ZONING STRATEGY STUDY

BASED ON THE PROPOSED CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK

Prepared for

GREAT BARRIER REEF MARINE PARK AUTHORITY

Prepared by

ENVIRONMENT SCIENCE & SERVICES
in association with the
ZONING STRATEGY STUDY GROUP

October, 1979

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The Authority decided to publish this report in limited numbers as an economy glossy for free distribution.

Name of Project Officer: John O'Dwyer

P.O. Box 1379
TOWNSVILLE, Q 4810
9 November 1979

Mr G. Kelleher
Acting Chairman
Great Barrier Reef Marine Park Authority
P.O. Box 1379
TOWNSVILLE, Q 4810

Dear Mr Kelleher,

Re: Zoning Strategy Study based on the Proposed Capricornia Section of the Great Barrier Reef Marine Park

I have considerable pleasure in submitting the report of the Zoning Strategy Study based on the proposed Capricornia Section of the Great Barrier Reef Marine Park. The report was prepared by Environment Science & Services in association with the Zoning Strategy Study Group.

The terms of reference for the study called for the development of alternative zoning strategies and management regimes for the Great Barrier Reef Marine Park based on the specific example of the Capricornia Section. The Study Group is satisfied that the report fulfils the terms of reference and formally adopted the report at its meeting on 8 November 1979.

The Study Group commends the report to the Authority as a valuable reference work and an important contribution to zoning plans for the Capricornia and subsequent Sections of the Great Barrier Reef Marine Park.

Yours sincerely,

R.A. Kenchington
Convener,
Zoning Strategy Study Group

Zoning Strategy Study Group

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Officers of the Qld Department of Health

Officers of the Qld Boating and Fisheries Patrol

Officers of the Qld Fish Board

Officers of the Gladstone Harbour Board

The Mayor and Officers of the Gladstone City Council

Officers of the Calliope Shire Council

The Chairman and Officers of the Miriam Vale Shire Council

Port Curtis Air Sea Rescue Squadron

Australian Bureau of Meteorology

Australian Department of Transport

Staff and Management of Heron Island Pty Ltd

Heron Island Research Station field and administrative staff

One Tree Island Research Station administrative staff

Whittaker Airways

Barrier Reef Airways and Safaris

Helitrans Pty Ltd

Ms Denise Tudman

Dr Peter Flood

Dr Joel Hamilton

Mr Mike West

Charter boat operators

Various commercial and amateur fishermen

Representatives of various clubs, groups and organizations using the Section.

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NOTE

The term 'Capricornia Section' is used in this report to describe all reefs, shoals, islands, waters etc. within the boundaries shown on Map 1. It differs from the strict definition of the term required under the Great Barrier Reef Marine Park Act 1975, which specifically excludes islands or parts of islands that form part of Queensland.

1.0 INTRODUCTION

1.1 BACKGROUND

On 2 February 1977, the Great Barrier Reef Marine Park Authority, with advice from the Great Barrier Reef Consultative Committee, selected the area encompassing all the reefs and shoals of Lady Elliott Island and the Bunker and Capricorn Groups, the sea and seabed surrounding these, and any land, submerged lands and waters under Commonwealth jurisdiction for consideration as the first area of the Great Barrier Reef Marine Park. This area was selected because of its proximity to southern capital cities; because of its importance in the fields of commerce, recreation, tourism and science; and because it is regarded as one of the best known areas of the Great Barrier Reef Region. The area was subsequently named the Capricornia Section and is delineated by the boundaries shown on Map 1.

Under the terms of the Great Barrier Reef Marine Park Act 1975, the Governor-General may, by proclamation, declare the Capricornia Section to be part of the Great Barrier Reef Marine Park and thereby direct the Authority to prepare a zoning plan for the Capricornia Section. Any such zoning plan will need to:

(i) be based on multi-objective planning to balance conservational, commercial and recreational requirements in accordance with Section 32(7) of the Act, and

(ii) permit harmonious and consistent management of both Queensland and Commonwealth jurisdictional areas within the Capricornia Section.

Given the innovative nature of the Great Barrier Reef Marine Park legislation and the need to develop rational and realistic approaches to zoning issues, the Authority commissioned the present study to investigate alternative zoning strategies for the Capricornia Section. In brief, the overall aim of the study was to address methodological issues associated with the preparation of zoning plans within a marine park environment, based on the specific example of the Capricornia Section. It is envisaged that the output from this study will become a valuable source document in the preparation of zoning plans for the Capricornia and subsequent Sections of the Great Barrier Reef Marine Park.

1.2 SCOPE OF THE STUDY

The study has been undertaken by Environment Science and Services as one member of a Study Group appointed by and responsible to the Authority. Other members of the Study Group were:

- Director of Research & Planning, Great Barrier Reef Marine Park Authority (Convener)
- Senior Planner, Qld Co-ordinator-General's Dept
- Representative, the Great Barrier Reef Consultative Committee
- Director, Qld Fisheries Service
- Director, Qld National Parks & Wildlife Service.

Each member of the Study Group has played an important role in providing information and professional assistance in the development of alternative zoning strategies and management regimes.

Terms of reference for the Zoning Strategy Study are outlined in the study brief prepared by the Authority in March 1979. As detailed in Appendix A, this study brief called for the project to be divided into the following 3 phases:

Phase 1 - Data Collection and Analysis

(i) An inventory of the natural resource base and human factors within the Capricornia Section based upon currently available information.

(ii) An appraisal of available evidence describing the impacts of various human activities within the Capricornia Section.

(iii) Identification of existing constraints and opportunities that should influence future use and management of the Capricornia Section.

Phase 2 - Strategy Generation

Preparation of alternative strategies for future use and management of the Capricornia Section based on the output from Phase 1 and in accordance with the objects specified in Section 32(7) of the Great Barrier Reef Marine Park Act 1975.

Phase 3 - Strategy Evaluation

Evaluation of the alternative strategies developed in Phase 2 using recognized multi-criteria procedures.

In this report the output from Phase 1 is contained in Chapters 2 to 5 and the outputs from Phases 2 and 3 are contained in Chapters 6 and 7 respectively.

Since the terms of reference required that the study be undertaken on the basis of existing information supplied by officers of the Authority and state government departments, there were no opportunities to collect additional data during the course of the study. For this reason there are several instances in the report where analysis has been curtailed due to lack of data or informed judgements have had to be made on the part of the consultant. These instances have been documented to provide an assessment of critical data gaps and an overall assessment of data reliability.

It should also be pointed out that the consultant has prepared this report with the benefit of only minimal on-site experience. Apart from a short period on Heron Island, no time was spent in the Section by the staff of Environment Science and Services. Many of the decisions in this report are therefore based on the collective recollections, testimonies and opinions of many people rather than first hand experience.

2.0 NATURAL RESOURCES INVENTORY

2.1 INTRODUCTION

The Capricornia Section of the Great Barrier Reef Marine Park contains 13 major named reefal shoals which are submerged at all tides, and 21 drying reefs. Thirteen of the drying reefs support vegetated islands. Together the major reefs and reefal shoals form several distinctive groups within the Section. This is illustrated below.

Karamea Bank	REEFAL SHOALS TO NORTH OF CAPRICORN GROUP		CAPRICORNIA SECTION
Moresby Bank			
Edgell Bank			
Goodwin Shoal			
Innamincka Shoal			
Haberfield Shoal			
Guthrie Shoal			
Johnson Patch			
Douglas Shoal			
North Reef	CAPRICORN NORTH GROUP	CAPRICORN GROUP	
Brew Shoal			
Tryon Island Reef			
Broomfield Reef			
North West Island Reef			
Wilson Island Reef			
Wreck Island Reef			
Sykes Reef	CAPRICORN SOUTH GROUP		
Heron Island Reef			
Wistari Reef			
Erskine Island Reef			
One Tree Island Reef			
Masthead Island Reef			
Irving Reef (Shoal)			
Polmaise Reef			
Rock Cod Shoal			
Lamont Reef			
Fitzroy Reef			
Llewellyn Reef			
Boult Reef	BUNKER GROUP		
Hoskyn Islands Reef			
Fairfax Islands Reef			
Lady Musgrave Island Reef			
Lady Elliott Island Reef	REEF AND REEFAL SHOALS TO THE SOUTH OF BUNKER GROUP		
Herald Patches			

In addition to the major features already identified, there are numerous other un-named and/or uncharted submerged shoals and coral outcrops located throughout the Section. No estimates of numbers, size or location are available.

Although separated geographically from the main body of the Great Barrier Reef by the Capricorn Channel, the reefs and reefal shoals of the Capricornia Section comprise the southern end of the Great Barrier Reef Region. All the reefs in the Section have similar hydrological, bathymetric, geological and tectonic settings although they differ in size, shape, lagoon development and cay development. A brief description of each major feature, its location and approximate area is contained in Table 1. The location of major features is shown on Map 1.

Excellent general descriptions of many of the physical and biological attributes of the Capricornia Section can be found in Jell & Flood (1978), Mather & Bennett (1978) and Great Barrier Reef Committee (n.d.). Physiographic terminology adopted in this report follows that contained in Jell & Flood (1978).

2.2 REEFAL SHOALS

Within the Capricornia Section there are 13 reefal shoals with a total area of about 3,400 hectares. The largest is the Herald Patches. The reefal shoals rise to within 10 to 20 metres of the water surface at low spring tides. They occur as individual mounds (e.g. Rock Cod, Douglas, Haberfield, Guthrie and Innamincka), as submarine platforms between reefs (e.g. between North

TABLE 1. MAJOR CHARACTERISTICS OF THE CAPRICORNIA SECTION

NAME	LOCATION		DESCRIPTION	APPROX. AREA (ha)	
	LATITUDE SOUTH	LONGITUDE EAST		REEF/SHOAL (a)	ISLAND (b)
REEFAL SHOALS TO THE NORTH OF THE CAPRICORN GROUP					
Karamea Bank	$22^{\circ}39'$	$151^{\circ}32'$	Small reefal shoal	<60	–
Moresby Bank	$22^{\circ}52'$	$151^{\circ}43'$	Small reefal shoal	<60	–
Edgell Bank	$22^{\circ}53'$	$151^{\circ}46'$	Small reefal shoal	<60	–
Goodwin Shoal	$22^{\circ}55'$	$151^{\circ}44'$	Small reefal shoal	<60	–
Innamincka Shoal	$23^{\circ}01'$	$151^{\circ}50'$	Small reefal shoal	60	–
Haberfield Shoal	$23^{\circ}02'$	$151^{\circ}44'$	Small reefal shoal	60	–
Guthrie Shoal	$23^{\circ}03'$	$151^{\circ}51'$	Small reefal shoal	60	–
Johnson Patch	$23^{\circ}05'$	$151^{\circ}37'$	Small reefal shoal	<60	–
Douglas Shoal	$23^{\circ}06'$	$151^{\circ}39'$	Reefal shoal	120	–
CAPRICORN GROUP (North Group)					
North Reef	$23^{\circ}11'$	$151^{\circ}54'$	Drying reef with a small island	295	*4.5* 15
Brew Shoal	$23^{\circ}16'$	$151^{\circ}45'$	Small reefal shoal	60	–
Tryon Island Reef	$23^{\circ}15'$	$151^{\circ}47'$	Small drying reef with a small island	190	*5.7* 30
North West Island Reef	$23^{\circ}18'$	$151^{\circ}42'$	Large drying reef with a large island	3,000	*93.9* 125
Broomfield Reef	$23^{\circ}16'$	$151^{\circ}56'$	Drying reef with a bare sand cay	720	–
Wilson Island Reef	$23^{\circ}18'$	$151^{\circ}55'$	Small drying reef with a small island	145	*4.9* 10
Wreck Island Reef	$23^{\circ}20'$	$151^{\circ}57'$	Drying reef with a small island	470	*10.1* 30

(a) Source: Division of National Mapping, Canberra

(b) Source: Number in italic type, Qld Department of Lands; number in roman type, Division of National Mapping, Canberra

TABLE 1. MAJOR CHARACTERISTICS OF THE CAPRICORNIA SECTION

NAME	LOCATION LATITUDE SOUTH	LOCATION LONGITUDE EAST	DESCRIPTION	APPROX. AREA (ha) REEF/SHOAL (a)	APPROX. AREA (ha) ISLAND (b)
CAPRICORN GROUP (South Group)					
Sykes Reef	23°26'	152°03'	Drying reef	630	-
Heron Island Reef	23°27'	151°55'	Large drying reef with a small island	2,700	17
Wistari Reef	23°28'	151°52'	Large drying reef	2,250	-
Erskine Island Reef	23°30'	151°46'	Small drying reef with a small island	95	*2.0* 5
One Tree Island Reef	23°30'	152°05'	Large drying reef with an island	1,290	*2.4* 20
Masthead Island Reef	23°32'	151°44'	Drying reef with an island	640	*64.8* 40
Irving Reef (Shoal)	23°33'	151°38'	Reefal shoal?	190	-
Polmaise Reef	23°34'	151°41'	Drying reef	820	-
Rock Cod Shoal	23°41'	151°37'	Reefal shoal	625	-
Lamont Reef	23°36'	152°03'	Drying reef	310	-
Fitzroy Reef	23°37'	152°08'	Large drying reef	1,380	-
Llewellyn Reef	23°42'	152°20'	Large drying reef	1,440	-
BUNKER GROUP					
Boult Reef	23°45'	152°16'	Drying reef	600	-
Hoskyn Islands Reef	23°49'	152°18'	Small drying reef with two islands	285	*12.0* (E island = *3.0* W island = *9.0*) 25

(a) Source: Division of National Mapping, Canberra

(b) Source: Number in italic type, Qld Department of Lands; number in roman type, Division of National Mapping, Canberra

TABLE 1. MAJOR CHARACTERISTICS OF THE CAPRICORNIA SECTION

NAME	LOCATION LATITUDE SOUTH	LOCATION LONGITUDE EAST	DESCRIPTION	APPROX. AREA (ha) REEF/SHOAL (a)	APPROX. AREA (ha) ISLAND (b)
BUNKER GROUP (Cont.)					
Fairfax Islands Reef	23°52'	152°22'	Drying reef with two islands and a bare sand cay	315	*19.0* (E island = *16.0* W island = *3.0*) 60
Lady Musgrave Island Reef	23°55'	152°24'	Large drying reef with an island	1,050	*20.3* 60
REEF AND REEFAL SHOALS SOUTH OF THE BUNKER GROUP					
Lady Elliott Island Reef	24°07'	152°43'	Drying reef with an island	70	*36.4* 60
Herald Patches	24°13'	152°42'	Large reefal shoal	1,910	-

(a) Source: Division of National Mapping, Canberra
(b) Source: Number in italic type, Qld Department of Lands; number in roman type, Division of National Mapping, Canberra

West, Wilson and Broomfield; between Heron and Sykes; and between Wistari and Erskine), or as submarine platforms underlying other reefs (e.g. beneath North and Fitzroy) (Jell & Flood 1978).

All the patches, banks and reefal shoals appear to be pre-existing reef masses on which coral growth was not able to keep pace with the rising sea level during the Holocene transgression.

The 13 named reefal shoals are described in more detail in Appendix B.

2.3 REEFS

There are 21 drying reefs with a total surface area of approximately 18,700 hectares. The individual reefs vary in size from about 95 hectares to about 3,000 hectares (see Table 1).

(i) Reef Types

Jell & Flood (1978) identifies the following 6 reef types in the Capricornia Section:

- wall reefs - Lamont and Sykes;
- platform reefs - North, Tryon, Wilson, Wreck, Erskine and Lady Elliott;
- elongate platform reefs - North West, Masthead and Polmaise;
- lagoonal platform reefs - Heron, Wistari, One Tree and Broomfield;
- closed ring (platform) reefs - Fitzroy, Llewellyn, Boult and Lady Musgrave;
- ingrown closed ring reefs - Fairfax and Hoskyn.

From south to north (excluding Lady Elliott Island Reef), the reef type changes from closed ring to lagoonal platform to platform. In the same direction the lagoon becomes progressively infilled by the sand zone, the lagoon floor shallows and the radial coral zonation developed on the reef flat is eventually obliterated by a thin cover of sediment and/or by algae growing on the tops of the reef flat corals (Flood 1976). A similar progression occurs from east to west across the Section.

Present reef growth is a thin veneer upon prior reef surfaces and the progression of reef types results from differential subsidence of the platforms on which they are localized. With stable sea levels the reefs will continue to develop through the succession of closed ring reef to lagoonal platform to platform reef (Flood 1977).

More detailed physiographic information about each of the reefs in the Capricornia Section is contained in Appendix B.

(ii) Reef evolution

The geological, geophysical and hydrological evidence suggests that individual reefs can be classified in a progressive series from juvenile (e.g. Boult) to senile (e.g. North) (G.B.R. Committee, n.d.).

(iii) Reef morphology

Hard corals are responsible for the very existence of the reefs. Together with algae, soft corals, sponges etc., they form the living veneer of the reef and provide shelter for numerous other organisms. Due to its offshore location the coral community in the Capricornia Section is better developed than many of the nearshore reefs to the north. Approximately 128 coral species have been recorded from the Capricornia Section.

The biota of these reefs is diverse and abundant. Available information about the most well-known components (corals, algae, crustaceans, molluscs, echinoderms and fishes) has been summarized in Mather & Bennett (1978).

A comprehensive and detailed description of reef morphology is beyond the scope of this report. However, given that the Reef ecosystem is the cornerstone of the Marine Park concept, a brief 'lay' description of reef morphology and processes is included in recognition of their vital importance.

The following description is based on the work of Great Barrier Reef Committee (n.d.) and Jell & Flood (1978). Although it provides a generalized overview of reef morphology and processes, it should be emphasized that the Capricornia Section is an area of contrasts and variety where individual reefs and even parts of reefs may display distinct characteristics.

As illustrated in Figure 1, three representative zones are encountered traversing a reef from windward to leeward. Morphology, ecology and sedimentology within each zone are closely related.

(a) Windward reef slope

The windward reef slope is steeply inclined, extending from the reef rim downwards to the relatively flat continental shelf area of the off-reef plain. Spur-and-groove structures may occur on the upper part. The upper surface spurs, which are exposed during low water tides, are the sites of luxuriant low-profile growths of *Acropora* spp. whereas the growing edges and the terraces support the branching (staghorn) varieties of *Acropora* spp. Corals decrease markedly below water depths of 10 m where the reef becomes a coral veneered, cemented limestone mass.

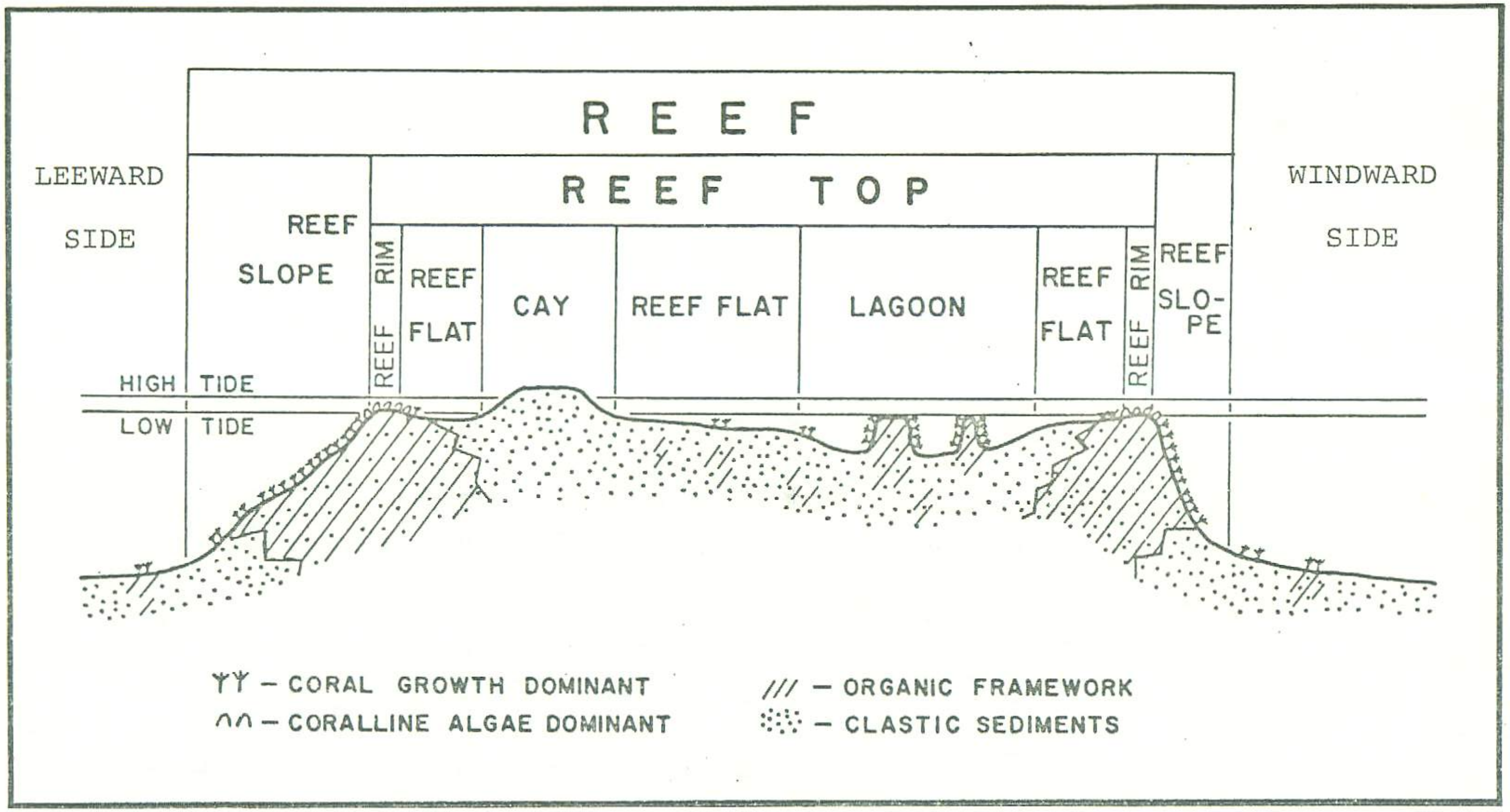


Fig. 1. Generalized cross-section view of a lagoonal platform reef
Source: Jell & Flood (1978)

The windward margin is the principal growth area of a reef. Little sediment accumulates on this slope.

(b) Reef top

The reef top includes that part of the reef surface enclosed within the outer edge of the reef rim, and is divisible into 4 morphological sub-zones which are described below.

. The reef rim surrounds each reef top and is slightly higher than the adjacent reef flat. Coralline algal encrustations are dominant but coral shingle may form an extensive cover over the algal pavement.

. The reef flat extends from the reef rim as a series of radial lineations, consisting of living corals arranged normal to the refracted wave fronts. Moving inwards, living coral progressively covers less of the reef flat area, giving way to areas of sand cover. Both branching and massive corals are common, together with echinoids, algae, molluscs, foraminiferans and holothurians.

. Lagoons occupy the central position of the reef tops, and at low water are never more than 10 m deep. The lagoonal floor is usually relatively flat with scattered patch reefs. The junction between the lagoon and the reef flat may or may not be clearly defined. A subtidal accumulation of sand is usually present. The lagoons vary in size, occupying from approximately 30 percent of the reef top surface area in the case of Lady Musgrave, Llewellyn and Fitzroy Reefs to about 20 percent for Heron and Wistari Reefs, and practically nothing in the case of Broomfield Reef.

- Cays or islands are those parts of the reef permanently above high water. There are 13 islands in the Capricornia Section with a total surface area of about 300 hectares. (For details, see Section 2.4 and Appendix B.)

(c) Leeward reef slope

The leeward reef slope descends gently from the outer edge of the leeward reef rim to about 0.5 km offshore. Massive corals (e.g. *Porites* spp.) are common in water depths to about 10 m. Skeletal carbonate sand, which has been washed from the reef top, produces sandy areas in the lee of the reef. All the reefs are actively growing and flourishing along their leeward margins.

2.4 ISLANDS

The 13 islands in the Capricornia Section are coral cays made from reef products, and therefore part of the whole reef ecosystem. They display an extremely interesting variety of sizes, shapes and vegetation. There are 3 cay types:

- shingle cays;
- sand cays; and
- mixed shingle/sand cays.

All cays, except for the shingle type, are located toward the leeward margin of the reef-top and cover from

1 to 20 percent of the reef-top surface area. There does not appear to be any correlation between island size, reef size or stage of reef development. Cay types and their size are summarized in Table 2 and described in more detail in Appendix B.

Beach rock is exposed on all islands, and cay rock (supratidally lithified sediments) occurs on Tryon, Fairfax east, Lady Musgrave and Lady Elliott Islands. Some reefs do not possess a cay but have intertidal sand and/or shingle bodies on the reef flat (e.g. Boult, Fitzroy, Wistari and Broomfield).

The oldest and largest cays have a central forest of *Pisonia* surrounded by a band of shrubs and small trees, bordered on its seaward side by pioneer grasses and herbs. The *Pisonia* forest is typically absent on the small cays (see Table 2). Most of the plant species on the cays have a wide distribution in the tropical Indo-Pacific region.

Many of the cays are important nesting and roosting sites for seabirds and there is an intimate relationship between the vegetation growing on the cays and these seabirds. The nutrients that the seabirds transfer from the sea fertilize and maintain the vegetation, which in turn stabilizes the cay and protects it against erosion.

The cays are also important nesting sites for sea turtles.

2.5 FISHERIES RESOURCES

The fishes of the coral reefs in the Capricornia Section are the most conspicuous component of the marine fauna. Many are bizarre and colourful and they range in size from minute species exploiting habitats in weed, coral

TABLE 2. CAYS IN THE CAPRICORNIA SECTION

ISLAND	APPROX. AREA[a] (ha)	CAY TYPE[b]	VEGETATION[c]	COMMENTS
North Reef Island	4.5	Sand	Shrubs with creepers and grass.	-
Tryon Island	5.7	Sand	Predominantly *Pisonia* forest.	-
North West Island	93.9	Sand	Predominantly *Pisonia* forest.	Some disturbance by past guano mining.
Wilson Island	4.9	Mixed shingle/sand	*Pandanus* dominant with creepers and herbs.	-
Wreck Island	10.1	Sand	Predominantly shrubs, creepers & herbs - small clumps of trees.	-
Heron Island	17.0	Sand	Predominantly *Pisonia* forest.	Degraded in the vicinity of the hotel/research station. Many weeds. Some erosion problems.
Erskine Island	2.0	Mixed shingle/sand	Covered in shrubs, creepers and herbs.	-
One Tree Island	2.4	Shingle	Predominantly low shrubs, creepers & succulents. A few clumps of trees.	Has a small brackish pond.
Masthead Island	64.8	Sand	Predominantly *Pisonia* forest.	Prickly Pear is well established all over the island.
Hoskyn (East) Island	3.0	Shingle	30% *Pisonia* forest 70% Creepers and herbs	-
Hoskyn (West) Island	9.0	Sand	Predominantly *Pisonia*-*Pandanus* forest.	-
Fairfax (East) Island	16.0	Shingle	30% *Pisonia* forest 70% Creepers and herbs	Both islands modified by guano mining, grazing goats & military target practice. Eastern island has two small brackish ponds.
Fairfax (West) Island	3.0	Sand	30% *Pisonia* forest 70% Creepers and herbs	
Lady Musgrave Island	20.3	Mixed shingle/sand	Predominantly *Pisonia* forest.	Has a small brackish pond.
Lady Elliott Island	36.4	Shingle	Covered with creepers, herbs & maritime grasses. Several groups of trees.	Greatly modified in the past by guano mining.

(a) Source: Queensland Department of Lands
(b) Source: Fairbridge, 1950; Steers, 1937; Maxwell, 1968; Aust. Env. Research Fdn, 1978.
(c) Source: Cribb, 1965, 1969a, 1972; Domm, 1971; Fosberg et al, 1961; Flood, 1977; Aust. Env. Research Fdn, 1978.

crevasses and under rocks, to large gropers, sharks and rays. The species richness and diversity is amazing: about 870 species have been recorded in the Capricornia Section. For details, see Mather & Bennett (1978); Woodland & Slack-Smith (1963); and Goeden (1974).

The fishes constitute an important commercial and recreational resource.

(i) Edible fish resources

There are 4 main fisheries in the Capricornia Section:

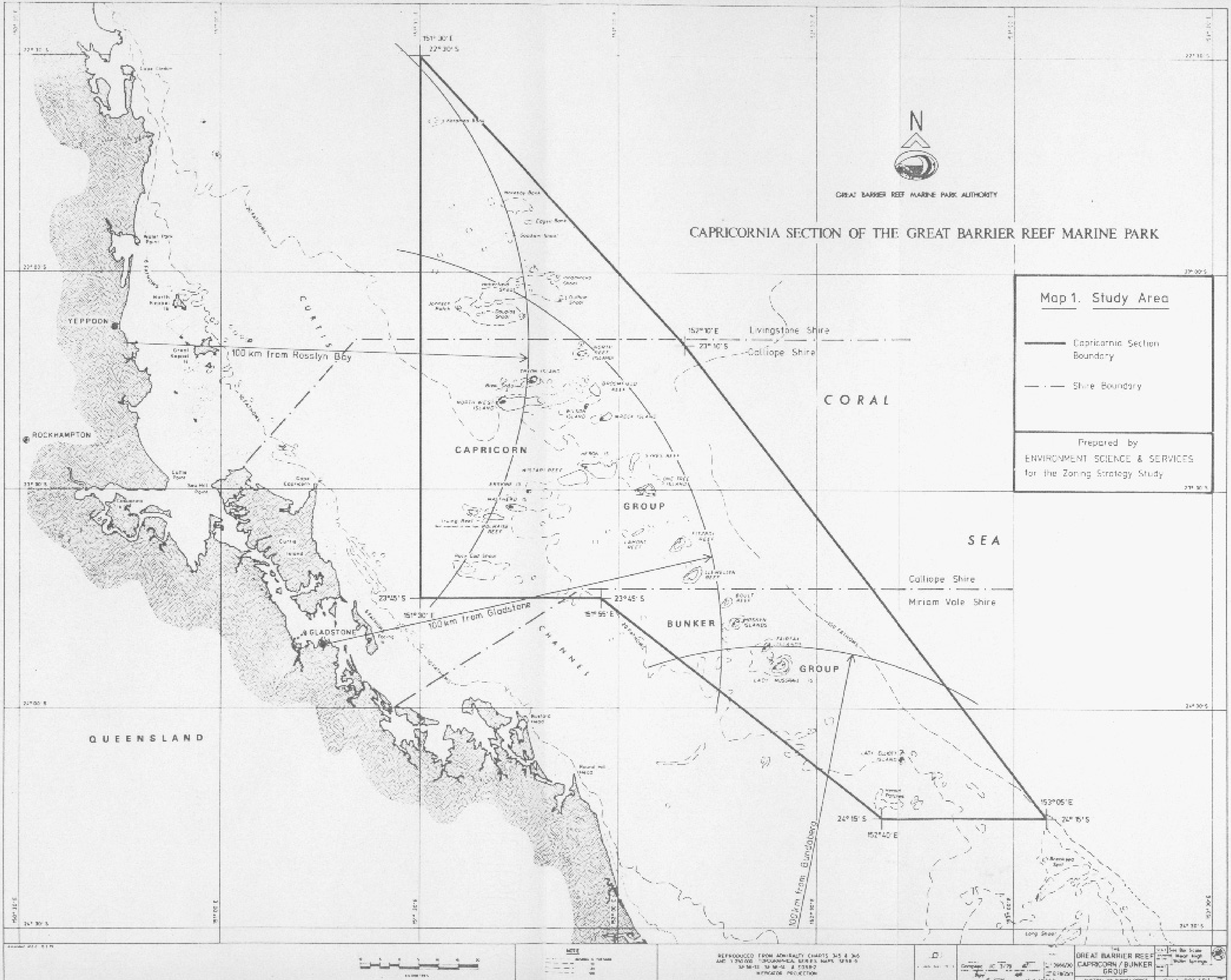
. the pelagic fishery;
. the demersal reef fishery;
. net fishery; and
. scallops.

Currently, very little is known about the biology or ecology of the fish populations presently being exploited. Detailed information about other aspects of these four fisheries is contained in Fisheries Division Dept of Primary Industry, Queensland Fisheries Service and Queensland Commercial Fishermen's Organization (1977) and summarized below.

(a) Pelagic fishery

Mackerel, kingfish, pike, trevally and tuna are the major pelagic, or migratory fishes, caught in the Capricornia Section. The five species of mackerel (*Scomberomorus commersoni*, *S. queenslandicus*, *S. semifasciatus*, *S. niphonius* and *Grammatoroynus bicarinatus*) comprise the major part of this pelagic fishery. Most of the mackerel caught in the Capricornia Section are *S. commersoni*.

Each year mackerel undertake a breeding migration. In May-June the breeding migration commences and the individuals begin to congregate around the reefs in



GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 1. Study Area
Capricornia Section Boundary
Shire Boundary
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
QUEENSLAND
CORAL
SEA
YEPPOON
ROCKHAMPTON
GLADSTONE
CAPRICORN
GROUP
BUNKER
GROUP
CURTIS
CHANNEL
100 km from Rosslyn Bay
100 km from Gladstone
100 km from Bundaberg
Livingstone Shire
Calliope Shire
Calliope Shire
Miriam Vale Shire
151°30'E
22°30'S
152°10'E
23°10'S
23°45'S
151°30'E
23°45'S
151°55'E
24°15'S
152°40'E
153°05'E
24°15'S
REPRODUCED FROM ADMIRALTY CHARTS 345 & 346
AND 1:250 000 TOPOGRAPHICAL SERIES MAPS SF56-9
MERCATOR PROJECTION
GREAT BARRIER REEF
CAPRICORN / BUNKER
GROUP

the Capricornia Section, the most southerly limit of the breeding congregations. As the schools increase in size they move northward and by October they reach the reef-waters east of Townsville and Cairns where they spawn. After spawning the mackerel lose condition and after a short resting period scatter and return to southern Queensland waters.

Mackerel are inconsistent with respect to the locations in which they are found from year to year. They are most numerous in locations where the currents and eddies cause their food to accumulate. Most of the mackerel landed are taken near reef rims.

The pelagic fishery is exploited by amateur, pro-amateur and professional fishermen.

(b) Demersal reef fishery

Fisheries et al (1977) lists the principal demersal fishes caught in the Capricornia Section as: coral trout, sweetlip, emperor, snapper, cod and parrot. Many of these common names cover a number of species - for details, see Appendix C.

Almost nothing is known about the population dynamics of demersal reef fishes. Coral trout are known to undergo a sex change (from female to male) between about 33 and 51 cm total length. The effect of fishing out mostly males (minimum angling size limit is 35 cm) is unknown (W. Craik pers. com.). Demersal reef fishes spawn between about December and February.

Red Emperor and other Lutjanids may make long inter-reef migrations, and their location may be highly unpredictable from year to year. However, coral trout are believed to be relatively stationary with respect to their habitat (W. Craik pers. com.).

This fishery is subject to considerable pressure from amateur, pro-amateur and professional line fishermen, as well as spear fishermen.

(c) Net fishery

The principal species taken are whiting, sea mullet, wrasse and queenfish from around Masthead, North West and One Tree reefs. It is a minor activity in the Capricornia Section.

(d) Scallops

Extensive saucer scallop beds (*Amusium balloti*) are located west of the reefs and reefal shoals of the Capricornia Section. These scallop beds extend from Fraser Island to north of Yeppoon and are approximately delineated by the 17 and 25 fathom isobaths. A small section of these scallop beds is included in the Capricornia Section (see Map 3). They are worked commercially, predominantly by fishing vessels from the Capricorn Coast, Gladstone and Bundaberg.

The scallop fishery is inherently unstable. Landings from year to year vary greatly and there is no guarantee that an area which has never before supported scallop stocks will not do so in the future (M. Dredge pers. com.). Likewise there is no guarantee that an area that has scallops one year will have them the next or any other year.

Small numbers of Painted Spiny Lobsters and oysters are also found in the Capricornia Section. They are not a commercial proposition but are prized and enjoyed by divers and reef walkers. Shovel-nosed Lobsters (Moreton Bay Bugs) are sometimes landed when trawling for scallops. They are not a commercial proposition in their own right but if landed as part of the scallop catch they are sold.

(ii) Aquarium fish resources

Many of the small, spectacular fishes, such as Blue Tang, Harlequin Tuskfish, Black Angels and Rainfords Butterfly, are prized aquarium fishes and are collected by both amateurs and professionals.

(iii) Fishes as an aesthetic resource

Fishes are a conspicuous, colourful and diverse component of the coral reef ecosystem. They are viewed, enjoyed and admired by divers, photographers, glass-bottom boat viewers, naturalists, reef walkers etc.

2.6 SEA TURTLES

According to G.B.R. Committee (n.d.), the following 4 sea turtle species have been recorded in the Capricornia Section:

- Green Turtle
- Loggerhead Turtle
- Hawksbill Turtle
- Leatherback Turtle.

Green and Loggerhead Turtles have major nesting sites within the Section. The total nesting population of both species in the Capricornia Section is estimated to be between 5,000 and 6,000 (Goeden 1977). Bustard (1972) considers that the Capricornia Section is one of the three most important turtle nesting sites in the world.

(i) The Green Turtle rookery

The Green Turtle rookery in the Capricornia Section is the second largest in the Great Barrier Reef Region - a region which collectively supports the world's largest breeding stock of Green Turtles (Limpus 1979 and Bustard 1972). As one of the largest of the world's 15 remaining Green Turtle rookeries, the Capricornia Section is of international importance in the worldwide conservation of Green Turtles. Furthermore, as pointed out in Limpus (1979), the Capricornia Section rookery is the only one of the 4 major rookeries in northern and eastern Australia that is currently available for effective conservation and management.

The relative importance of each of the islands in the Capricornia Section as a nesting site for Green Turtles is shown on Table 3. With several thousand females nesting per season, North West Island supports the largest breeding aggregation in the Section.

(ii) The Loggerhead Turtle rookery

The Capricornia Section supports the largest breeding aggregation of Loggerhead Turtles in the Pacific Ocean, if not the world. Almost the entire nesting for this species in the south west Pacific Ocean is concentrated in the Capricornia Section (the most important area) along the Bundaberg to Round Hill coast, and in the Swains Reefs (Limpus 1979).

The relative importance of the islands of the Capricornia Section as nesting sites for Loggerhead Turtles is shown on Table 3. Wreck Island supports the largest breeding aggregation with over 1,000 females in some seasons.

TABLE 3. RANKING OF TURTLE NESTING SITES

Source: Limpus (1979)

RANK	ISLANDS USED AS NESTING GROUNDS	
	Loggerhead Turtles	Green Turtles
Principal	Wreck[(a)] Tryon	North West[(b)] Wreck Hoskyn
Secondary	Masthead Lady Musgrave Erskine	Heron Tryon Masthead Wilson Fairfax Lady Musgrave Erskine
Minor	North West Heron Wilson Hoskyn Lady Elliott North Reef	Lady Elliott North Reef
Very minor	One Tree Fairfax	One Tree Broomfield Reef

(a) The most important nesting site for Loggerhead Turtles.
(b) The most important nesting site for Green Turtles.

In both an Australian and world context the Capricornia Section, and particularly Wreck Island, is an extremely important Loggerhead Turtle rookery.

(iii) Temporal aspects

Mating occurs, usually in lagoons, between mid-August and mid-November. Nesting begins mid-October, reaches a peak between December and January and continues until the end of March. The first hatchlings emerge in mid-December and the last about mid-May (Limpus 1979).

(iv) Other important aspects

The Capricornia Section is an important feeding ground for both resident and breeding turtles. All the reefs support large numbers of Green, Loggerhead and Hawksbill Turtles. The numbers of turtles feeding on any particular reef appear to be proportional to the size of both the reef and its lagoon (Limpus 1979).

The reefs known to be important Green Turtle mating sites and temporary residences for females during the inter-nesting intervals are: North West, Heron, Hoskyn, Lady Musgrave, Polmaise, Boult, Fitzroy and Llewellyn. Main areas for Loggerhead Turtle mating in the Capricornia rookery have not yet been identified (Limpus 1979).

Heron Island is of major importance as a scientific reference point in world sea turtle study following extensive research by Moorehouse (from 1929 to 1930), Bustard (from 1964 to 1973) and Limpus (from 1974 to 1979).

2.7 BIRDS

The Capricornia Section is noted for its avifauna, particularly the nesting seabirds which nest in their thousands on the islands and feed in the surrounding waters. In the Capricorn Group alone it has been estimated that there are '2,500,000 to 3,000,000 Wedge-tailed Shearwaters, 1,500,000 White-capped Noddy Terns and possibly more than 10,000 each of Crested Terns, Bridled Terns, Roseate Terns, and Black-naped Terns, and more than 1,000 Silver Gulls' (Goeden 1977 based on Lavery & Grimes 1971).

Lavery & Grimes (1971) have identified the 33 most important seabird nesting sites in Queensland and ranked them in order of their relative importance. Nine of the 14 most important breeding sites are in the Capricornia Section (see Table 4). The location and importance of the colonies of seabirds nesting in the Capricornia Section is also shown on Table 4.

All available information about seabirds nesting in the Capricornia Section is summarized in Aust. Env. Research Fdn (1978). The salient points are:

- All the major White-capped Noddy breeding sites in Queensland are in the Capricornia Section and Masthead Island is the principal breeding colony (Lavery & Grimes 1971; G.B.R. Committee n.d.). White-capped Noddy Terns nest in trees and therefore only breed on forested islands.
- Fifty percent of all the major Crested Tern nesting sites in Queensland are in the Capricornia Section and One Tree Island supports a principal nesting colony (G.B.R. Committee n.d.; Lavery & Grimes 1971).
- Forty-five percent of all known Roseate Tern breeding colonies in Queensland are in the Capricornia Section (G.B.R. Committee n.d.).

TABLE 4. RANKING OF NESTING SEABIRD VALUES AND THE LOCATION OF SEABIRD BREEDING COLONIES

(Based on Lavery & Grimes 1971 and Aust. Env. Research Fdn 1978)

ISLAND	RANKING (a)	NESTING SEABIRD COLONIES[b]											
		WEDGE-TAILED SHEARWATER	BROWN BOOBY	REEF HERON	SILVER GULL	BRIDLED TERN	ROSEATE TERN	BLACK-NAPED TERN	CRESTED TERN	LITTLE TERN	LESSER CRESTED TERN	COMMON NODDY	WHITE-CAPPED NODDY
Masthead Island	3rd	major	-	colony	major	colony	colony	colony	major	-	colony	-	principal
North West Island	5th	principal	-	colony	colony	colony	-	-	major	-	-	-	principal
One Tree Island	6th	-	-	colony	colony[c]	major	colony	major	principal	-	colony	-	colony
Wilson Island	8th	colony	-	major	colony	-	major	major	colony	-	-	-	-
Lady Musgrave Island	10th	major	-	colony	major	major	colony	colony	colony	-	-	-	major
Fairfax Islands	11th	major	principal	colony	major	-	colony	colony	colony	colony	colony	-	colony
Hoskyn Islands	12th	major	major	-	-	major	-	-	-	-	-	-	colony
Tryon Island	13th	major	-	colony	colony	major	colony	colony	-	-	-	-	colony
Heron Island	14th	major	-	colony	-	-	-	-	-	-	-	-	principal
North Reef Island	Unranked	-	-	colony	-	-	-	-	-	-	-	-	-
Wreck Island	Unranked	colony	-	colony	colony	major	-	colony	-	-	-	-	-
Erskine Island	Unranked	colony	-	-	-	-	-	-	-	-	-	-	-
Lady Elliott Island	Unranked	colony	-	colony	-	colony	-	-	colony	colony	-	colony	colony

(a) Ranking of importance as seabird nesting islands in Queensland.
(c) No nesting records recently.

