islands. Water movement associated with the reefs of the Capricorn/Bunker Groups have been monitored at Wreck, One Tree, Fitzroy and Fairfax. Under dominant southeast winds, resultant water movements are from windward to leeward, across the reefs, at approximately 20 cm/sec. Measurement of the annual production of calcium carbonate on windward margins (7.7 thousand tonnes for One Tree Reef), the annual destruction (at least equal to the production), and the direction of removal, together with identification of the depositional sites, allows the following conclusions to be drawn:

- a. Most windward margins are in a delicate state of balance. Some windward margins are actively eroding, i.e. destruction and removal is greater than production. The equilibrium situation is particularly relevant to reef flat situations.

Perturbations of the sediment transport system, either by oversupply or blocking of routes, will result in sediment choking of the reef flat, with resultant changes in fauna and flora.

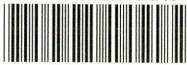
- b. Eroded material is carried leewards into the lagoon and onto the leeward margins.
- c. Lagoons are infilling at the present day at a rate of $2 \text{ kg. CaCO}_3 \text{ m}^{-2} \cdot \text{yr}^{-1}$. The main lagoon at One Tree Reef will infill within 5,000 years. Maximum sedimentation in lagoons is occurring along windward lagoonal margins close to the inner reefs flats.
- d. Leeward margins are accreting CaCO_3 at a rate of $4-5 \text{ kg. m}^{-2} \cdot \text{yr}^{-1}$. The reefs are therefore actively growing and flourishing along their leeward margins.

Reef Evolution

The geological, geophysical and hydrological data from the Capricorn/Bunker Reefs suggest that individual reefs can be classified in a progressive series from juvenile to senile.

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CONSERVATION AND
USE OF THE CARIBBEAN
AND BUNKER GROUPS
OF ISLANDS AND
CORAL REEFS

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C. Dalliston

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GREAT BARRIER REEF MARINE PARK AUTHORITY

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