(b) principal - a principal colony in Queensland;
major - a major colony in Queensland;
colony - a viable breeding colony.

- The Capricornia Section is an important area for Black-naped Terns, Bridled Terns and Lesser Crested Terns (G.B.R. Committee n.d.).
- North West Island supports a principal nesting colony of Wedge-tailed Shearwaters - about 120,000 individuals (Aust. Env. Research Fdn 1978).
- Two of Queensland's major Brown Booby nesting colonies are in the Bunker Group on Hoskyn and Fairfax Islands (Lavery & Grimes 1971).
- Seabird nesting on the islands occurs primarily from November to February.
- All these seabirds feed in the waters of the Capricornia Section.
- The seabirds have an important relationship with the islands since they are one of the agencies involved in the establishment and the maintenance of cay stability. They transfer nutrients from the sea to the land, thus fertilizing the sand that supports the vegetation helping to stabilize the islands.

Migratory waders have been recorded feeding on the reef flats of most of the drying reefs. (Fifteen species recorded on Heron Island - Kikkawa & Boles 1976.)

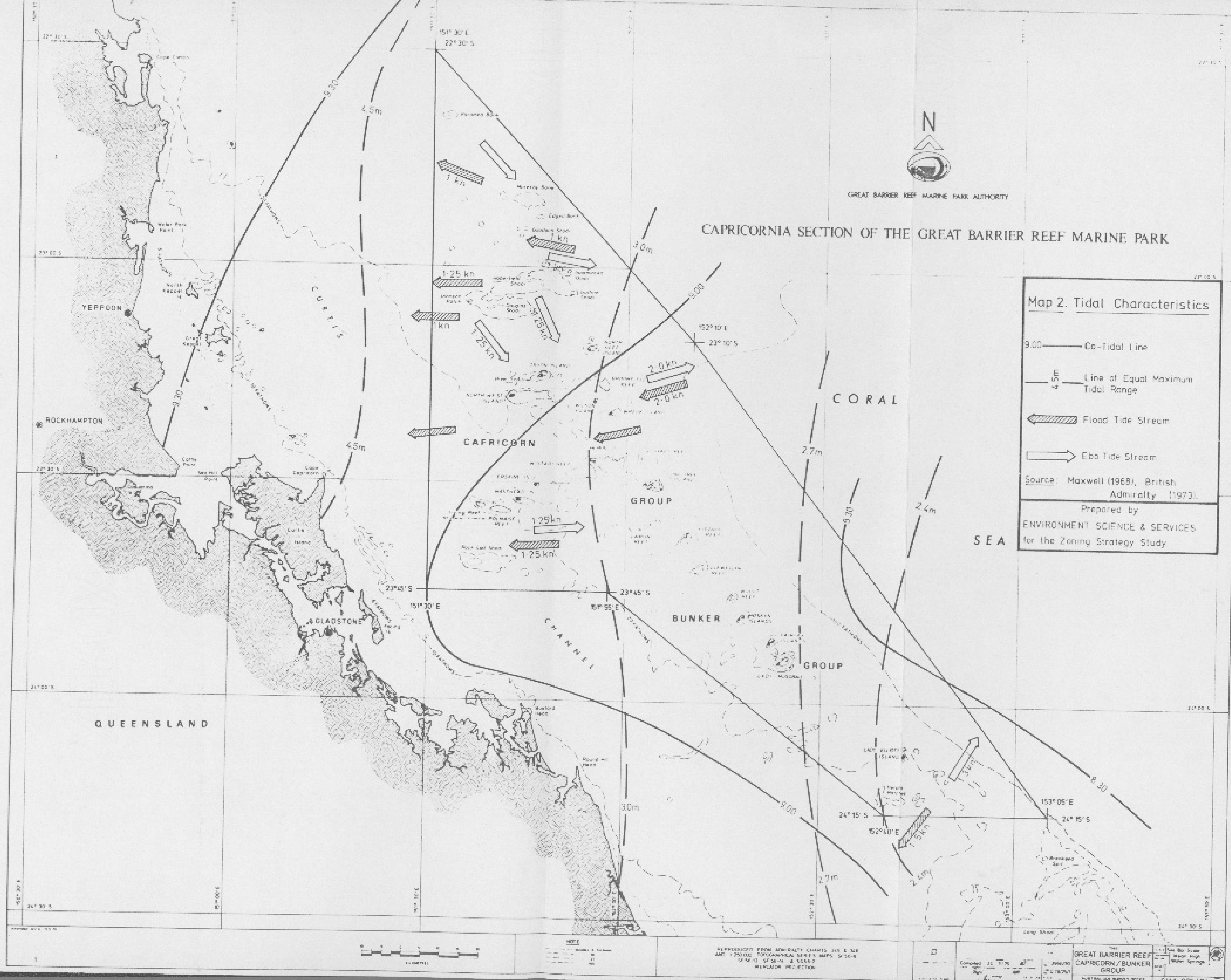
Many other bird species are found in the area, the most interesting being Sea Eagles, Ospreys and the Banded Land Rails. Kikkawa (1976) summarizes all the available avifauna information relevant to the Capricornia Section.

2.8 HYDROLOGY

Examination of bathymetric data for the Capricornia Section reveals well defined submarine drainage patterns which are closely related to the continental drainage systems of adjacent rivers (Maxwell 1968). The Burnett-Kolan system, the Baffle Creek system and the Colosseum-Oaky Creek system all drain through the Bunker Group and empty over the shelf edge north of Lady Elliott Island Reef. The Boyne and Calliope Rivers appear to have flowed along the southern side of the Capricorn Group and the Fitzroy River course can be traced as far as North West Island Reef before it bifurcates through the reefal shoals to the north of the Capricorn Group (Maxwell 1968). The overall pattern of drainage through the Capricornia Section is one of convergence towards an area 80 km north east of Lady Elliott Island Reef.

The Great Barrier Reef as a whole is situated in a region of high tidal range which sets it apart from most other coral reef provinces in the world (Maxwell 1968). Tidal ranges, co-tidal lines and tidal currents in the vicinity of the Capricornia Section are shown on Map 2. The large tidal range results in large volume exchanges between high and low tides. These exchanges, coupled with the restrictions placed on water movement by reefs and shoals, generate strong tidal currents in the channels between reefs. Maximum tidal ranges vary from approximately 2.5 m near Lady Elliott Island Reef to approximately 4.5 m near the western boundary of the Capricornia Section.

In addition to tidal movement, two other forms of water exchange are present. Firstly, the prevailing south-easterly air stream generates currents which set north to


N
GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 2. Tidal Characteristics
9.00 Co-Tidal Line
4.5m Line of Equal Maximum Tidal Range
Flood Tide Stream
Ebb Tide Stream
Source: Maxwell (1968), British Admiralty (1973).
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
YEPPOON
ROCKHAMPTON
GLADSTONE
QUEENSLAND
CURTIS
CAPRICORN
GROUP
BUNKER
GROUP
CHANNEL
CORAL
SEA
9.30
4.5m
3.0m
2.7m
2.4m
9.00
1 kn
1.25 kn
2.0 kn
1.5 kn
151° 30' E
22° 30' S
23° 10' S
152° 10' E
23° 45' S
151° 55' E
24° 15' S
152° 40' E
153° 05' E
GREAT BARRIER REEF
CAPRICORN/BUNKER
GROUP

north-west along the Reef. In cases where wind induced currents are opposed to tidal currents, choppy seas and turbulence result. Secondly, there may be some influence from the Eastern Australian oceanic current which sweeps southwards past the Capricornia Section.

The net movement of water is complex with little data available to assess the individual effects of the various current regimes. Limited investigations of surface water movements in the area of the Capricornia Section have been undertaken and the results are discussed in Woodhead (1970) and Pickard, Donguy, Henin & Rougerie (1977).

Ocean swells between 1 m and 3 m in amplitude arrive from the east and south-east. Breaking waves on the windward (south-east) sides of reefs can exceed 2 m and produce lateral transport of sedimentary particles from windward to leeward.

2.9 CLIMATE

The Capricornia Section extends from latitude 22°30'S to latitude 24°15'S and experiences a maritime sub-tropical climate. There is a pronounced summer rainfall peak in January and February with an equally pronounced dry weather period during September and October. The maritime influence limits temperature extremes with daily maximum summer temperatures rarely exceeding 31°C and daily minimum winter temperatures rarely falling below 14°C.

Weather conditions are strongly influenced by the South-East Trade Winds which constitute the prevailing wind pattern throughout the year. They are strongest and most consistent during the winter months when sea conditions are usually roughest. During the summer months the south-easterly air stream is weaker and less consistent although its high water-vapour content is responsible for much of the summer rainfall.

The principal climatic hazards facing both the natural and man-made environments result from the passage of cyclonic depressions over or adjacent to the Capricornia Section. Although infrequent in these latitudes, destructive cyclones have the potential to endanger lives and inflict major property and environmental damage by way of high winds, torrential rainfall and storm surges.

Some relevant aspects of the climatic regime are discussed below in greater detail. Meteorological data over the Capricornia Section has been obtained from records of weather observations on North Reef Island, Heron Island and Lady Elliott Island published by the Australian Bureau of Meteorology.

(i) Rainfall

Mean rainfall statistics for the island weather stations and Gladstone (the nearest mainland city) are contained in Table 5. They show that there is little variation in rainfall over the Capricornia Section and that island rainfall is greater than that recorded in Gladstone.

Rainfall records from Heron Island reveal a variation in annual rainfall totals from a low of approximately 400 mm to a high of approximately 2,050 mm (period of observation not known).

(ii) Temperature

Mean daily maximum and minimum temperatures for the island weather stations and Gladstone are contained in Table 6. The maritime influence on temperature extremes is evident when the islands are compared with the mainland city of Gladstone.

TABLE 5. MEAN RAINFALL AND RAINDAYS

	Mean Rainfall (mm)			Mean Annual Raindays
	January	July	Annual	
North Reef Is.	158	92	1057	146
Heron Is.	154	88	1069	136
Lady Elliott Is.	161	99	1212	152
Gladstone	190	37	944	108

TABLE 6. MEAN TEMPERATURES

	Mean Daily Maximum (^{o}C)			Mean Daily Minimum (^{o}C)		
	January	July	Annual	January	July	Annual
North Reef Is.	29.3	21.2	25.8	23.8	17.1	20.9
Heron Is.	29.6	21.3	26.1	23.8	16.2	20.5
Lady Elliott Is.	28.8	20.8	25.4	23.5	16.5	20.6
Gladstone	31.1	22.6	27.7	22.2	12.9	18.2

(iii) Humidity

Mean 3.00 p.m. relative humidities for the island weather stations and Gladstone are contained in Table 7. Again, all the island observations are very similar but consistently higher than Gladstone. Relative humidity on the islands is relatively constant throughout the year and shows little seasonal variation.

TABLE 7. MEAN RELATIVE HUMIDITIES

	Mean Relative Humidity (%)		
	January	July	Annual
North Reef Is.	72	72	71
Heron Is.	70	67	67
Lady Elliott Is.	71	69	69
Gladstone	63	51	58

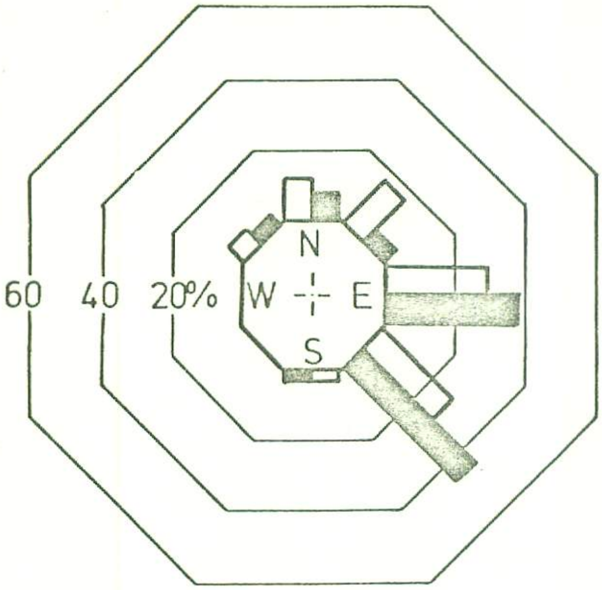
(iv) Wind

Wind conditions are the single most important factor governing boat usage, and therefore most recreational and commercial activities, in the Capricornia Section. Wind roses depicting the percentage occurrence of wind by direction in Figure 2 are based on 3.00 p.m. wind observations at Heron Island. The prevailing easterly and south-easterly movement of air is evident, and is particularly pronounced for winds in excess of 20 km/hour. Nearly all recorded gale force winds in excess of 50 km/hour are from the south-east, although occasional storm winds have been recorded from the north.

(v) Cyclones

An analysis of all available data of cyclones in the Australian region between July 1909 and June 1975 is

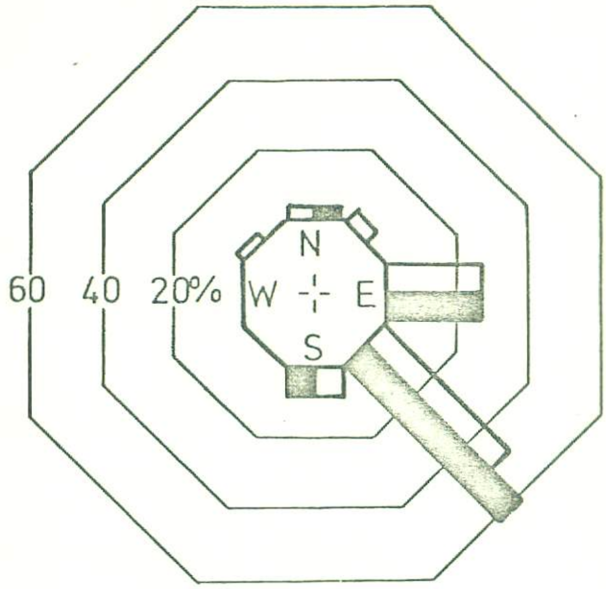
Figure 2: Surface Wind Observations at Heron Island



Calm Observations = 5%

Observations > 20 km/hr = 40%

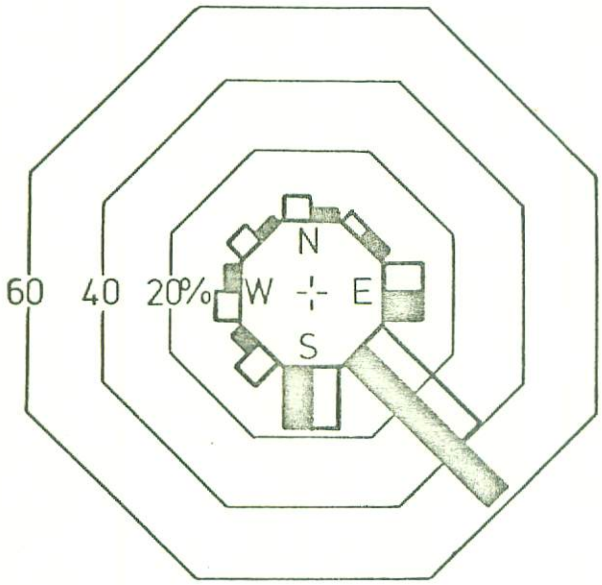
January



Calm Observations = 6%

Observations > 20 km/hr = 58%

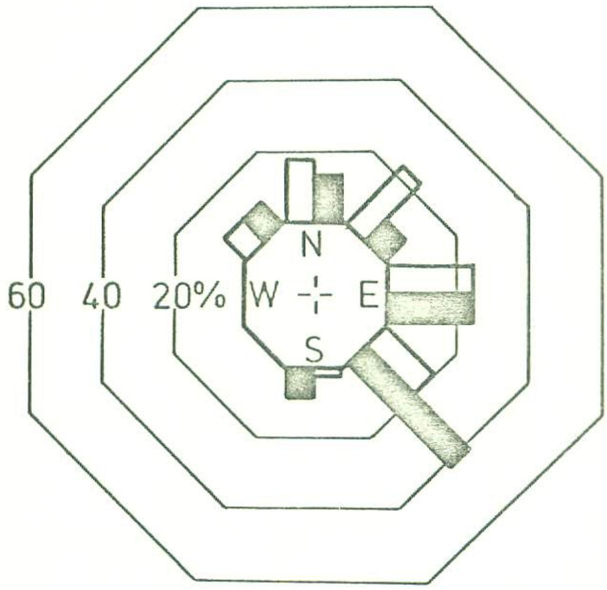
April



Calm Observations = 5%

Observations > 20 km/hr = 50%

July



Calm Observations = 4%

Observations > 20 km/hr = 29%

October

Percentage Occurrence vs. Direction : 3.00 pm LST

All Winds ▭ Winds > 20 km/hr ▨

presented in Lourensz (1977). The average decadal incidence of tropical cyclones in the 5^{o} latitude/longitude square containing the Capricornia Section is:

Dec.	Jan.	Feb.	Mar.	All Months
1.4	3.5	3.0	3.8	13.8

Several recorded cyclones in the general area of the Capricornia Section have been severe enough to cause loss of life and extensive property damage. The most important of these are described below.

Date	Area of Impact	Comments
1918	Rockhampton-Mackay	30 lives lost; \$2 million property damage at Mackay; 3.9 m storm surge.
1949	Rockhampton-Gladstone-Bundaberg	4 lives lost; \$1.6 million property damage.
1955	Mackay-Rockhampton	Lugger *Barrier Princess* lost with 8 hands; gales to 145 km/hr between Mackay and Cape Capricorn.
1967	Curtis Coast	Cyclone Dinah, one of the most intense cyclones to affect southern Queensland, skirted the coastline.
1972	Gladstone	Cyclone Emily, 8 deaths at sea; maximum recorded wind gust of 150 km/hr.
1976	Yeppoon	Cyclone David, moderate wind damage, shoreline erosion.

2.10 NATURAL HAZARDS

Although droughts and fire can have important deleterious impacts on cay vegetation, the most important natural hazards in the Capricornia Section are those connected with the passage of tropical cyclones. The impact of cyclones on man-made structures and communication systems is well documented and a brief historical summary of major destructive cyclones in the area is contained in Section 2.9.

Apart from Flood (1974), there are few detailed accounts of cyclone impacts on the natural resources of the Capricornia Section. However, there are well documented accounts of catastrophic storm damage to coral reef systems in other areas (Endean 1976 and Stoddart 1971). Cyclonic weather conditions can inflict damage to coral reef systems in 4 ways:

(i) Strong winds

Principal impact is the destruction or defoliation of trees and subsequent loss of habitat for tree nesting birds.

(ii) Torrential rain

Widespread reef destruction in southern Queensland has been attributed to rapid falls in salinity caused by torrential rainfall and river flooding (Hedley 1925). Similar impacts have been recorded in Kingston, Jamaica, following hurricane activity (Goodbody 1961).

(iii) Storm seas

Wave action can result in massive mechanical damage to coral communities. After the 1954 cyclone at Low Isles, Stephenson, Endean & Bennett (1958) found that the most resistant coral species were the massive ones and the least resistant, the fragile branching forms. The impacts are most profound on the windward sides of reefs and on reef flats.

Wave action is also the major cause of cay erosion and changes in beach profiles. Disappearance of cays has been reported on British Honduras reefs (Stoddart 1971).

(iv) Storm surges

Cyclonic storm surges of approximately 3 m have been recorded along the Queensland coast near the Capricornia Section, and there is evidence of complete inundation of Fairfax Island in the latter 1960s (Qld Interdepartmental Committee on the Future Use of North West and Masthead Islands 1973). None of the cays rise to more than a few metres above sea level and they must all therefore be prone to inundation.

It must be accepted that tropical cyclones have, and will continue to play a significant role in shaping the reef and cay systems in the Capricornia Section.

3.0 HUMAN FACTORS INVENTORY

3.1 INTRODUCTION

Since the 1850s, the Capricornia Section has attracted considerable attention as an important resource for various commercial, recreational and scientific activities. Today it is one of the best known and most intensively used areas of the Great Barrier Reef.

The principal purpose of this chapter is to document the existing patterns of human usage, to identify man-made structures and services supporting this usage, and to describe current administrative controls and management practices. A brief summary of important historical features is included together with a review of major factors which will influence the future demand for opportunities in the Section.

Accurate statistical information describing patterns of use and resultant pressures on the natural resource base is unavailable for the majority of human activities. Quantitative data which is presented has been pieced together from a wide variety of different sources, including:

- previous reports undertaken for the Authority (especially Domm 1977);
- material held on Authority files;
- discussions with Authority officers;
- discussions with officers of Qld National Parks and Wildlife Service and Qld Boating and Fisheries Patrol;
- Fish Board representatives at Rockhampton, Yeppoon, Rosslyn Bay, Gladstone and Bundaberg;
- local authority representatives;
- professional fishermen;
- charter boat operators;

- resort operators; and
- representatives of recreational user groups.

The amount and reliability of information provided by individual sources varied considerably. It has been collated, checked wherever possible, and presented here to provide a composite summary of total usage in the Section. Data gaps have been identified together with information which is considered to be of doubtful reliability.

It should be emphasized that the terms of reference for this study called for the analyses to be based on currently available and collated data. During the data collection program, it became apparent that additional raw data describing use patterns exists, but in a form which requires considerable effort to extract the relevant information. It is considered that a much more reliable estimate of use patterns and pressures could be generated from a thorough analysis of all available raw data.

3.2 SITES OF HISTORIC INTEREST

The history of the Capricornia Section has been documented by Ogilvie (1977), A. Cribb (1969) and the Great Barrier Reef Marine Park Authority (n.d.). The most significant events in the area's history were:

- the guano mining operations on North West Island, Lady Elliott Island and Fairfax Islands between 1863 and 1900;
- the turtle cannery operations on North West Island between 1904 and 1914, and again between 1924 and 1928. Subsequently this operation was transferred to Heron Island and in 1932 the operation was subleased and converted into a tourist resort.

Despite its interesting history of commercial exploitation, little remains of either the turtle canneries or the guano mining operations - certainly nothing that could be classified as historically interesting. There are 6 sites of historic interest:

(1) The lighthouse on Lady Elliott Island which was built in 1866 (Aust. Dept of Transport, pers. com.).

(2) The lighthouse on North Reef Island which was built in 1878 (Aust. Dept of Transport, pers. com.).

(3) A child's grave dated 1899 on North West Island. The child was the baby daughter of the Captain of the barque *Limari* which was engaged in transporting guano from the island (A. Cribb 1969).

(4) The wreck of the steamship *Cooma* which was stranded on the eastern side of North Reef in 1927 (P. Ogilvie, pers. com.).

(5) The rusting hulk of the *Sidney* which was beached on Heron Island in 1943 to form a breakwater for the harbour. This wreck is of interest to naval historians because originally it was the *Protector* of the South Australian Navy (P. Ogilvie, pers. com.).

(6) The sea eagles' nest on One Tree Island which was first described in the early 1840s by J. Beete Jukes, the naturalist on the *Fly* (G.B.R. Committee n.d.).

3.3 EXISTING ADMINISTRATIVE CONTROLS

The existing administrative framework governing control and use of the Capricornia Section is complex, with powers and responsibilities divided between all three tiers of government. Jurisdiction over the marine areas is shared between the Commonwealth and Queensland governments while jurisdiction over the islands is shared between the Commonwealth, Queensland and local governments.

(i) Marine areas

(a) Fisheries

Control and management of fishing activities are primarily carried out under the following legislation:

. Queensland

Fisheries Act, 1976
Queensland Marine Act, 1958-75

. Commonwealth

Fisheries Act, 1953
Continental Shelf (Living Natural Resources) Act, 1968
Whaling Act, 1960

Details about these acts and regulations are contained in two reports to the Great Barrier Reef Marine Park Authority by Fisheries Division et al (1977) and Craik (1978c).

(b) Boating activities

Boating activities (both commercial and non-commercial) are principally controlled by the Queensland Marine Act and Regulations, and the Harbours Act.

(c) Conservation

Under the Queensland Fisheries Act 1976, the Governor in Council may set apart and declare marine parks in which 'the cardinal principle to be observed in the management ...... shall be the preservation to the greatest possible extent of their natural condition'. One such marine park has been gazetted in the Capricornia Section to date. It is named the Heron-Wistari Reefs Marine Park and covers 'an area of about 9,700 ha comprising the foreshores of Heron Island, the reef surrounding Heron Island, Wistari Reef and the seabed and waters surrounding such reefs to an outer limit to approximately 1 km from the outer reef edges' (Qld Govt Gazette, 2 Nov. 1974, p.846). It is under the jurisdiction of the Queensland Fisheries Service.

Except for recreational line fishing, the taking of fishes, shells, coral, marine organisms, sand, etc. is prohibited. Within this Marine Park there are 2 designated 'No Fishing Areas' where all fishing, including recreational line fishing, is absolutely prohibited. The 2 'No Fishing Areas', both on Heron Island Reef, are:

"(a) within 250 metres of low water mark on Heron Island for a distance of 500 metres on either side of the feature known as the 'Blue Pools'; and

(b) within 250 metres of low water mark from the western extremity of the Heron Island Reef near the feature known as 'The Bommie' for a distance of 2 km in a south-easterly direction along low water mark." (Qld Govt Gazette, 14 Jan.1978, pp.105-6.)

(d) Military Practice Areas

Fairfax Island Military Practice Area, Restricted Area (R699), is centred on Fairfax Islands and covers all the reefs and islands in the Bunker Group. The limits of Restricted Area (R699) are defined as "a circle of radius 15 miles centred on a position 23°51'S and 152°23'E" (Aust. Dept of Transport 1976). Designated as a naval bombardment and live bombing area, R699 is administered by the Royal Australian Navy (see Figure 3).

It was used for target practice during World War II, the 1950s and the 1960s. On Fairfax Islands numerous deep bomb craters can still be seen among the mullock heaps left by the guano miners. Unexploded shells undoubtedly remain on the island and in surrounding waters.

Restricted Area (R699) has not been used for target practice for some 8 or 9 years and the Great Barrier Reef Marine Park Authority has requested that this Military Practice Area be de-gazetted. 'The possibility of de-gazetting Restricted Area (R699) ..... is being sympathetically considered by the Dept of Defence.' (G.B.R. Marine Park Authority files.)

The Hervey Bay Military Practice Area, Restricted Area (R693), a naval gunnery area, lies close to the southern boundary of the Capricornia Section. When these restricted areas are used for target practice, access by all non-military vessels and personnel is prohibited.

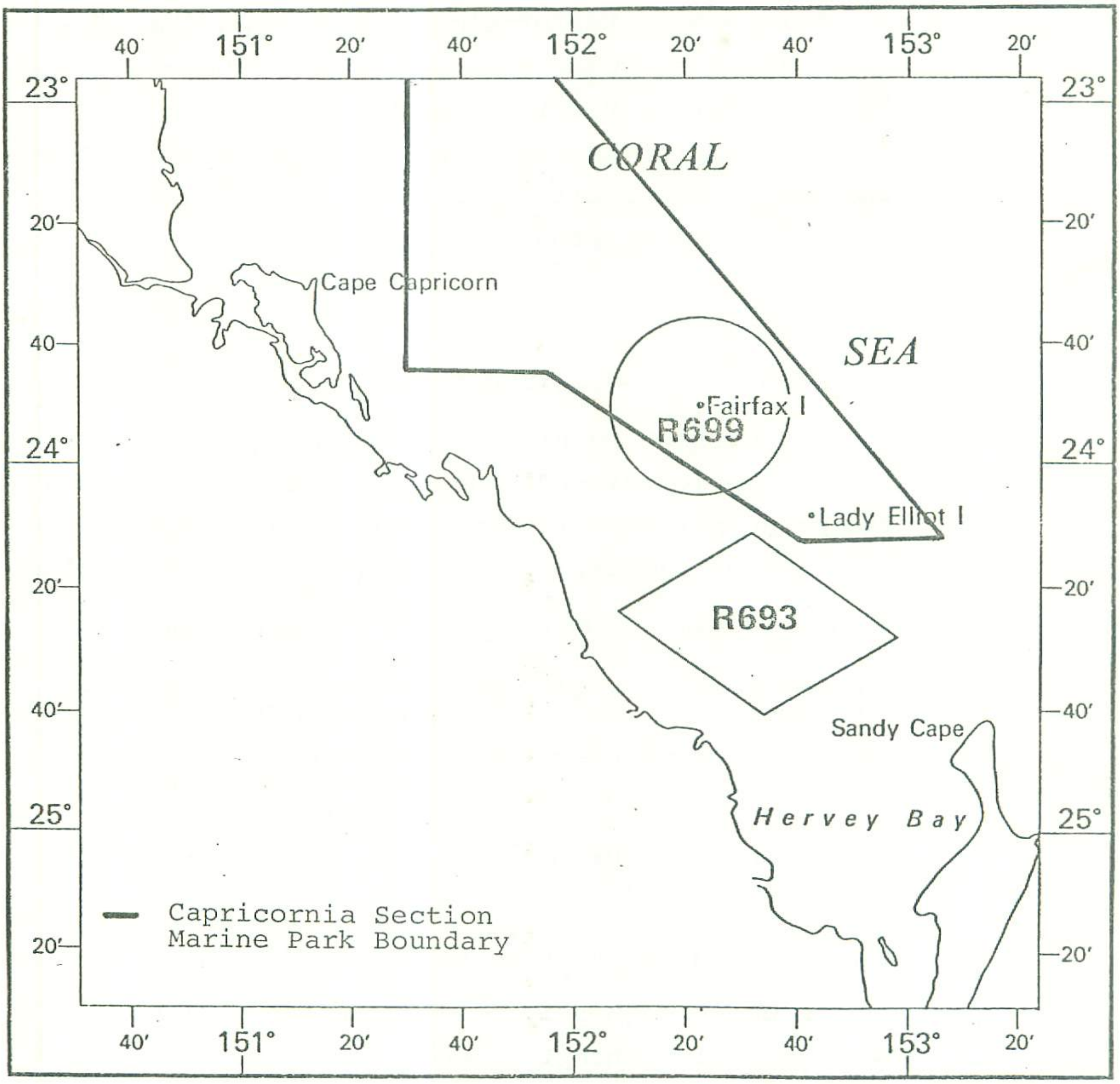


Fig.3. Military Practice Areas:
Restricted Areas (R693) & (R699)

Source: Aust. Dept of Transport (1976)

(e) Petroleum Exploration Permits

Portions of Exploration Permits Q4/P and Q5/P fall within the Capricornia Section. Under Section 38 of the Great Barrier Reef Marine Park Act 1975, once the Capricornia Section is declared as part of the Marine Park, all operations for the recovery of minerals will be prohibited.

(ii) Islands

(a) Tenure and administration

The current tenure and vesting of all islands in the Capricornia Section is contained in Table 8. The principal legislation governing the administration and management of the islands is set out below.

Tenure Class	Jurisdiction	Legislation
Commonwealth Property	Commonwealth	Commonwealth Lighthouse Act 1911-16
National Parks	Queensland	Forestry Act 1977 Forestry Amendment Acts 1964-73
Crown Land	Queensland	Land Acts & Regulations

(b) Local authority town planning controls

As shown on Map 1, islands in the Capricornia Section fall within the local authority areas of Calliope Shire and Miriam Vale Shire. At the present time, none of the islands are covered by local authority town planning schemes. A scheme for the balance of Calliope Shire (including the islands) is being prepared and should be placed on public exhibition during 1979.

TABLE 8. TENURE OF ISLANDS

ISLAND	PRESENT TENURE	AREA[a] (ha)	VESTING OR LESSEE	COMMENTS
North Reef Island	Lighthouse Transferred Property No.16	4.05	Commonwealth of Australia	Purpose: Lighthouse
Tryon Island	Vacant Crown Land	5.67	Qld Department of Lands	-
North West Island	Vacant Crown Land	93.88	Qld Department of Lands	-
Wilson Island	Vacant Crown Land	4.86	Qld Department of Lands	-
Wreck Island	Special Lease 33716	10.12	J.J. Booth, Sydney, N.S.W.	Purpose: Marine Scientific Research Lease expires 31.12.79.
Heron Island	National Park (Reserve No.231)	12.34	Qld National Parks & Wildlife Service	-
	Within National Park - Special Lease 36562 - 2.02 ha		Heron Island Research Station Board	Purpose: Research Station Lease expires 31.3.92.
	Perpetual Country Lease No.1612, Non-Competitive Lease	4.65	Heron Island Pty Ltd	Purpose: Tourist Resort
	Permit to Occupy No.33	0.046	Heron Island Pty Ltd	Purpose: Helicopter Pad
Erskine Island	Vacant Crown Land	2.02	Qld Department of Lands	-
One Tree Island	Special Lease 33351	2.43	University of Sydney, N.S.W.	Purpose: Marine Scientific Research Lease expires 31.7.84.
Masthead Island	Recreation & Scientific Reserve (Reserve No.211)	64.75	Qld Department of Lands	-
Hoskyn Islands	National Park (Reserve No.219)	12.0	Qld National Parks & Wildlife Service	Has been declared as a Scientific Area.
Fairfax Islands	National Park (Reserve No.219)	19.0	Qld National Parks & Wildlife Service	Has been declared as a Scientific Area.
Lady Musgrave Island	National Park (Reserve No.224)	20.23	Qld National Parks & Wildlife Service	-
	Lighthouse Reserve (Permissive Occupancy)	0.04	Commonwealth of Australia	Purpose: Lighthouse
Lady Elliott Island	Lighthouse Transferred Property No.21	36.40	Commonwealth of Australia	Purpose: Lighthouse
	Part of this Transferred Property (22.3 ha) is leased by the Commonwealth		D. Adams, Pialba, Qld	Purpose: Airstrip & Tourist Resort Lease expires 31.7.79. (Currently being renewed for 5 years.)

(a) Areas from Queensland Department of Lands.

(c) Fauna Sanctuaries

All islands in Queensland are fauna sanctuaries under the Fauna Conservation Act, 1974.

3.4 CURRENT MANAGEMENT PRACTICES

The principal, active contributors to the management of the Capricornia Section are the Queensland Fisheries Service, Queensland Boating and Fisheries Patrol, Commonwealth Dept of Transport, Queensland National Parks and Wildlife Service, and Queensland Dept of Lands. Qld Fisheries Service and Qld Boating and Fisheries Patrol administer both State and Commonwealth legislation. Their areas of jurisdiction, responsibilities, management activities and management inputs are summarized in Table 9.

Minor management contributions are also made by:

. Air Sea Rescue organizations in Yeppoon-Rosslyn Bay, Port Curtis and Bundaberg, whose members voluntarily provide surveillance and rescue services to the users of the Capricornia Section.

. Heron Island tourist resort personnel and individual operators who endeavour to monitor and responsibly control the activities of their guests/users.

. Qld Dept of Harbours and Marine which is responsible for the small boat harbour on Heron Island.

. Beach Protection Authority with regard to erosion problems on Heron Island.

TABLE 9. CURRENT MANAGEMENT OF THE CAPRICORNIA SECTION

ORGANIZATION	AREA OF JURISDICTION RELEVANT TO THIS SECTION	RESPONSIBILITIES RELEVANT TO THIS SECTION	MANAGEMENT ACTIVITIES	MANAGEMENT INPUT		
				Equipment used in the Section	Manpower input (person-days per annum)	Approximate expenditure per annum
Queensland Fisheries Service	Heron-Wistari Reef Marine Park. All fishing activities.	Enforcement of the Fisheries Act & Regulations.	Surveillance of the Marine Park by a Marine Park Ranger. Research and education.	NIL		
Queensland Boating & Fisheries Patrol	All fishing & boating activities both in and around the Capricornia Section.	Enforcement of the State & Commonwealth Fisheries Acts & Regulations. Enforcement of the State Marine Acts & Regulations.	Issue permits & licences. Surveillance of all fishing activities. Surveillance of all boating activities. (Officers rarely visit the Section.)	Very occasionally charter a boat.	180 (mainly the Marine Park Ranger)	$20,000
Commonwealth Department of Transport	Commonwealth Lighthouse Properties.	Maintenance of Navigation Aids. Safety of Shipping.	Maintenance of 3 lighthouses.	3 lighthouses. Tender (Cape Moreton). Helicopter & light planes (on contract).	750	$130,000
Queensland National Parks and Wildlife Service	National Park Islands & terrestrial fauna.	Enforcement of the Forestry Act & Regulations. Enforcement of the Fauna Conservation Act.	Maintenance of National Park islands & occasional surveillance of all islands. Educational programs. Issuing permits for camping on National Parks. Research.	2 caravans for accommodation on Heron Island. 1 x 10 m launch.	65	$12,000
Queensland Department of Lands	Crown land	Enforcement of the Land Acts & Regulations.	Issuing of leases on Crown land. Issuing permits for camping on Vacant Crown Land.	NIL	Occasional administration input from Head Office, Brisbane.	NIL

3.5 STRUCTURES AND SERVICES

Man-made structures have been constructed on 7 islands in the Section. Details of structures on each island are contained in Table 10. The most important of these are the lighthouses on North Reef, Lady Musgrave and Lady Elliott Islands and the Resort and Research Station on Heron Island. There is also a small scale resort operation on Lady Elliott Island where visitors are flown in from the mainland and accommodated in tents and 2 small cabins.

Details of services provided on each island are contained in Table 11 page 50. The provision of basic services has largely been undertaken by individual owners and lessees to meet the immediate needs of populations on each island. In addition to the services outlined in Table 11, Qld National Parks and Wildlife Service officers, charter boat operators and some members of the general public clean up rubbish left on islands and beaches. Heron Island has the best developed infrastructure servicing the needs of the hotel and resort, the research station, occasional visiting yachts and speed boats, and in some circumstances, the research station on One Tree Island.

Provision of adequate and reliable freshwater supplies is a problem on all islands. Rainfall catchment on roofs is used as the basis for collecting freshwater on all but Heron Island, where this source is supplemented by a reverse osmosis desalination plant generating 13,500 litres of freshwater per day. The output from the desalination plant is mixed with 9,000 litres of rainwater per day and then chlorinated. There are no usable groundwater resources on any of the islands.

TABLE 10. MAN-MADE STRUCTURES

ISLAND	MAN-MADE STRUCTURES	OWNER
North Reef Island	Lighthouse (unmanned).	Australian Department of Transport
North West Island	2 huts. Remnants of tramline. Small channel across reef flat. Graves (possibly 3).	Queensland Department of Lands
Wilson Island	Seat, table and small shelter.	Heron Island Pty Ltd?
Wreck Island	Hut	J.J. Booth
Heron Island	Resort and hotel. Helipad.	Heron Island Pty Ltd
	Boat harbour and channel across reef flat.	Queensland Department of Harbours & Marine
	Research Station.	Heron Island Research Station Board
	Weather Station.	Australian Bureau of Meteorology
	Caravan accommodation.	Queensland National Parks and Wildlife Service
One Tree Island	Research Station.	University of Sydney
Fairfax (West) Island	Old army igloo.	Queensland National Parks and Wildlife Service
Lady Musgrave Island	Lighthouse (unmanned).	Australian Department of Transport
Lady Elliott Island	Lighthouse (manned). 3 residences and sheds. Weather Station.	Australian Department of Transport
	Airstrip. 2 huts.	Lessee (D. Adams)

TABLE 11. SERVICES

ISLAND	SERVICE	PROVIDED FOR	PROVIDED BY
North Reef Island	Lighthouse maintenance by helicopter	Regular maintenance	Helitrans Pty Ltd
	Lighthouse maintenance by ship	Major maintenance	Australian Department of Transport
	Freshwater supply by rainfall catchment	Visiting maintenance personnel	
	Septic tanks for sewage and sullage	Visiting maintenance personnel	
	Electricity (diesel generating plant)	Visiting maintenance personnel	
Heron Island	Helicopter connection to Gladstone	Resort & research station visitors and staff	Helitrans Pty Ltd
	Launch connection to Gladstone	Resort & research station visitors and staff	Heron Island Pty Ltd
	Freshwater supply by desalination plant and rainfall catchment	Resort visitors and staff	
	Septic tanks for sewage and sullage	Resort visitors and staff	
	Electricity (240 v A.C. diesel generator)	Resort & research station visitors and staff	
	Solid waste collection	Resort visitors and staff	
	Freshwater supply by rainfall catchment	Research station visitors and staff	Heron Island Research Station Board
	Septic tanks for sewage and sullage	Research station visitors and staff	
	Solid waste collection	Research station visitors and staff	
	Radio telephone to mainland	Resort & research station visitors and staff	Telecom Australia
	Postal agency	Resort & research station visitors and staff	Australia Post
	Banking agency	Resort & research station visitors and staff	National Bank of Australasia Limited
One Tree Island	Freshwater supply by rainfall catchment	Research station staff and visitors	University of Sydney
	Electricity (wind generator)	Research station staff and visitors	
Lady Musgrave Island	Lighthouse maintenance by ship	Regular maintenance	Australian Department of Transport
Lady Elliott Island	Freshwater supply by rainfall catchment	Resident lighthouse staff	Australian Department of Transport
	Septic tanks for sewage and sullage	Resident lighthouse staff	
	Electricity (diesel generating plant)	Resident lighthouse staff and light	
	Lighthouse maintenance by ship	Major maintenance	
	Lighthouse maintenance by light aircraft	Regular maintenance	Whittaker Airways
	Light aircraft connection to Maryborough	Camping and day visitors	
	Light aircraft connection to Noosa	Camping and day visitors	Noosa Airways
	Light aircraft connec- to Brisbane	Camping and day visitors	Barrier Reef Airways

3.6 ACCESS

Although the range of activities currently undertaken in the Capricornia Section is extensive, and the interactions between activities complex, the patterns of access which bring people into the Section are relatively simple and well defined. Eight specific modes of access into the Section have been identified. Each mode of access is considered in some detail in this Section, and estimates of use pressure generated by each mode are made.

(i) Helicopter

Helitrans Pty Ltd operates a helicopter service to the Capricornia Section from Gladstone. They provide:

. an unscheduled daily service to Heron Island transporting most of the resort guests and staff and many of the research station visitors and staff;

. transport for the North Reef Island lighthouse servicing personnel;

. occasional charters for sightseeing and other purposes from both Gladstone and Heron Island.

(a) Flights to Heron Island

Helicopters transport 5,500 people per annum to Heron Island. The annual usage generated by the guests to the resort and the research station is estimated to be:

Resort guests -	28,500 person-days
Research station guests -	5,800 person-days.

(b) Flights to service North Reef lighthouse

The helicopters transport 2 or 3 service personnel to the North Reef lighthouse about 10 times a year. The service personnel stay on the island for 2 or 3 days each trip. The annual use generated by this helicopter service is estimated to be about 65 person-days.

(c) Charters

Probably less than 20 charters per year are done by the helicopters (G.B.R. Marine Park Authority, pers. com.).

(ii) Light aircraft

(a) Lady Elliott Island

The private airstrip on Lady Elliott Island is the only airstrip in the Capricornia Section. It is a short (580 m), unsealed airstrip suitable only for light twin-engined aircraft. These planes are used to transport day-visitors and resort visitors to and from the island, and to service the lighthouse.

Currently Whittaker Airways, operating out of Maryborough and Noosa (as Noosa Airways), fly to Lady Elliott Island on an unscheduled basis on average twice a week. One trip per week is for day-visitors and the other is for resort guests who then stay on the island for 7 days. On average, there are 7 people per flight.

Recently Barrier Reef Airways, operating out of Brisbane, have begun an unscheduled service to take day-visitors and campers to Lady Elliott Island. The operator aims to be taking 20 campers per week and 20+ day-visitors per week to the island in the near future. Currently, this operation generates little use of the island.

Whittaker Airways also takes supplies to the lighthouse staff on a fortnightly basis. In addition to this, about 20 special flights per year are made to the island for medical emergencies or the transport of specialized service personnel.

In summary, the annual use generated by light aircraft visitors to Lady Elliott Island is estimated to be:

Recreational use -	3,000 person-days
Lighthouse maintenance -	10 person-days.

(b) Aerial sightseeing tours

Aerial sightseeing tours over the Capricornia Section are operated by Countryair out of Rockhampton and Sunbird Airlines out of Gladstone. Approximately 200 persons have used these services over the past 12 months.

(iii) Seaplane

A small number of people visit the Capricornia Section in amphibious aircraft. Nearly all these people spend some time camping on the islands, with Lady Musgrave, Fairfax and Hoskyn Islands being the favoured locations. It is estimated that approximately 30 person-trips per year are made by this means of transport and this generates approximately 100 person-days of use per year.

(iv) Professional fishing boat

Professional fishing boats, operating principally from the Capricorn Coast (Yeppoon-Rosslyn Bay and Rockhampton), Gladstone and Bundaberg fish for scallops, pelagic fishes and demersal reef fishes in the Capricornia Section. The numbers of professional fishing boats working regularly in the area are shown below.

	PROFESSIONAL FISHING BOATS		
	Scallop Trawling	Pelagic Fishing	Demersal Fishing
Maximum number of boats working intermittently in the Section	40	20	30
Full-time equivalent boats	4	5	9

The area worked by these professional fishing boats is shown on Map 3.

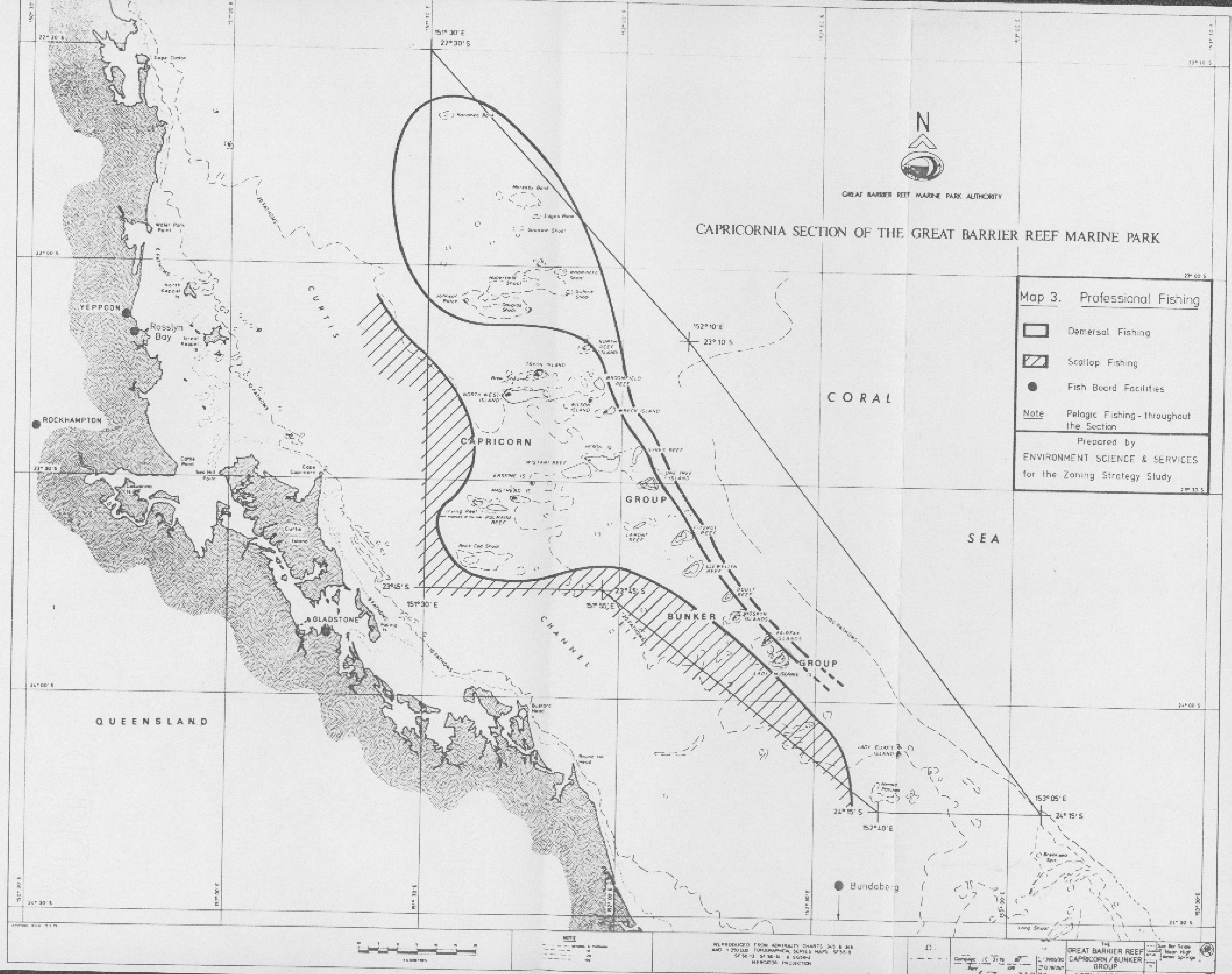
(a) Capricorn Coast professional fishing boats

Professional fishing boats from the Capricorn Coast fish throughout the area, in close proximity to the reefs, for pelagic fishes. These professional fishermen do little or no demersal reef fishing or scallop trawling in the Capricornia Section.

(b) Gladstone professional fishing boats

Professional fishing boats from Gladstone work the following areas in the Capricornia Section:

- Pelagic fishes - throughout the area in close proximity to the reefs.
- Demersal reef fishes - mainly around the northern shoals and the windward sides of the reefs


GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 3. Professional Fishing
Demersal Fishing
Scallop Fishing
Fish Board Facilities
Note Pelagic Fishing - throughout the Section
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
N
ROCKHAMPTON
YEPPOON
Rosslyn Bay
GLADSTONE
Bundaberg
QUEENSLAND
CURTIS
CHANNEL
CAPRICORN
GROUP
BUNKER
GROUP
CORAL
SEA
151° 30' E
22° 30' S
152° 10' E
23° 10' S
23° 45' S
151° 30' E
151° 55' E
24° 15' S
152° 40' E
153° 05' E
24° 15' S
GREAT BARRIER REEF
CAPRICORN / BUNKER
GROUP

along the eastern boundary of the Capricorn Group.

These professional fishermen rarely trawl for scallops within the Capricornia Section.

(c) Bundaberg professional fishing boats

Professional fishing boats from Bundaberg work the following areas in the Capricornia Section:

. Pelagic fishes - throughout the area in close proximity to the reefs.

. Demersal reef fishes - mainly in the area south of Hoskyn Islands Reef.

. Scallops - mainly around the southern side of Lady Musgrave Island Reef but also to the north-west and south of Masthead and Polmaise Reefs.

(v) Charter boat/ferry

Charter boats from the Capricorn Coast (Yeppoon-Rosslyn Bay-Rockhampton), Gladstone and Bundaberg operate in the Capricornia Section. These boats are chartered by fishing parties, diving groups, shell collectors, groups of campers, tourists (groups who wish to participate in a range of activities, e.g. fishing, reef-walking, snorkelling, sightseeing, film making), research personnel and government officers working in the area.

The number of charter boats operating in the Capricornia Section and the usage generated by charter boat patrons is shown on Table 12. The annual usage generated by charter boat operations in the area is estimated to be approximately 20,000 person-days. It should be noted that most of the camping use generated by charter baots is spent on islands rather than on the boats.

TABLE 12. USAGE GENERATED BY CHARTER BOATS

ORIGIN	NUMBER OPERATING	ANNUAL USE PRESSURE (person-days per year)						
		Fishing	Diving	Camping	Shell Collectors	Tourists	Other[a]	Total
Capricorn Coast (Rosslyn Bay)	4	1,500	400	1,100	50	310	-	3,360
Gladstone	13[b]	2,400	1,520	4,500	50	410	500	9,380
Bundaberg	6[c]	1,800	1,800	2,500	50	470	200	6,820
TOTAL	23	5,700	3,720	8,100	150	1,190	700	19,560

(a) Includes government charters, professional photographers.
(b) Six operate regularly and seven only occasionally.
(c) Three operate regularly and three only occasionally.

The ferry *Atunga* transports resort and research station guests and staff to Heron Island. The annual usage generated at the resort and research station by these guests is estimated to be:

Resort guests -	5,000 person-days
Research station guests -	1,200 person-days.

The ferry service between Gladstone and Heron Island is expected to be discontinued in the near future (Heron Is. Pty Ltd, pers. com.).

(vi) Speed boat

Private speed boats which are trailed to and launched from coastal boat ramps are one of the principal means of access to most reefs and islands in the Section. Speed boats visiting the Section may be subdivided into 2 classes. Firstly, there are larger, well-equipped boats over 5.5 m in length which tend to operate within a radius of approximately 100 km from their launching point. Secondly, there are smaller, lighter boats between 4.5 m and 5.5 m in length which operate within a radius of approximately 60 km from their launching point. Speed boats less than 4.5 m in length rarely attempt the long journey to the Reef.

As set out on Table 13, there are 5 principal launching points for the 2 classes of speed boat visiting the Capricornia Section. Gladstone and Turkey are the only embarkation points which place any of the reefs and islands within the safe operating range of the smaller boats.

TABLE 13. PRINCIPAL LAUNCHING POINTS

	Class of Boat	
	4.5 to 5.5 m	More than 5.5 m
Capricorn Coast (Yeppoon-Rosslyn Bay - Rockhampton)	No	Yes
Gladstone	Yes	Yes
Turkey (Rodds Bay)	Yes	Yes
Seventeen Seventy (Round Hill Head)	No	Yes
Bundaberg	No	Yes

Distribution of speed boat use within the Section falls into a fairly distinct pattern determined principally by:

. the location of principal points of embarkation relative to the Capricornia Section;

. the range of the boats; and

. the availability of safe anchorages.

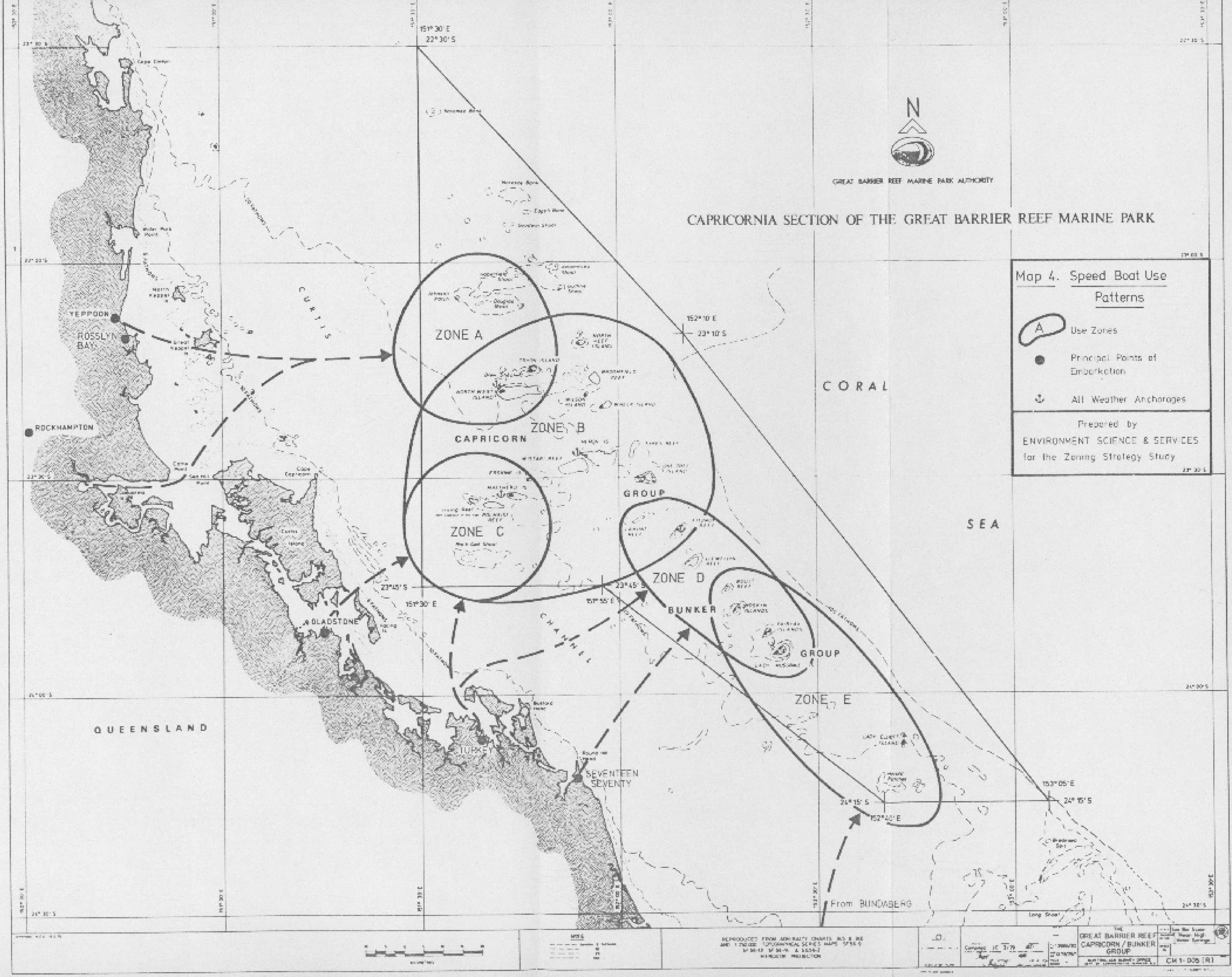
The 5 principal use zones are shown on Map 4 and discussed below.

Zone A is the principal area used by speed boats in the 5.5 m and over class from the Capricorn Coast.

Zone B is the principal area used by boats in the 5.5 m and over class from Gladstone.

Zone C is the principal area used by the smaller boats (4.5 m to 5.5 m) from both Gladstone and Turkey. It is also used for one-day trips by the 5.5 m and over class boats from Gladstone and Turkey.

Zone D is the principal area used by boats in the 5.5 m and over class from Turkey and Seventeen Seventy.



GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 4. Speed Boat Use Patterns
Use Zones
Principal Points of Embarkation
All Weather Anchorages
Prepared by ENVIRONMENT SCIENCE & SERVICES for the Zoning Strategy Study
ZONE A
ZONE B
ZONE C
ZONE D
ZONE E
CAPRICORN
GROUP
BUNKER
GROUP
CORAL
SEA
CURTIS
CHANNEL
QUEENSLAND
YEPPOON
ROSSLYN BAY
ROCKHAMPTON
GLADSTONE
TURKEY
SEVENTEEN SEVENTY
From BUNDABERG
151° 30' E
22° 30' S
152° 10' E
23° 10' S
23° 45' S
151° 55' E
24° 15' S
152° 40' E
153° 05' E
GREAT BARRIER REEF
CAPRICORN / BUNKER GROUP

Zone E is the principal area used by boats in the 5.5 m and over class from Bundaberg.

Prevailing weather conditions are the major determinants of levels of use. In the absence of any reliable data describing use levels, a broad estimate of annual use levels has been made on the basis of recorded weather conditions and discussions with local participants. The method is based on estimating the number of boats which visit the Section from each launching point on a 'good weekend', then assessing how use decreases as weather conditions deteriorate. It involves the following assumptions:

Wind Speed (km/hr)	Description	Use Level Relative to a 'Good Weekend'
0 - 10	good weekend	1.0
11 - 20	fair weekend	0.5
Over 20	poor weekend	0.0

By using daily wind speed records over a year and making allowances for school holidays and other holiday periods, estimates of annual boat trips to the Section were made. These estimates, together with estimates of annual use pressure are contained in Table 14.

The occupants of speed boats participate in a wide variety of activities. Some come to the area to participate in one specific activity, but many appear to participate in a range of related activities. The principal activities in which the occupants of speed boats participate include fishing, diving, reef-walking, spearfishing, shell collecting, camping and aquarium fish collecting.

TABLE 14. ESTIMATES OF USAGE GENERATED BY SPEED BOATS

Origin	Boat Trips per year	Annual Use Pressure[(a)] person-days/year
Capricorn Coast	50	350
Gladstone	1,260	8,820
Turkey	210	1,470
Round Hill Head - Seventeen Seventy	300	2,100
Bundaberg	525	3,675
Total (rounded)	2,350	16,400

(a) Estimate based on: 30% of boats stay one day
60% of boats stay two days
10% of boats stay five days
Average occupancy 3.5 persons.

(vii) Yacht

Islands and reefs with safe anchorages are visited intermittently by yachts cruising up or down the Queensland coast. The most popular destination is Lady Musgrave Island, where the lagoon provides safe anchorage for up to 100 yachts per year. Other favoured anchorages are the boat harbour at Heron Island, Fitzroy Reef lagoon and in the lee of both North West and Wistari Reefs. The majority of cruising yachts visit the area during the winter months. It is estimated that cruising yachts could generate an annual use pressure of up to 2,000 person-days.

Racing yachts also pass through the Section between Lady Musgrave and Lady Elliott Islands. The Brisbane to Gladstone race takes place each Easter and is followed almost immediately by the Gladstone to Bundaberg (via Lady Elliott Island) race. In 1979 there were 40 entrants in the race to Gladstone and 23 entrants in the race to

Bundaberg. Although the racing yachts themselves place few additional pressures on the resources of the Capricornia Section, it is likely that promotion of the races and their increasing popularity will increase the numbers of cruising yachts visiting the Section.

(viii) Ship

(a) Shipping traversing the Capricornia Section

Commercial shipping using the ports of Maryborough, Bundaberg, Gladstone and Rockhampton traverses the Capricornia Section.
Relevant Port Statistics for 1977 are shown on the following table. The principal commodities carried through the Section are raw sugar, coal, bauxite and alumina.

Port	Number of vessels in 1977	Gross registered tonnage
Maryborough	14	202,000
Bundaberg	96	978,000
Gladstone	630	11,402,000
Rockhampton	80	564,000
Total	820	13,146,000

Source: G.B.R. Marine Park Authority files.

Recommended shipping routes are shown on Map 5. Most ships use these recommended routes although a few (probably less than 2 per cent) traverse the Capricornia Section in other locations. These are also shown on Map 5.

(b) Shipping in close proximity to the Capricornia Section

The Capricornia Section is bounded by the Curtis Channel and the Capricorn Channel which both lead into the Inner Route, the major shipping channel between the mainland and the Great Barrier Reef (see Map 5).

The number of ships using the Inner Route was 1,550 in 1977 and is increasing at about 1% per annum. Approximately 25% of these ships do not carry pilots.

(c) Lighthouse tender

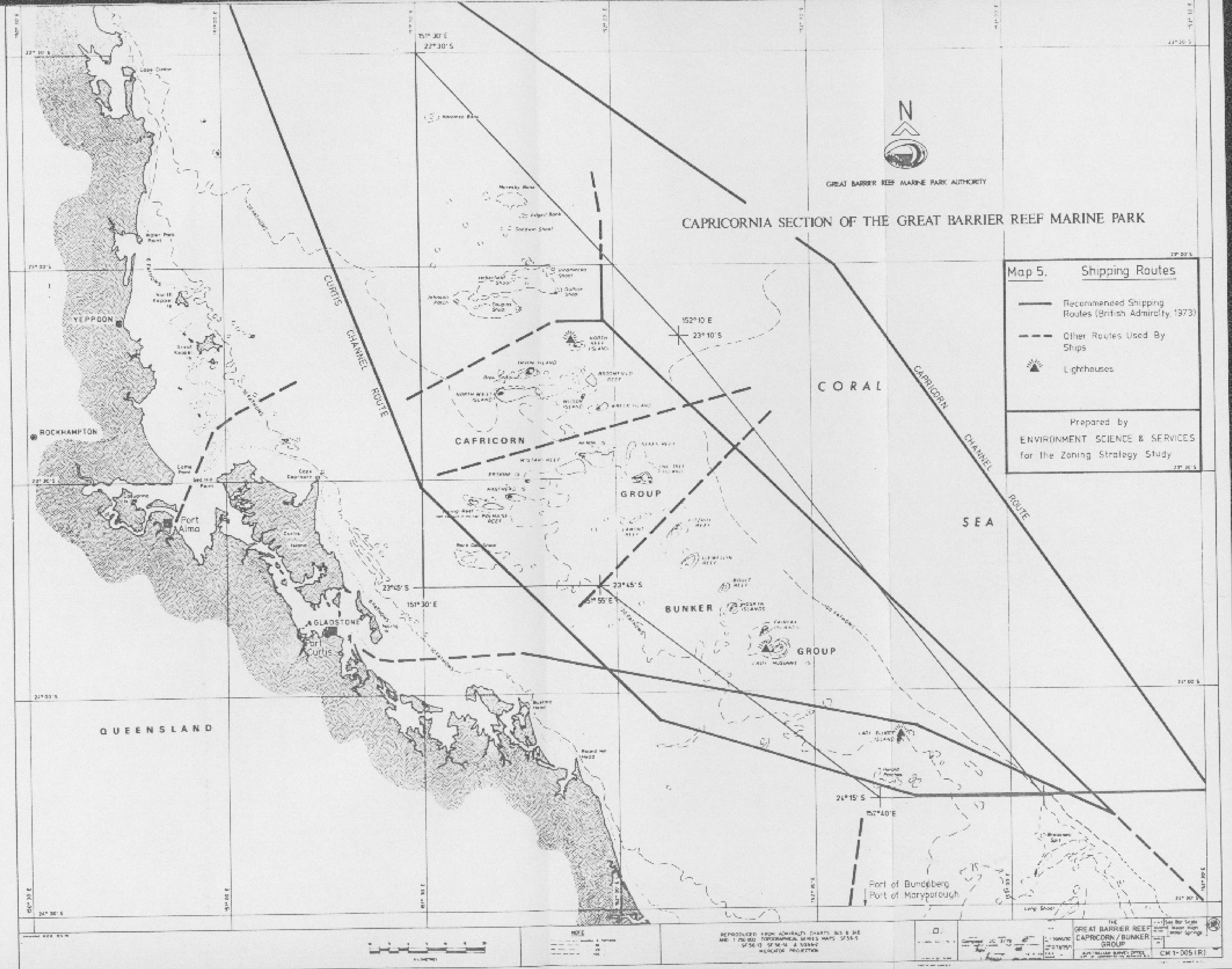
The M.V. *Cape Moreton* is used to re-fuel and service the lighthouses on North Reef, Lady Musgrave Island and Lady Elliott Island as follows:

. North Reef lighthouse
  3 to 4 days once every 12 to 18 months for re-fuelling and maintenance.

. Lady Musgrave Island lighthouse
  3 to 4 days once a year for re-fuelling and maintenance;
  1 one-day inspection per year.

. Lady Elliott Island lighthouse
  1 to 2 days once a year for re-fuelling and re-stocking.

The annual usage generated by personnel from the M.V. *Cape Moreton* is estimated to be 100 person-days.



CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
GREAT BARRIER REEF MARINE PARK AUTHORITY
N
Map 5. Shipping Routes
Recommended Shipping Routes (British Admiralty 1973)
Other Routes Used By Ships
Lighthouses
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
CURTIS CHANNEL ROUTE
CAPRICORN CHANNEL ROUTE
CORAL SEA
QUEENSLAND
ROCKHAMPTON
YEPPOON
Port Alma
GLADSTONE
Port Curtis
CAPRICORN GROUP
BUNKER GROUP
Port of Bundaberg
Port of Maryborough
152° 10' E
23° 10' S
23° 45' S
151° 30' E
151° 55' E
22° 30' S
24° 15' S
152° 40' E
GREAT BARRIER REEF
CAPRICORN / BUNKER GROUP
CM1-005 (R)

(ix) Summary

Based on the estimates of use levels derived in this section, an overview of total annual use pressure generated by each access mode can be obtained. These use pressures, measured in annual visitor-days, are contained in Table 15. It should be noted that the estimates do not include:

- contributions from permanent residents on the islands, or
- contributions from professional fishermen.

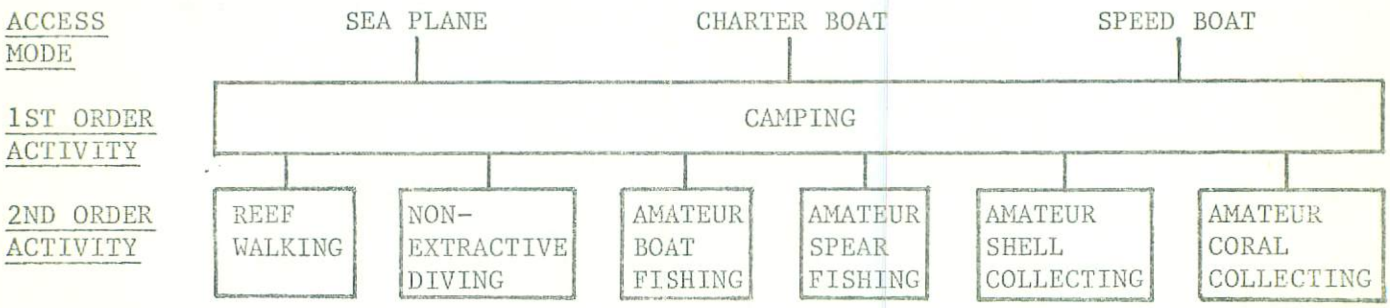
TABLE 15. USE PRESSURES GENERATED BY ACCESS MODES

Access Mode	Generated Use Pressure (visitor-days per annum)	Reliability
Helicopter	34,400	good
Light aircraft	3,200	good
Seaplane	100	fair
Charter boat	19,560	poor
Speed boat	16,400	poor
Yacht	2,000	poor
Ship	100	good
Total	75,760	

3.7 ACTIVITIES AND USE PATTERNS

In the previous section, methods of access to the Capricornia Section were discussed and estimates of annual use pressures generated by the various access modes were produced. The purpose of this section is to look at usage of the Capricornia Section from an activity point of view, to trace the linkages between access and activity patterns and to estimate, wherever possible, how much and where each activity is occurring.

Because the activity patterns are complex and highly inter-related it is useful to introduce the concept of first and second order activities to trace the links between access modes and eventual participation in individual activities. The relationship between access modes, first order activities and second order activities is illustrated below for the case of camping.



Some activities can be classified as either first or second order. In the above example, amateur boat fishing is a second order activity. However, when amateur boat fishing is undertaken directly from a speed boat on a day trip, it is regarded as a first order activity.

The links between each access mode and the various activities currently undertaken in the Capricornia Section are identified in Figure 4. Current activities not represented in Figure 4 are photography and nature appreciation, since both may be an integral part of most other activities and on their own produce few deleterious impacts.

Each of the activities and the various contributions which make up the activity are now considered individually.

(i) Resort visits

Holiday resorts are located on Heron Island and Lady Elliott Island. Access to Heron Island is by helicopter

Activities / Access Mode	Resort Visit	Res'ch Station Visit	Camping	Light House Maint'ce	Educ'n & Interp'n	Reef Walking	Non Ext've Diving	Boat Fishing		Spear Fishing		Shell Collecting		Coral Collecting		Aq. Fish Collecting	
								Comm.	Amateur	Comm.	Amateur	Comm.	Amateur	Comm.	Amateur	Comm.	Amateur
Helicopter	●	●		●	▼ ▲	▼ ▲	▼ ▲		▼		▲		▼ ▲		▲		
Light Aircraft	●			●		▼	▼		▼		▼		▼		▼		
Seaplane			●			▼	▼		▼		▼		▼		▼		
Professional Fishing Boat								●				●					
Charter Boat/ Ferry	●	●	●		▼ ▲	▼ ● ▲ ▲	▼ ● ▲ ▲	●	▼ ● ▲		● ▲ ▲		▼ ● ▲ ▲		● ▲ ▲		
Speed Boat			●			▼ ●	▼ ●	●	▼ ●		▼ ●	●	▼ ●		▼ ●	●	●
Yacht						●	●		●		●		●		●		
Ship				●													

1st. Order Activity ●   2nd. Order Activity ▼ or ▲

Figure 4: Activity Generation Matrix

or ferry, and to Lady Elliott Island by light aircraft. Annual levels of use of resort accommodation are summarized below.

	Annual Use of Accommodation (person-days)	
	Heron Island	Lady Elliott Island
Guests	33,500	3,000
Resident staff & families	20,400	nil
Total	53,900	3,000

(ii) <u>Research station visits</u>

Scientific research stations are located on Heron Island and One Tree Island. Access to both stations is via the helicopter and ferry services to Heron Island. Annual levels of use of research station accommodation are summarized below.

<table>
<tr><th></th><th colspan="2">Annual Use of Accommodation (person-days)</th></tr>
<tr><th></th><th>Heron Island Research Station</th><th>One Tree Island Field Station</th></tr>
<tr><td>Research scientists</td><td>2,000</td><td rowspan="2">1,100</td></tr>
<tr><td>Research students</td><td>4,000</td></tr>
<tr><td>Secondary students</td><td>700</td><td>nil</td></tr>
<tr><td>Resident staff & families</td><td>2,900</td><td>700</td></tr>
<tr><td>Total</td><td>9,600</td><td>1,800</td></tr>
</table>

Queensland National Parks and Wildlife Service have 2 caravans located on Heron Island to accommodate visiting research workers. Annual use is estimated to be 100 person-days.

(iii) Camping

Camping is a popular activity on islands in the Capricornia Section. It is undertaken primarily by family groups, clubs and groups of secondary and tertiary students. Methods of access to the islands are:

- . speed boat;
- . charter boat drop-off (parties often take a small boat);
- . seaplane.

The most popular camping periods are school holidays, Christmas and Easter. Lengths of stay vary from overnight to 1 month with group sizes of up to approximately 30 people.

Estimates of annual levels of camping use on individual islands are given below. These estimates are based on information from a variety of sources including Domm (1977), G.B.R. Marine Park Authority files and discussions with users, charter boat operators, officers of Qld National Parks and Wildlife Service and officers of Qld Fisheries Service.

Island	Annual Camping Use (person-days)
North West	6,000
Lady Musgrave	5,000
Masthead	2,500
Tryon	800
Hoskyn	600
Wreck	500
Erskine	100
Wilson	100
Fairfax	100
Total	15,700

(iv) Lighthouse maintenance

Lighthouses are situated on North Reef, Lady Elliott Island and Lady Musgrave Island. The North Reef light is serviced by helicopter and ship, the Lady Elliott light by light aircraft and ship, and the Lady Musgrave light by ship alone. Levels of use generated by lighthouse maintenance are summarized below.

	Annual Lighthouse Maintenance Use (person-days)		
	North Reef Light	Lady Musgrave Light	Lady Elliott Light
Visiting maintenance personnel	100	45	30
Resident staff & families	nil	nil	4,400
Total	100	45	4,430

(v) Education and interpretation

Current education and interpretation activities are generated by people staying at the resort and research station on Heron Island.* Estimated annual levels of education/interpretation generated from the resort are:

Conducted reef walks	1,000 person-days
Heron Island Bird School	300 person-days
Heron Island Naturalists Week	100 person-days
Total	1,400 person-days

Senior high school students undertake educational activities from the Heron Island research station. During 1977-78 this resulted in about 700 person-days use.

*Some additional educational and interpretive use is generated by groups of students camping on islands. This use has been included in the figures for camping documented on p.66.

Most of the education/interpretation activities are centred around Heron Island and Wistari Reefs, although the Heron Island Bird School involves short visits to Masthead, Fairfax and Lady Musgrave Islands.

(vi) Reef walking

Reef walking occurs as either a direct (first order) activity from charter boats and speed boats, or as an indirect (second order) activity by resort visitors, research station visitors and campers. Although specific use levels are unknown, it can be assumed that the majority of resort visitors, research station visitors and campers will walk on part of the reef during their stay. The most heavily used reefs for reef walking are:

Heron Island Reef
North West Island Reef
Wilson Island Reef
Masthead Island Reef
Lady Musgrave Island Reef,

although it is likely that some reef walking occurs on all emergent reefs.

(vii) Non-extractive diving

Non-extractive diving occurs directly from charter boats, speed boats and yachts, and indirectly by resort visitors, research station visitors and campers. Level of non-extractive diving on Heron Island and Wistari Reefs generated by resort visitors is estimated to be 3,000 person-days per annum. Domm (1977) and W. Deas (pers. com.) identify the following additional reefs as popular diving locations:

Tryon Island Reef
North West Island Reef
Masthead Island Reef
Polmaise Reef
Fitzroy Reef, and
Lady Musgrave Island Reef,

although the remaining reefs in the Section are also dived on intermittently. Apart from Heron Island and Wistari Reefs, use levels are not known.

(viii) Boat fishing

(a) The fishermen

Three groups of fishermen work the Capricornia Section - professional, amateur and pro-amateur.

Professional fishermen hold a master fisherman's licence and work from a registered fishing vessel. They take pelagic fish, demersal fish and scallops from the Section and sell their catches to the Qld Fish Board or on the 'black market'. At least 90 professional fishermen work intermittently in the areas shown on Map 3 (refer to Section 3.6 p.54.) Detailed accounts of professional fishing activities in the Section are contained in Fisheries et al (1977) and Jensen (1979).

Amateur fishermen pursue both demersal reef fishes and pelagic fishes for their own purposes and enjoyment (i.e. consumption, recreation, giving away to friends etc.). They do not sell any part of their catch. Amateur fishermen work from speed boats, charter boats and yachts. Although the most intensive amateur fishing is centred around the best and closest small boat anchorages, some fishing occurs on most of the reefs, reefal shoals and coral patches in the Section. Domm (1977) and W. Craik (pers. com.) agree that the areas most heavily fished by amateur fishermen are:

North West Island Reef
Heron Island Reef
Wistari Reef
Fitzroy Reef
Masthead Island Reef
Irving Reef
Polmaise Reef
Rock Cod Shoal
Lady Musgrave Island Reef.

The numbers of amateur fishermen and total time spent in amateur fishing activities in the Section are not known.

Pro-amateur fishermen are basically amateur fishermen who, because they sell all or part of their catch, are classed as pro-amateurs. They work from speed boats and charter boats and fish throughout the area for demersal and pelagic fishes. In January 1978 the Qld Fisheries Service introduced a 'Permit to sell surplus fish'. This permit enables the pro-amateur fishermen to sell his surplus catch to the Qld Fish Board.* In the 12 months July 1978 to June 1979, 122 of these permits were issued from the Rockhampton, Gladstone and Bundaberg Qld Boating & Fisheries Patrol offices. Some of these permit holders probably took and sold fish from the Capricornia Section. However, a large component of the total catch sold by pro-amateur fishermen is known to be traded on the 'black market' rather than through the Fish Board. For this reason it is not

*A permit to sell surplus fish is issued for a period of 28 days at a fee of $18.00.

possible to make a reasonable estimate of the number of fishermen who operate as pro-amateurs.

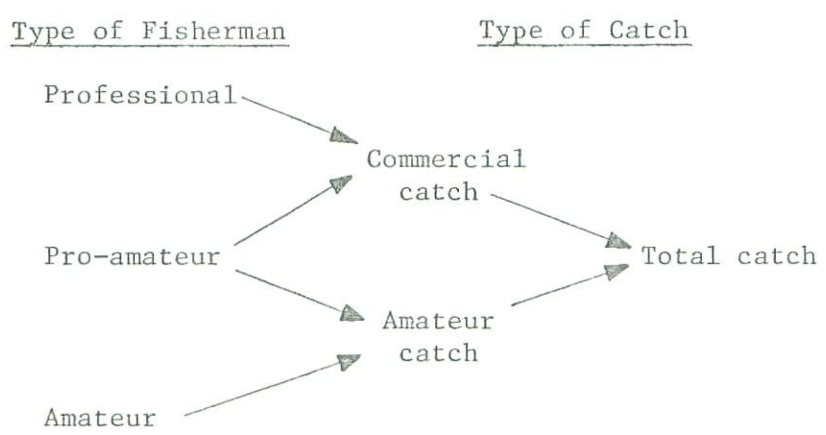
(b) The catch

The total catch in the Capricornia Section can be divided into the following 2 components:

- the commercial catch, and
- the amateur catch.

The commercial catch is made up of fishes and scallops which are sold either to the Qld Fish Board or on the 'black market'. The amateur catch is made up of the other fishes which are caught in the Section but not sold.

The way in which the 3 types of fishermen operating in the Section contribute to these catches is shown below.



. The commercial catch

The commercial catch is derived from the scallop, pelagic and demersal fisheries.

Estimated annual commercial landings of scallop meat from the Capricornia Section in 1978 was about 100,000 kg. All scallop fishing is undertaken by professional fishermen principally between September and November.

The principal pelagic fish caught in the Section is mackerel. Estimated annual commercial landings (whole fish equivalents) of pelagic fishes by professional and pro-amateur fishermen from the Capricornia Section are:

Rockhampton/Yeppoon/Rosslyn Bay	20,000 kg
Gladstone	16,000
Bundaberg	64,000
Total	100,000

In the Capricornia Section the mackerel season extends from May to August.

The principal demersal fishes, which are caught all year round, are coral trout, sweetlip, emperor, snapper and cod. Estimated annual commercial landings (whole fish equivalents) of demersal fish by professional and pro-amateur fishermen from the Capricornia Section are:

Rockhampton/Yeppoon/Rosslyn Bay	nil
Gladstone	125,000 kg
Bundaberg	100,000
Total	225,000

. The amateur catch

The amateur catch is derived from the pelagic and demersal fisheries by pro-amateur and amateur fishermen. The size of this catch is unknown.

(ix) Spearfishing

(a) Commercial

In Queensland commercial spearfishing is illegal south of latitude 13°S. Although illegal in the Capricornia Section, from time to time there are reports of its occurrence.

(b) Amateur

Amateur spearfishing occurs intermittently on most of the reefs outside the Heron-Wistari Reefs Marine Park. It is undertaken as a direct activity from charter boats and speed boats and indirectly by resort visitors on Lady Elliott Island, campers, and visitors to the research stations.

(x) Shell collecting

(a) Commercial

Most of the commercial shell collecting is done by dredging (from commercial fishing boats) and by diving (from speed boats). Although there is no available information on the quantities of shells taken, the principal sources reported in Fisheries Division et al (1977) are:

. around North West Island Reef in 14 fathoms;
. around Tryon Island Reef;
. east of Innamincka Shoal in 60-70 fathoms;
. around One Tree Island Reef in 20-29 fathoms;
. around Lamont Reef in 30 fathoms;
. around Llewellyn and Fitzroy Reefs;
. west of Boult Reef in 31 fathoms; and
. around, and in the lagoon of, Lady Musgrave Island Reef.

(b) Amateur

Amateur shell collection is undertaken principally by people walking on reefs and is most common on reefs where there are aggregations of people camping or staying at resorts. Divers are the other major group of people responsible for amateur shell collection. There are reports of major exploitation of shell resources by shell collecting clubs (G.B.R. Marine Park Public Submissions File).

Although there are no records of quantities of shells taken, the total number of shells removed from the reefs is probably quite large. Domm (1977) considers that the principal areas for amateur shell collecting are:

North West Island Reef
Wilson Island Reef
Masthead Island Reef
Lady Musgrave Island Reef.

(xi) Coral collecting

(a) Commercial

There are no current coral collecting leases for the commercial collection of coral in the Capricornia Section (Qld Fisheries Service, pers. com.). Illegal collection on a limited scale is probably occurring.

(b) Amateur

Amateur coral collection is undoubtedly being undertaken by divers and reef walkers. Although the amounts of coral being taken are unknown, most of it is probably being removed from reefs which are most heavily used for other activities.

(xii) Aquarium fish collecting

(a) Commercial

There is one known commercial aquarium fish collector operating in the Section. There is no available information on the areas being worked and the numbers of fishes being taken.

(b) Amateur

Levels of amateur aquarium fish collecting in the Section are unknown. However it is known that some divers in the Section collect aquarium fishes from time to time (L. Zell, pers. com.).

(xiii) Summary

A summary of the relative importance and spatial distribution of activities within the Section is contained in Table 16.

3.8 WASTES AND WASTE DISPOSAL

Wastes currently generated by human activities and shipping in the Section are:

- solid waste which includes combustible, non-combustible, organic and inorganic material;
- human metabolic wastes;
- liquid wastes - sullage, washing water, effluent from desalination plant etc.;
- ballast from ships.

The present methods of waste disposal are shown in Table 17 page 77. The detailed nature and quantities of the wastes being discharged into the marine environment of the Capricornia Section are not known.

TABLE 16. SPATIAL DISTRIBUTION OF ACTIVITIES

LOCATION[a]	RESORT VISITS	RESEARCH STATION VISITS	CAMPING	LIGHT-HOUSE MAINT-ENANCE	EDUCA-TION & INTER-PRETA-TION	REEF WALKING	NON-EXTRACTIVE DIVING	BOAT FISHING (DEMERSAL)[b]		SPEARFISHING		SHELL COLLECTING		CORAL COLLECTING		AQUARIUM FISH COLLECTING	
								COMMERCIAL	AMATEUR	COMMERCIAL	AMATEUR	COMMERCIAL	AMATEUR	COMMERCIAL	AMATEUR	COMMERCIAL	AMATEUR
Northern Shoals (Karamea Bank to Douglas Shoal)	-	-	-	-	-	-	minor	major	minor	ILLEGAL - LOCATIONS AND LEVELS NOT KNOWN	THROUGHOUT THE AREA (EXCEPT HERON AND WISTARI REEFS) SPECIFIC LOCATIONS AND LEVELS NOT KNOWN	minor	-	NO CURRENT LEASES	LOCATIONS AND LEVELS NOT KNOWN	LOCATIONS AND LEVELS NOT KNOWN	LOCATIONS AND LEVELS NOT KNOWN
North Reef	-	-	-	minor	-	minor	minor	minor[c]	minor			-	minor				
Brew Shoal	-	-	-	-	-	-	minor	-	minor			-	-				
Tryon I. Reef	-	-	medium	-	minor	medium	major	-	minor			major	medium				
Broomfield Reef	-	-	-	-	-	minor	minor	minor[c]	minor			-	medium				
North West I. Reef	-	-	major	-	medium	major	major	-	major			major	major				
Wilson I. Reef	-	-	minor	-	-	major	minor	-	minor			-	major				
Wreck I. Reef	-	-	medium	-	-	medium	minor	minor[c]	minor			-	medium				
Sykes Reef	-	-	-	-	-	-	minor	minor[c]	minor			-	-				
Heron I. Reef	major	major	-	-	major	major	major	-	medium			-	minor				
Wistari Reef	-	-	-	-	-	medium	major	-	major			-	minor				
Erskine I. Reef	-	-	minor	-	-	medium	minor	-	minor			-	minor				
One Tree I. Reef	-	minor	-	-	-	medium	minor	minor[c]	minor			major	minor				
Masthead I. Reef	-	-	major	-	minor	major	major	-	major			-	major				
Irving Reef	-	-	-	-	-	-	minor	-	major			-	minor				
Polmaise Reef	-	-	-	-	-	medium	major	-	major			-	medium				
Rock Cod Shoal	-	-	-	-	-	-	minor	-	major			-	minor				
Lamont Reef	-	-	-	-	-	-	minor	-	minor			major	-				
Fitzroy Reef	-	-	-	-	-	medium	major	minor[c]	minor			major	medium				
Llewellyn Reef	-	-	-	-	-	minor	minor	minor[c]	minor			major	medium				
Boult Reef	-	-	-	-	-	minor	minor	minor[c]	minor			major	minor				
Hoskyn Is. Reef	-	-	medium	-	-	minor	minor	minor[c]	minor			-	minor				
Fairfax Is. Reef	-	-	minor	-	minor	medium	minor	minor[c]	minor			-	medium				
Lady Musgrave I.Reef	-	-	major	minor	minor	major	major	minor[c]	major			major	major				
Lady Elliott I. Reef	minor	-	-	major	-	medium	minor	?	minor			-	medium				
Herald Patches	-	-	-	-	-	-	?	?	?			-	-				
ANNUAL USE PRESSURE	56,900 p.-days	11,500 p.-days	15,700 p.-days	4,575 p.-days	2,100 p.-days	Unknown	Unknown	225,000 kg	Unknown	Low	Unknown	Unknown	Unknown	Nil	Unknown	Unknown	Unknown
RELIABILITY	Good	Good	Poor	Good	Fair	-	-	Poor	-	Fair	-	-	-	Fair	-	-	-

(a) Includes the named shoal or reef (and island) and the waters surrounding that reef or shoal
(b) Pelagic fishing is seasonal and occurs throughout the area. Scallop trawling occurs in seabed areas shown on Map 3.
(c) Windward side.

TABLE 17. PRESENT WASTE DISPOSAL METHODS

Origin of waste	Type of Waste			
	Solid waste	Human metabolic waste	Liquid waste	Ballast
Speed boats and charter boats	sea[a]	sea[a]	sea[a]	-
Campers and One Tree Island Field Station	sea[a] buried burnt	sea[a] buried	sea[a] surface drainage	-
Resorts, Heron Island Research Station and lighthouses	sea[a] buried burnt	septic system	septic system surface drainage[b] old well [a?][c]	-
Ships	sea[a]	sea[a]	sea[a]	sea[a]

(a) Denotes sources of marine pollutants. (b) Aquarium waste water from research station. (c) Effluent from desalination plant for Heron Island resort is discharged into an old well.

It is illegal for ships to discharge oil or oily wastes within 160 km of the Great Barrier Reef and in general, oil and oil wastes from ships are not discharged in the vicinity of the Capricornia Section (Qld Dept of Harbours & Marine, pers. com.).

3.9 ECONOMIC ASPECTS

A detailed assessment of the economic significance of activities dependent on the Capricornia Section is not attempted here. Some data relevant to the derivation of estimates of the 'value' of these activities and their impacts on other sectors, both regionally and more broadly, have been obtained, but the necessary detailed analysis is left to the evaluation stage of this study. As well, the measurement of the direct and indirect effects on the various sectors of the economy has been reported in Jensen (1979) as part of another project for the Great Barrier Reef Marine Park Authority. However some indication of the importance of reef oriented recreation, research, fishing etc. for the regional economy can be presented at this stage.

As noted elsewhere in this report the reefal shoals, reefs, islands and surrounding waters serve commercial fishing and a variety of other activities which mostly can be classified as 'tourism'.

(i) Tourism

Tourism is generally defined to include activities related to travel irrespective of the purpose of that travel, the essential characteristic being the common use of transport and certain accommodation facilities. Day trippers are often specifically excluded, either because of lack of relevant data or because of a prime interest in such aspects as commercial accommodation. However for this exercise expenditure by the relatively small number of such persons is included with that of other visitors according to the particular activity involved. It should be noted that commercial fishing in some circumstances might be included under a broad definition of tourism, but is examined separately here.

Excluding travel between usual places of residence and the coastal areas adjacent to the reefs, the major commercial activities arising from tourism are associated with the operation of the Heron Island resort, charter boats and the island research stations. Transport services, mainly by helicopter, connecting the resort to the mainland and expenditure on mainland accommodation etc. related to activity in the Capricornia Section, also contribute to the gross value of tourism output. Campers on the islands, though perhaps significant in number, appear to be of little commercial consequence apart from their use of charter boats. Purchases of other commodities generate little extra local revenue. Operating costs of private boats used for visits to the reefs generate some further revenue, though estimates of private boat usage and operating costs are somewhat unreliable. Even so, the most generous estimate suggests that this component of expenditure is relatively small.

Overall, this tourism expenditure (including grants to the research stations, but excluding inter-regional travel costs and staff expenditure on Heron Island) for the full year 1978 is estimated to total approximately $2.7 million; and of this, over 80% is attributable to the resort and research station operations. To put this figure into perspective it is worth noting that retail sales in the Fitzroy Statistical Division for an earlier year (1975-76) totalled $158 million.

The total expenditure figure exaggerates the real impact of this tourism on economic activity, particularly locally. A more meaningful impression of the direct effects can be obtained by considering the level of employment involved. It is estimated that the equivalent of approximately 100 full-time personnel are directly employed, with the majority of this employment being on Heron Island. This contrasts with total employment of 7,712 persons in Gladstone City at 30 June 1976 and 51,562 in the Fitzroy Statistical Division at the same date. Furthermore, it represents only an estimated 3% of the total workforce in the entertainment, recreation and hotel sector for the Fitzroy Statistical Division.

Estimates of the indirect effects on employment and production in other sectors supplying this tourism sector are contained in Jensen (1979). Because of the isolation of the principal firm (i.e. Heron Island Pty Ltd) from Gladstone and the nature of its operations, the impact on other local industries is less than would be expected normally. The resort's commercial contacts with the adjacent mainland centres are limited mostly to the purchase of perishables and the servicing of some equipment. Much of the resort's supplies and the goods sold through the island shop, though shipped through Gladstone, are not produced locally or purchased through local wholesalers or retailers. Such goods are obtained via a consortium purchasing scheme arranged through the Brisbane head office.

(ii) Commercial fishing

The other major economic activity dependent on the Capricornia Section is commercial fishing. Some problems arise in assessing the extent to which the various fishing activities can be attributed to this Section. Based on 1978 statistics, it is estimated that catches of pelagic and demersal fish totalling about 325,000 kg (whole fish equivalents) in 1 year can be attributed to the Capricornia Section. In addition, about 100,000 kg of scallop meat per annum was obtained from the area in 1978. Estimated total value of this output is \$820,000 while the number of persons directly employed in this production is 38 (full-time equivalents). Servicing of craft, purchase of materials and equipment, as well as marketing and processing activities, have influences on other sectors. Estimates of the levels of some of these influences are contained in Jensen (1979).

(iii) Other employment

In addition to the above activities further employment can be attributed to the Capricornia Section through the operation of the 3 lighthouses (3 staff) and the local activities of the Qld Fisheries Service, Qld Boating and Fisheries Patrol, Qld National Parks and Wildlife Service (equivalent of approximately 1 full-time person).

3.10 FACTORS AFFECTING FUTURE USE

Predictions of future demand pressures on the resources of the Capricornia Section are beyond the scope of this study. Indeed, given that existing consumption levels of various activities in the Section are barely known, attempts at future predictions seem rather fruitless at this stage. It is possible, however, to identify several factors which will play a major role in shaping the types and levels of future demand. These factors are discussed below.

(i) Growth of Gladstone

Gladstone is being promoted as a focus of industrial development in Queensland. Past population figures and the latest population projections from the Qld Co-ordinator-General's Dept for Gladstone City and the surrounding Calliope Shire confirm the rapid growth rates expected in these local authority areas (see below).

POPULATION OF GLADSTONE CITY AND CALLIOPE SHIRE

	Gladstone City	Calliope Shire	Total
1971	16,645	4,225	20,870
1978	20,360	5,510	25,870
1990	Not available	Not available	45,000
2000	Not available	Not available	50,000

Source: Aust. Bureau of Statistics and Qld Co-ordinator-General's Dept.

The continued expansion of the industrial base of Gladstone will influence use of the Capricornia Section in at least 2 ways. Firstly, shipping movements adjacent to or through the Section will increase substantially. Projections of shipping trade through Gladstone Harbour are given in E.T.M. Consultants (1979) and reproduced below.

Cargo	Existing (tonnes p.a.)	1990 (tonnes p.a.)	2000 (tonnes p.a.)
Bauxite	5,320,000	6,500,000	6,500,000
Fuel oil & caustic	600,000	1,200,000	1,200,000
Petroleum products	230,000	380,000	430,000
Coal	6,340,000	10,100,000	15,000,000
Alumina	2,100,000	2,200,000	2,200,000
Grain (wheat etc.)	80,000	350,000	390,000
Rundle fuel oil	-	1,000,000	5,400,000
Clinker	-	500,000	1,000,000
Aluminium	-	360,000	360,000
Total	14,930,000	22,760,000	32,680,000

It is worth noting that if these projections are realized then Rundle fuel oil will be the third largest component of the total shipping trade by 2000.

A second impact of Gladstone's growth will be an increase in the number of speed boats in the Gladstone/ Calliope area. At present there are approximately 1,900 speed boats in the area or 75 boats per 1,000 population. E.T.M. Consultants (1979) forecasts an increase in boat ownership to 104 per 1,000 population by year 2000 with total speed boat registrations of approximately 5,200 (an increase of 174% on the 1979 figure). Given that speed boat ownership per head of population has been relatively stable in Queensland over recent years and that increasing fuel prices will probably have a noticeable effect on speed boat usage (and also speed boat ownership) the above projections seem to be somewhat optimistic.

If speed boat ownership per head of population is assumed to remain relatively constant to the year 2000, a seemingly more reasonable estimate of total speed boat registrations of 3,800 in the year 2000 is obtained (an increase of 100% on the 1979 figure). There is probably some rough correlation between increases in numbers of speed boats and increases in numbers of trips to the Capricornia Section, although any trend towards ownership of smaller, lighter and more economical boats will weaken this correlation.

(ii) Resort developments

There are two resort development packages (one existing and one proposed) on the Capricorn Coast which may influence future tourist use of the Capricornia Section. The existing resort package is located in the Keppel Isles and includes the resort on Great Keppel Island and the underwater observatory on Middle Island. Although not situated on the Great Barrier Reef, the Keppel Isles are marketed as a Barrier Reef resort package. Future plans for the Great Keppel Island resort are not known at this stage.

The proposed resort will be located at Farnborough, approximately 5 km north of Yeppoon. The developers, Iwasaki Sangyo Co. (Aust.) Pty Ltd have announced plans for the ultimate construction of a major tourist resort complex which will cater predominantly for Japanese tourists. Although little is known about the ultimate plans of the developer, the company has entered into an agreement with the Queensland Government to proceed with the first stage. If development of the resort proceeds as planned, substantial demands for recreational fishing, diving, reef walking, island visiting etc. may be generated.

(iii) Relative accessibility

Situated at the southern extreme of the Great Barrier Reef, the Capricornia Section already has a relative advantage in a tourism sense over other areas in the Great Barrier Reef Region because it is closer to southern population centres. In the absence of data on the origins of visitors to various areas of the Reef, it is extremely difficult to ascertain the effects that this accessibility advantage is having on current use patterns.

The accessibility differential between the Capricornia Section and other parts of the Reef will increase in the future as the generalized cost of domestic travel increases. This increasing accessibility advantage, together with the projected increase in the size of the potential market through cheaper overseas air fares and the new international airport at Brisbane, may generate a substantial increase in demand pressures for tourism and recreation opportunities in the Section.

(iv) Increasing fuel costs

Fuel costs are a major component of the total cost of boat trips to the Capricornia Section. In view of the fact that a boat trip to the Section requires a round trip journey of at least 120 km, it can be expected that increasing fuel prices will affect boat usage in the Section in at least 2 ways.

Firstly, visitors to the Section in speed boats will be faced with making a choice between a range of alternatives such as:

(a) visiting the Section just as often and paying more;
(b) visiting the Section less often and paying approximately the same;
(c) making the same number of trips but with a diversion of trip destination from the Section to closer coastal areas;
(d) disposing of the speed boats.

Faced with a similar range of alternatives in the terrestrial situation, private vehicle users have largely adopted alternative (c) for their new recreational trip making patterns. It would be foolhardy to predict a similar outcome in the marine situation because a 'coastal' experience is not necessarily an acceptable substitute for a 'reef' experience, and owners are much less constrained in the disposal of speed boats than they are in the case of family cars. Despite the difficulties in predicting future use patterns as fuel prices increase, it does seem reasonable to assume however that there will be some decrease in the rate of trip making to the Section by speed boats.

A second, and related impact is likely to be a trend towards the use of more 'efficient' modes of access to the Section from coastal centres. Such a trend will involve much greater use of charter boats at the expense of speed boats and possibly lead to the introduction of new, large capacity vessels such as hovercraft in situations where use densities are high and a suitable rate of return can be generated from the large capital investment.

(v) Leisure time

The most pronounced change in work time over recent years has been not the small decrease in average weekly hours worked, but rather the re-structuring of work time to provide 4½-day working weeks and 9-day working fortnights. This trend is increasing the relative supply of 3-day leisure periods, and will increase opportunities for camping and/or fishing trips from nearby coastal areas. The impacts from this trend will be compounded by any increases in the length of annual leave periods.

(vi) Promotion

Existing tourist operators in the Capricornia Section have indicated that tourist visitation rates are closely related to promotion activities. Promotion of the Capricornia Section can occur either directly by the actions of people in the tourist industry or indirectly by public debate of Reef-related issues.

Current debate over oil exploration on or near the Reef is focussing public attention on the Reef and its values. This is certain to promote public interest in the Reef as a whole and generate higher visitation rates to the more accessible areas. The lesson learned on Fraser Island could easily be repeated in the Capricornia Section.

4.0 IMPACT OF HUMAN ACTIVITIES

4.1 INTRODUCTION

The impact of human activities in the Capricornia Section is manifest in 2 ways - as impacts on the resource and as conflicts between the various user groups. Management practices can be instigated to modify or avoid some of these impacts and conflicts. For example, the impact of fishing on the resource can be reduced by way of size or catch limits, and conflicts between line fishermen and spearfishermen can be alleviated by zoning areas for particular purposes. However, some impacts are virtually independent of management (e.g. shipwrecks).

4.2 RESOURCE IMPACTS

In the Capricornia Section, human impacts may degrade resources in 4 ways. These are:

- depletion or removal;
- physical damage;
- environmental pollution;
- disruption of target and non-target populations.

The nature of existing impacts and potential impacts which may be generated by human activities in the Capricornia Section is summarized on Table 18. Activities listed in the table include both existing activities and potential activities which may become components of the planning strategies.

Although the information contained in Table 18 is useful in identifying potential impact problem areas, the analysis must be taken one step further to consider the

TABLE 18. IMPACTS AND POTENTIAL IMPACTS IN THE CAPRICORNIA SECTION

RECREATIONAL ACTIVITIES

ACTIVITY	NATURE OF IMPACTS AND POTENTIAL IMPACTS						
	RESOURCE REMOVAL OR DEPLETION	PHYSICAL DAMAGE TO RESOURCE	ENVIRONMENTAL POLLUTION			DISRUPTION TO (OTHER) FAUNA	
			MARINE	ISLAND	NOISE	MARINE	ISLAND
Line fishing	Pelagic & demersal fish	-	-	-	-	-	-
Spear fishing[(a)]	Demersal fish	-	-	-	-	Alters fish behaviour. Removes large predators.	-
Shell collecting[(b)]	Shells - live or dead	-	-	-	-	-	-
Coral collecting[(a)]	Hard coral	Damage to reefs by removal of coral.	-	-	-	-	-
Aquarium fish collecting	Small reef fish	-	-	-	-	Alters fish behaviour.	-
Diving (Non-exploitive)	-	Coral broken by cylinders, flippers & hands.	-	-	-	-	-
Reef walking	Reef flat corals	Trampling of reef flat corals & organisms. Turning & displacement of coral blocks.	-	-	-	Killing, removal & prodding of reef flat organism.	-
Operating speedboats & glass bottom boats	-	Running aground on reefs. Damaging coral with anchors. Damage to corals by oil. Damage to sea turtles by propellers.	Oil from engines. Waste-solid, liquid, metabolic.	-	Engine noise	Planktonic organisms (oil impact)	-
Operating seaplanes	-	-	-	-	Engine noise	-	Avifauna. Nesting sea turtles.
Submersibles, diver tugs, power torpedoes	-	Damage to coral & reefs.	-	-	-	-	-
Sailing	-	Running aground on reefs. Damaging coral with anchors.	Waste-solid, liquid, metabolic.	-	-	-	-
Interpretation, education, photography, wildlife observation	Some collection of marine organisms, shells etc. may occur.	Trampling of reef flat corals. Turning & displacement of coral blocks. Coral broken by cylinders, flippers & hands. Trampling of island vegetation/habitat.	Litter	Litter	-	-	Avifauna. Nesting sea turtles.
Camping & day-visitors to islands	Island vegetation (trees used for firewood etc.)	Trampling of island vegetation/habitat.	-	Waste - solid, liquid, metabolic	Entertainment noise (radios etc.)	-	Ground nesting seabirds. Nesting sea turtles. Vermin & feral animals introduced.
Resort visitors on islands	Island vegetation.	Trampling of island vegetation/habitat.	Solid waste. Sewage outfall. Septic overflow or seepage.	Solid waste (rubbish & fires).	Entertainment noise	-	Ground nesting seabirds. Nesting sea turtles.

(a) Also include those impacts caused by diving. (b) Also include those impacts caused by reef walking.

TABLE 18. IMPACTS AND POTENTIAL IMPACTS IN THE CAPRICORNIA SECTION

	ACTIVITY	NATURE OF IMPACTS AND POTENTIAL IMPACTS						
		RESOURCE REMOVAL OR DEPLETION	PHYSICAL DAMAGE TO RESOURCE	ENVIRONMENTAL POLLUTION			DISRUPTION TO (OTHER) FAUNA	
				MARINE	ISLAND	NOISE	MARINE	ISLAND
COMMERCIAL EXPLOITATION	Line fishing	Pelagic & demersal fish	-	-	-	-	-	-
	Net fishing	Whiting, sea mullet, wrasse & queenfish	-	-	-	-	Other marine organisms caught in nets.	-
	Scalloping	Scallops	Sea bed disrupted.	Silt?	-	-	Other seabed organisms killed or disrupted.	-
	Shell collecting (dredging)	Shells	Seabed disrupted.	Silt	-	Engine noise	Other seabed organisms killed or disrupted.	-
	Coral collecting[(a)]	Hard coral	Damage to coral reefs & loss of habitat.	-	-	-	Loss of habitat for marine organisms.	-
	Aquarium fish collecting	Small reef fish	-	-	-	-	Alters fish behaviour.	-
	Operating professional fishing boats	-	Running aground on reefs. Damaging coral with anchors. Damage to sea turtles by propellers.	Waste - solid, liquid, metabolic	-	-	-	-
	Operating charter boats	-	Running aground on reefs. Damaging coral with anchors. Damage to sea turtles by propellers.	Waste - solid, liquid, metabolic	-	-	-	-
	Operating helicopters	-	Construction of helipad on beach.	-	-	Engine noise	-	Avifauna
	Operating hovercraft	-	-	-	-	Engine noise	Reef flat organisms.	Avifauna. Nesting sea turtles.
	Operating light aircraft	Island vegetation	Airstrip - removal of vegetation/habitat.	-	-	Engine noise	-	Avifauna. Nesting sea turtles.
	Construction & operation of resorts	Island vegetation	Removal of vegetation/ habitat. Cay dynamics disturbed.	Solid waste. Sewage outfall. Septic overflow or seepage. Desalination plant effluent?	Solid waste (rubbish tips & fires)	Plant noise. Entertainment noise	-	Avifauna. Nesting sea turtles. Introduction vermin & feral animals.
	Shipping	-	Running aground on reefs. Damage to sea turtles by propellers.	Waste-solid, liquid & metabolic. Ballast discharge. Accidental oil spills.	-	Propeller noise	Introduction of exotic organisms. Planktonic organisms (oil impact).	Seabirds (oil impact).

(a) Also include those impacts caused by diving.

TABLE 18. IMPACTS AND POTENTIAL IMPACTS IN THE CAPRICORNIA SECTION

	ACTIVITY	NATURE OF IMPACTS AND POTENTIAL IMPACTS						
		RESOURCE REMOVAL OR DEPLETION	PHYSICAL DAMAGE TO RESOURCE	ENVIRONMENTAL POLLUTION			DISRUPTION TO (OTHER) FAUNA	
				MARINE	ISLAND	NOISE	MARINE	ISLAND
SCIENTIFIC RESEARCH ACTIVITIES	Construction & operation of Scientific Research Station	Island vegetation	Removal of vegetation/ habitat.	Solid waste Sewage outfall. Septic overflow or seepage.	Solid waste	Plant noise	-	Nesting seabirds. Turtle hatchlings.
	Non-manipulative research & collection of specimens (a)(b)	All types of marine organisms.	Trampling of reef flat coral & organisms. Turning & displacement of coral blocks. Coral broken by cylinders, flippers & hands. Collection of corals damages the reef. Permanent pegs & markers.	-	-	-	All types of marine organisms.	Avifauna. Nesting sea turtles.
	Manipulative research (a)(b)	All types of marine organisms.	Damage to reef or cay.	Silt	-	-	All types of marine organisms.	Avifauna. Nesting sea turtles.
OTHER ACTIVITIES	Military target practice	Island vegetation	Destruction of cays & reefs.	-	-	Explosions	All fauna.	All fauna.
	Construction & operation of lighthouses	Island vegetation	Removal of vegetation/ habitat.	Solid waste. Septic overflow or seepage.	Solid waste	Plant noise	-	Nesting seabirds. Nesting sea turtles.
	Harbours, groynes, retaining walls, breakwaters, jetties	-	Destruction of reef flat. Degradation of beaches. Erosion resulting from current/sediment deposition changes.	Silt	-	-	Destruction of organisms. Smothering by silt.	Nesting sea turtles.
	Construction & operation of underwater observatory	-	Destruction of reef caused by construction. Removal of coral from other areas for observatory.	Silt (during construction)	-	-	Organisms at site of observatory. Smothering by silt.	-

(a) Also include those impacts caused by diving. (b) Also include those impacts caused by reef walking.

relative magnitude of impacts and to arrive at an understanding of the consequences of such impacts in a coral reef ecosystem. These impacts can vary across a scale from almost zero at low, intermittent levels of use to complete degradation or depletion under conditions of over-use.

Before discussing the impacts in detail, 2 important points should be emphasized. These are:

- That any level of human activity in the Capricornia Section will generate impacts of one form or another. This means that some notion of what constitutes an 'acceptable' degree of change to the natural environment becomes an important determinant in the planning and management of human activity patterns.
- Based on available evidence, the Capricornia Section is still functioning as an intact and viable ecosystem. Only at the most intensively used locations (Rock Cod Shoal, Polmaise Reef, Masthead Island Reef and Heron Island Reef) are there indications of either over-exploitation or under-management.

Based on information from other coral reef ecosystems and available evidence in the Capricornia Section, relevant consequences of each type of impact are documented below.

(i) Resource removal or depletion

(a) Demersal fisheries

Over-fishing leads to the depletion of demersal fish stocks in coral reef ecosystems. In the Capricornia Section demersal fish stocks are exploited by:

- individual amateur fishermen;
- clubs of amateur fishermen;
- pro-amateur fishermen;
- professional fishermen, and
- spearfishermen.

The resultant pressure has depleted demersal fish stocks on the reefs closest to the mainland - Rock Cod Shoal and Masthead, Irving and Polmaise Reefs. These reefs are no longer yielding the same size or number of fishes (Domm 1977; G.B.R. Committee n.d.; Goeden 1979). The possible biological consequences of this impact are documented on p.108.

Although they have been fished regularly for many years, the more distant reefs do not appear to be over-fished. Since the mid-1960s, mean catch sizes of amateur fishing clubs have remained about the same, but the size of coral trout and sweetlip caught appears to have decreased over the last 9 years (Craik 1978a). Goeden (1977) has reported the local extinction of coral trout on the north-west corner of North West Island, an area that has been heavily fished by professional, pro-amateur and amateur fishermen for many years.

Taking the Capricornia Section as a whole, the mean fish weight of demersal reef fishes caught is the lowest of all Great Barrier Reef areas; i.e. the further north on the Reef, the larger the fishes. Whether this is a result of fishing is unknown, but it is probably fair to say that the Capricornia Section has been subject to greater fishing pressure for demersal reef fishes than other areas (W. Craik pers. com.).

Both Rooney, Talbot & Clark (1978) and Saenger (1976) state that spearfishermen kill considerably fewer fishes than line fishermen. However, because they kill the largest fishes, the total weight of catch may be as large as that taken by line fishermen in the same area. Ray (1977) reports that spearfishing can result in the rapid depletion of fish resources because target fishes are more readily pursued by spearfishermen than line fishermen. Although it is known that spearfishing tends to be concentrated in the more accessible areas (Craik 1978c), the impact that spearfishing has had on fish stocks in the Capricornia Section is unknown. The changes that spearfishing induces in behaviour patterns of fishes is documented on p.110.

(b) Scallops and pelagic fisheries

If over-exploited, these resources may be depleted. The stocks, potential and sustainable yields of both these fisheries in the Capricornia Section is unknown. The impact of the current levels of exploitation is unknown, although Qld Fisheries Service is currently undertaking research:

- in the Bundaberg-Yeppoon area in order to delineate stocks of scallops;
- on the biology, range, distribution and ecology of mackerel.

(c) Aquarium fishes

The taking of small, colourful fishes by both amateur and commercial aquarium fish collectors is known to:

- cause major changes in the population dynamics of target species (Robinson 1973);
- cause major changes in behaviour patterns in target species (Robinson 1973). They become fearful of divers and are then rarely seen by other recreational divers;
- severely deplete the resource (e.g. Moreton Bay).

In the Red Sea area, Ormond (1976) reports that commercial aquarium fish collecting has put considerable pressure on the resource because of the high mortality factor and the fact that 200,000 fish sales were required to maintain a profitable aquarium fish business.

Nothing is known about the occurrence, nature, frequency or impact of aquarium fish collecting in the Capricornia Section.

(d) Shell collecting

Shell collection leads to the depletion of the molluscan fauna (Salvat 1974) and causes considerable damage to the reef flat (Bennett 1971). The substantial ecological role played by molluscs in coral reef systems is becoming more and more evident. The impact of the removal of live molluscs may become evident in unexpected (and critical) trophic levels, such as an outbreak of a predatory or pest species normally held in check by mollusc predation (Robinson 1977).

In the Capricornia Section commercial shell collectors take live molluscs by dredging around reefs and in lagoons. The numbers of operators is small but nothing is known about the quantity or types of shells taken, the size of the areas worked, or the impact generated by this activity. Commercial collectors also undertake large-scale collecting operations by hand on the exposed reefs and by scuba in deeper water (G.B.R. Committee n.d.). There is no information about the intensity, frequency or impact of these activities.

Amateur shell collectors, fossicking on reef flats, have severely depleted the shell resources of North West, Lady Musgrave and Wilson Reefs (Domm 1977). Heron, Wistari, Llewellyn and Fitzroy Reefs have also been subject to heavy pressure from shell collectors. Although the taking of live shells from Heron Island Reef is prohibited, the diversity of molluscs in the accessible parts of the reef has been reduced and many gastropod species depleted (G.B.R. Committee n.d.). In the Capricornia Section as a whole, the populations of 2 species, the Heron Island Volute and the Trumpet Shell, are known to have been depleted by amateur shell collectors.

(e) Coral collecting

Reefs can be severely degraded by uncontrolled, intensive and continual coral collecting. Until recently there was a coral collecting lease on Tryon Island. It is not known how this lease was worked or how much coral was taken from the area. The impact generated by this activity and the state of the area at present is also unknown.

Unauthorized collection of live coral as souvenirs by visitors to the Virgin Islands Marine National Park is a frequent practice and has resulted in considerable coral damage (Robinson 1973). In the Capricornia Section small pieces of live coral are undoubtedly 'souvenired' by reef walkers and divers. The quantities of coral taken and the effects of this 'souveniring' are not known.

(f) Collection for scientific and educational purposes

Marine organisms are collected from time to time for educational and scientific purposes. The most heavily used areas for this form of collection are Heron Island, Wistari and One Tree Island Reefs.

Since Heron Island and Wistari Reefs are within a Marine Park, Qld Fisheries Service issues permits for the collection of marine organisms from these reefs. The most commonly collected marine organisms are molluscs, fishes, invertebrates, algae and coral. For details, see Appendix D.

Although there is no documented evidence on the impacts of collecting marine organisms for scientific and educational purposes, resort management staff on Heron Island have expressed concern about the apparent removal of large numbers of marine organisms by uncontrolled groups of students.

(g) Removal of wood

The removal of dead wood from the cays for use as firewood by campers and day visitors destroys lizard and insect refuges. The lizard population on Wilson Island, for example, would disappear if much dead wood was removed (G.B.R. Committee n.d.). Firewood collection from live trees causes habitat destruction, visual degradation and eventual tree mortality.

(ii) <u>Physical damage to the resource</u>

(a) Anchor damage

Branching corals such as staghorns are the most vulnerable to anchor damage. Anchor chains and lines drape across the coral and as boats swing on their anchors swaths of coral may be broken and re-broken several times until nothing but rubble remains. In this way substantial areas of staghorn coral have been demolished on the Florida Coast (Davis 1977). Massive corals, though sometimes scarred by an anchor, will not usually be dislodged. Indiscriminate boat anchoring is considered to be the most significant source of visitor-related damage in some areas of the Virgin Islands Marine Park (Robinson 1973).

Apart from a little minor damage around some of the most popular anchorages, very little anchor damage has been observed in the Capricornia Section by the G.B.R. Marine Park Authority survey team.

(b) Running aground

Boats of all size damage coral if they run aground. Even small dinghies being rowed over shallow reefs damage branching corals (Robinson 1973). Ships running aground can cause massive physical destruction of corals and reefs. There is no information about the occurrence or impact of groundings in the Capricornia Section.

(c) Reef walking

The trampling of some fragile, branching corals, small invertebrates and algae is an unavoidable consequence of reef walking. Although up to 60 people per day walk on the reef flat near the resort on Heron Island, they are not concentrated in a particular area. The resultant impact of this activity is very difficult to identify or quantify. Woodland and Hooper (1977) demonstrated that continual, very intensive trampling devastated reef flat corals on Wistari Reef. This may not, however, be a true guide to the impacts of reef walking in the Capricornia Section, since in practice:

- use levels are neither continuous nor intensive, and
- most reef walkers prefer to walk on the sand between the coral or on dead coral foundations rather than on the live jagged coral itself.

Fossicking reef walkers cause physical damage to the reef by turning, displacing, breaking or failing to replace coral blocks.

(d) Diving

Robinson (1973) reports that the most frequently observed visitor-related damage on reefs in the Virgin Islands Marine Park is the accidental breakage of tips of fragile species of coral by novice snorkellers. Inexperienced snorkellers break coral:

- with their fins while treading water to rest or adjust a poorly fitting mask;
- while holding onto a branch to steady themselves or hold themselves under water, and
- with their fins, elbows, knees etc. because they get too close to the coral.

Scuba divers may cause more extensive damage by striking coral formations with their air cylinders, arms and legs.

Each year many experienced and inexperienced scuba divers and snorkellers dive around the 'Bommie' at Heron Island. There is little visual evidence of physical damage to the coral caused by these divers (R. Kenchington, pers. com.).

(e) Construction of marine facilities

Cays are produced and maintained essentially by wave action and any interference with the natural hydrological and sedimentological processes through the construction of channels, jetties, groynes, breakwaters and harbours is likely to have considerable and not easily predictable effects on cay stability. Current erosion problems on both Heron Island and Green Island (near Cairns) have been caused by the construction of such facilities.

Human interference is responsible for significant changes at Heron Island. A concrete retaining wall constructed in the early 1960s on the northwest corner of the island is responsible for erosion of the western beach. The wall alignment reflects and refracts waves approaching from the northwest and northeast onto the western beach and also increases the erosive energy of waves in that area. This erosion problem has been exacerbated by the dredging of the harbour and channel in 1967 (Flood 1977). The construction and maintenance of this harbour has altered the drainage pattern and sedimentation pattern in the immediate vicinity of the harbour and has caused sediment choking of the reef flat and localized changes in the fauna.

In the Capricornia Section, only Heron Island has been degraded by this type of man-induced erosion. Apart from a narrow channel across the reef flat on North West Island Reef, no other channels, harbours, retaining walls or breakwaters have been constructed in the Section.

(f) Construction on cays

The construction of resorts, research stations, lighthouses and airstrips requires the removal of vegetation from the cay. This can:

- lead to the erosion of the cay;
- detrimentally affect the bird populations nesting in the trees;
- change wind penetration patterns in the remaining trees and this may also detrimentally affect the trees and nesting birds.

The removal of vegetation and subsequent construction of buildings, paths, roads, septic tanks, tennis courts etc. reduces the amount of space available for nests of the burrowing Wedge-tailed Shearwaters and the surface nesting terns.

(g) Military activities

Military activities may be responsible for total destruction of reefs and cays. Although Fairfax Island has not been used for military target practice for approximately 10 years, there are still bomb and shell craters on the eastern island.

(iii) Environmental pollution

(a) Marine pollution

Under present circumstances, principal pollutants entering the marine environment of the Capricornia Section appear to be solid wastes, human metabolic wastes, desalination planteffluent, discharged ballast and other liquid wastes. The sources of these pollutants have previously been identified in Table 17 p.77.

Solid wastes deposited at sea in the Capricornia Section are generated by:

- campers;
- boats, yachts and ships;
- resorts;
- research stations;
- lighthouses.

Neither the quantities of wastes dumped nor the resultant impacts are known, although 'sharks are said to be more common where garbage is habitually dumped' (G.B.R. Committee n.d.).

Untreated human metabolic wastes are added to the marine environment from boats and some of the campers on islands. Although this practice does not appear to have generated any deleterious impacts to date, increasing human use of the Section without adequate management will eventually generate sufficient metabolic wastes to cause visual and marine pollution around heavily used areas.

The effluent from desalination plants is characterized by elevated salinity and temperature, and elevated levels of heavy metals such as copper and zinc (Salvat 1979). The deleterious effects generated by discharging this type of effluent into the marine environment are documented by Wood & Johannes (1975) and Endean (1976). Van Eepoel & Grigg (1970) noted that coral and other invertebrates were killed to a distance of 200 m from a power desalination plant near St Thomas, Virgin Islands. Apparently the effluent from the desalination plant on Heron Island is pumped into an old well. The environmental consequences of this method of disposal are unknown. It is possible that at least some of this effluent is entering the marine environment.

The quantity and quality of the ballast being discharged by ships traversing the Capricornia Section is unknown. The likelihood of the introduction of exotic marine organisms and their effect in this ecosystem is also unknown.

Other liquid wastes include sullage (e.g. waste water from kitchens, laundries, campsites etc.) and seepage and overflows from septic tanks. It is likely that some of these liquid wastes enter the marine environment although there is no available information describing quantity, quality or impacts.

Evidence from coral reef ecosystems in other parts of the world has shown that massive coral mortality can be caused by:

- oil spills (see for example, Gooding 1971; Endean 1976; Johannes, Maragos & Coles 1972; Salvat 1974; Wood & Johannes 1975; Rinkevich & Loya 1977);
- discharge of sewerage effluent (see for example, Banner & Bailey 1970; Smith, Chave & Kam 1973; Endean 1976; Wood & Johannes 1975);

- industrial pollutants and silt (see for example, Mitchell & Ducklow 1977; Bak 1978; Fishelson 1977; Endean 1976; Salvat 1979; Wood & Johannes 1975).

It must be assumed that major oil spills, large scale discharge of sewerage effluent, other chronic pollution of an industrial nature and siltation generated by major dredging activities would have similar impacts in the Capricornia Section. Since the Marine Park Act is aimed at managing and regulating human activities (including dredging and discharge of sewage effluent) to achieve long term conservation of the Reef, the most likely sources of catastrophic impacts such as those described above are shipwrecks and possibly pollutant generating mainland land uses.

(b) Island pollution

Islands become polluted when the users fail to dispose of solid and metabolic wastes adequately. Campers and day visitors to islands usually bury their solid and metabolic wastes. Problems occur when these wastes are exhumed by nesting turtles, burrowing Wedge-tailed Shearwaters and other campers. The manner in which large quantities of buried organic and metabolic wastes, generated by heavy usage, affects the nutrient status of the soil and hence the vegetation, is unknown.

(c) Noise pollution

In a natural environment noise from aircraft, generators, helicopters etc. can become intrusive to the visitor seeking a 'wilderness' or 'natural' experience. Undoubtedly, the continual intrusion of passing helicopters conflicts with the 'natural' experience sought by many of the campers on Masthead Island.

Nesting birds and sea turtles are also disrupted to some degree by the noise of aircraft and helicopters.

(iv) Disruption to flora and fauna

(a) Sea turtles

C. Limpus (pers. com.) ranks the causes of detrimental impacts on sea turtles as follows:

1. Lights around resorts and navigation lights which disorientate hatchlings.
2. The construction of rock walls and breakwaters, erosion and the alienation of dunes; all of which result in the reduction of space available for nesting.
3. Introduced predators (e.g. rats on Wreck and Fairfax Islands).

It is Limpus' opinion that in comparison to these impacts, the impacts caused by direct human interference (e.g. disturbing nesting turtles, interfering with nests, noise etc.) are relatively minor.

In the Capricornia Section both Green and Loggerhead Turtles have been adversely affected by these and other human-induced impacts such as damage by propellers, problems through swallowing plastics dumped in the sea etc. On Heron Island their primary laying area is now at Sharks Bay, the most distant point from the resort and the research station (G.B.R. Committee n.d.).

The degree to which human activities in the Capricornia Section have adversely affected these turtle populations is unknown.

(b) Avifauna

The impact of human activities on the avifauna is greatest and most obvious on the islands subjected to the most use and the most habitat modification/ destruction. On Heron Island the avifauna has been affected in the following ways:

- loss of habitat and nesting areas. Tree-nesting birds (White-capped Noddy Terns and Reef Herons) are adversely affected by the removal of trees while the surface nesting and burrowing birds are adversely affected by the construction of buildings, concreting, rubbish dumps etc. that reduce the amount of space available for nest sites.
- flight paths interrupted by buildings;
- behaviour patterns altered by lights;
- introduction of exotic fauna and vermin (see (c) p.107);
- disturbance by humans. Surface nesting birds (Black-naped, Roseate, Bridled, Lesser Crested and Crested Terns) are very sensitive to disturbance and disruption by humans. Their absence on Heron Island is due to human impact (G.B.R. Committee n.d.). Also, reef walkers frighten away the local and migratory waders that feed on the reef flat areas.
- increased numbers of scavengers (Silver Gulls) facilitated by the presence of garbage and

scraps on the islands. This results in increased predation by the gulls on the chicks and eggs of seabirds.

. changes in dietary habits facilitated by scraps of food being left on the ground and the feeding of birds by people. This can directly and indirectly affect the rail, silver-eye and heron populations.

. disappearance of the Pied Currawong caused by the constant presence of people (Kikkawa & Boles 1976);

. cessation of breeding of sea eagles and oystercatchers caused by the constant presence of people (Kikkawa & Boles 1976);

. nesting birds disturbed by helicopters and noise.

The constant presence of people and the concomitant destruction of habitat has substantially changed and degraded the avifauna of Heron Island (Kikkawa 1970; Kikkawa & Boles 1976).

In comparison, the effects that campers and day visitors have had on the avifauna of the other islands in the Capricornia Section appear to be minor. The Wedge-tailed Shearwater population seems to be relatively unperturbed by the presence of humans. However, some of the surface nesting birds (e.g. the terns and the Brown Boobies) are much more vulnerable to disturbance by humans. When disturbed by people, the parent birds temporarily leave their nests leaving the chicks and eggs vulnerable to predators. Camping is prohibited on Lady Musgrave Island during the bird breeding season in order to reduce the impact of human disturbance in these breeding colonies.

The manner in which the three lighthouses and the small tourist resort on Lady Elliott Island affect the avifauna of these islands is unknown.

(c) Introduced fauna and weeds on islands

Cats, domestic fowls, mice, insects and weeds have been introduced to North West Island by past and present human activities. The degree to which these introduced animals and plants have affected the ecology of North West Island is unknown.

Prickly pear is common on Masthead Island but appears not to have done much damage (G.B.R. Committee n.d.). Although Masthead Island is subject to considerable human use, the impact caused by the introduction of exotic plants and animals is minor compared to that experienced by Heron and North West Islands.

Peacocks, guinea fowls, domestic fowls, ducks, parrots, rats, cockroaches and exotic ants have been introduced to Heron Island, and have undoubtedly affected the native fauna to some degree. For example, the introduced ant has ousted the native ants (Heatwole 1976). Weeds, particularly *Euphorbia*, are common all over the island.

When the guano miners left Fairfax Island early this century, a flock of goats was left on the island. Revegetation was impossible until, in 1972, the Qld Department of Forestry shot all but one of the goats. This solitary goat does little damage to the rapidly revegetating island (Cribb, R. 1979).

(d) Marine fauna

Much of the marine community disruption caused by human activities in coral reef ecosystems has already been noted in this section. However, the biological and/or ecological consequences of this disruption are not known. For example, the destruction of plankton by oil spills has far-reaching effects in a coral reef ecosystem as many seabirds and fish feed on plankton, and the eggs and larvae of many marine organisms are planktonic.

Some of the biological and ecological consequences of fishing in coral reef ecosystems are well known. For example, it is known that over-fishing by either line fishing or spearfishing, causes a reduction in population size of the fished species, particularly the reef dwelling species such as coral trout and red emperor. It also causes shifts in the size and age structure of the fished species to smaller and younger fishes.* The ecological consequences of this are complex and not fully understood. However, the following is known:

- Over-fishing results in fewer predators and therefore a reduction in predation on the fished species' prey. This can have far-reaching effects on the composition and diversity of the fish fauna of a coral reef. High predation seems important in the maintenance of diversity right through the food chain. Thus, the dynamics of the ecosystem is affected, and population and community structure changed (G.B.R. Committee, n.d.).

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*In the Capricornia Section, Rock Cod Shoal and Polmaise Reef are reported to be over-fished - the catch sizes and fish sizes have declined rapidly over the last few years (W. Craik, pers. com.).

. Coral trout are known to undergo a sex change, from female to male, between about 33 and 51 cm in total length. The effect of selectively fishing out the larger (mostly male) fishes is unknown. However, Goeden (1978) considers that the reproductive potential of coral trout populations could be endangered by the removal of the bulk of the larger (male) fishes.

. 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 (G.B.R. Committee n.d.).

. Faeces of fish 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 kg/ha/year of calcareous material passes through fishes' guts. The largest of the fishes and those that are most often caught, are an important source of rich faeces (G.B.R. Committee n.d.).

Dredging for scallops and shells not only removes the target organisms but many other benthic organisms. For example, scallop fishermen also catch shovel-nosed lobster, squid and blue swimmer crabs. Many benthic organisms are disturbed and killed by dredging.

The impact and consequences of dredging in the Capricornia Section are unknown.

Spearfishing and aquarium fish collecting cause changes in the behaviour patterns of both the target and non-target species. These fish become fearful of divers and are then rarely seen by non-extractive divers, photographers etc. (Rooney et al 1978; Ogilvie 1972; Ray 1977). Such activities degrade the recreational value of these reefs for other divers, but the biological consequences of these altered behaviour patterns are not known.

(v) Indirect effects - Ciguatera

A serious and sometimes fatal disease is sometimes contracted by people eating fish from coral reef areas. The disease is known as ciguatera.

Banner (1976) discusses the many theories about the origin of ciguatoxin, the principal toxin which causes certain fishes to become highly poisonous to humans. Outbreaks of the disease occur naturally. However, Bagnis (1972) showed a relationship between the incidence of ciguatera and the degradation of coral reefs by human activities such as dredging and pollution.

In Queensland, cases of ciguatera fish poisoning have been recorded all along the coast from Hervey Bay to Cairns (Qld Dept of Health, pers. com.). The main sources of ciguatera fish poisoning have been coral trout and spanish mackerel. Ciguatera fish poisoning must therefore be accepted as a possible indirect effect of intensive human use of the Capricornia Section.

4.3 IMPACTS ON OTHER USERS

Conflicts arise between the various users when:

- users compete to remove the same resource, e.g. professional, pro-amateur, amateur and spear-fishermen all compete for the same reef fish;
- incompatible user groups compete for the use of the same area, e.g. non-extractive divers and spearfishermen;
- the activity of one user group endangers another user group, e.g. speed boats and divers;
- one user group modifies, pollutes or destroys the aspect of the environment valued by another user group, e.g. shell collectors denuding the reef flats;
- a particular user group is excluded from an area set aside for another purpose, e.g. spearfishermen excluded from the Heron-Wistari Reefs Marine Park.

Existing and potential incompatibilities between various user groups can be identified from Table 18 p.88. Obviously, incompatibilities and conflicts between user groups will be exacerbated by;

- over-exploitation or excessive use (e.g. over-fishing reefs, spearfishermen 'shoot out' reefs);
- irresponsible or inconsiderate use or exploitation (e.g. divers not displaying a diving flag on their boats, shell collectors 'cleaning out' reefs, littering and dumping of solid waste etc.).

Incompatibilities between various user groups competing to use the same area arise because of:

. different tolerances and expectations of the users;
. different recreational experiences sought by users;
. different levels of user environmental awareness;
. differences in density of use (e.g. club activities can conflict with the activities of individuals);
. safety aspects;
. poor management of the area.

Undoubtedly, as use levels in the Capricornia Section increase, as pollution and physical damage increase, and as more user groups compete for the same resources and areas, the potential for conflict situations will increase.

Potential impacts and conflicts between user groups in marine areas are summarized by Rooney et al (1978). Based on Domm (1977) and field observations, the major incompatibilities between user groups currently identifiable within the Capricornia Section are:

Conflicting User Groups	Reason
Professional fishermen - pro-amateur fishermen - amateur fishermen - spearfishermen.	Compete for the same demersal fish.
Shell collectors with reef walkers, photographers, educational groups etc.	Denuding the reef flat.
Spearfishermen with non-extractive divers.	Spearfishing makes fish fearful of divers. Want to dive in same area. Safety aspects.
Aquarium fish collectors with non-extractive divers and photographers etc.	Target fish become fearful of divers and are rarely seen by non-extractive divers, photographers etc.
Operators of boats (fishing, charter, speed) with divers.	Utilize the same areas - endanger divers.
Speed boats with swimmers.	Utilize the same areas - endanger swimmers.
Scientific research with resort users.	Uncontrolled specimen collection from mutually used areas.
Line fishermen with divers and swimmers.	Utilize the same area - endanger divers and swimmers.

4.4 MANAGEMENT OF IMPACTS

Many impacts and potential impacts have been identified. Some of these can be reduced or controlled by management, others cannot. The aim of good management is to achieve a balance between the level of control which is needed to protect the resource and a level of control which does not over-restrict individual freedom and detract from visitor enjoyment. In practice this balance is not easy to achieve, and does in fact necessitate a compromise between protecting the resource and meeting the demands of the users.

The implementation of all management controls must be considered in the light of financial costs, resource costs and the resultant loss of personal freedom, as well as the benefits to the resource and the other users.

(i) Impacts that are not amenable to management

- Accidental damage caused by boats and ships running aground, subsequent oil and industrial pollution, propellers, submersibles and some damage by divers, snorkellers and reef-walkers.
- Seabed disruption and silting caused by scalloping and shell dredging.
- Changes in fish behaviour caused by spearfishing and aquarium fish collecting.
- Transport-related noise.

(ii) Impacts that are partially manageable

Impact	Possible Management Methods
Trampling of vegetation, nests and corals.	. Regulations - zoning. . Sound planning & design of facilities. . Boardwalks over reef flat corals. . Education of users.
Solid waste & human metabolic waste.	. Regulation - policing & penalties. . Collecting/treatment services. . Education of users.
Littering & vandalism.	. Regulation - policing & penalties. . Education of users.
Disruption to flora & fauna.	. Regulation - policing & penalties, - zoning. . Seasonal restrictions on use. . Education of users. . Sound planning & design of facilities & services.
Accidental damage by divers & snorkellers.	. Education of users.
Impacts caused by construction.	. Regulations. . Lease conditions. . Sound planning & design of facilities.
Anchor damage.	. Buoys in conjunction with regulations - zoning. . Education of users.

(iii) Impacts that are manageable

Impacts generated by the removal of fishes, coral, shells, scallops and other living organisms could be ameliorated by regulations that include licensing, zoning, prohibition, catch limitations etc. and the policing of these regulations.

5.0 CONSTRAINTS AND OPPORTUNITIES

5.1 INTRODUCTION TO CONSTRAINTS

As part of the Natural Resources Inventory in Chapter 2 and the Human Activities Inventory in Chapter 3, a number of physical factors, biological factors and institutional commitments have been identified as issues which will influence future use of the Capricornia Section. This information has been used to generate a set of constraints which will, in turn, form an important input into each of the alternative strategies.

The nature of the constraints is such that they tend to modify use of particular areas rather than preclude use per se. In the majority of cases this also implies limits on levels of use.

Several of the constraints apply to use of islands rather than marine areas. Although the Marine Park Authority has no jurisdiction over islands which are part of Queensland and not owned by the Commonwealth of Australia, the constraints are still relevant within a Marine Park context where there can be no arbitrary division between marine and terrestrial activities.

The constraints are presented in 3 sections. Physical constraints are derived from the nature of the coral reef physiography, biological constraints are derived from consideration of the Section's biological resources, and institutional constraints describe existing commitments and policies which will influence future use patterns.

5.2 PHYSICAL CONSTRAINTS

In 1973, a Queensland Interdepartmental Committee on the future use of North West and Masthead Islands reported that,

> 'each cay is a product of its reef and is composed of and continually replenished by sand and aggraded calcareous material derived, respectively, from its lagoon and reef rim. Both shape and behaviour of a cay are produced essentially by wave action and any interference with these natural processes through construction of channels, groynes or off-shore mass structures is likely to have considerable and not easily predictable effects on cay stability.'
>
> (Qld Interdepartmental Committee on the Future Use of North West and Masthead Islands 1973.)

Existing erosion problems on Heron Island and Green Island reinforce the importance of maintaining natural hydrological regimes and retaining island vegetation.

The abovementioned Committee also investigated the capability of cays in the Capricorn Group to accommodate landing strips for light aircraft. They concluded that construction of airstrips would reduce island vegetation significantly, could upset island stability and therefore should not be contemplated.

The Capricornia Section is in a tropical cyclone area and there is evidence that islands have been inundated by storm surges. While this does not necessarily preclude the construction of further accommodation facilities on the islands, the risk of cyclonic weather conditions is real and should be taken into account in the design and construction of any structures. Almost all recorded cyclones in the vicinity of the Capricornia Section have occurred between and including the months of December and March.

5.3 BIOLOGICAL CONSTRAINTS

The Great Barrier Reef Marine Park Act calls inter alia for the conservation of the Reef and its resources. While this does not necessarily preclude particular commercial or recreational activities, it does imply a need to management use of the Reef and exploitation of its resources.

The Capricornia Section supports populations of nesting turtles and nesting seabirds which are of international and national significance respectively. The most important islands for nesting turtles and seabirds are:

North West
Tryon
Masthead
Wreck
Heron
One Tree
Hoskyn,
Fairfax, and
Lady Musgrave.

All the other islands except North Reef support sizable though less important breeding colonies. The nature, location and levels of activities on any of the islands should not be allowed to endanger the survival of these species in the Capricornia Section as a whole. To achieve this it may be necessary to close certain reefs and islands or to prohibit certain activities during the mating and nesting seasons. Periods of the year which are critical in the breeding cycles of turtles and seabirds are (Limpus 1979):

- turtle mating between mid-August and mid-November;
- turtle nesting between December and January;
- emergence of turtle hatchlings between mid-December and mid-May; and
- seabird nesting between early November and late February.

Fisheries resources in the Section are exploited by professional, pro-amateur and amateur fishermen. It is important for economic, ecological and aesthetic reasons that fisheries resources are not over-exploited. This will require ongoing monitoring and possible restrictions on some fishing activities even though reliable estimates of productivity and sustainable yields are not available.

5.4 INSTITUTIONAL CONSTRAINTS

Existing institutional constraints which apply to islands and marine areas are documented in Table 19. They relate to areas which have either been gazetted for special purposes or leased for special purposes. Although most of these constraints apply directly to the islands, many of them have indirect implications for types and levels of use in adjoining marine areas.

5.5 INTRODUCTION TO OPPORTUNITIES

The range of strategic planning options available in the Capricornia Section will be decided, in part, by the availability of opportunities for various commercial and

TABLE 19. INSTITUTIONAL CONSTRAINTS

LOCATION	NATURE OF CONSTRAINT	AREA (ha)	DURATION OF CONSTRAINT	ACTIVITIES EXCLUDED	ACTIVITIES PERMITTED [(a)]	IMPLICATIONS FOR ADJOINING AREAS
Wreck Island	Special Lease	10	Current lease expires 31.12.79.	At discretion of lessee subject to Special Lease conditions.		-
Heron Island	National Park (incl. Research Station Lease)	12	Indefinite.	All extractive activities.	Non-extractive recreation, education & scientific research.	-
	Perpetual Country Lease (Resort)	5	Indefinite.	At discretion of lessee subject to Lease conditions.		Resort will continue to attract visitors to island & adjacent reefs.
One Tree Island	Special Lease	2	Current lease expires 31.7.84.	At discretion of lessee subject to Special Lease conditions.		-
Hoskyn Islands	National Park Scientific Area	12	Indefinite.	All except scientific research.	Scientific research.	Need to control use of surrounding reef.
Fairfax Islands	1. National Park Scientific Area 2. Military Practice Area	19	1. Indefinite. 2. Unknown.	All except scientific research.	Scientific research.	-
Fairfax Islands Reef	Military Practice Area	315	Unknown.	All except scientific research.	Scientific research.	-
Lady Musgrave Island	National Park	20	Indefinite.	All extractive activities.	Non-extractive recreation, education & scientific research.	Need to control use of lagoon and surrounding reef.
Lady Elliott Island	Commonwealth Lease	22	Current lease expires 31.7.79. Likely to be renewed till 31.7.84.	At discretion of lessee subject to Lease conditions.		-
Heron-Wistari Reefs	Queensland Marine Park	9,700	Indefinite.	All extractive activities except hand-line fishing in designated areas.	Non-extractive recreation, education, scientific research & hand-line fishing in designated areas.	-

(a) Generally subject to some form of management control, e.g. by permit.

recreational activities. The opportunities presented in this chapter are based upon:

- the reference list of human activities (supplied by the Marine Park Authority - see Appendix E) and their individual requirements;
- known physical and biological resources of the Section;
- available information on current use patterns, and
- relevant constraints.

The opportunities are identified and discussed under the following 3 headings:

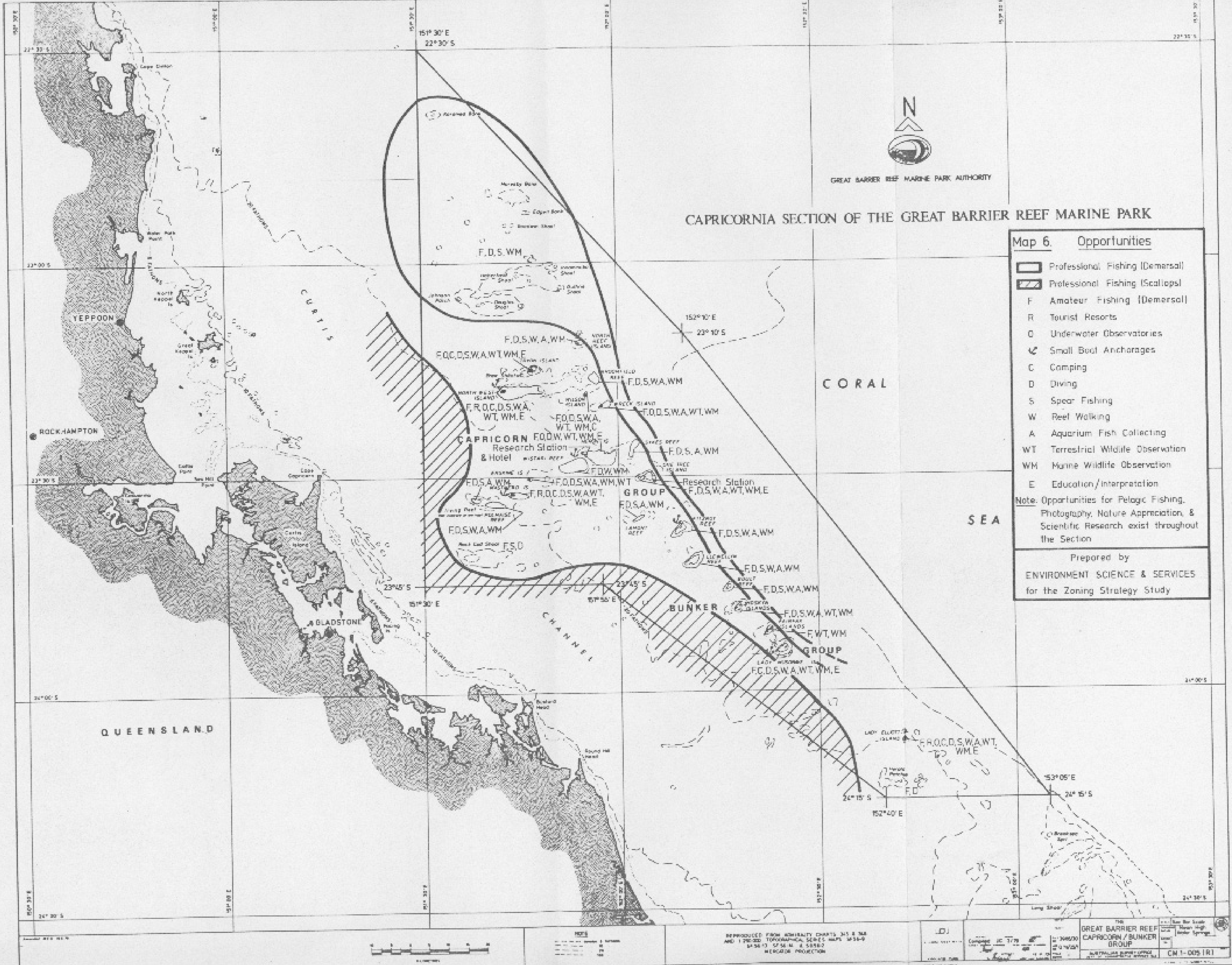
- commercial opportunities;
- recreational opportunities;
- educational and scientific research opportunities.

Spatial distribution of the various opportunities is presented on Map 6. It can be seen from this summary map that many of the reefs provide opportunities for incompatible and conflicting activities. This competition for use of particular reefs or exploitation of particular resources will be reconciled during the development of the alternative strategies.

5.6 COMMERCIAL OPPORTUNITIES

(i) Tourist resorts

Evidence of impacts from the existing resort/research station on Heron Island suggests that extensive biological modification has occurred over the whole island and to a lesser extent the reef. Bearing in mind that resort operation requires not only accommodation facilities, but also a range of services to provide access, remove wastes etc., it is considered that only the largest cays in the Section


CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
GREAT BARRIER REEF MARINE PARK AUTHORITY
N
Map 6. Opportunities
Professional Fishing (Demersal)
Professional Fishing (Scallops)
F Amateur Fishing (Demersal)
R Tourist Resorts
O Underwater Observatories
Small Boat Anchorages
C Camping
D Diving
S Spear Fishing
W Reef Walking
A Aquarium Fish Collecting
WT Terrestrial Wildlife Observation
WM Marine Wildlife Observation
E Education/Interpretation
Note: Opportunities for Pelagic Fishing, Photography, Nature Appreciation, & Scientific Research exist throughout the Section
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
QUEENSLAND
YEPPOON
ROCKHAMPTON
GLADSTONE
CURTIS
CHANNEL
CORAL
SEA
CAPRICORN
GROUP
BUNKER
GROUP
Research Station & Hotel
Research Station
F,D,S,WM
F,D,S,W,A,WM
F,O,C,D,S,W,A,WT,WM,E
F,R,O,C,D,S,W,A,WT,WM,E
F,D,S,W,A,WM
F,O,D,S,W,A,WT,WM
F,O,D,S,W,A,WT,WM,C
F,O,D,W,WT,WM,E
F,D,S,A,WM
F,D,W,WM
F,D,S,A,WM
F,O,D,S,W,A,WM,WT
F,R,O,C,D,S,W,A,WT,WM,E
F,D,S,W,A,WT,WM,E
F,D,S,A,WM
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F,S,D
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F,D,S,W,A,WM
F,D,S,W,A,WM
F,D,S,W,A,WT,WM
F,WT,WM
F,C,D,S,W,A,WT,WM,E
F,R,O,C,D,S,W,A,WT,WM,E
F,D
151° 30' E
22° 30' S
152° 10' E
23° 10' S
23° 45' S
151° 30' E
23° 45' S
151° 55' E
24° 15' S
152° 40' E
153° 05' E
24° 15' S
REPRODUCED FROM ADMIRALTY CHARTS 345 & 348 AND 1:250 000 TOPOGRAPHICAL SERIES MAPS SF56-9 SF56-13 SF56-14 & SG56-2
MERCATOR PROJECTION
THE GREAT BARRIER REEF CAPRICORN / BUNKER GROUP
CM1-005 (R)

could provide opportunities for resort development. Other important criteria in the selection of potential resort sites include:

- . easy access to mainland cities;
- . easy access to a range of recreational opportunities for fishing, diving, reef walking etc.

Based on these requirements, the following islands could be expected to provide opportunities for tourist resort development:

North West Island
Masthead Island
Lady Elliott Island.

(ii) Underwater observatories

Underwater observatories are assumed to operate in conjunction with tourist resorts, either on the same reef or on adjacent reefs. Potential sites for underwater observatories are therefore:

Tryon Island Reef
North West Island Reef
Wilson Island Reef
Wreck Island Reef
Erskine Island Reef
Masthead Island Reef
Heron Island Reef
Lady Elliott Island Reef.

On nearly all of these reefs construction of an underwater observatory would also involve the construction of landing and access facilities. Bearing in mind the previously identified constraints on the construction of off-shore mass structures, any such landing and access facilities would need to be transparent to waves (e.g. piled structures) and subject to careful design considerations.

(iii) Professional fishing

Professional fishing opportunities are considered for each of the fisheries resources in the Section. In each case the existing activities of professional fishermen are taken as indicators of professional fishing opportunities.

(a) Scallop fishery

Areas currently being worked for scallops are shown on Map 6. In view of recent discoveries of commercial scallop beds south-west of Lady Musgrave Island Reef, there is a possibility that opportunities for commercial scallop trawling may exist in other, presently unworked, parts of the Section.

(b) Pelagic fishery

Because of the migratory nature of the principal pelagic fish species caught in the Section, and the inability to predict fish locations with accuracy, the whole Section must be regarded as offering opportunities for professional exploitation of the pelagic fishery.

(c) Demersal reef fishery

Parts of the Section where demersal reef fishes are currently caught by professional fishermen are shown on Map 6. In view of the heavy amateur fishing pressures in other parts of the Section, additional opportunities for professional demersal reef fishing are unlikely.

(iv) Shell dredging

Dredging for shells on a commercial basis has been recorded around several of the reefs. Although there are probably extensive shell resources around and between the reefs, no locational information is available.

(v) Coral collecting and aquarium fish collecting

Opportunities for these activities are identified under recreational opportunities (see below).

5.7 RECREATIONAL OPPORTUNITIES

Because visitors to the Capricornia Section have enjoyed almost unrestricted access to most of the reefs and islands over a long period of time, the existing use patterns are a good indicator of available opportunities. Since most of the recreational use of the Section relies heavily on boat transport (either charter boats or speed boats) it is not surprising that use patterns tend to be concentrated around the best boat anchorages. The boat anchorages

- in the lee of North West Island;
- in the lee of Masthead Island;
- at Heron Island/Wistari Reefs;
- in the lagoon of Fitzroy Reef;
- in the lagoon of Lady Musgrave Reef;

will continue to provide the foci for boating activities and subsequent recreational activities.

Opportunities for the following recreational activities are shown on Map 6:

. amateur fishing (demersal);
. camping;
. diving (includes shell collecting and coral collecting);
. spearfishing;
. reef walking (includes shell collecting and coral collecting);
. aquarium fish collecting;
. terrestrial wildlife observation;
. marine wildlife observation.

Opportunities for photography and general nature appreciation are assumed to exist throughout the Section.

5.8 EDUCATIONAL AND SCIENTIFIC RESEARCH OPPORTUNITIES

Although there are opportunities over the whole Section for education in its broadest sense, structures and facilities for education and interpretation are best provided where concentrations of people occur and basic services may exist. The most likely locations for educational and interpretive facilities are therefore on reefs and islands supporting resort developments, research stations or camping activities. Opportunities for various kinds of scientific research exist throughout the Section.

6.0 GENERATION OF ALTERNATIVE STRATEGIES

6.1 INTRODUCTION

This chapter develops alternative strategies for the management of the Section to the year 2000 in accordance with the objectives defined in Section 32 of the Great Barrier Reef Marine Park Act, 1975. As a starting point it is worth reiterating 2 basic principles which are embodied in the Marine Park legislation.

The first of these is that long term conservation of the Reef should be the prime objective of zoning plans. In other words a conservation ethic should provide a common theme in each of the alternative strategies.

The second basic principle is that the Capricornia Section will become a multiple use Park and must therefore be managed as such. In the words of the Australian Dept of Agriculture, Forestry and Timber Bureau (1975):

> 'some uses are incompatible under certain circumstances and since maximum yields from all uses are physical and biological impossibilities, a decision has to be reached as to which uses will be given priority. Total net benefits to the community can often be increased, if not maximized, through some combination of two or more uses ...., but there are also situations where a single use may be superior. In effect this means determining the use, or combination of uses, to which the various zones .... are suitable in the light of the natural environment and of social and economic considerations.'

Multiple use does not imply that all possible uses should be accommodated in all Sections of the Great Barrier Reef Region.

At the present time, and in the foreseeable future, 3 major interest groups will be competing for resources in the Capricornia Section. These interest groups can be broadly defined as:

- the fishing industry;
- participants in the tourist/recreation industry; and
- the preservation lobby.

Within certain limits defined by the need to conserve the Reef, it is proposed that all of these interest groups be represented in each of the alternative strategies. The strategies will differ in the amount of bias afforded each interest group and in the relative priority assigned to activities associated with each group.

Available opportunities for various activities have already been defined in Chapter 5. These opportunities can be used to generate alternative strategies in the following manner:

(a) make maximum use of fishing industry opportunities to generate a Fishing Industry Strategy;

(b) make maximum use of tourism/recreation opportunities to generate a Tourism/Recreation Strategy;

(c) make maximum use of preservation opportunities to generate a Preservation Strategy.

In each case compatible opportunities not taken up would be allocated to the other interest groups to make them minor participants in the strategy. Particular activities which would be given priority under each strategy are identified in Section 6.3.

6.2 OBJECTIVES

Five objectives for the preparation of zoning plans are specified under Sub-section 32(7) of the Great Barrier Reef Marine Park Act 1975. These objectives may be paraphrased as:

(a) conservation;
(b) regulation of use;
(c) controlled exploitation;
(d) provision of areas for public appreciation and development;
(e) preservation of areas in their natural state.

The first two objectives are fundamental to the very existence and successful management of the Park and should therefore be given the highest priority in any feasible strategy. The remaining three objectives may, however, be conflicting and depending on the relative priorities assigned to each will generate fundamentally different strategies. The converse is also true in the sense that preparation of any strategy will imply that some lexicographic ordering, or ranking, of these three objectives has been made.

Thus under the Fishing Industry Strategy, objective (c) will be given priority over objectives (d) and (e). Under the Tourism/Recreation Strategy, objective (d) will be given priority over objectives (c) and (e), and under the Preservation Strategy objective (e) will be given priority over objectives (c) and (d).

6.3 ALLOCATION OF ACTIVITIES WITHIN STRATEGIES

The preceding sections have described a general methodological approach to the generation of alternative strategies. The next important step involves translating the descriptive strategies into activity packages which reflect the intended bias towards various interest groups.

The available opportunities for all activities under consideration in the Capricornia Section have been documented in Chapter 5 and shown on Map 6. Those activities which will be assigned the highest priority to take up available opportunities under each strategy are identified below.

FISHING INDUSTRY STRATEGY	TOURISM/RECREATION STRATEGY	PRESERVATION STRATEGY
Commercial shell collecting	Pro-am boat fishing	Non-extractive diving
Commercial coral collecting	Amateur boat fishing	Photography
Commercial aquarium fish collecting	Amateur spear fishing	Nature appreciation
Professional boat fishing	Amateur shell collecting	Interpretation
Pro-am boat fishing	Amateur coral collecting	Education
	Amateur aquarium fish collecting	Research Station visit
	Resort visit	'Wilderness' (no activity)
	Camping	
	Reef walking	
	Non-extractive diving	
	Photography	
	Nature appreciation	
	Interpretation	

The inter-relationship between priority activities under the three strategies is shown in Figure 5. It should be noted that Figure 5 refers to priority activities only. The other non-priority activities will be allocated amongst remaining opportunities in each case.

6.4 REPRESENTATION OF ALTERNATIVE STRATEGIES

The alternative strategies are intended to embody distinct philosophical approaches and to produce fundamentally different use patterns and levels of economic activity. Under each strategy the distribution of people, activities and impacts will be represented by the system

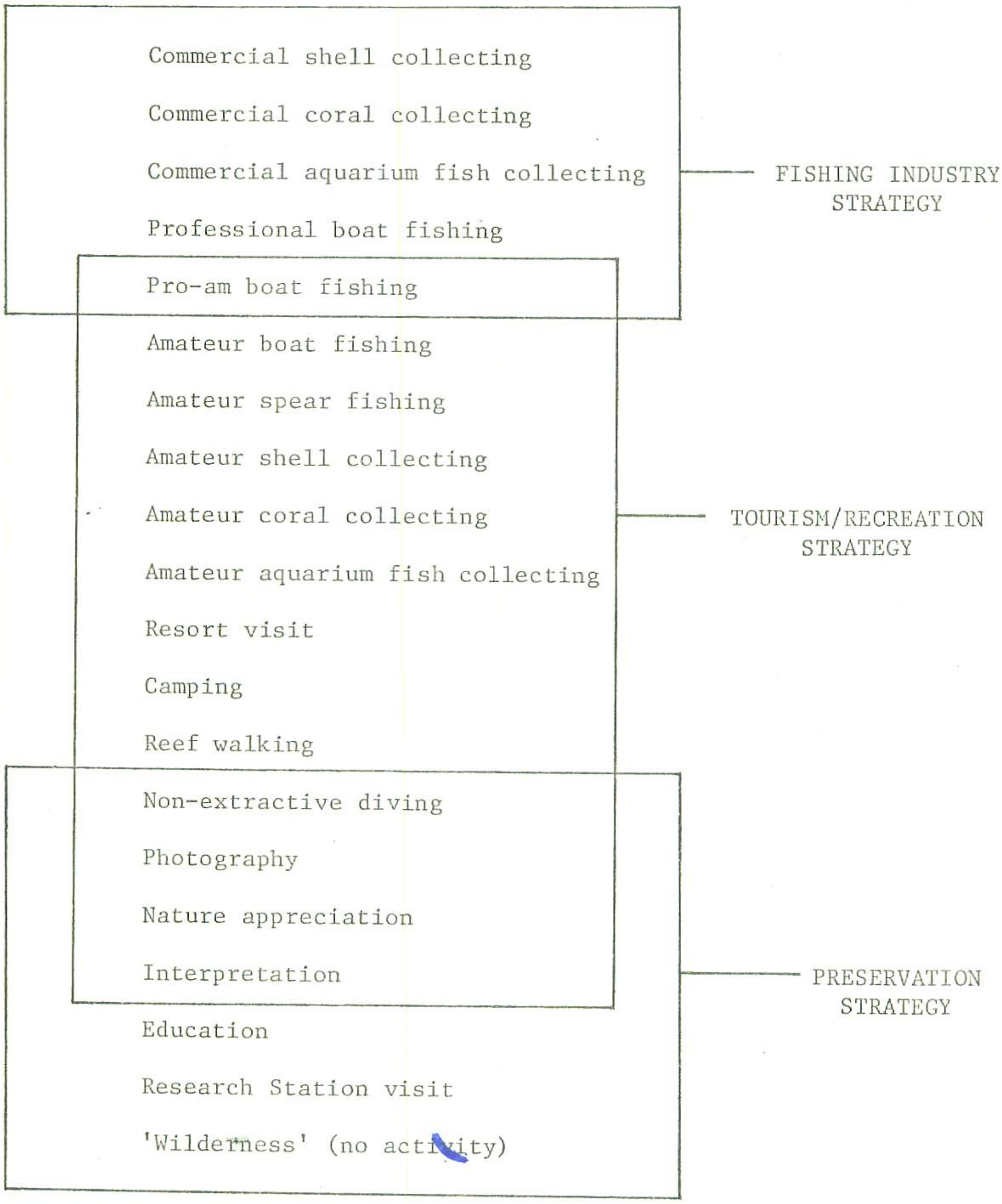


Fig. 5. Allocation of Priority Activities

of zones outlined in Table 20.

TABLE 20. SYSTEM OF ZONES

ZONE NUMBER	ZONE NAME	INTENT
1	Protection A	Preservation of areas in their natural state.
2	Replenishment	Replenishment of resource stocks such as fish, shells, coral, etc. This is a temporary zone which would be moved from time to time.
3	Protection B	Used for non-extractive recreational activities (e.g. non-extractive diving, photography).
4	Recreation A	Used for low density extractive activities (e.g. amateur boat fishing, low density camping).
5.	Professional fishing	Commercial fishing activities (e.g. professional fishing, charter boat operation).
6.	Recreation B	Used for high density recreational activities (e.g. resort operation, intensive camping).
7.	Institutional purposes	Public utilities etc. (e.g. light-houses).
8.	Shipping lanes	Commercial shipping lanes.

Specification of the zones in terms of important management factors is shown in Figure 6. It is important to note the logical progression of the zones and the consistency of management factor levels within each zone, for these are the keys to minimizing use conflicts.

Particular activities and works which may be undertaken freely, undertaken only by consent (e.g. permit or licence) or are prohibited in each type of zone are identified in Table 21.

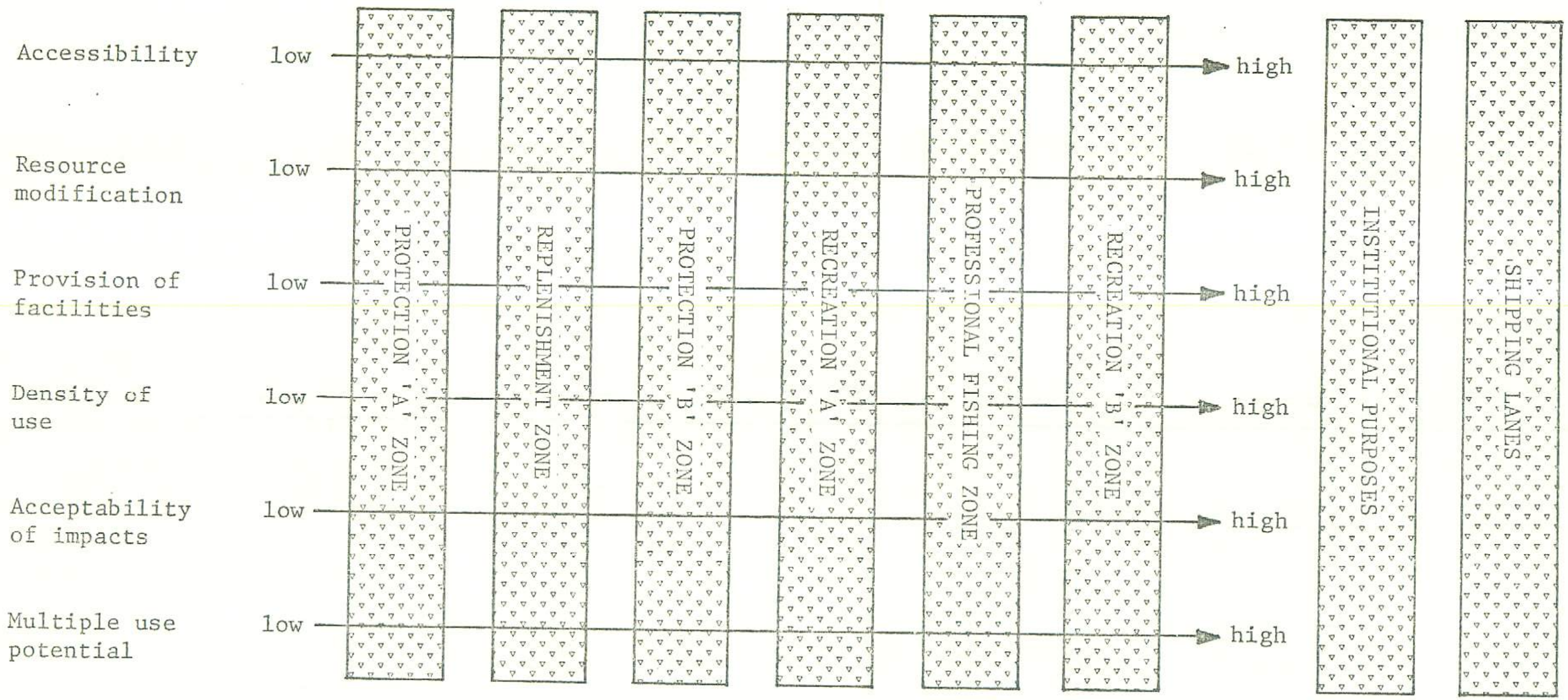


Fig.6. Zoning System and Management Factors

TABLE 21. ALLOCATION OF ACTIVITIES AND WORKS WITHIN ZONES

		ZONE							
		PROTECTION A	REPLENISHMENT	PROTECTION B	RECREATION A	PROFESSIONAL FISHING	RECREATION B	INSTITUTIONAL PURPOSES	SHIPPING LANES
ACTIVITIES	Commercial shell collecting	X	X	X	C	C	X	X	X
	" coral "	X	X	X	C	C	X	X	X
	" aquar. fish "	X	X	X	C	C	X	X	X
	Professional boat fishing:								
	- demersal	X	X	X	X	✓	X	X	C
	- pelagic	X	X	X	✓	✓	X	X	C
	- scallops	X	X	X	X	✓	X	X	C
	Pro-am boat fishing†	X	X	X	✓	✓	X	X	X
	Amateur boat fishing†	X	X	C*	✓	X	C	X	X
	" spear "	X	X	X	C*	X	X	X	X
	" shell collecting	X	X	X	C	X	X	X	X
	" coral "	X	X	X	C	X	X	X	X
	" aquar.fish "	X	X	X	C	X	X	X	X
	Camping	X	X	C	C	X	C	X	X
	Reef walking	X	X	✓	✓	✓	✓	X	X
	Non-extractive diving	X	C	✓	✓	✓	✓	C	X
	Photography	X	C	✓	✓	✓	✓	C	X
	Nature appreciation	X	C	✓	✓	✓	✓	C	X
	Interpretation	X	C	✓	✓	✓	✓	C	X
	Education	X	C	✓	✓	✓	✓	C	X
	Non-manipulative research	C	C	✓	✓	✓	✓	C	C
	Manipulative research	X	C	C	C	C	C	C	C
	Commercial shipping	X	X	X	X	X	X	X	✓
WORKS	Construction of:								
	- resort	X	X	X	X	X	C	X	X
	- research station	X	X	C	C	X	C	C	X
	- helipad	X	X	X	C	X	C	C	X
	- underwater observatory	X	X	X	X	X	C	X	X
	- camping facilities	X	X	C	C	X	C	X	X
	- jetty	X	X	X	C	X	C	C	X
	- moorings	X	X	X	C	X	C	C	X

✓ Activities or works which may be undertaken without consent.
C Activities or works which require consent, e.g. permit or licence.
X Activities or works which are prohibited.
* Sustenance fishing by campers only.
† Subject to catch limits.

The system of zones is designed to cover all water, reef and island areas in the Section. Although the Marine Park Act does not operate over islands or parts of islands that form part of Queensland, such land areas have been zoned as though they were in the Capricornia Section in the expectation that relevant State Government management authorities would use the designated zoning as the basis of future management policies.

Objective evaluation of the strategies requires a notional assessment of levels of use and economic activity in the year 2000 to be made for each alternative. These estimates, contained in Sections 6.5, 6.6 and 6.7, have been undertaken in the light of the following assumptions:

(a) available leisure time suitable for trips to the Capricornia Section will increase;

(b) the demand for opportunities in the Capricornia Section will be relatively greater than that for opportunities in other, less accessible, parts of the Reef;

(c) the demand for low cost, low level of service resorts will increase at a faster rate than that for high cost, high level of service resorts;

(d) the economics of boat operation will tend to favour charter boats at the expense of private speed boats;

(e) some larger (say 50 passenger), faster charter boats or ferries will be operating in the Section by the year 2000;

(f) no significant additional areas of islands or reefs will be required for lighthouses or other navigational aids before the year 2000.

It is important to understand that the strategies are put forward as <u>representations</u> of alternative future uses of the Section and that the estimated activity levels should not be interpreted as accurate predictions of use in the year 2000.

For the purposes of evaluation it is necessary to define and document an unambiguous scenario for future use under each strategy. This does not mean, however, that one and only one valid scenario can be defined under each strategy. Under the Tourism/Recreation Strategy, for example, a predominantly domestic use option has been generated. An alternative option would be one that included large-scale day visits to the Section from the proposed Iwasaki development at Yeppoon. Both options are valid but the domestic use option has been preferred in this study because of the uncertainties and complete absence of useful data surrounding the Iwasaki project.

6.5 THE FISHING INDUSTRY STRATEGY

Map 7 depicts the distribution of people, activities and impacts that would occur under the Fishing Industry Strategy. It has been derived by making maximum use of commercial fishing opportunities within the framework of the multiple objectives outlined in Section 6.2. The strategy is designed to:

- maintain the total fishing catch at a level close to the estimated optimum sustainable yield;
- favour commercial fishing at the expense of amateur fishing; and
- provide fishing replenishment areas in which designated reefs and shoals would intermittently be closed to fishing.

In addition, it also:

- provides resort accommodation on 2 islands;
- allows camping by permit on 4 islands;
- protects 25% of the seabed from trawling;
- protects 22% of the total area of reefs and shoals in Protection or Replenishment Zones;*
- protects 100% of the principal and 67% of the secondary breeding sites for Loggerhead Turtles;
- protects 67% of the principal and 71% of the secondary breeding sites for Green Turtles; and
- protects 75% of all seabird nesting colonies.

---

*The Division of National Mapping, Canberra, figures for the areas of reefs and shoals have been used in this calculation.

(i) Major components of year 2000 use patterns

(a) Resort visits

Heron Island resort would continue in its present role with some upgrading of accommodation and a slight increase in use. A low cost family resort of 40 x 5 bed cabins would be constructed on Lady Elliott Island. Access to this island would be by light aircraft and a possible ferry connection to Bundaberg. Annual use by visitors would be in the vicinity of:

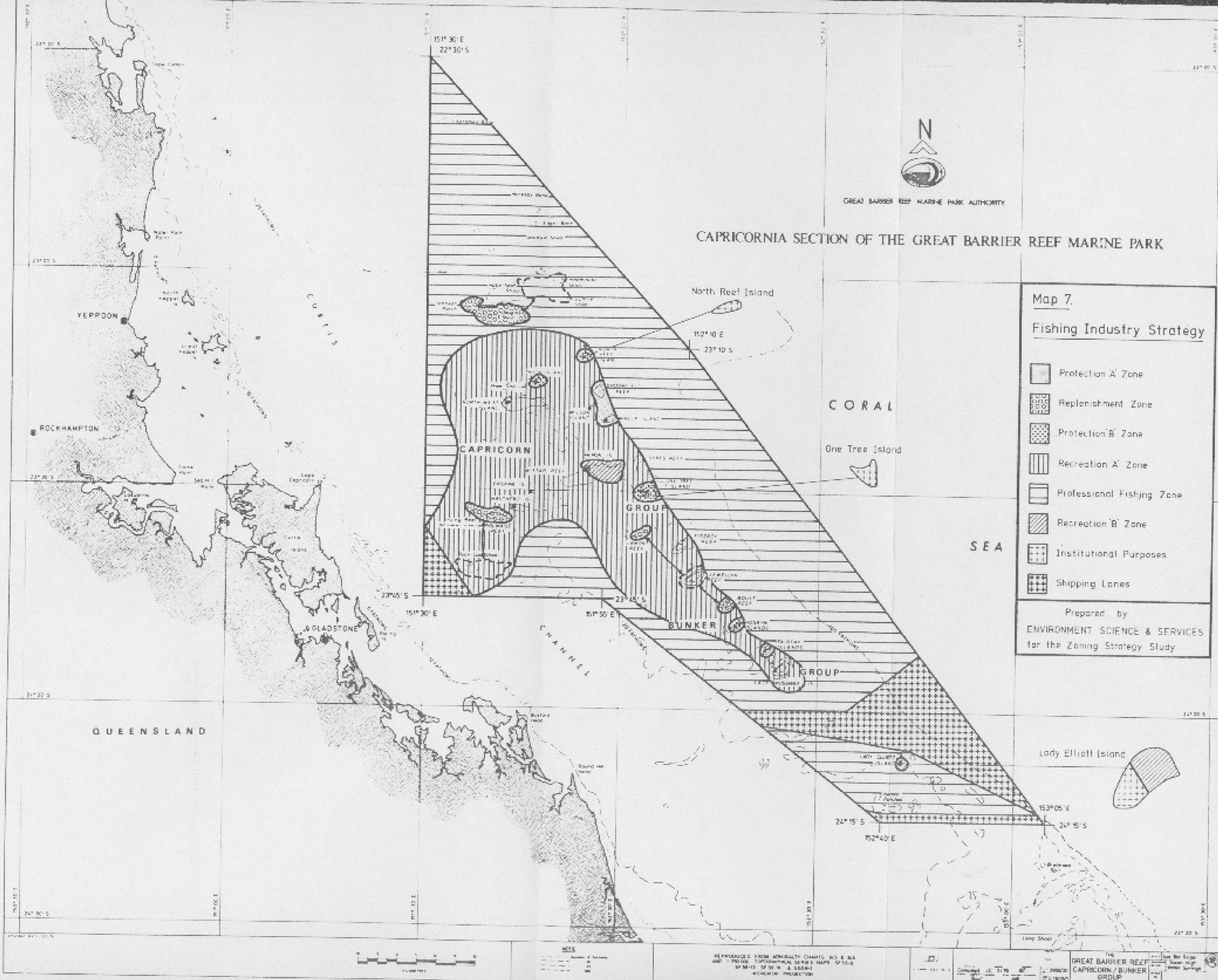
	NO. BEDS	ANNUAL USE (visitor-days)
Heron Island resort	250	50,000
Lady Elliott Island resort	200	40,000
TOTAL	450	90,000

(b) Research station visits

Research stations would remain on Heron and One Tree Islands. Annual use would increase to approximately 11,000 visitor-days largely as a result of monitoring work undertaken by Authority staff.

(c) Charter boat/ferry operation

The equivalent of approximately 48 full-time boats would be operating in the Section. It is assumed that 3 of these boats would be larger (say 50 passengers), faster vessels such as hovercraft or hydrofoils. Annual use of charter boats and ferries is estimated to be 51,000 person-days.



GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 7.
Fishing Industry Strategy
Protection 'A' Zone
Replenishment Zone
Protection 'B' Zone
Recreation 'A' Zone
Professional Fishing Zone
Recreation 'B' Zone
Institutional Purposes
Shipping Lanes
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
N
CORAL
SEA
North Reef Island
One Tree Island
Lady Elliott Island
CAPRICORN
GROUP
BUNKER
GROUP
QUEENSLAND
YEPPOON
ROCKHAMPTON
GLADSTONE
CURTIS
CHANNEL
151° 30' E
22° 30' S
152° 10' E
23° 10' S
23° 45' S
151° 30' E
151° 55' E
153° 05' E
24° 15' S
152° 40' E
GREAT BARRIER REEF
CAPRICORN / BUNKER
GROUP

(d) Speed boat use

Speed boat use is expected to increase at a slower rate than population growth in adjacent coastal cities because:

. large increases in operating costs of private speed boats are likely;

. there will be a decrease in amateur fishing opportunities available to the residents of Bundaberg.

Level of speed boat use under this strategy has therefore been estimated at 17,000 person-days.

(e) Scenic flights

Scenic flights over the Section could generate approximately 4,000 person-days of use in the year 2000.

(f) Yachts and seaplanes

Level of use generated by yachts and seaplanes could be of the order of 4,000 person-days per annum.

(g) Camping

Camping would be allowed by permit on 4 islands, with limits applied to the maximum number of campers on each island at one time. Limits and annual use pressures are shown below.

	LIMIT (persons)	ANNUAL USE (person-days)
Tryon Island*	50	1,000
North West Island	300	9,500
Masthead Island*	100	1,500
Lady Musgrave Island	200	5,000
TOTAL	650	17,000

*Closed to camping from Dec.1st to Jan.31st.

The major camping area, on North West Island, would have developed facilities including fresh water supply, tent sites, toilets etc. The remaining camping areas would be supplied with toilet facilities only.

(h) Fishing

The Fishing Industry Strategy is designed to maintain the total fishing catch at a level close to the optimum sustainable yield. Although the optimum sustainable yield of fisheries resources in the Capricornia Section is not known, available evidence suggests that existing catches have been relatively constant over a number of years and over-fishing is only evident on the most accessible and heavily fished reefs.

Fishing activities would therefore be regulated to maintain the components of the total catch at or near their present levels, viz:

Commercial scallop fishing	100,000 kg scallop meat p.a.
Commercial demersal fishing	225,000 kg whole fish equiv. p.a.
Commercial pelagic fishing	100,000 kg whole fish equiv. p.a.
Amateur fishing	same as present catch (not known)

(ii) Management input

The level of management input required under the Fishing Industry Strategy in the year 2000 is outlined below.

(a) Offices

A regional office in Gladstone would act as management headquarters for the Section, with local offices at Bundaberg and Rosslyn Bay to act as permit, licensing and information centres. An agent in Rockhampton may also be required.

Computer access would be provided in the regional and local offices to assist with the issuing of permits and licences, the retrieval of monitoring data and day to day operational tasks.

(b) Equipment

. 1 x 15 m boat
. 3 x 9 m boats
. 1 x 10 m landing barge
. 2 vehicles
. 3 computer terminals
. radio communication between base & 6 mobiles.

(c) Staff

. 1 manager
. 1 secretary
. 1 clerk/radio operator
. 4 clerks
. 2 educational officers
. 6 rangers/masters
. 11 technical assistants/deckhands/labourers
. 4 research staff (full-time equivalents).

(d) Deployment

Gladstone would be the operational headquarters of management activities in the Section. During off peak periods (e.g. February-March), all the boats would be based in Gladstone. During peak periods, such as school holidays and the Christmas vacation, 9 m boats and crews would be based on North West and

Lady Elliott Islands. The research staff would be based in Townsville with extended visits for field work as required.

It is assumed that resources of the Authority would have some involvement in search and rescue operations in the Section and adjacent coastal areas. General surveillance inputs could be increased by enlisting the support of charter boat masters as honorary rangers.

(iii) Capital works

Capital works under the Fishing Industry Strategy would include:

(a) some replacement and upgrading of accommodation and facilities at the Heron Island resort;

(b) development of low cost resort accommodation on Lady Elliott Island with:
- . 40 cabins plus facilities;
- . electricity generating plant;
- . desalination plant;
- . jetty;

(c) campground on North West Island with
- . 100 campsites;
- . desalination plant;
- . toilet and shower facilities;

(d) toilet facilities on Tryon, Masthead and Lady Musgrave Islands;

(e) temporary ranger accommodation on North West Island;

(f) temporary ranger accommodation on Lady Elliott Island (accommodation at lighthouse may be suitable if vacant);

(g) overnight ranger accommodation on Lady Musgrave Island.

(iv) <u>Employment</u>

The level of employment generated under the Fishing Industry Strategy by the year 2000 would be:

OCCUPATION	EMPLOYMENT (full-time equivalents)
Fishing	40
Charter boat crew	80
Resort staff	90
Research station staff	12
Marine Park management	30
Lighthouse maintenance	1
Other	20
TOTAL	273

6.6 THE TOURISM/RECREATION STRATEGY

Map 8 depicts the distribution of people, activities and impacts that would occur under the Tourism/Recreation Strategy. It has been derived by making maximum use of opportunities for tourism and recreation within the framework of multiple objectives outlined in Section 6.2. The Strategy is designed to:

- provide resort accommodation over a range of standards;
- allow camping on islands;
- allow development of an underwater observatory; and
- favour amateur fishing at the expense of commercial fishing.

In addition, it also:

- provides for one fishing replenishment area in which designated reefs and shoals would intermittently be closed to fishing;
- protects 60% of the seabed from trawling;
- protects 21% of the total area of reefs and shoals in Protection or Replenishment Zones;*
- protects 100% of the principal and 67% of the secondary breeding sites for Loggerhead Turtles;
- protects 67% of the principal and 57% of the secondary breeding sites for Green Turtles; and
- protects 68% of all the seabird nesting colonies.

---

*The Division of National Mapping, Canberra, figures for areas of reefs and shoals have been used in this calculation.

(i) Major components of year 2000 use patterns

(a) Resort visits

Heron Island resort would continue in its present role with some upgrading of accommodation and a slight increase in use.

Lady Elliott Island would be developed as a resort with standards of service similar to those on Heron Island, but offering a different experience which relied less on the Reef and its natural values as the principal attraction. A 400 bed hotel is proposed with light aircraft connections to Brisbane, light aircraft and/or fast ferry connections to Bundaberg and day trips to Lady Musgrave Island.

A low cost family resort is proposed on North West Island, with 80 x 5 bed cabins, and associated campground facilities. Access would be by fast ferry and/or helicopter from Gladstone. An underwater observatory would be established on Wilson Island to be used by day visitors from both North West and Heron Islands.

Annual use of resorts by guests would be in the vicinity of:

	NO. BEDS	ANNUAL USE (visitor-days)
Heron Island	250	50,000
Lady Elliott Island	400	75,000
North West Island (excluding campers)	400	75,000
TOTAL	1,050	200,000

(b) Research station visits

Research stations would remain on Heron and One Tree Islands. Annual use would increase to approximately 11,000 visitor-days largely as a result of monitoring work undertaken by Authority staff.

(c) Charter boat/ferry operation

The equivalent of approximately 48 full-time boats would be operating in the Section. It is assumed that 5 of these boats would be larger (say 50 passengers), faster vessels such as hovercraft or hydrofoils. Annual use of charter boats and ferries is estimated to be 60,000 person-days.

(d) Speed boat use

The amount of private speed boat use is expected to be constrained by large increases in operating costs. The level of speed boat use under this strategy is expected to be similar to that under the Fishing Industry Strategy and amount to approximately 16,000 person-days per annum.

(e) Scenic flights

Scenic flights over the Section could generate approximately 4,000 person-days of use in the year 2000.

(f) Yachts and seaplanes

Levels of use generated by yachts and seaplanes could be of the order of 4,000 person-days per annum.

(g) Camping

Camping would be allowed by permit on 4 islands, with limits applied to the maximum number of campers on each island at one time. Limits and annual use pressures are shown below.

	LIMIT (persons)	ANNUAL USE (person-days)
Tryon Island*	50	1,000
North West Island	400	11,000
Masthead Island*	200	3,000
Lady Musgrave Island	200	5,000
TOTAL	850	20,000

*Closed to camping from Dec.1st to Jan.31st.

The major camping area, on North West Island, would be developed in conjunction with the low cost resort accommodation and have access to a range of services including fresh water supply, showers, toilets, etc. The remaining camping areas would be supplied with toilet facilities only.

(h) Fishing

The total fishing catch would be kept at a level near the optimum sustainable yield but with a bias towards amateur fishing at the expense of commercial fishing. Again the sustainable yield is not known but is assumed to be in the vicinity of existing annual catches.

Fishing activities would therefore be regulated to maintain the total catch at or near its present levels but with the following components:

Commercial scallop fishing	75,000 kg scallop meat p.a.
Commercial demersal fishing	120,000 kg whole fish equiv. p.a.
Commercial pelagic fishing	100,000 kg whole fish equiv. p.a.
Amateur fishing	twice present catch

(ii) <u>Management input</u>

The level of management input required under the Tourism/Recreation Strategy in the year 2000 is outlined below.

(a) Offices

Management under this strategy would be more decentralized than under the other two strategies. The regional headquarters would still be located in Gladstone, with local offices at Bundaberg, Rosslyn Bay and Rockhampton. Full-time field stations would be located on North West and Lady Elliott Islands.

Computer access would be provided in the regional and local offices to assist with the issuing of permits and licences, the retrieval of monitoring data and day to day operational tasks.

(b) Equipment

- 1 x 15 m boat
- 4 x 9 m boats
- 1 x 10 m landing barge
- 3 vehicles
- 4 computer terminals
- radio communication between base, 2 field stations and 8 mobiles.

(c) Staff

- . 1 manager
- . 1 secretary
- . 1 clerk/radio operator
- . 5 clerks
- . 4 education officers
- . 11 rangers/masters
- . 15 technical assistants/deckhands/labourers
- . 4 research staff (full-time equivalents).

(d) Deployment

Gladstone would be the operational headquarters of management activities, supported by 9 m boats and crews permanently stationed on North West and Lady Elliott Islands. The 15 m boat and two 9 m boats would be based at Gladstone. Research staff would be based in Townsville with extended visits for field work as required.

It is assumed that resources of the Authority would have some involvement in search and rescue operations in the Section and adjacent coastal areas. General surveillance inputs could be increased by enlisting the support of charter boat masters as honorary rangers.

(iii) Capital works

Capital works under the Tourism/Recreation Strategy would include:

(a) some replacement and upgrading of accommodation and facilities at the Heron Island resort;

(b) development of 400 bed hotel and facilities on Lady Elliott Island together with:

. upgrading airstrip;

. construction of jetty;

(c) development of low cost resort and campground on North West Island with:

. 80 cabins;

. 150 tent sites;

. jetty;

. desalination plant;

. electricity generating plant;

. toilet and shower facilities;

(d) toilet facilities on Tryon, Masthead and Lady Musgrave Islands;

(e) permanent ranger accommodation and information centre on North West Island;

(f) permanent ranger accommodation and information centre on Lady Elliott Island (accommodation at lighthouse may be suitable if vacant);

(g) overnight ranger accommodation on Lady Musgrave Island;

(h) construction of underwater observatory and jetty on Wilson Island.

(iv) Employment

The level of employment generated under the Tourism/ Recreation Strategy by year 2000 would be:

	EMPLOYMENT (full-time equivalents)
Fishing	30
Charter boat crew	85
Resort staff	190
Research station staff	12
Marine Park management	42
Lighthouse maintenance	1
Other	40
TOTAL	400

6.7 THE PRESERVATION STRATEGY

Map 9 depicts the distribution of people, activities and impacts that would occur under the Preservation Strategy. It has been derived by making maximum use of opportunities to preserve areas in an undisturbed state within the framework of multiple objectives outlined in Section 6.2. The strategy is designed to:

- . protect the seabed;
- . protect all other elements of the marine ecosystem;
- . protect all the principal and as many as possible of the secondary breeding sites for both Loggerhead and Green Turtles;
- . protect all the principal and as many as possible of the other known seabird nesting colonies; and
- . upgrade existing research station facilities.

In addition, it also:

- . prohibits professional fishing activities in the Section;
- . provides for resort accommodation on 2 islands;
- . allows camping by permit on 2 islands; and
- . provides 3 fishing replenishment areas in which designated reefs and shoals would intermittently be closed to fishing.

(i) Major components of year 2000 use patterns

(a) Resort visits

Heron Island would continue in its present role with some upgrading of accommodation and a slight increase in use. A low cost family resort of 20 x 5 bed cabins would be constructed on Lady Elliott Island with access by light aircraft or ferry.

Annual use by guests would be in the vicinity of:

	NO. BEDS	ANNUAL USE (visitor-days)
Heron Island Resort	250	50,000
Lady Elliott Island Resort	100	20,000
TOTAL	350	70,000

(b) Research station visits

Research stations on Heron and One Tree Islands would be upgraded to encourage scientific research interest within the Section. Together with monitoring work undertaken by Authority staff, this would increase research station visits to approximately 13,000 visitor-days per annum.

(c) Charter boat/ferry operation

The equivalent of approximately 40 full-time boats would be operating in the Section. It is assumed that 2 of these boats would be larger (say 50 passengers), faster vessels such as hovercraft or hydrofoils.

Charter boat/ferry activity is assumed to be less than under the other strategies because fewer opportunities exist for fishing and other recreational activities. Annual use levels are estimated to be 32,000 person-days.

(d) Speed boat use

The level of speed boat use under this strategy will be constrained by:

- large increases in operating costs of private speed boats;
- a significant decrease in easily accessible recreational opportunities.

The level of speed boat use has therefore been estimated at 15,000 person-days per annum.

(e) Scenic flights

Scenic flights over the Section could generate approximately 5,000 person-days of use by the year 2000. This is higher than the use under the other strategies in view of the decrease in available 'on-ground' opportunities.

(f) Yachts and seaplanes

Levels of use generated by yachts and seaplanes could be of the order of 4,000 person-days per annum.

(g) Camping

Camping would be allowed by permit on 2 islands, with limits applied to the maximum number of campers on each island at one time. Limits and annual use pressures are shown below.

	LIMIT (persons)	ANNUAL USE (person-days)
Erskine Island*	10	500
Lady Musgrave Island*	100	4,000
TOTAL	110	4,500

*Closed to camping from Nov.1st to Feb.28th.

Toilet facilities would be provided on Lady Musgrave Island.

(h) Fishing

Under the Preservation Strategy, the total fishing catch would be maintained well below the sustainable yield and no trawling or other activities likely to damage the seabed would be permitted. Fishing activities would therefore be regulated to maintain the components of the total catch at or near the following levels:

Commercial scallop fishing	nil
Commercial demersal fishing*	50,000 kg whole fish equiv. p.a.
Commercial pelagic fishing*	50,000 kg whole fish equiv. p.a.
Amateur fishing	half present catch

(ii) Management input

The level of management input required under the Preservation Strategy in the year 2000 is outlined below.

(a) Offices

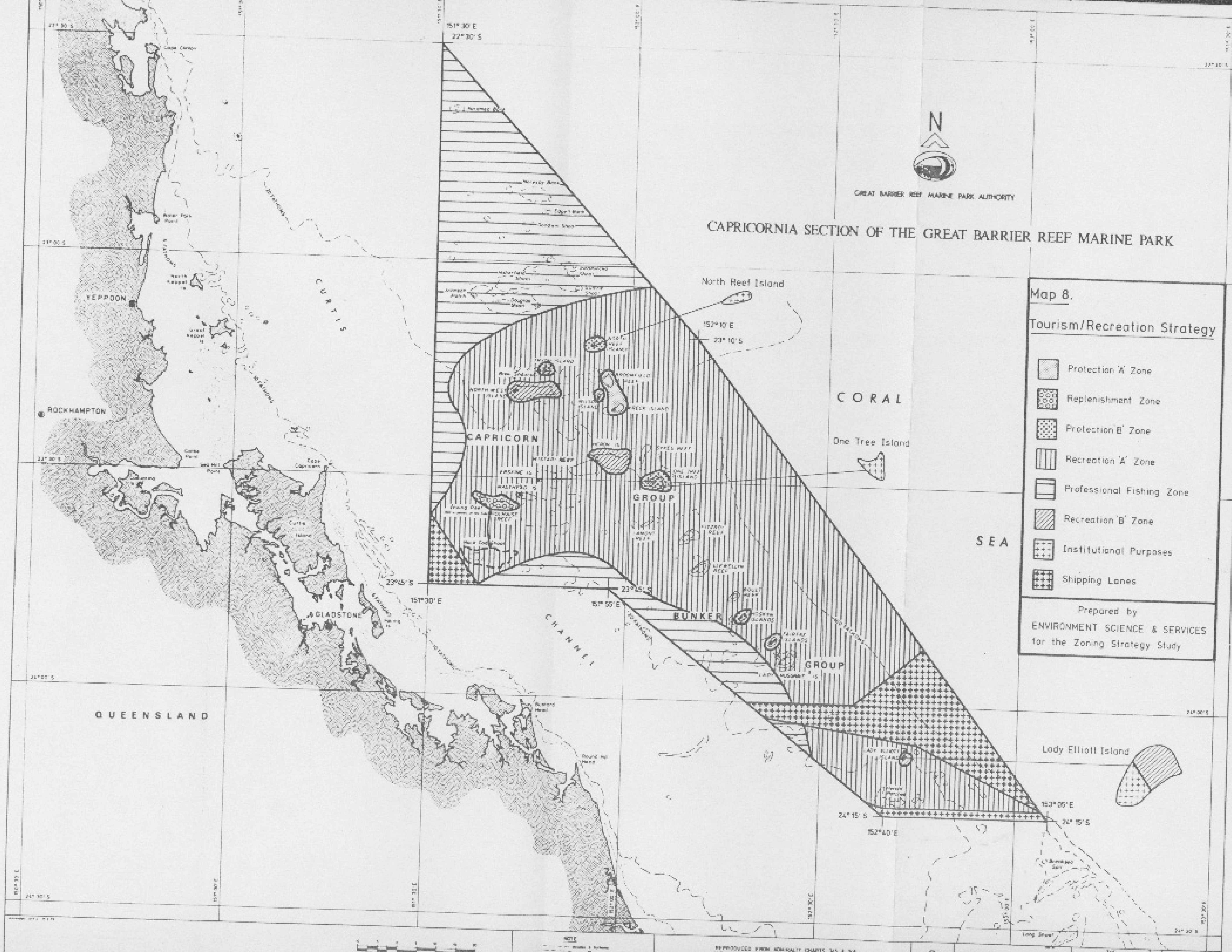
Management under this strategy would be more centralized than under the other two strategies. A regional office would still be located in Gladstone although agencies would probably be sufficient in Bundaberg and Rosslyn Bay. Temporary ranger accommodation would be located on Heron Island.

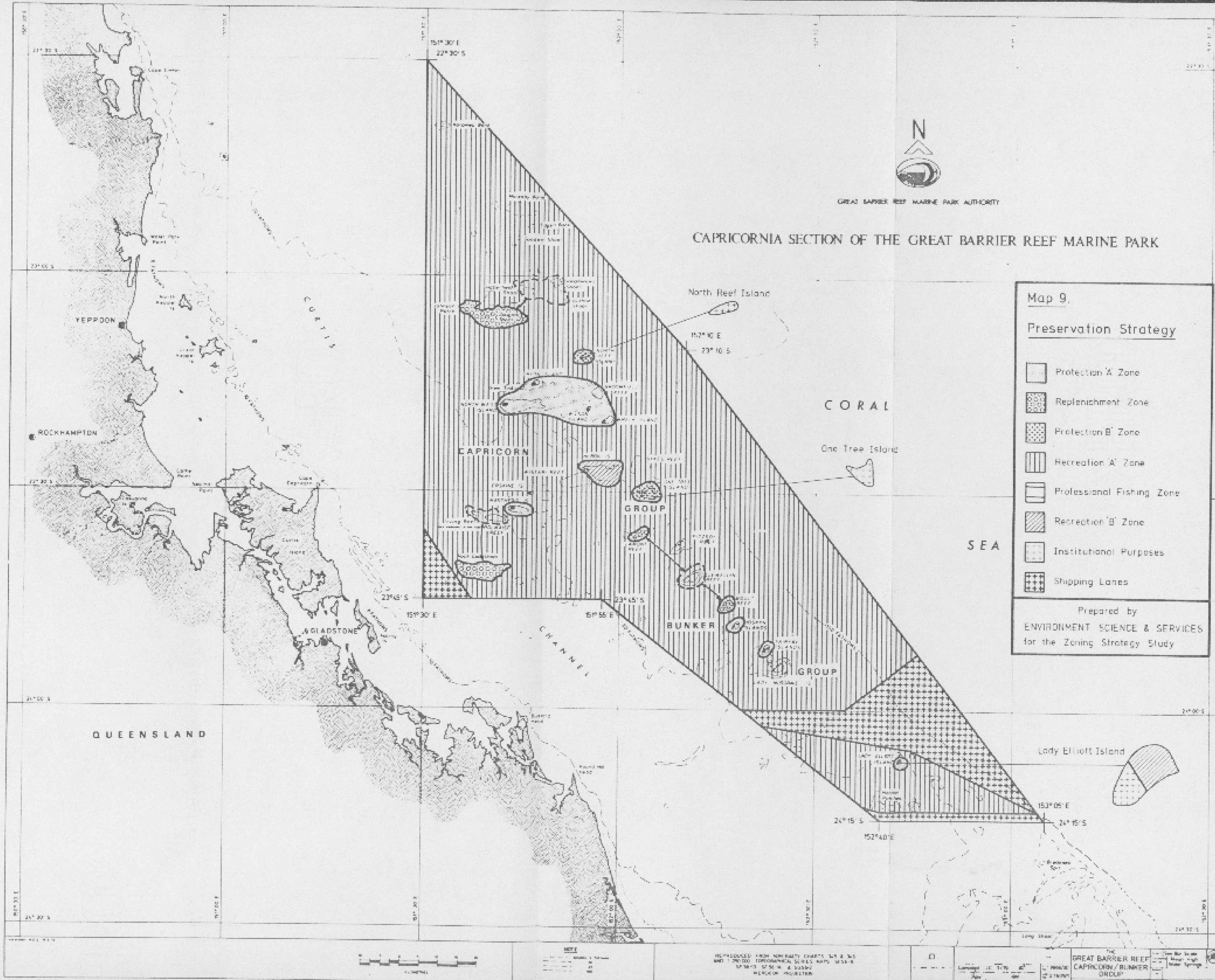
In view of the restricted public access and decreased workload associated with issuing permits and licences, provision for computer access has not been included under this strategy.

(b) Equipment

- 2 x 15 m boats
- 1 x 9 m boat
- 2 vehicles
- radio communication between base and 5 mobiles.

*Landed by pro-amateur fishermen.


GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 8.
Tourism/Recreation Strategy
Protection 'A' Zone
Replenishment Zone
Protection 'B' Zone
Recreation 'A' Zone
Professional Fishing Zone
Recreation 'B' Zone
Institutional Purposes
Shipping Lanes
Prepared by
ENVIRONMENT SCIENCE & SERVICES
for the Zoning Strategy Study
N
North Reef Island
One Tree Island
Lady Elliott Island
CORAL
SEA
CURTIS
CHANNEL
CAPRICORN
GROUP
BUNKER
GROUP
QUEENSLAND
ROCKHAMPTON
YEPPOON
GLADSTONE
151° 30' E
22° 30' S
152° 10' E
23° 10' S
23° 45' S
151° 55' E
24° 15' S
152° 40' E
153° 05' E



GREAT BARRIER REEF MARINE PARK AUTHORITY
CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK
Map 9.
Preservation Strategy
Protection 'A' Zone
Replenishment Zone
Protection 'B' Zone
Recreation 'A' Zone
Professional Fishing Zone
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Institutional Purposes
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N
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CURTIS
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CORAL
SEA
CAPRICORN
GROUP
BUNKER
GROUP
North Reef Island
One Tree Island
Lady Elliott Island
151°30' E
22°30' S
23°45' S
151°55' E
152°10' E
23°10' S
24°15' S
152°40' E
153°05' E
GREAT BARRIER REEF
CAPRICORN/BUNKER
GROUP

(c) Staff

- . 1 manager
- . 1 secretary
- . 1 clerk/radio operator
- . 1 clerk
- . 2 education officers
- . 4 rangers/masters
- . 13 technical assistants/deckhands/labourers
- . 3 research staff (full-time equivalents).

(d) Deployment

Gladstone would be the operational headquarters of management activities in the Section. All boats would be based in Gladstone although temporary operation out of Heron Island would occur from time to time. Research staff would be based in Townsville with extended visits for field work as required.

It is assumed that resources of the Authority would have some involvement in search and rescue operations in the Section and adjacent coastal areas. General surveillance inputs could be increased by enlisting the support of charter boat masters as honorary rangers.

(iii) Capital works

Capital works under the Preservation Strategy would include:

(a) some replacement and upgrading of accommodation and facilities at the Heron Island resort;

(b) development of low cost resort accommodation on Lady Elliott Island with:
  - . 20 cabins plus facilities;
  - . electricity generating plant;
  - . desalination plant;

(c) toilet facilities on Lady Musgrave Island;

(d) upgrading research station facilities on Heron and One Tree Islands;

(e) temporary ranger accommodation on Heron Island.

(iv) Employment

The level of employment generated under the Preservation Strategy by year 2000 would be:

OCCUPATION	EMPLOYMENT (full-time equivalents)
Fishing	nil
Charter boat crew	60
Resort staff	80
Research station staff	15
Marine Park management	26
Lighthouse maintenance	1
Other	10
TOTAL	192

6.8 IMPLEMENTATION

The zoning system described in Section 6.4 has been used to represent alternative distributions of people, activities and impacts to the year 2000. For each strategy, a map and descriptive text has been prepared as a blueprint for future use of the Section. Such a blueprint is an important component of overall management for it provides a goal for longer term use and development, and thus a sense of direction for management policies.

Just as the goal, or blueprint, is important, the means of pursuing the goal are equally important. Under the terms of the Great Barrier Reef Marine Park Act 1975, the Authority is empowered to manage the Capricornia Section by way of a zoning plan and associated regulations. With the aid of these tools several different management regimes are possible. For example:

(a) management by zones in which a complex set of zones are rigidly defined for particular activities in association with relatively few, general regulations;

(b) management by regulations in which few zones are more loosely defined and more complex regulations become the prime means of controlling use;

(c) a more equitable mixture of zones and regulations.

Selection of an appropriate management regime should be based on the following criteria:

- it should be flexible and easily amended during the early years of Park management;

- it should be readily understood by the public;
- it should be capable of translation into a legally binding statutory planning scheme;
- it should generate monitoring data to assist in the management process;
- it should not impose high recurring administrative costs.

For the purposes of strategy evaluation in this study, it will be assumed that administrative costs of alternative management regimes are approximately equal.

6.9 SUMMARY

A system of zones has been used to represent the distribution of people, activities and impacts to the year 2000 under the following alternative strategies:

(a) The Fishing Industry Strategy
(b) The Tourism/Recreation Strategy
(c) The Preservation Strategy.

Approximate areas of the Section within particular zones under each strategy are summarized in Table 22. In addition, the percentage distribution between extractive and non-extractive zones of the total area of reefs and shoals is contained in Table 23.

The need for conservation of the Reef and its resources has played an important role in shaping each of the strategies. An indication of the relative levels of protection afforded to the seabed, reefs and shoals, turtle nesting sites and seabird nesting sites under each strategy is documented as part of the evaluation in Section 7.6.

TABLE 22. APPROXIMATE AREA WITHIN EACH ZONE

	ZONE							
	Protection A (ha)	Replenishment (ha)	Protection B (ha)	Recreation A (ha)	Professional Fishing (ha)	Recreation B (ha)	Institutional Purposes & Shipping Lanes (ha)	Total area of the Section (ha)
Fishing Industry Strategy	5,000	7,500	4,500	279,000	700,000	4,000	125,000	1,125,000
Tourism/ Recreation Strategy	5,000	3,500	4,500	670,000	309,000	8,000	125,000	1,125,000
Preservation Strategy	14,500	9,000	3,500	969,000	-	4,000	125,000	1,125,000

TABLE 23. PERCENTAGE DISTRIBUTION OF TOTAL AREA[a] OF REEFS AND SHOALS

	NON-EXTRACTIVE ZONES (Protection A, Protection B and Replenishment)	EXTRACTIVE ZONES (Recreation A, Recreation B, Professional Fishing and Shipping Lanes)
Fishing Industry Strategy	22%	78%
Tourism/ Recreation Strategy	21%	79%
Preservation Strategy	41%	59%

(a) Based on areas supplied by Division of National Mapping, Canberra.

The Capricornia Section is to be managed as a multi-use park and as such will accommodate a range of human activities controlled within acceptable levels of use. A summary of notional annual use patterns and employment under each strategy at the year 2000 is contained in Table 24.

TABLE 24. NOTIONAL ANNUAL USE PATTERNS AND EMPLOYMENT FOR YEAR 2000

COMPONENTS	EXISTING	FISHING INDUSTRY	TOURISM/ RECREATION	PRESERVATION
Resort visits (visitor-days)	37,000	90,000	200,000	70,000
Research station visits (visitor-days)	8,000	11,000	11,000	13,000
Charter boat/ferry use (person-days)	12,000	51,000	60,000	32,000
Speed boat use (person-days)	9,000	17,000	16,000	15,000
Scenic flights (person-days)	200	4,000	4,000	5,000
Yachts and seaplanes (person-days)	2,000	4,000	4,000	4,000
Camping (person-days)	16,000	17,000	20,000	4,500
Commercial fishing (kg)				
- scallops	100,000	100,000	75,000	-
- demersal	225,000	225,000	120,000	50,000
- pelagic	100,000	100,000	100,000	50,000
Amateur fishing (kg)	x	x	2x	0.5x
Employment (full-time equivalents)				
- fishing	38	40	30	-
- charter boats	25	80	85	60
- resorts	60	90	190	80
- research stations	8	12	12	15
- management	1	30	42	26
- lighthouse	3	1	1	1
- other	7	20	40	10
TOTAL	142	273	400	192

7.0 EVALUATION OF ALTERNATIVE STRATEGIES

7.1 INTRODUCTION

In the previous chapter, 3 alternative strategies for future use of the Capricornia Section were generated in accordance with the objectives contained in Section 32(7) of the Great Barrier Reef Marine Park Act, 1975. Although these strategies reflect distinct philosophical approaches in the amount of bias afforded various interest groups, they have all been determined within an overall context of conservation.

In this chapter the 3 alternative strategies are evaluated with the aid of recognized multi-criteria procedures. The evaluation does not seek to produce a single measure of performance but describes each strategy outcome in several dimensions. It is anticipated that the identification of the impacts and consequences of each strategy will assist in the subsequent task of generating a final preferred strategy.

For the purposes of evaluation in this study, the Capricornia Section is treated as a self-supporting management unit in the sense that all management costs are charged against the Section. In view of the continuing debate over the broader issues of Australian coastal surveillance requirements, it is possible that some economies of scale may eventuate by incorporating surveillance duties in the Capricornia Section into a broader, multi-purpose coastal surveillance system.

7.2 EVALUATION METHODOLOGY

In evaluation, the principal tasks are:

. to define alternative courses of action;

. to compare the effects of each; and

. to determine the 'best' of the available options.

'Best' has to be interpreted in terms of the preferences of some relevant group of individuals. In the context of this study, the objective might be stated as that of maximizing the welfare of society. Society's welfare is considered here as some aggregation of individual welfare, which itself can be assessed by reference to individual preferences: i.e., in line with the usual 'Paretian' precept of modern economics, the individual is assumed to be the best judge of his own welfare. However it is recognized that this assumption may not be universally accepted.

This apparently simple notion of evaluation, implying a single objective function, leads to major difficulties in practice.

(i) Trade-offs

In any non-trivial choice situation each alternative will have consequences in a variety of areas. The extent to which the effect in a particular area represents a gain (or loss) to society can be expected to vary among the strategies. As well we could expect that the various consequences would, if employed separately, produce conflicting preference orderings of the strategies. For example, in a particular case we might find that strategy A is preferred to strategy B in terms of the effects on recreational enjoyment, whereas the converse is true with respect to the effect on the scientific value of the resource. Thus the decision-maker has to accept that choice will involve 'trade-offs'. To achieve gains (or avoid losses) in one area, some other opportunity has to be foregone.

To carry out the complex set of trade-offs usually involved in public decision-making, some device is needed by which the overall performance of each strategy is assessed in such a way as to provide an unambiguous ranking of the alternatives. This implies that ideally for each strategy we should be able to aggregate the various effects to provide a single measure of contribution to welfare.

To produce such a single measure, not only must we be able to quantify all effects, but also there needs to be some common scale or numeraire in terms of which each can be expressed. The fact that we observe that individuals do make choices (and hence trade-offs) which apparently involve comparison of seemingly unalike effects is consistent with the notion of such a numeraire. However, in practice, while money has often been employed as the unit of measurement for certain types of effects, evaluation usually falls short of representing all effects with some common unit of measurement.

In part this difficulty of finding a basis for comparing effects arises because not all consequences appear to be readily quantifiable. While many effects can be quantified quite simply, in other cases no obvious physical or monetary dimension arises. Thus, in many cases certain effects of a decision may only be described qualitatively.

Where such a situation exists it is suggested that multiple objectives need to be considered. In essence this means that the evaluation will not seek to produce a single measure of performance, but each strategy outcome will be described in several dimensions. Where an appropriate numeraire exists relevant effects will be aggregated; otherwise effects will be presented in the most usable form, quantitative or qualitative as is practical and appropriate. By this approach it is possible to summarize the effects of each course of action as an aid to the decision-maker, without attempting to identify the 'best' strategy.

When dealing with environmental issues, some such approach is unavoidable given the diversity and nature of effects that are likely to be relevant. However, it should be noted that in a real sense this procedure simply postpones or transfers to some other body the difficult task of making the ultimate trade-offs. Though it may have achieved a more concise description of the consequences of each strategy, in the end the decision to select a particular strategy either explicitly or implicitly must involve some 'weighting' of the various effects.

At this stage in the study of the Capricornia Section, the choice of a particular strategy is not an issue since there is no suggestion that any one of the three strategies being investigated would comprise the optimum course of action. As explained elsewhere, the strategies were defined to cover a range of activities so that their evaluation would provide information relevant to the generation of the preferred strategy. This preferred strategy might embody elements of each of the initial three. However, this 'building' of the preferred strategy is to be pursued in a subsequent stage of the overall study.

(ii) Cost-benefit analysis

The outline here and in subsequent sections is not intended as a rigorous presentation of the techniques of cost-benefit analysis. Nor is it intended as a justification of the use of the technique. Rather it seeks only to provide some minimal understanding of the concepts employed in this evaluation.

The earlier comments on methodology are, in general terms, consistent with the economists' view of cost-benefit analysis; viz, the consideration of all effects of a project, measurable and immeasurable, tangible and intangible, and the assessment of their consequences for the welfare of society. More specifically, cost-benefit analysis seeks to provide a way of appropriately valuing these various consequences. The numeraire used in the aggregation of benefits is money.

While cost-benefit accepts the need to take account of all significant effects, it is not suggested that economic science is in practice so well developed or that sufficient data would be available to allow the monetary evaluation of all these effects. As already implied, some benefits or costs associated with certain consequences may not be readily measured on a scale such as money, and it is accepted that in certain cases some alternative approach will be needed.

Cost-benefit analysis has in fact been criticised on a number of grounds, particularly in respect of the failure of some practitioners to give adequate attention to factors other than those readily valued in dollar terms. In addition, criticism has focused on certain equity aspects. Here we have sought to ensure consideration of the full range of consequences including some analysis of equity implications of the strategies.

(iii) Benefit and cost streams

The effects of some project or action may appear as a 'stream' of benefits and costs over a number of years.

This raises the question of how costs or benefits arising at different times should be compared.

Obviously the earning today of say $X, is presently worth more than the prospect of $X at some future time. Or in other words, the 'present value' of a future $X is in fact less than $X.

The present value of any future dollars can be obtained by appropriately discounting that future return over the relevant time period. A stream of values can thus be reduced to a single figure for present value, by first discounting the value relating to each future time period and then adding.

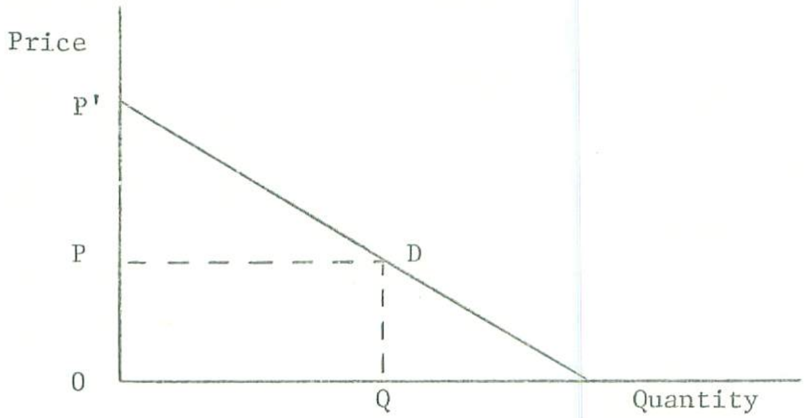
It is the choice of the appropriate discount rate which is a major source of argument. Various bases are suggested for selecting this rate. Here, as we are concerned with the welfare of society, the social rate of time preference - the rate at which society is believed to discount future costs and benefits - should be appropriate. However, this still leaves the question of the actual rate to be used. Arguments surrounding this question are complex, but it is generally agreed that the rate should be less than commercial rates. To allow sensitivity tests, a range of rates has been employed here. Rates of 3%, 5% and 7% are used in line with the approach of other similar evaluations.

Biases can be introduced into the evaluation if the time period considered is too short. Here an infinite time period has been considered. However, given that forecast visitor numbers etc. for the year 2000 effectively represent capacity limits under the strategies, the forecasts have been held constant for each year from that date. Note also that all dollar value estimates throughout this report are in terms of 1979 prices.

(iv) The concept of costs and benefits

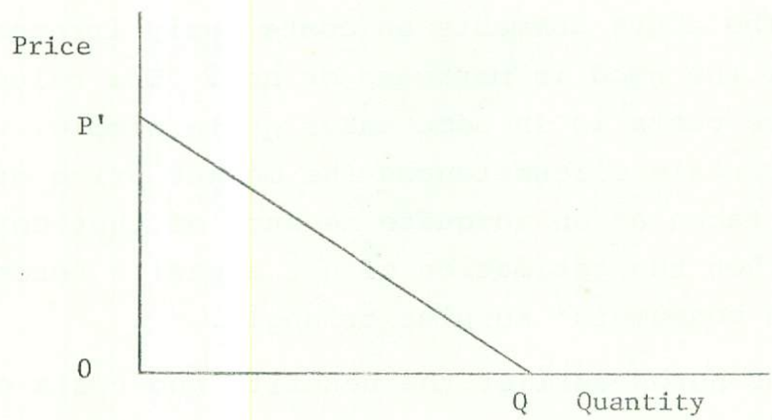
Concern here is only with what are termed economic effects, i.e. effects which in some way add to, or subtract from society's welfare. Thus transactions, in so far as they merely represent transfers between members of society, do not alter society's welfare and so are not relevant here. The effects of such transactions are referred to as financial effects.

Society's welfare has been loosely defined as some aggregation of individuals' preferences. In the cost-benefit approach these preferences are represented by individuals' willingness to pay for commodities. This willingness to pay can be described by reference to the familiar demand curve as shown below.



This figure shows that at the ruling price P, the quantity sold would be Q, so that consumers would pay out an amount of OQDP; but this is not a measure of their willingness to pay since the demand curve also indicates that some units of the commodity could have attracted a higher price than P. At prices higher than P (but not higher than P') we can see that some quantity would be sold. Total willingness to pay is therefore the area OQDP', i.e. the rectangle OQDP (or total price paid P.Q) plus the consumers' surplus triangle PDP'. Consumers' surplus can be interpreted as the benefit that accrues to individuals over and above the amount they pay for the commodity.

Even where a commodity currently is not marketed, but is provided at zero price - such as is the case for admission to many public parks - a demand curve does exist. This amounts to no more than saying that there is some relationship between price and the quantity that would be bought. The difference between this and the previous case is shown below.



Now the ruling price is O, at which price the quantity consumed is again labelled Q. No actual payment is made by consumers. However, the curve shows that some of the commodity would still be consumed at prices above zero (but not higher than P'). Total willingness to pay for the quantity Q is then the area of the consumers' surplus triangle OQP'.

This total willingness to pay is a measure of the value of the commodities to consumers, but to determine the net gain to society we need to subtract the cost of resources used in producing them; i.e. we need benefits-costs. These resource costs to be subtracted should not be confused with financial costs and behavioural costs. Rather they are what are termed 'social opportunity costs'.

Resources are limited, so that using a resource for one project means that some opportunity to employ that resource elsewhere (produce some other commodity) has been foregone. The benefit that society could have derived from the foregone project is the social opportunity cost of that resource. In effect resource cost is what society would be willing to pay for the output that could be obtained by employing the resource in the best alternative project.

The above comments on costs apply irrespective of whether the good is marketed or not. The calculation of resource costs is in some cases quite simple. For example, under certain circumstances the market price of an input may be taken as an adequate measure of that cost. In such cases then the estimation of net benefits becomes a search for the consumers' surplus triangle.

As noted earlier the benefits and costs of a strategy or project may arise over some considerable period of time. Hence the appropriate decision rule will be - assuming all effects are appropriately measurable - that the optimum course of action is the one for which the present value of the stream of net benefits (benefits less costs) is a maximum. Alternatively, if a single project is being evaluated the obvious rule is that the project should not be undertaken unless the present value of net benefits is positive.

Note that the above approach of putting dollar values on benefits accruing to an individual simply implies that willingness to pay validly expresses that individual's strengths of preferences. However adding these dollar values to get a measure of society's welfare means that, at least potentially, 'market power' will determine the extent of influence any individual has on the particular decision.

7.3 FORECASTS

The first step in determining costs and benefits has been to estimate the likely levels of each of the defined activities up to the year 2000 and under each of the three strategies. Note that these strategies have been defined in detail elsewhere.

Forecasts of usage levels etc. provided here must be accepted with caution and regarded only as reasonable estimates of orders of magnitude. Unfortunately there is a considerable lack of information relevant to the production of such forecasts.

As outlined earlier, even estimates of current levels of some activities must be regarded as being of poor reliability. Furthermore, relevant demand studies providing quantitative estimates of the determinants of recreational behaviour are not available. Hence prediction has had to be based on à priori reasoning as to the likely impact of estimated population growth and changes in economic circumstances, bearing in mind also the constraints and opportunities contained in each of the strategies.

The resultant forecasts contained in Appendix G must be considered only as informed judgements. However, it should be noted that for those activities which depend on major man-made facilities (e.g. resort type use and camping), upper limits to levels of use are set by the definitions of strategies. In these cases it is only the time taken for capacity to be reached which is in doubt.

7.4 VALUATION OF SOME IMPORTANT WELFARE EFFECTS

This section contains an assessment of recreational benefits, commercial fishing benefits, option value and management costs as they apply to the Capricornia Section under each strategy.

(i) Recreational benefits

Recreational activities provided for in the strategies being evaluated range from the use of the waters and reefs by individuals in private boats to more commercial tourism. In evaluating the benefits to society of these activities, the philosophy adopted here is that, conceptually, recreational demand is not different from the demand for any other commodity. In particular, it is argued that even in the case of recreational amenities traditionally provided at zero price to the consumer, a demand function (price/quantity relationship) does exist. At least theoretically then, 'willingness to pay' can serve as a basis for determining recreational benefits.

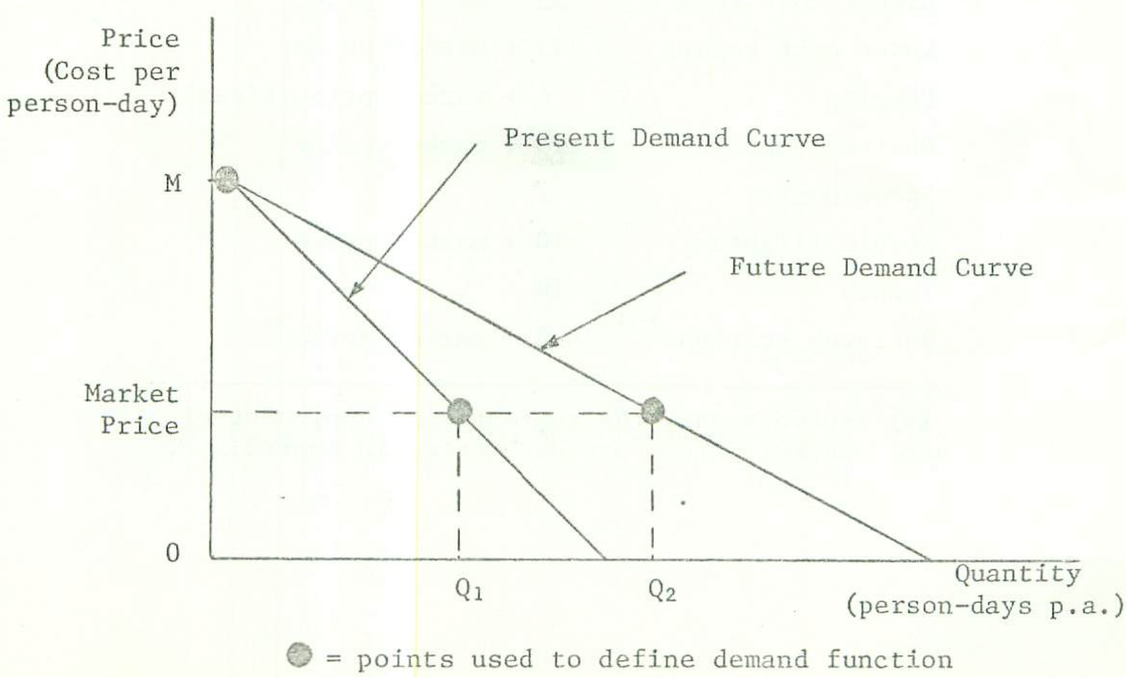
Essentially this approach requires the estimation of appropriate demand curves. As is usual in economics, experimentation to provide estimates of relevant relationships is not practical; nor are suitable time series or other data readily available to allow estimation via econometric studies, as might be the case for some other commodities. Practitioners have therefore been forced to devise alternative methods for estimation. Survey methods have been employed to directly question respondents to ascertain how much they would be willing to give up to obtain the specified benefit. Indirect methods, notably the travel-cost method, are also often employed. These methods involve assessing all expenditure required to take part in an activity.

Both the direct and indirect methods appear theoretically sound, though they have been the subjects of some criticism in practice. However, these approaches would appear to be the best available at present.

Unfortunately lack of both relevant data and the opportunity to carry out any surveys prevented the authors from using those methods. Instead, a cruder approach has had to be used to obtain the required estimates. However, while it would be foolish to claim a high degree of precision in the resulting estimates, it is believed that they reliably indicate orders of magnitude.

To simplify proceedings it has been assumed that all relevant demand curves can be reasonably approximated by linear relationships - at least over the segment of interest. In practice the relevant demand functions are unlikely to be linear. However, as it is only the area under the curve which is of interest in this evaluation, the notion of using a straight line approximation should be less disturbing.

Given the unfortunate lack of data relevant to this study, the assumption of linearity in the two variable relationships has obvious advantages: only two points need be determined to fix the position of each line. In fact for each demand function one of these points has already been defined, i.e. the previously derived estimates of present and future levels of recreational activities at market prices (which is some cases are zero). These estimates are denoted Q_1 and Q_2 on the demand functions shown below.



The second point for each function is taken as that which corresponds to a price sufficiently high that very few, if any, individuals would undertake the activity; i.e. the area under the curve to the left of this point is supposed to be negligible. The possibility that a very few people may be willing to pay exceptionally high prices for some activities is accepted. The true curve may be highly inelastic close to the price axis. However, given the likely shape of the true demand curve - 2nd derivative positive - the apparent exclusion of the few exceptional cases should not be of concern.

This second point used to fix each line is denoted by the symbol M. Values of M used in calculating recreational benefits are shown in Table 25. Again, it should be emphasized that there is considerable lack of data relating to recreational behaviour and attitudes. This means that these estimates of M can be regarded only as informed judgements based on the collective experience of the authors and the assessment of various minor pieces of

TABLE 25. DOLLAR VALUES OF M ($/person-day)

Higher cost resort	25 + market price
Lower cost resort	15 + market price
Camping	4 + market price (fees)
Charter boats	15 + market price
Speed boats	7
Scenic flights	10 + market price
Yachts	10
Research station [(a)]	8 + market price

(a) Includes only the recreational component of use. Market prices are documented in Appendix F.

information gleaned from a variety of sources. It is considered however, that the values of M used are sufficiently reliable as indicators of orders of magnitude.

An overriding assumption in arriving at these values has been that the Capricornia Section does possess some unique features for recreation/tourism. In other words there is a scarcity of close substitutes, so that the demand curves are not highly elastic - hence consumers' surpluses do accrue. It should also be noted that the demand curves of interest here relate only to the activity in the area and not to the total holiday/recreation experience. For example, the cost or benefit of travel to the area is not of interest. Thus M could be regarded as indicating the approximate maximum fee that would be paid to enter the area.

The largest increment in the value of M applies in the case of resort visits. It is assumed that resort visitors would probably have greater capacity (and therefore willingness) to bear price increases. As well, it should be noted that there is considerable evidence that it is the relative (not absolute) price change which is most relevant to changes in consumption. This latter factor also helps to explain the somewhat lower values of M for the less costly activities.

In each case quantity demanded is expressed in person-days. Thus M refers to a price per day and the impact of increased costs would be greater for those groups staying for longer periods. This too is part of the rationalization for setting a low value for M in the case of camping. It has been assumed that camping fees would be levied under each strategy.

The assumption is made that the resources used in the commercial operations (resorts etc.) can be valued at their market price and that any economic rent accruing to the operators is negligible. Thus the net benefit of these activities in each year can be calculated as the area of the consumers' surplus triangle. As explained earlier, a similar calculation can be performed for the non-marketed recreational activities. Finally, by appropriately discounting benefits and summing, the present value of benefits for each activity in each strategy can be obtained. These values are summarized in Table 26.

It should be noted that the concept of economic rent is in some sense similar to consumers' surplus, except that it accrues to the 'owner' of the resource or producer. Current evidence suggests that the earlier assumption that this is negligible is reasonable. However, in the longer term, population growth and expanded promotion of and interest in the Reef might produce a strong monopoly position for the operators of the limited facilities in the area. In such a case some economic rent would accrue, to be earned by the operators or extracted through licence fees or otherwise by some government agency. No attempt has been made here to estimate the level of this possible future benefit.

The preceding analysis has involved the summation of benefits for all visitors, irrespective of their place of residence. In effect, the benefits calculated represent the recreational gains from a global point of view. Obviously the consumers' surplus accrues to the individual visitors. While there would seem little point in discriminating between local or Queensland residents and other Australians, there might be some argument for different

TABLE 26. PRESENT VALUES OF RECREATIONAL ACTIVITIES' BENEFITS[a] ($'000)

STRATEGY	3% DISCOUNT RATE			5% DISCOUNT RATE			7% DISCOUNT RATE		
	Fishing Industry	Tourism/ Recreation	Preserv-ation	Fishing Industry	Tourism/ Recreation	Preserv-ation	Fishing Industry	Tourism/ Recreation	Preserv-ation
ACTIVITY									
Higher cost resort	17,963	32,962	17,963	11,213	17,800	11,213	8,163	11,550	8,163
Lower cost resort	6,758	11,070	3,810	3,675	5,640	2,213	2,348	3,413	1,504
Camping	997	1,132	305	629	703	207	463	511	162
Charter boats	8,528	9,623	5,910	4,695	5,183	3,435	3,083	3,330	2,363
Speed boats	1,635	1,477	1,480	987	900	914	697	644	665
Scenic flights	419	419	516	220	220	270	138	138	167
Yachts	515	515	515	305	305	305	215	215	215
Research station (recreation)	1,280	1,280	1,456	803	803	898	588	588	648
TOTAL	38,095	58,478	31,955	22,527	31,554	19,455	15,695	20,389	13,887

(a) Net of resource costs directly attributable to the particular activity.

treatment in the case of foreign visitors. Particularly with respect to resort visits we could expect a high proportion of foreign visitors, and to the extent that this occurs the present values of benefits shown in Table 26 overstate the benefit to Australian citizens.

(ii) Commercial fishing benefits

(a) Demersal fishery

The commercial catch of demersal fishes from the Section currently accounts for approximately 13 per cent of the total Queensland demersal reef fish catch.* Demand for demersal fish is assumed to be somewhat inelastic and benefits in the form of consumers' surplus will accrue, depending upon a number of factors, including the availability of substitutes and the related matter of the relative size of the local industry. Unfortunately, there are few guides as to the parameters of the demand function.

Using a tactic similar to that described for measuring recreational benefits and assuming that the equivalent of M is market price (see Appendix F) plus $2 (per kg of whole fish), present value of net benefits in terms of consumers' surplus associated with the demersal fishery are:

STRATEGY	PRESENT VALUES OF COMMERCIAL DEMERSAL FISHERY BENEFITS ($'000)		
	@ 3%	@ 5%	@ 7%
Fishing Industry	5,132	3,215	1,826
Tourism/Recreation	3,299	2,257	1,497
Preservation	1,709	1,261	933

*Based on previously estimated catch from the Capricornia Section and Qld Fish Board records of total Queensland catch. It assumes that the level of black market trading in demersal fishes from the Section is representative of that applying to the whole Queensland catch.

(b) Scallop fishery

The catch of scallops from the Section currently accounts for between 10 and 20 per cent of the total Queensland scallop catch* but a much smaller percentage of the total Australian catch. Again, the shape of the demand curve is unknown although it is assumed that benefits in the form of consumers' surplus will accrue.

The annual scallop catch is uncertain and the forecasts contained in Appendix G should be regarded as maximum catches only. For this reason an annual average catch of 50% of the maximum catch has been used to calculate benefits under each strategy. Using a value of M equal to market price (see Appendix F) plus $2 (per kg of scallop meat) present values of net benefits associated with the scallop fishery are:

STRATEGY	PRESENT VALUES OF SCALLOP FISHERY BENEFITS ($'000)		
	@ 3%	@ 5%	@ 7%
Fishing Industry	1,130	707	401
Tourism/Recreation	872	547	310
Preservation	0	0	0

(c) Pelagic fishery

Mackerel, the principal pelagic fishes landed, are migratory and spend only about 3 months of each year in the Section (Fisheries Division et al 1977). The total supply of pelagic fishes would not therefore be significantly affected by the choice of strategy and

*Based on previously estimated catch from the Capricornia Section and Qld Fish Board records of total Queensland catch. It assumes that there is no significant black market trading in scallop meat.

the opportunity cost of any reduction in the catch from the area is assumed to be negligible.

(iii) Option value

Consideration has so far been given to benefits which accrue from obvious sources such as recreation and commercial fishing. Recent literature has drawn attention to an aspect of evaluation in connection with the natural environment which is perhaps not quite so obvious.

The aspect referred to has been termed option value. It can be taken to include the notions of irreversibility and authenticity, although some authors have treated irreversibility, authenticity and option value as 3 separate elements. However, this would appear to imply some double-counting of values since, as should be clear from the following discussion, option value derives from the other two factors.

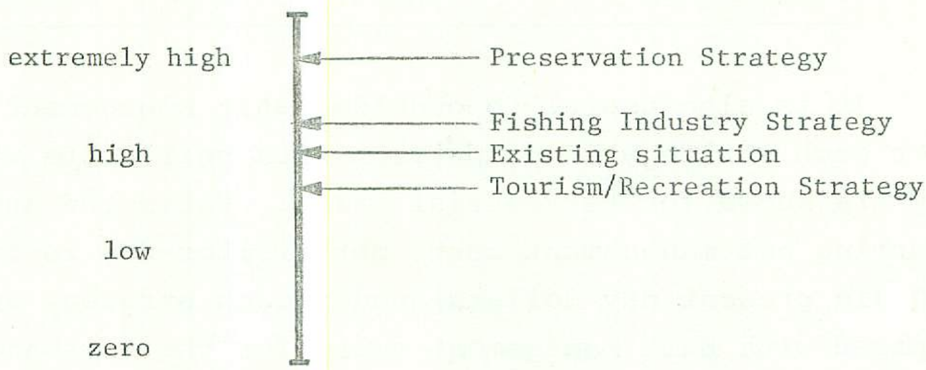
The basic proposition is that development tends to be irreversible - the natural environment may not be re-created - whereas the alternative of preservation leaves open the option to preserve or develop in the future when better information with respect to the decision becomes available. Following this line of reasoning, this option is said to have a value which should be taken account of in the evaluation.

Where it is believed that preservation benefits are rising faster than development benefits and the evaluation is taken over a limited period (say the life of the development project), the evaluation will be biased in favour of the development. In such a case it would make sense to add some value for the preservation alternative to compensate for this bias. Alternatively of course, one could just extend the period over which the evaluation is worked out.

Of greater concern is the situation where there is uncertainty about the effects of the alternatives being considered, but where there is a possibility that in the future a more precise assessment of these alternatives can be undertaken as a result of more relevant information becoming available. The strategy with least irreversible effects has additional value in that it provides the greatest opportunity to take advantage of any additional information.

While the rationale for the inclusion of option value is accepted, it has not been possible to measure this component in such a way as to be readily comparable with measures of other effects. Instead, only a qualitative assessment of option value has been made, based on a judgement of the physical impacts of the strategies and the quality of information used in the overall evaluation.

If the option value of the Capricornia Section at the present time is taken to be high, then option values under each strategy are judged to assume the following positions on a qualitative scale.



These option values have been assessed on both levels of development and degrees of uncertainty associated with each strategy.

(iv) Management costs

Details of management inputs and related costs under each strategy were documented as part of the definition of strategies and are summarized in Appendix G. Revenues generated by the imposition of camping fees (set at $4/person-day for the purpose of this evaluation) have been deducted from gross management costs, and the benefits stream from camping activities has been reduced accordingly. Assuming that the management task requires only marginal amounts of factors attracted from other uses, it is valid to calculate the resource cost as equal to the cost of providing the management. The resulting net management costs represent a charge against each strategy in total. Present values of the streams of net management costs are shown in Table 27.

TABLE 27. PRESENT VALUES OF MANAGEMENT COSTS ($'000)

STRATEGY	DISCOUNT RATE		
	3%	5%	7%
Fishing Industry	20,225	12,455	8,934
Tourism/Recreation	26,229	15,548	10,803
Preservation	18,887	11,516	8,184

It is also useful to consider unit management costs under each strategy in comparison with unit costs where they are known for terrestrial parks. Estimated annual recurring net management costs per visitor-day in the year 2000 (in present day dollars) under each strategy are compared with unit management costs for the Brisbane Forest Park and Warrumbungle National Park (N.S.W.) in Table 28.

It is evident that unit management costs are considerably higher than traditionally accepted costs for

TABLE 28. UNIT MANAGEMENT COSTS (1979 $'s)

	Year	Annual net recurring management cost ($)	Annual visitor-days	Cost per visitor-day ($)
Fishing Industry Strategy[a]	2000	780,000	195,000	4.00
Tourism/Recreation Strategy[a]	2000	1,063,000	315,000	3.37
Preservation Strategy[a]	2000	696,000	144,000	4.83
Brisbane Forest Park[b]	1980	400,000	1,000,000	0.51
Warrumbungle National Park[c]	1977-78	44,000	86,000	0.40

(a) See Appendix G.
(b) Source: Environment Science & Services (1979).
(c) Source: Ulph & Reynolds (1978).

terrestrial parks. Two points should be made in relation to these figures:

- firstly, to achieve a given level of management presence and effectiveness, costs will be higher in a marine situation because boats are considerably more expensive to operate than terrestrial vehicles; and

- secondly, if we take the view that management costs can be regarded as an insurance premium (i.e. a small but certain cost) to safeguard against possible major irreversible effects (i.e. a large but uncertain loss) then the high management costs can be considered as necessary to achieve the high option values which have been assigned to the strategies.

It should also be noted that reduction in management costs under the prescribed activity levels would generate additional environmental costs.

7.5 ECONOMIC IMPACTS

As explained earlier, in assessing net economic benefits it is necessary to subtract from the total benefit the (opportunity) cost of resources used in producing that benefit. Consequently, for example, in measuring recreational benefits, the employment of labour in the provision of resort services was treated as a cost. At first glance this might seem inappropriate in that the creation of employment might be regarded as a plus for society.

However, it is important to recognize that resource cost is defined as the value that the resource would have in an alternative use. Thus the implication of treating the use of labour as a cost is that it is assumed the labour could have been otherwise employed. In the light of existing levels of unemployment this might seem to be an inappropriate assumption. Certainly in the context of a particular region and/or a limited time period labour might be regarded as costless. But with a much broader and longer term perspective as is relevant in the context of this study, labour cannot be regarded as having no alternative use.

Therefore comparison of the impacts of the strategies on employment (or income or production) is not directly relevant to strategy evaluation. However, assessment of impacts is relevant to planning for the implementation of a strategy. Furthermore, political considerations and the attitudes of particular interest groups will be important in the final evaluation and in that respect impacts on sectors of the economy will need to be examined.

Estimates of the likely effects of each strategy on numbers employed have therefore been made. These estimates are based largely on interpretation of the results of an input-output study reported in Jensen (1979).

Estimates of employment created by the current levels of activity in the Capricornia Section are shown in Table 29. It was not possible to derive national estimates of numbers employed from the input-output study as only regional and Queensland data was analysed. In fact numbers employed within Australia would be expected to be slightly higher than for Queensland alone, though this would be unlikely to affect significantly the comparison of strategies.

TABLE 29. EMPLOYMENT (PERSONS) CREATED BY CURRENT ACTIVITY IN THE CAPRICORNIA SECTION
(Based on Jensen 1979.)

	WIDE-BAY, FITZROY REGION		QUEENSLAND	
	Direct & Indirect[(a)]	Direct, Indirect & Induced[(b)]	Direct & Indirect[(a)]	Direct, Indirect & Induced[(b)]
Commercial fishing	95	135	115	192
Research	10	14	11	17
Resort based activity	227	317	269	455
Other recreation	67	90	98	158
TOTAL	399	556	493	822

(a) Direct employment plus that in support industries. (b) Induced employment is not part of what is required to produce the relevant commodity, but is that created as a result of spending of incomes earned in production.

Estimates of regional and state (Queensland) employment generated by forecast activities as at the years 1990 and 2000 are shown in Tables 30 and 31. These estimates should be treated only as indicators of the relative magnitude of the employment impacts under the various strategies. Employment numbers for future years have been obtained by scaling up or down current figures using indexes of forecast growth in usage levels. There are several reasons why this could lead to imprecision in estimates. For example, this procedure implies that industry structure will remain unaltered over time and this is not likely to be valid.

The most striking conclusion evident in this data is that in general the tourism/recreation strategy generates substantially more employment than do the other strategies. The preservation strategy consistently is associated with the lowest levels of employment. It should be noted that these employment figures make no allowance for the once-off impacts arising from construction of resort facilities etc.

7.6 ENVIRONMENTAL ISSUES

An important component of the overall evaluation procedure is the documentation of environmental impacts generated under each strategy. Bearing in mind that available data for predicting levels of impacts and flow on effects is less than adequate, and that many of the environmental interactions themselves are not fully understood, it has been necessary to aggregate individual impacts and flow on effects into what can broadly be defined as environmental issues.

TABLE 30. EMPLOYMENT CREATED IN WIDE BAY, FITZROY STATISTICAL DIVISIONS UNDER ALTERNATIVE STRATEGIES
(Based on Jensen 1979.)

	DIRECT AND INDIRECT[a]			DIRECT, INDIRECT AND INDUCED[b]		
	Fishing Industry Strategy	Tourism/Recreation Strategy	Preservation Strategy	Fishing Industry Strategy	Tourism/Recreation Strategy	Preservation Strategy
As at year 1990						
Commercial fishing	95	66	23	135	94	32
Research	13	13	15	18	18	21
Marine Park management	29	36	26	39	49	35
Resort based activity	400	552	429	558	770	597
Other recreation	96	98	72	130	131	96
TOTAL	633	765	565	880	1,062	781
As at year 2000						
Commercial fishing	95	66	23	135	94	32
Research	13	13	15	18	18	21
Marine Park management	30	42	26	41	57	35
Resort based activity	552	1,226	429	770	1,712	599
Other recreation	135	173	90	181	202	121
TOTAL	825	1,520	583	1,145	2,083	808

(a) and (b) See footnote to Table 29.

TABLE 31. EMPLOYMENT CREATED IN QUEENSLAND UNDER ALTERNATIVE STRATEGIES
(Based on Jensen 1979.)

	DIRECT AND INDIRECT[a]			DIRECT, INDIRECT AND INDUCED[b]		
	Fishing Industry Strategy	Tourism/Recreation Strategy	Preservation Strategy	Fishing Industry Strategy	Tourism/Recreation Strategy	Preservation Strategy
As at year 1990						
Commercial fishing	115	79	28	192	132	46
Research	13	13	16	22	22	25
Marine Park management	29	36	26	48	59	43
Resort based activity	473	654	508	801	1,105	860
Other recreation	141	143	105	228	231	169
TOTAL	771	925	683	1,291	1,549	1,143
As at year 2000						
Commercial fishing	115	79	28	192	132	46
Research	13	13	16	22	22	25
Marine Park management	30	42	26	50	69	43
Resort based activity	654	1,453	508	1,105	2,457	860
Other recreation	197	220	131	318	355	212
TOTAL	1,009	1,807	709	1,687	3,035	1,186

(a) and (b) See footnote to Table 29.

Ten important environmental issues and their most likely catalysts within the Capricornia Section are identified in Table 32. Each issue encompasses a major area of public and/or scientific concern which may emerge from the impacts of human use on natural resources, ecological processes and amenity values in the Section. Although the issues are discussed individually in this section of the report, the point should be made that they are in fact highly interdependent. Construction and operation of an island resort, for example, may generate several environmental issues including marine pollution, physical damage to coral reefs, removal of island vegetation, noise pollution and degradation of aesthetic values. A single issue such as the removal of island vegetation may also be the catalyst for other issues such as cay instability and disruption of seabird populations.

In theory, the issues could generate a wide range of potential impacts ranging from complete destruction of the Reef system under conditions of gross over-exploitation to beneficial impacts arising from the elimination of many existing environmental stresses under conditions of complete preservation. In practice, however, the magnitude of potential impacts is constrained by the objectives contained in Section 32 of the Great Barrier Reef Marine Park Act 1975, which in effect place upper and lower bounds on the allowable magnitude of environment impacts. These bounds, defined by the requirements to ensure long term conservation of the Reef system and to allow 'reasonable use', are illustrated diagrammatically in Figure 7.

The end result is that all strategies which meet the requirements of the Act, and in particular the 3 strategies being evaluated here, will generate environ-

TABLE 32. ENVIRONMENTAL ISSUES AND CATALYSTS

	Environmental Issue	Catalysts
1.	Damage to seabed	Trawling; dredging.
2.	Impacts of resource extraction	Fishing; shell collecting; aquarium fish collecting; coral collecting; scalloping; scientific research.
3.	Physical damage to coral reefs	Reef walking; diving; boats running aground; anchors; coral collection; scientific research.
4.	Marine pollution	Liquid, solid and metabolic wastes from resorts, campers, boats and ships; oil spills; shipwrecks; run-off from mainland.
5.	Impact on turtle populations	Island development, visitors disrupting nesting; marine pollution; food scarcity; propeller damage.
6.	Impact on seabird populations	Habitat destruction; disruption by visitors; marine pollution; food scarcity; feral animals; exotic plants; aircraft.
7.	Impact on island vegetation	Clearing for construction; camping; trampling; fire; introduced plants.
8.	Cay instability	Removal of island vegetation; hydrological changes.
9.	Noise pollution	Resorts; camping areas; aircraft; helicopters; speed boats; hovercraft.
10.	Degradation of aesthetic values	Water pollution; litter; physical damage to coral; vegetation removal; scared fish; inappropriate design and construction of facilities.

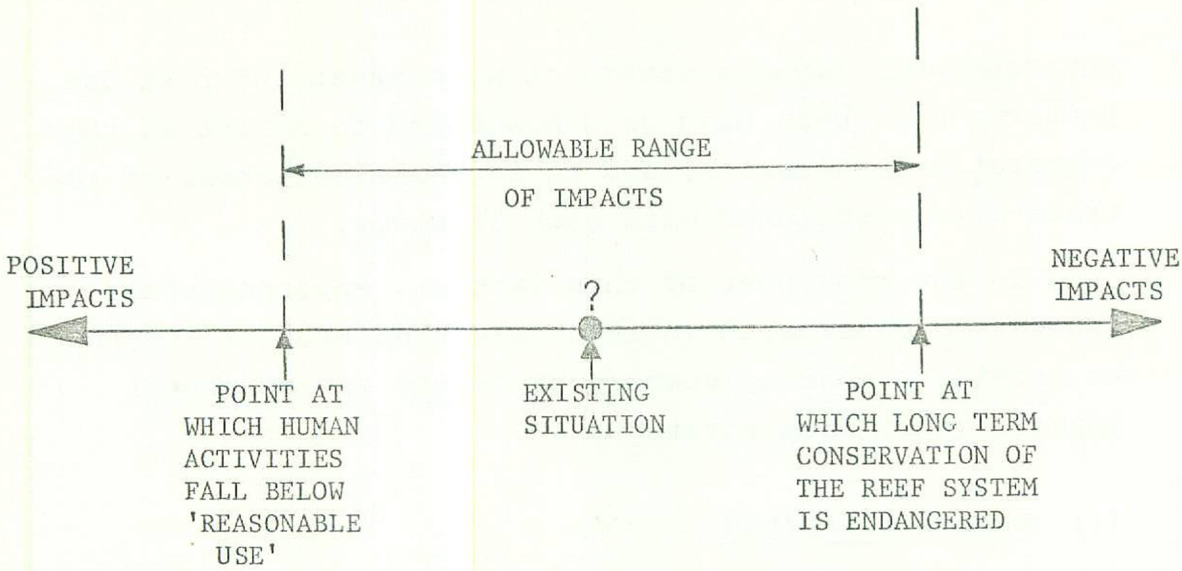


Fig.7. Constraints on Environmental Impacts

mental impacts which fall within that portion of the total impact spectrum illustrated in Fig.7. To some extent this makes the comparative evaluation of environmental impacts more difficult because strategies with extreme impacts are not considered.

The levels of some activities prescribed under the alternative strategies may be such that environmental control measures will be required to maintain the generated impacts below the point at which long term conservation of the Reef system is endangered. The only environmental costs documented in this section are those which remain after environmental controls (such as sewerage treatment plants, solid waste disposal systems etc.) have been instigated by the management agency or the commercial operators. The costs of the environmental control measures themselves are included elsewhere in the evaluation.

Wherever possible during this phase of the evaluation, impacts have been quantified, although in many cases this has not been possible due to deficiencies in the data base and/or insufficient understanding of the complex interactions and threshold effects. In some cases existing environmental impacts generated by current and past use patterns have been used as a benchmark to assist in the comparative evaluation, and to increase awareness of the trade-offs associated with each strategy.

In the remainder of this section, environmental issues are considered individually then brought together to provide a concise summary of likely environmental impacts under each strategy.

(i) Damage to seabed

The most likely sources of seabed damage are trawling and dredging - activities which cause major and often widespread impacts. Benthic communities are disturbed or killed, non-target organisms are removed and/or killed, turbidity is increased and siltation of coral reefs is possible.

(a) Trawling

Seabed areas which would be protected from scallop trawling activities under each strategy are shown below.

	PERCENTAGE OF SEABED PROTECTED
Existing	0.5%
Fishing Industry Strategy	25%
Tourism/Recreation Strategy	60%
Preservation Strategy	100%

These figures do not, however, provide a true indication of scallop trawling impact because considerable areas of non-protected areas are unsuitable for scallop trawling. A more accurate indication of scallop trawling impact is given below by the estimates of seabed areas which are likely to be trawled and the annual catch in each case.

	PERCENTAGE OF SEA BED BEING TRAWLED FOR SCALLOPS	ESTIMATED ANNUAL CATCH (KG OF SCALLOP MEAT)
Existing	35%	100,000
Fishing Industry Strategy	40%	100,000
Tourism/Recreation Strategy	30%	75,000
Preservation Strategy	0%	0

No allowances have been made for changes in impacts which may result from development of new trawling gear.

Trawling for scientific purposes is regarded as manipulative scientific research and would be strictly controlled under each strategy to avoid severe impacts. No other types of trawling would be permitted under any of the strategies.

(b) Dredging

Shell dredging is currently carried out around some reefs and in lagoons. Although the extent of these operations is unknown, they are believed to generate local but intensive impacts on other benthic communities and adjacent coral reefs.

Shell dredging would not be permitted under the Tourism/Recreation or Preservation Strategies. Under the Fishing Industry Strategy, it is anticipated that limited shell dredging would be permitted on a licence basis which specified locations and conditions aimed at minimizing deleterious impacts.

From time to time, and particularly after severe storms, Heron Island harbour is dredged. Past impacts have been severe but localized (Great Barrier Reef Committee, n.d.). The frequency, extent and impact of future dredging activities are assumed to be the same under each strategy.

(ii) Impacts of resource extraction

The most important resource extracting activities in the Section will be line fishing, scalloping, spear-fishing, shell collecting, aquarium fish collecting, coral collecting and scientific research.

(a) Line fishing

Estimates of annual line fishing catches at the present time and under each of the strategies are shown below.

	COMMERCIAL FISHING (KG/YR)[a]		AMATEUR FISHING (KG/YR)
	Demersal	Pelagic	
Existing	225,000	100,000	x
Fishing Industry Strategy	225,000	100,000	x
Tourism/Recreation Strategy	120,000	100,000	$2x$
Preservation Strategy	50,000	50,000	$0.5x$

(a) Catch measured in kg of whole fish equivalent.

It has previously been assumed that the existing fishing catch is a reasonable approximation to the optimum sustainable yield from the Section. Thus both the Fishing Industry and Tourism/Recreation Strategies will maintain future catches in the vicinity of the optimum sustainable yield while the Preservation Strategy will maintain future catches well below this figure.

Long term conservation of fishing stocks should therefore be assured under each strategy. Over-fishing of the most accessible reefs and shoals already is, and will continue to be, an issue from time to time even though the provision of replenishment zones should maintain fish populations in these areas over the long term.

(b) Scalloping

Estimated scallop catches from the Section are:

	ANNUAL SCALLOP CATCH (kg of scallop meat)
Existing	100,000
Fishing Industry Strategy	100,000
Tourism/Recreation Strategy	75,000
Preservation Strategy	0

Catches vary considerably from year to year as scallops migrate, and the above figures are best interpreted as maximum annual catches not necessarily repeated each season. On the basis of available information, permitted levels of scallop extraction are not expected to endanger long term stocks of scallops. It should be noted, however, that scallops in the Capricornia Section are just a small part of a larger scallop fishery, and it is possible that over-exploitation of scallop beds outside the Section may deplete the entire resource.

(c) Spearfishing

Spearfishing is known to selectively deplete fishing stocks by removing larger individuals and to change behaviour patterns of both target and non-target species. At the present time it occurs intermittently on most of the reefs outside the Heron-Wistari Reefs Marine Park although documented evidence of impacts has not been collected. Spearfishing activities which would be permitted under each of the strategies are:

STRATEGY	PERMITTED SPEARFISHING ACTIVITIES
Fishing Industry	Sustenance fishing by campers on Tryon, North West and Masthead Islands.
Tourism/Recreation	Sustenance fishing by campers on Tryon, North West and Masthead Islands.
Preservation	Nil

It must be accepted that spearfishing will have some effect on local demersal fish populations, although the importance of these impacts is unknown.

(d) Shell collecting, aquarium fish collecting and coral collecting

Collection of shells, aquarium fishes and coral is undertaken by both amateurs (individuals and clubs) and professionals. Opportunities for collection under each of the strategies are shown below.

STRATEGY	TYPE OF COLLECTION PERMITTED		APPROX. NO. OF COLLECTION AREAS
	Amateur	Professional	
Fishing Industry	Yes	Yes	10
Tourism/Recreation	Yes	No	5
Preservation	No	No	0

It is envisaged that all professional and amateur collectors would be strictly controlled by licence or permit.

Local stocks of shells and aquarium fishes are likely to be severely depleted in collection areas. The numbers of collection areas are therefore a reasonable indication of relative impacts under the 3 strategies.

(e) Scientific research

All resource extraction under the guise of scientific research would require a permit and be controlled to ensure that impacts were minimal. It is assumed that similar impacts would be generated under each strategy.

(iii) Physical damage to coral reefs

The most likely sources of physical damage are reef walkers, divers, boating activities, scientific research and shipwrecks.

(a) Reef walkers and divers

Estimated gross visitor-days and areas of reefs and shoals available for reef walking and snorkelling are shown below.

	TOTAL VISITOR-DAYS	AREA OF REEF AND SHOALS AVAILABLE FOR WALKING AND SNORKELLING (ha)
Existing	84,000	22,000
Fishing Industry Strategy	195,000[(a)]	19,000
Tourism/Recreation Strategy	315,000[(a)]	20,000
Preservation Strategy	143,000[(a)]	15,000

(a) Year 2000

Considerable additional shoal and inter-reef areas would be available for scuba diving under each strategy.

Increases in use to the year 2000 tend to be concentrated on resort islands rather than being distributed uniformly over the Section. The impacts of high density use are not easily predicted, and in fact may be less than first expected since:

- high density use would be accompanied by high management inputs, and
- Heron Island Reef currently supports 41,000 visitor-days use without major evidence of physical damage to the coral under current use patterns.

Although physical damage to coral reefs would be greatest under the Tourism/Recreation Strategy and least under the Preservation Strategy, relative levels of impact should be less than proportional to increases in forecast visitor use levels.

(b) Boating activities

Estimated total boat-days in the Section are shown below. They include contributions from charter boats, speed boats, fishing boats, surveillance craft and yachts.

	ESTIMATED TOTAL BOAT-DAYS
Existing	10,000
Fishing Industry Strategy	17,000 [(a)]
Tourism/Recreation Strategy	17,500 [(a)]
Preservation Strategy	11,000 [(a)]

(a) Year 2000

Boats may be responsible for coral damage by either running aground or anchoring. The measure of total boat-days is probably a reasonable reflection of relative damage which would be generated by boats running aground. Anchor damage should be avoided to a large extent by the provision of mooring buoys at popular anchorages and policing their use. This should ensure that anchor damage becomes a relatively minor impact under each strategy.

(c) Scientific research

Scientific research activities may involve destructive testing of coral, securing pegs/markers, selective removal of species, use of explosives etc. in addition to damage caused by associated diving, boating and reef walking activities. Since all manipulative research would be strictly controlled and supervised under each strategy, the impacts are not expected to be significant.

(d) Shipwrecks

Although the probability of a shipwreck is small, the potential impact is great. Shipping tonnage through the Port of Gladstone is expected to double by the year 2000 with a substantial increase in average ship size. The probability of a shipwreck should decrease slightly if vessels can be kept within the recommended shipping routes. The probability of a shipwreck should not be affected materially by the choice of strategy.

(iv) Marine pollution

Marine pollutants are subdivided into those generated on islands and those generated on boats and ships.

(a) Pollutants from islands

Principal pollutants generated on the islands include:

. solid wastes (organic and inorganic);
. human metabolic wastes;
. saline discharge from desalination plants; and
. sullage

from resorts and camping areas. Since the quantities of wastes are approximately proportional to levels of island use, the estimates of island use shown below can be used to compare relative levels of waste generation under each strategy. The estimates of island use include campers, visitors and staff at research stations, and visitors and staff at resorts.

	ANNUAL LEVEL OF ISLAND USE (person-days)
Existing	87,000
Fishing Industry Strategy	155,000 [a]
Tourism/Recreation Strategy	305,000 [a]
Preservation Strategy	120,000 [a]

(a) Year 2000

The quantities of wastes generated are not, however, a true reflection of marine pollution nor the resultant impact generated under each strategy. If the Capricornia Section were to remain in its present, almost unmanaged state, then increasing levels of island use would almost certainly increase marine pollution and produce environmental costs in excess of those permitted under the Marine Park Act.

Under each of the strategies, management input has therefore been increased to maintain environmental costs within 'acceptable' limits. These increased management inputs include:

- package treatment plants for resort sewage and sullage;
- septic toilets on camping islands;
- collection, compaction and removal of solid waste from resorts and camping areas for subsequent disposal at sea or on the mainland.

Levels of marine pollution from islands would be highest under the Tourism/Recreation Strategy and lowest under the Preservation Strategy, although the differences between strategies would be much less than suggested by the island use levels.

(b) Pollutants from boats and ships

Principal pollutants generated on board boats and ships include:

- . solid wastes (organic and inorganic);
- . human metabolic wastes;
- . sullage;
- . oil and fuel spills; and
- . discharged ballast.

Even under conditions of high boat usage generated by the Tourism/Recreation Strategy, pollutants from charter boats, speed boats, yachts etc. are not expected to produce significant impacts in open waters. Where high concentrations of boats occur in the lee of islands and in lagoons, local marine pollution could be evident. Incidences of marine pollution from ships passing through the Section may occur from time to time with the same probability of occurrence under each Strategy.

(v) Impact on turtle populations

The principal sources of deleterious impacts to turtle populations are:

- . lights around resorts and navigation lights which disorientate hatchlings;
- . the construction of rock walls and breakwaters, erosion and the alienation of dunes - all of which result in the reduction of space available for nesting; and,
- . introduced predators such as rats.

The Capricornia Section is currently of world significance as a breeding ground for Green Turtles and of Pacific Region significance as a breeding ground for Loggerhead Turtles. The existing distribution of turtle breeding populations on islands in the Section has previously been outlined in Table 3 and is taken to represent a form of equilibrium under existing use patterns and levels of environmental stress.

The impacts of the strategies on the existing known distribution of nesting populations are shown in Tables 33, 34 and 35. These tables identify individual colonies which would be destroyed, degraded, unchanged or better protected under each strategy. The most significant impacts generated under each strategy are outlined below.

<u>Fishing Industry Strategy</u>

. protection of Wreck Island - the most important breeding site for Loggerhead Turtles;

. no deterioration of North West Island - the most important breeding site for Green Turtles - as a nesting site;

. improved protection for turtles nesting on Tryon and Masthead Islands;

. degradation of Lady Musgrave and Lady Elliott Islands as turtle nesting sites.

<u>Tourism/Recreation Strategy</u>

. protection of Wreck Island - the most important breeding site for Loggerhead Turtles;

. improved protection for turtles nesting on Masthead and Tryon Islands;

TABLE 33. IMPACT ON TURTLE NESTING POPULATIONS UNDER THE FISHING INDUSTRY STRATEGY (Based on Table 3 page 23.)

ISLAND/CAY	SIGNIFICANCE OF NESTING POPULATION	
	Loggerhead Turtles	Green Turtles
North Reef	Minor	Minor
Tryon	Principal	Secondary
North West	Minor	Principal
Wilson	Minor	Secondary
Wreck	Principal	Principal
Heron	Minor	Secondary
Erskine	Secondary	Secondary
One Tree	Very minor	Very minor
Masthead	Secondary	Secondary
Hoskyn	Minor	Principal
Fairfax	Very minor	Secondary
Lady Musgrave	~~Secondary~~	~~Secondary~~
Lady Elliott	~~Minor~~	~~Minor~~
Broomfield Reef	-	Very minor

Legend: Minor = Improved protection

Minor = Unaffected

~~Minor~~ = Degraded

~~Minor~~ = Destroyed

TABLE 34. IMPACT ON TURTLE NESTING POPULATIONS UNDER THE TOURISM/RECREATION STRATEGY
(Based on Table 3 page 23.)

ISLAND/CAY	SIGNIFICANCE OF NESTING POPULATION	
	Loggerhead Turtles	Green Turtles
North Reef	Minor	Minor
Tryon	Principal	Secondary
North West	Minor	Principal
Wilson	Minor	Secondary
Wreck	Principal	Principal
Heron	Minor	Secondary
Erskine	Secondary	Secondary
One Tree	Very minor	Very minor
Masthead	Secondary	Secondary
Hoskyn	Minor	Principal
Fairfax	Very minor	Secondary
Lady Musgrave	Secondary	Secondary
Lady Elliott	Minor	Minor
Broomfield Reef	-	Very minor

Legend: Minor = Improved protection
Minor = Unaffected
Minor = Degraded
Minor = Destroyed

TABLE 35. IMPACT ON TURTLE NESTING POPULATIONS UNDER THE PRESERVATION STRATEGY
(Based on Table 3 page 23.)

ISLAND/CAY	SIGNIFICANCE OF NESTING POPULATION	
	Loggerhead Turtles	Green Turtles
North Reef	Minor	Minor
Tryon	$\underline{\text{Principal}}$	$\underline{\text{Secondary}}$
North West	$\underline{\text{Minor}}$	$\underline{\text{Principal}}$
Wilson	$\underline{\text{Minor}}$	$\underline{\text{Secondary}}$
Wreck	Principal	Principal
Heron	Minor	Secondary
Erskine	Secondary	Secondary
One Tree	Very minor	Very minor
Masthead	$\underline{\text{Secondary}}$	$\underline{\text{Secondary}}$
Hoskyn	Minor	Principal
Fairfax	Very minor	Secondary
Lady Musgrave	Secondary	Secondary
Lady Elliott	$\boxed{\cancel{\text{Minor}}}$	$\boxed{\cancel{\text{Minor}}}$
Broomfield Reef	-	Very minor

Legend:

$\underline{\text{Minor}}$ = Improved protection

Minor = Unaffected

$\boxed{\cancel{\text{Minor}}}$ = Degraded

$\boxed{\xcancel{\text{Minor}}}$ = Destroyed

- degradation of Lady Musgrave, Wilson and North West (the most important breeding site for Green Turtles) Islands as turtle nesting sites;
- no turtles nesting on Lady Elliott Island.

Preservation Strategy

- protection of Wreck Island - the most important breeding site for Loggerhead Turtles;
- protection of North West Island - the most important breeding site for Green Turtles;
- improved protection for all turtles nesting on Tryon, North West, Wilson and Masthead Islands;
- degradation of Lady Elliott Island as a turtle nesting site.

(vi) Impact on seabird populations

The existing distribution of seabird breeding colonies under present use patterns and levels of environmental stress has previously been described in Table 4. As a first step in identifying future impacts under each of the strategies, the vulnerability of nesting birds to likely disturbances is discussed below.

(a) Burrowing birds

The Wedge-tailed Shearwaters nest in burrows. Breeding colonies do not appear to have been adversely affected by development on Heron Island and the species seems to be relatively resilient to island development and the presence of people during the bird breeding season.

(b) Surface-nesting birds

Surface-nesting species which nest in the Section are:

Crested Tern
Roseate Tern
Brown Booby
Black-naped Tern
Bridled Tern
Silver Gull
Little Tern,
Lesser Crested Tern, and
Common Noddy.

All surface-nesters are vulnerable to disturbance by humans with those that nest on beach fronts (e.g. Roseate Tern and Black-naped Tern) being highly sensitive. Evidence is available which shows that surface-nesters have been displaced from Heron Island as human use has increased (G.B.R. Committee, n.d.).

(c) Tree-nesting birds

Tree-nesting species which nest in the Section are the White-capped Noddy and the Reef Heron. White-capped Noddies are reasonably insensitive to disturbance by humans as evidenced by the large breeding colony on Heron Island. Reef Herons tend to be more shy than White-capped Noddies and thus more vulnerable to disturbance by humans. They are, however, less sensitive to human disturbance than the surface-nesters.

Burrowing, surface-nesting and tree-nesting birds are all affected by the loss of habitat (nesting space).

The impacts of the strategies on the existing distribution of nesting colonies are shown in Tables 36, 37 and 38. These tables identify individual colonies which would be destroyed, degraded, unchanged or better protected under each strategy.

The most significant impacts generated under each strategy are outlined below.

Fishing Industry Strategy

. improved protection of breeding colonies on Masthead and Tryon Islands;

. major degradation of breeding colonies on Lady Elliott Island;

. destruction of 1 small colony and degradation of 1 major and 2 small colonies of Crested Terns out of a total of 23 known breeding colonies off the Queensland east coast.

Tourism/Recreation Strategy

. improved protection of breeding colonies on Tryon Island;

. major degradation of breeding colonies on North West, Wilson and Lady Elliott Islands;

. destruction of 1 major colony and degradation of 1 small colony of Roseate Terns out of a total of 11 known breeding colonies off the Queensland east coast;

. destruction of 1 major colony and 2 small colonies of Crested Terns out of a total of 23 known breeding colonies off the Queensland east coast;

TABLE 36. IMPACT ON SEABIRD COLONIES UNDER THE FISHING INDUSTRY STRATEGY
(Based on Table 4 page 26.)

Legend: $\underline{\text{Colony}}$ = Improved protection Colony = Unaffected $\boxed{\cancel{\text{Colony}}}$ = Degraded $\boxed{\xcancel{\text{Colony}}}$ = Destroyed

ISLAND	RANKING (a)	NESTING SEABIRD COLONIES (b)											
		WEDGE-TAILED SHEARWATER	BROWN BOOBY	REEF HERON	SILVER GULL	BRIDLED TERN	ROSEATE TERN	BLACK-NAPED TERN	CRESTED TERN	LITTLE TERN	LESSER CRESTED TERN	COMMON NODDY	WHITE-CAPPED NODDY
Masthead Island	3rd	major	-	$\underline{\text{colony}}$	$\underline{\text{major}}$	$\underline{\text{colony}}$	$\underline{\text{colony}}$	$\underline{\text{colony}}$	$\underline{\text{major}}$	-	$\underline{\text{colony}}$	-	principal
North West Island	5th	principal	-	colony	$\boxed{\cancel{\text{colony}}}$	$\boxed{\cancel{\text{colony}}}$	-	-	$\boxed{\cancel{\text{major}}}$	-	-	-	$\boxed{\cancel{\text{principal}}}$
One Tree Island	6th	-	-	colony	colony (c)	major	colony	major	principal	-	colony	-	colony
Wilson Island	8th	colony	-	major	$\boxed{\cancel{\text{colony}}}$	-	$\boxed{\cancel{\text{major}}}$	$\boxed{\cancel{\text{major}}}$	$\boxed{\cancel{\text{colony}}}$	-	-	-	-
Lady Musgrave Island	10th	major	-	colony	major	$\boxed{\cancel{\text{major}}}$	$\boxed{\cancel{\text{colony}}}$	$\boxed{\cancel{\text{colony}}}$	$\boxed{\cancel{\text{colony}}}$	-	-	-	major
Fairfax Islands	11th	major	principal	colony	major	-	colony	colony	colony	colony	colony	-	colony
Hoskyn Islands	12th	major	major	-	-	major	-	-	-	-	-	-	colony
Tryon Island	13th	major	-	colony	$\underline{\text{colony}}$	$\underline{\text{major}}$	$\underline{\text{colony}}$	$\underline{\text{colony}}$	-	-	-	-	colony
Heron Island	14th	major	-	colony	-	-	-	-	-	-	-	-	principal
North Reef Island	Unranked	-	-	colony	-	-	-	-	-	-	-	-	-
Wreck Island	Unranked	colony	-	colony	colony	major	-	colony	-	-	-	-	-
Erskine Island	Unranked	colony	-	-	-	-	-	-	-	-	-	-	-
Lady Elliott Island	Unranked	$\boxed{\cancel{\text{colony}}}$	-	$\boxed{\cancel{\text{colony}}}$	-	$\boxed{\xcancel{\text{colony}}}$	-	-	$\boxed{\xcancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$	-	$\boxed{\xcancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$

(a) Ranking of importance as seabird nesting islands in Queensland.
(c) No nesting records recently.

(b) principal - a principal colony in Queensland;
major - a major colony in Queensland;
colony - a viable breeding colony.

TABLE 37. IMPACT ON SEABIRD COLONIES UNDER THE TOURISM/RECREATION STRATEGY
(Based on Table 4 page 26.)

Legend: $\underline{\text{Colony}}$ = Improved protection   Colony = Unaffected $\boxed{\cancel{\text{Colony}}}$ = Degraded $\boxed{\xcancel{\text{Colony}}}$ = Destroyed

ISLAND	RANKING (a)	NESTING SEABIRD COLONIES[b]											
		WEDGE-TAILED SHEARWATER	BROWN BOOBY	REEF HERON	SILVER GULL	BRIDLED TERN	ROSEATE TERN	BLACK-NAPED TERN	CRESTED TERN	LITTLE TERN	LESSER CRESTED TERN	COMMON NODDY	WHITE-CAPPED NODDY
Masthead Island	3rd	major	-	colony	major	colony	colony	colony	major	-	colony	-	principal
North West Island	5th	$\boxed{\cancel{\text{principal}}}$	-	$\boxed{\cancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$	-	-	$\boxed{\xcancel{\text{major}}}$	-	-	-	$\boxed{\cancel{\text{principal}}}$
One Tree Island	6th	-	-	colony	colony (c)	major	colony	major	principal	-	colony	-	colony
Wilson Island	8th	$\boxed{\cancel{\text{colony}}}$	-	$\boxed{\cancel{\text{major}}}$	$\boxed{\xcancel{\text{colony}}}$	-	$\boxed{\xcancel{\text{major}}}$	$\boxed{\xcancel{\text{major}}}$	$\boxed{\xcancel{\text{colony}}}$	-	-	-	-
Lady Musgrave Island	10th	major	-	colony	major	$\boxed{\cancel{\text{major}}}$	$\boxed{\cancel{\text{colony}}}$	$\boxed{\cancel{\text{colony}}}$	$\boxed{\cancel{\text{colony}}}$	-	-	-	major
Fairfax Islands	11th	major	principal	colony	major	-	colony	colony	colony	colony	colony	-	colony
Hoskyn Islands	12th	major	major	-	-	major	-	-	-	-	-	-	colony
Tryon Island	13th	major	-	colony	$\underline{\text{colony}}$	$\underline{\text{major}}$	$\underline{\text{colony}}$	$\underline{\text{colony}}$	-	-	-	-	colony
Heron Island	14th	major	-	colony	-	-	-	-	-	-	-	-	principal
North Reef Island	Unranked	-	-	colony	-	-	-	-	-	-	-	-	-
Wreck Island	Unranked	colony	-	colony	colony	major	-	colony	-	-	-	-	-
Erskine Island	Unranked	$\boxed{\cancel{\text{colony}}}$	-	-	-	-	-	-	-	-	-	-	-
Lady Elliott Island	Unranked	$\boxed{\cancel{\text{colony}}}$	-	$\boxed{\xcancel{\text{colony}}}$	-	$\boxed{\xcancel{\text{colony}}}$	-	-	$\boxed{\xcancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$	-	$\boxed{\cancel{\text{colony}}}$	$\boxed{\xcancel{\text{colony}}}$

(a) Ranking of importance as seabird nesting islands in Queensland.
(c) No nesting records recently.
(b) principal - a principal colony in Queensland;
major - a major colony in Queensland;
colony - a viable breeding colony.

TABLE 38. IMPACT ON SEABIRD COLONIES UNDER THE PRESERVATION STRATEGY
(Based on Table 4 page 26.)

Legend: <u>Colony</u> = Improved protection   Colony = Unaffected   ~~Colony~~ = Degraded   ~~Colony~~ = Destroyed

ISLAND	RANKING (a)	NESTING SEABIRD COLONIES (b)											
		WEDGE-TAILED SHEARWATER	BROWN BOOBY	REEF HERON	SILVER GULL	BRIDLED TERN	ROSEATE TERN	BLACK-NAPED TERN	CRESTED TERN	LITTLE TERN	LESSER CRESTED TERN	COMMON NODDY	WHITE-CAPPED NODDY
Masthead Island	3rd	<u>major</u>	-	<u>colony</u>	<u>major</u>	<u>colony</u>	<u>colony</u>	<u>colony</u>	<u>major</u>	-	<u>colony</u>	-	<u>principal</u>
North West Island	5th	<u>principal</u>	-	<u>colony</u>	<u>colony</u>	<u>colony</u>	-	-	<u>major</u>	-	-	-	<u>principal</u>
One Tree Island	6th	-	-	colony	colony (c)	major	colony	major	principal	-	colony	-	colony
Wilson Island	8th	<u>colony</u>	-	<u>major</u>	<u>colony</u>	-	<u>major</u>	<u>major</u>	<u>colony</u>	-	-	-	-
Lady Musgrave Island	10th	major	-	colony	major	major	colony	colony	colony	-	-	-	major
Fairfax Islands	11th	major	principal	colony	major	-	colony	colony	colony	colony	colony	-	colony
Hoskyn Islands	12th	major	major	-	-	major	-	-	-	-	-	-	colony
Tryon Island	13th	<u>major</u>	-	<u>colony</u>	<u>colony</u>	<u>major</u>	<u>colony</u>	<u>colony</u>	-	-	-	-	<u>colony</u>
Heron Island	14th	major	-	colony	-	-	-	-	-	-	-	-	principal
North Reef Island	Unranked	-	-	colony	-	-	-	-	-	-	-	-	-
Wreck Island	Unranked	colony	-	colony	colony	major	-	colony	-	-	-	-	-
Erskine Island	Unranked	~~colony~~	-	-	-	-	-	-	-	-	-	-	-
Lady Elliott Island	Unranked	colony	-	colony	-	~~colony~~	-	-	~~colony~~	~~colony~~	-	~~colony~~	colony

(a) Ranking of importance as seabird nesting islands in Queensland.
(c) No nesting records recently.
(b) principal - a principal colony in Queensland;
major - a major colony in Queensland;
colony - a viable breeding colony.

. destruction of 1 major colony and degradation of 1 small colony of Black-naped Terns out of a total of 28 known breeding colonies off the Queensland east coast.

Preservation Strategy

. improved protection of breeding colonies on Masthead, North West, Wilson and Tryon Islands;

. no colonies destroyed.

(vii) Impact on island vegetation

Damage to island vegetation results from:

. removal for construction or access purposes, and

. disturbance or destruction by visitors.

Levels of vegetation degradation under each strategy are contained in Table 39. Where vegetation is removed or disturbed, it may have important consequences in terms of cay stability, loss of bird and animal habitat, and degradation of aesthetic values.

TABLE 39. IMPACT ON ISLAND VEGETATION

	PERCENTAGE OF TOTAL VEGETATION COVER		
	Permanently removed by construction	Subject to disturbance by visitors	Total area degraded
Existing	15%	13%	28%
Fishing Industry Strategy	18%	12%	30%
Tourism/Recreation Strategy	22%	20%	42%
Preservation Strategy	15%	6%	21%

(viii) Induced Cay instability

Evidence of erosion on Green Island and to a lesser extent on Heron Island has demonstrated that cays are particularly sensitive to hydrological changes. Under each strategy, restrictions have been placed on removal of shoreline vegetation and construction of any facilities that would alter hydrological regimes. It is therefore assumed that the only induced cay instability under each strategy would be the existing erosion problems on Heron Island.

(ix) Noise pollution

Noise in the Section is primarily associated with:

- transport (e.g. helicopters, light aircraft, speed boats), and
- resort operation (e.g. plant noise, entertainment).

Although noise levels under each of the strategies would be low by urban standards and even by most mainland resort standards, they may become intrusive in this environment where ambient noise levels are very low and people's expectation of solitude is high.

Noise is roughly correlated with levels of use and would be highest under the Tourism/Recreation Strategy and lowest under the Preservation Strategy. Individual perception of noise - noise pollution - is more difficult to predict since visitors under the Preservation Strategy may have a lower tolerance to noise than those under the Tourism/Recreation Strategy. Overall noise pollution should not be a major issue under any of the strategies, although local disturbance may occur where regular transport services pass close to camping islands.

Bird colonies may also be disturbed by helicopter, aircraft or hovercraft services. Although the burrowing and tree-nesting species on Heron Island appear to tolerate the regular helicopter services, it is possible that the more sensitive surface-nesting species are more susceptible to disturbance by noise.

(x) Degradation of aesthetic values

Under current levels of use and current levels of management, some degradation of aesthetic values is evident where:

- resort and research station development has been allowed to proceed without proper regard to the island environment;
- coral damage is caused by anchors and divers at popular diving spots;
- high levels of camping have generated litter and damaged vegetation;
- fishes have been frightened by spearfishing; and
- litter has been dumped in reef areas by people in boats.

Under the Fishing Industry and Tourism/Recreation Strategies, levels of use would increase substantially but at the same time:

- conditions would be placed on resort and camp ground developments to ensure that design and construction was undertaken sympathetically;
- popular diving locations would have buoyed moorings;
- waste collection services would be provided;

- education of visitors would be given a high priority;
- regulations aimed at preserving aesthetic values would be invoked; and
- levels of surveillance would increase.

It is therefore anticipated that aesthetic values would be at least comparable to those under the present, almost unmanaged, system. Areas where some aesthetic degradation might be visible would be restricted to:

- reefs off camping islands (due to spearfishing and littering); and
- resort islands where heavy use was concentrated in small areas.

Under the Preservation Strategy, use levels would be lowered and management input increased so that aesthetic values should, in fact, be improved.

(xi) Summary of environmental impacts

To assist in the comparative evaluation of environmental impacts under each strategy, impacts associated with each environmental issue are summarized in Figure 8. Levels of impact used to rank the issues are:

Negligible	-	undetectable or insignificant;
Visible	-	detectable to the trained observer but not of major concern;
Obvious	-	detectable by any observer and cause for concern;
Catastrophic	-	grounds for major concern - natural resources, ecological processes or amenity values destroyed.

Two factors are involved in bringing about a change of impact compared to the existing situation. The first is a change in levels of use under each strategy which tends to increase negative impacts as use increases and decrease them as use decreases. The second is a substantial increase in the management input under each strategy. This has the effect of making negative impacts increase less quickly than corresponding levels of use and has been employed under the Fishing Industry and Tourism/ Recreation Strategies to maintain the magnitude of impacts within 'acceptable' levels.

(xii) <u>Environmental impacts as costs and benefits</u>

So far environmental issues have been discussed in terms of impacts which have been rated along a scale from negligible to catastrophic. To complete the discussion on environmental issues, it is necessary to assess the effects in cost-benefit terms and in a form which is compatible with the rest of the evaluation methodology.

The values (either positive or negative) which accrue from environmental impacts can manifest themselves in the following 3 ways:

. as part of the recreational benefits previously calculated;
. as part of the option value arising from the degree of irreversibility and uncertainty associated with each strategy; and
. as a benefit which accrues to non-users who would be willing to pay something to protect the 'naturalness' of the Section.

The first 2 components have already been included in the calculation of net benefits and clearly, to avoid double

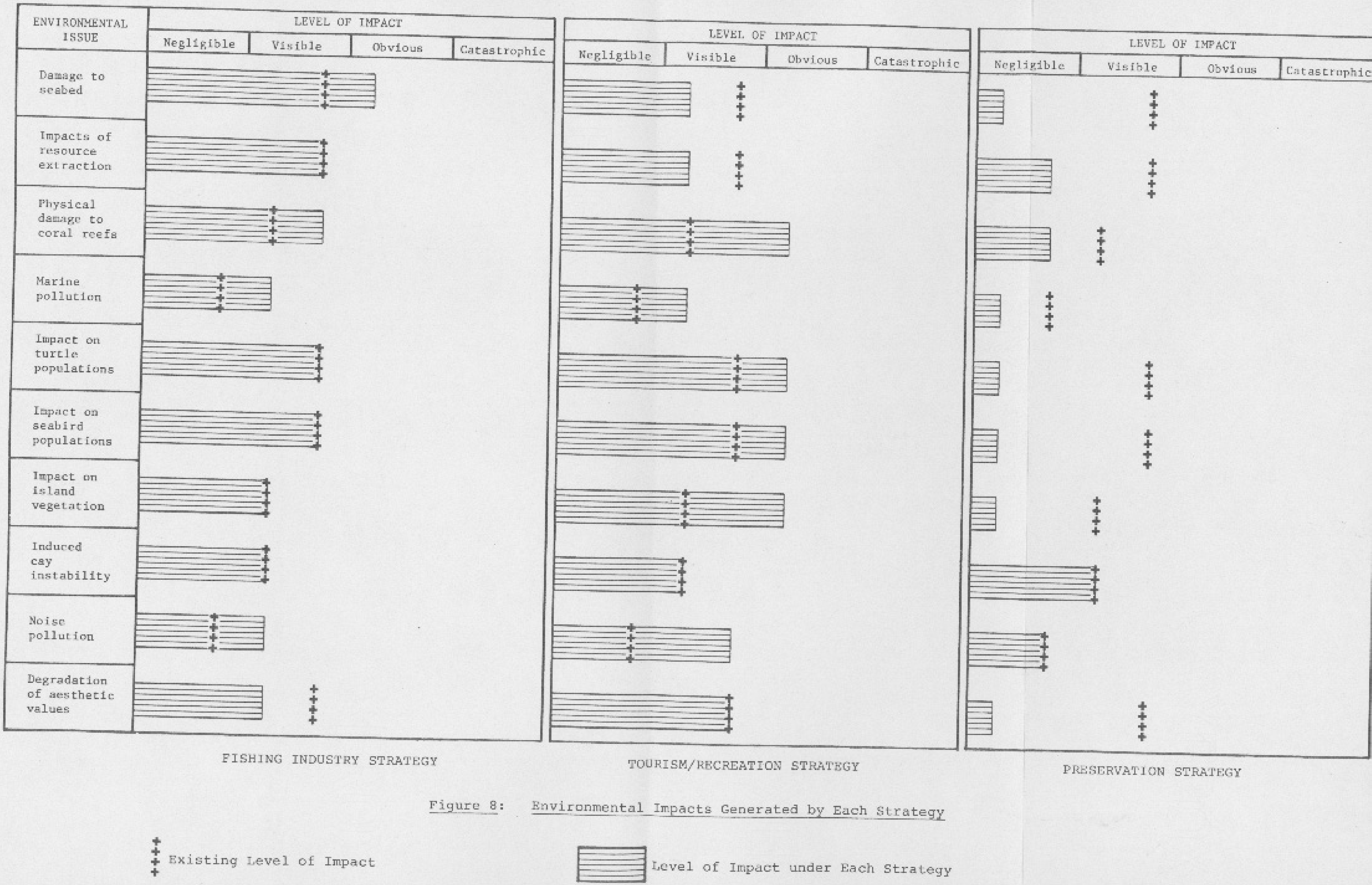


Figure 8: Environmental Impacts Generated by Each Strategy

counting, cannot be re-included here. The third component, which results from what is sometimes called 'vicarious demand', has not been counted elsewhere and is used here as the measure of environmental costs and benefits.

The benefits (or costs) associated with 'vicarious demand' are different from those associated with option value because they accrue to non-users who derive benefits from simply knowing that the Capricornia Section exists in a near natural state, or to those people with a benign attitude towards future generations.

Although they certainly exist, there is no basis on which to measure the values associated with 'vicarious demand'. If the convention of considering environmental impacts as economic costs is adopted, and the existing situation is taken as a reference point, then the following levels of environmental cost have been assigned to each strategy.

	ENVIRONMENTAL COST
Existing	zero
Fishing Industry Strategy	zero
Tourism/Recreation Strategy	medium, positive
Preservation Strategy	high, negative

7.7 OTHER ISSUES

(i) Social impacts

Social impacts generated by each strategy are considered under the headings of unemployment, internal conflict, equity and restrictions on an individual's freedom.

(a) Unemployment

Although it is accepted that expectations of employment may be affected differently under each strategy, the issue under consideration here is short term unemployment which would result from the implementation of each strategy. Short term unemployment implies the displacement of labour over a period which is too short to achieve adjustments necessary to utilize the idle resources.

The only industry adversely affected in the short term would be the fishing industry under the Preservation and Tourism/Recreation Strategies. Commercial fishing catches under each strategy would be stabilized at:

	ANNUAL TOTAL COMMERCIAL CATCH (kg)
Existing	425,000
Fishing Industry Strategy	425,000
Tourism/Recreation Strategy	295,000
Preservation Strategy	100,000

Direct, indirect and induced employment in Queensland attributable to current fishing activity in the Section is estimated to be 192 persons (Jensen 1979).

Although implementation of the Preservation Strategy, and to a lesser extent the Tourism/Recreation Strategy, would generate some immediate unemployment in the fishing industry, the impacts would be considerably less than first suggested by the annual catch figures shown above. This is because:

- part of the commercial fishing catch is generated by pro-amateur fishermen. To the extent that fishing is a secondary job, the loss of that employment is of lesser consequence than if fishing was the individual's principal employment;

- there are alternative fishing areas available outside the Capricornia Section; and
- catches would be progressively reduced to new levels over several years.

There is insufficient data to forecast actual short term unemployment levels in the fishing industry.

(b) Internal conflict

Within each strategy internal conflicts would arise from time to time as incompatible users compete for resources or as congestion occurs. Levels of conflict should increase with levels of use but decrease as management (e.g. zoning, regulations, surveillance) increases. The resultant levels of internal conflict under each strategy are estimated in Table 40.

(c) Equity

As explained earlier, employing the willingness to pay approach means that the services from the Section are valued as a marketed commodity would be. In effect, therefore, wealthier people, at least potentially, can have a greater say in the future of the Reef than can those with lesser 'market power'.

Alternatively, it might be held that the potential power to influence the choice of strategy for the Section should be distributed on a more even basis than 'market power', as is the case for certain public provided goods. Following this line it could

TABLE 40. LEVELS OF INTERNAL CONFLICT

NATURE OF INTERNAL CONFLICT	LEVEL OF CONFLICT			
	Existing	Fishing Industry Strategy	Tourism/ Recreation Strategy	Preserv- ation Strategy
Professional fishermen - pro-amateur fishermen - spearfishermen - amateur fishermen	considerable	low	low	nil
Shell, aquarium fish & coral collectors with other users	considerable	considerable	considerable	nil
Spearfishermen with non-extractive divers	considerable	low	low	nil
Charter boat operators with speed boat users	low	considerable	considerable	low
Boat operators & fishermen with divers	low	low	low	low
Speed boat operators with swimmers	low	low	considerable	low
Scientific research with other users	considerable	low	low	low

be appropriate to relatively depreciate the monetary valuation by wealthier individuals. Based on earlier discussion this might be achieved, in part, by scaling down the values attributed to the higher cost resort activities. However no attempt is made here to suggest what 'weights', if any, should be used to modify the consequences of the current distribution of income and wealth.

The approach to evaluation also involves simple aggregation of benefits and costs without considering the distributional effects of the strategies. Under each strategy there would be changes in individuals who gain or lose in accordance with the principles of recreation succession. It is difficult to identify particular groups who would gain or lose under each strategy and the extent to which individuals lose or gain cannot be determined without some knowledge of alternative opportunities in the Region.

The notion of equity therefore raises some serious philosophical questions which are outside the scope of this study. However, examples of specific equity issues generated under each strategy are identified in sections of the report dealing with internal conflict and community reaction.

(d) Restriction on individual freedoms

Park managers are often faced with the dilemma of trading off the need to protect areas by way of more stringent management conditions against the wish to retain the freedom of individuals to make choices. At the present time there are very few restrictions on visitors to the Section. Control of visitors and restrictions on their activities would increase under each strategy and be particularly severe under the Preservation Strategy. Although the reactions to loss of freedom can be mitigated to some extent by education of users and honesty on the part of the management authority, the fact remains that individual freedoms would be diminished under all strategies and severely restricted under the Preservation Strategy.

It has been shown that social costs would be incurred under each strategy. However, in comparison to urban projects such as freeway construction and inner city re-development, the levels of social impacts under consideration here are relatively minor. If the consequences of the current distribution of income are accepted, the following levels of social costs can be assigned to each strategy.

	SOCIAL COST
Fishing Industry Strategy	negligible
Tourism/Recreation Strategy	low
Preservation Strategy	low

(ii) Increased shipping costs

At the present time a small proportion of total shipping movements in and out of Gladstone Harbour divert from the recommended shipping routes and take short cuts between the reefs of the Capricornia Section (see Map 5). This decreases the total one way trip length between Gladstone and Japan or the west coast of America by approximately 5 nautical miles. Under each of the strategies shipping lanes would be defined in accordance with the recommended routes, and short cuts between the reefs would not be permitted.

Based on the 1977-78 annual report of the Gladstone Harbour Board, up to 400 shipping movements per annum are potential users of the non-recommended routes between the reefs. Assuming that 5% of these movements take the short cut, and that average ship operating costs at a speed of 18 knots are $10,000 per day, the total increase in shipping costs at present levels of activity would be approximately $3,000 per annum or $150 for each journey.

Under each strategy, the overall effect of confining ships to the recommended shipping routes would therefore be only a marginal increase in total ship operating costs. It is considered that these marginal increases would be more than offset by the decreased risk of shipwrecks and conflicts with other users.

7.8 SUMMARY OF EVALUATION OUTCOMES

For each strategy the final outcome of the evaluation procedure can be regarded as an amalgamation of the various costs and benefits documented in this chapter. In brief, the net benefits attributable to each strategy can be derived from the formula:

Net Benefits = Recreational Benefits + Commercial Fishing Benefits + Option Value - Management Costs - Environmental Costs - Social Costs.

In theory, it should be possible to combine all these costs and benefits to arrive at a single performance measure for each strategy. In practice such a single measure is unobtainable and each cost or benefit must be presented in the most appropriate measure available.

Where possible in this study, costs and benefits have been measured in monetary values. In other cases, descriptive measures have been used.

The various costs and benefits associated with each strategy are presented in Table 41 for a discount rate of 5%. Similar tables can readily be derived for the 3% and 7% discount rates. The casual reader is advised to consult the appropriate sections for details on the derivation and interpretation of the individual costs and benefits. In particular the reader should note that the attachment of monetary values to certain of the effects and not others in Table 41 is not intended to imply anything about the relative weighting to be given to individual costs or benefits.

Table 41 focuses attention on the types of trade-offs that will be necessary in arriving at a final preferred strategy. Since the purpose of this study is to investigate the consequences of alternative strategies, and not to select one particular strategy as being 'better' than another, the question of the final trade-offs has not arisen. Indeed, this trade-off issue warrants debate before a much larger audience than has contributed to this study.

In earlier chapters of the report, and particularly in Chapter 3, attempts were made to assess the reliability of data available to the study team. The consequences of using imperfect data flow through to the evaluation of the alternative strategies with the end result that the degree of confidence that can be assigned to the 'valuation' of the various costs and benefits tends to reflect, amongst other things, the reliability of the data on which they were based.

TABLE 41. COSTS AND BENEFITS ATTRIBUTABLE TO EACH STRATEGY

Monetary benefits and costs are in terms of present values.
Discount rate = 5%. Values in brackets are negative

BENEFITS AND COSTS			FISHING INDUSTRY STRATEGY	TOURISM/ RECREATION STRATEGY	PRESERVATION STRATEGY
Net Benefits	=	Recreation Benefits	\$22.5 m.	\$31.5 m.	\$19.5 m.
	+	Commercial Fishing Benefits	\$3.9 m.	\$2.8 m.	\$1.3 m.
	+	Option Value	high +	high -	extremely high
	-	Management Costs	\$12.5 m.	\$15.5 m.	\$11.5 m.
	-	Environmental Costs(a)(b)	0	medium	(high)
	-	Social Costs(a)	0	low	low

(a) Relative to the existing situation. (b) Excluding Recreation Benefits component and Option Value component.

The following points can therefore be made about the reliability of the costs and benefits contained in Table 41.

(a) Although quantified, the recreation benefits and the commercial fishing benefits should be regarded as being of poor reliability.

(b) Management costs should be regarded as being of good reliability.

(c) Although only ranked on an ordinal scale, option value, environmental costs and social costs should be regarded as being of fair reliability within the context of the measuring scale.

7.9 COMMUNITY REACTION

The evaluation methodology documented so far in this chapter describes mechanisms which can be used to assist in the generation of a final or preferred strategy. Although the generation of such a strategy is an important task in its own right, the related matter of implementing the preferred strategy is of equal importance.

This is because strategies which modify traditional use patterns or are seen to fall short of the expectations of particular interest groups will generate public outcry and short term political pressure from groups of people who see themselves as being disadvantaged. Although such reaction, or sometimes over-reaction, is often based on perceived rather than real threats, the potential exists for political harassment and embarrassment. It must therefore be accepted that interest groups have the ability to influence the decision-making process according to their political persuasiveness.

Expected reactions from relevant interest groups under each strategy are outlined below.

(a) Fishing Industry

- some reaction from traditional users such as campers and fishermen who would be unable to continue using traditional sites.

(b) Tourism/Recreation Strategy

- major reaction from preservation groups concerned about the impacts of increased human use;
- reaction from the scientific community concerned about the impacts of increased human use and loss of research opportunities;
- reaction from professional fishermen concerned about decreased fishing opportunities; and
- some reaction from traditional users such as campers who would be unable to continue using traditional sites.

(c) Preservation Strategy

- major reaction from professional fishermen concerned about the near total elimination of professional fishing opportunities;
- major reaction from traditional users concerned about the marked decrease in recreational opportunities throughout the Section;

- reaction from tourist operators concerned about restrictions on future development of the Section to accommodate increased numbers of visitors.

An additional reaction common to all 3 strategies would be forthcoming from people who felt obliged to question the implementation of a strategy which was derived with the assistance of so little quantitative data.

The point to be made is that almost any realistic strategy will invoke some criticism from certain sections of the community. The Authority therefore has a responsibility to ensure that proper consultation, involvement and education of interest groups is assigned a high priority during the planning process. The aim should be to take a positive course of action, to avoid misunderstanding, and above all to justify the planning decisions.

8.0 COMMENTS ON THE DATA BASE

At numerous points in this report reference has been made to the lack of quantitative data available to the study team. In some cases this lack of data has forced the study team members to make informed judgements based on the best available evidence (e.g. 'willingness to pay' in the calculation of recreational benefits) and in other cases to acknowledge that the required information just does not exist and cannot be estimated with any degree of reliability (e.g. the size of the amateur fishing catch). The impacts of these data deficiencies were felt most strongly during the evaluation of the alternative strategies. In many cases the absence of quantitative data has detracted from the usefulness of the evaluation procedure as anything more than a methodological exercise.

The most serious deficiencies in the data base, and those most needing attention before a zoning plan is prepared for the Capricornia Section, are outlined in Table 42. The data items in Table 42 are aggregated according to their priority for collection, although the ordering of items within any priority grouping is not meant to imply any ranking of importance.

TABLE 42. DEFICIENCIES IN THE DATA BASE

PRIORITY FOR COLLECTION	DATA ITEM	COMMENTS
First	More quantitative data on levels and patterns of human activities.	Additional data is available from charter boat operators, diving clubs, shell collecting clubs etc. but it has never been collected.
	Size of the amateur fishing catch.	Some additional information has been collected by W. Craik of G.B.R. Marine Park Authority. Additional assistance in defining the size of the amateur catch is expected from the study of the 'Economic Impact of Recreational and Commercial Fishing in the Capricorn and Bunker Groups' being undertaken by the I.A.S.R.
	Details of proposed resort development at Yeppoon.	Information has been requested from the developers (Iwasaki Sangyo) without success.
	Origins of visitors.	Some information is available for visitors to the Heron Island resort and Research Station.
	'willingness to pay' data.	Required for more accurate estimate of recreation benefits and commercial fishing benefits.
	Impacts of human activities.	Some additional information on spearfishing impacts has been collected by L. Zell of G.B.R. Marine Park Authority. Further information appears to exist in the scientific literature.
Second	Accurate areas of reefs, reefal shoals and islands.	Areas of reefs and islands have been supplied by the Australian Survey Office.

cont/..

PRIORITY FOR COLLECTION	DATA ITEM	COMMENTS
Second (cont.)	Optimum sustainable yields for fisheries resources.	-
	Detailed assessment of alternative opportun-ities for recreational and commercial activities.	-
	Location and use of shipping lanes.	Information has been requested from Aust. Dept of Transport without success.
Third	Currents and tidal movements of water.	-
	Stress thresholds for seabird and turtle populations.	-

N.B. Items within any priority grouping are assumed to have equal priority.

APPENDIX A

STUDY BRIEF FOR ZONING STRATEGY STUDY BASED ON THE PROPOSED CAPRICORNIA SECTION OF THE GREAT BARRIER REEF MARINE PARK

1 MAY 1979

BACKGROUND

1.1 The Great Barrier Reef Marine Park Act 1975 provides for the establishment of the Great Barrier Reef Marine Park Authority and for the creation of the Marine Park.

1.2 The Act provides, inter alia, that the Governor-General may by proclamation declare an area within the Great Barrier Reef Region (as defined in the Act) to be part of the Marine Park. As soon as possible after an area has been declared, the Authority is required to prepare a zoning plan for that area.

1.3 In preparation of a zoning plan the Authority is required by S.32(7) of the Act to have regard to the following objects:

(a) the conservation of the Great Barrier Reef;

(b) the regulation of the use of the Marine Park so as to protect the Great Barrier Reef while allowing the reasonable use of the Great Barrier Reef Region;

(c) the regulation of activities that exploit the resources of the Great Barrier Reef Region so as to minimize the effect of those activities on the Great Barrier Reef;

(d) the reservation of some areas of the Great Barrier Reef for its appreciation and enjoyment by the public; and

(e) the preservation of some areas of the Great Barrier Reef in its natural state undisturbed by man except for the purposes of scientific research.

1.4 The Authority is aware that the objects defined by the Act require multi-objective planning to balance conservational, commercial and recreational requirements within sections of the Great Barrier Reef Marine Park.

1.5 The Authority's area of responsibility is closely associated with areas which are under the jurisdiction of the Government of the State of Queensland. The Authority therefore recognizes the need for zoning strategies to be developed which, in addition to meeting the objects defined in Section 32(7) of the Act, will permit harmonious and consistent management of both Queensland and Commonwealth jurisdictional areas within the Great Barrier Reef Region.

1.6 The Authority desires to arrange for a study of strategy for zoning the Great Barrier Reef Marine Park based on the specific example of the proposed Capricornia Section.

GENERAL DESCRIPTION OF SERVICES REQUESTED

2.1 The services required involve the preparation, development and evaluation of a number of strategies for zoning the Great Barrier Reef Marine Park in conjunction with a Study Group. The study will be based on the Capricorn and Bunker reef area. The information requirements are expected to be met by staff of the Authority. The work is to be divided into discrete phases, each of which will consist of one or more tasks. At the conclusion of each phase, an internally consistent draft report should be produced.

2.2 The exercise is to be undertaken by the consultant as a member of a Study Group. The Group will involve one Authority staff member as a convener and experts from the State Government who will be responsible for providing information and professional assistance in the development of alternative zoning strategies and management regimes.

2.3 The exercise will be undertaken conjointly with the Study Group who will be appointed by, and responsible to, the Authority. All draft reports will be subject to review by the Authority Staff and will be provided to the Authority for information and comment.

2.4 Phase One of the study will run for six weeks. It will consist of the following tasks:

1) Inventory
2) Impact of Human Activities
3) Existing constraints.

2.5 Phase Two of the study will run for five weeks. It will consist of the preparation of alternative strategies. The number of strategies to be prepared will be determined by a meeting of the study group following the conclusion of Phase One: it is envisaged that about three strategies will be required.

2.6 Phase Three of the study will run for five weeks. It will consist of evaluation of the strategies developed during Phase Two.

2.7 The study group will meet approximately one week after the conclusion of each phase of the study to develop the final report on that phase and, as appropriate, determine the details of the succeeding phase.

2.8 Twelve copies of each draft report are to be submitted to the study group.

2.9 The final report of the study shall consist of the reports of each study phase incorporating any amendments required by the study group. Twenty copies of the final report are to be submitted to the Authority.

2.10 Finished reports are to be of 'A4' size with light card covers printed to an approved layout and a form of binding acceptable to the study group and the Authority.

2.11 The format should comply with the conventions set out in the Australian Style Manual and the Authority's guidelines for publications. (GBRMPA Technical Papers)

2.12 The Authority will provide a dyeline transparency at a scale 1:250 000 and access to 1:10 000 transparencies for the production of base maps for the study. Working maps may be produced by hand lettering on the base map provided.

2.13 The form of maps for the final report will be agreed between the Authority and the Study Group and their production will not be part of this study contract. Hand drawn working maps, prepared in a form suitable for instructing a technical draftsman, will be presented with the final report.

2.14 The consultant shall provide a secretary to attend and prepare minutes of meetings of the Study Group.

REQUIREMENTS FOR PHASE ONE

<u>Task 1 Inventory</u>:

3.1 Prepare:
(a) brief text;
(b) maps;
(c) necessary schedules, charts, figures, illustrations and diagrams;

sufficient to:
(1) provide a concise summary of background data relevant to this particular study;
(2) identify all sources of information.

3.2 Much of background data will be available from the Authority in collated or partly collated form. This includes:
(1) Terrestrial and Submarine Topography
(2) Climate
(3) Hydrology
(4) Marine Biology
(5) Human Activities.

3.3 The Queensland Fisheries Service will be able to supply the following:
(1) information about and the identification of historically significant sites and features - from the Goeden Report;
(2) Fish Board information relevant to the study area;

(3) information about commercial fishing in the area (Section b, iv) - from the Goeden Report;
(4) information regarding the impact of current uses and activities in the area (Section b, xii);
(5) information about current management practices and policies of Queensland Fisheries relative to the study area (Section c).

The Queensland Fisheries Service contact officer for this information will be Mr A. Winterton.

3.4 The Queensland National Parks and Wildlife Service will be able to provide the following:

(1) information about the terrestrial biology of the Capricornia-Bunker Group;
(2) information about and the identification of historically significant sites and features;
(3) information about the recreational use of the area - types, locations, numbers, seasonality, mode of transport, etc.
(4) information on current educational and interpretive programs in the area;
(5) information regarding the location and type of impacts caused by current uses and activities in the area (Section b, xii);
(6) information about current management practices and policies of Queensland National Parks and Wildlife Service relevant to the study area (Section c).

A contact officer will be advised.

3.5 The Department of the Co-ordinator-General of Queensland will be able to provide the following:

(1) information about Local Authority boundaries, land use controls, and services within the study area;
(2) details of tourist proposals on/near other parts of the reef.

The departmental contact officer for access to this information will be Mr J. Wheeler.

3.6 The following information has not been collected by any of the other Study Group members and therefore it will be necessary for the consultant to collect and collate the following:

(1) information about current and future proposals for islands under the control of the Queensland Department of Lands;
(2) information from workforce surveys;
(3) information about hotel/motel occupancy rates in the region relevant to this study;
(4) information and statistics on local employment in the region relevant to this study;
(5) information from charterboat operators regarding current use of the study area;
(6) information regarding gross turnover and projections of tourist growth;
(7) relevant information from Harbours and Marine Department regarding facilities provided in the area;
(8) information about current management practices and policies of the Queensland Department of Lands relevant to the study area.

Task 2 Impact of Human Activities:

3.7 Document available information on:

(1) the impact of individual usage types;
(2) the impact of activities on the resource base.

A reference list of human activities is attached in Appendix E.

3.8 Identify compatible and conflicting activities.

3.9 Discuss the role of management in modifying impacts.

Task 3 Existing constraints and opportunities:

3.10 On the base map provided by the Authority illustrate relevant constraints, recreational and commercial opportunities within the Capricornia section.

PHASE ONE REPORT

3.11 At the conclusion of Phase One, prepare a report for review by the study group to document relevant points from Tasks 1,2 and 3. The report should include:

(1) a review of data gaps and difficulties encountered due to unavailability of data;

(2) a discussion of implications for phases two and three of the study.

REQUIREMENTS FOR PHASE 2

4.1 On the basis of information assembled and evaluated during Phase 1 develop alternative strategies for the management of the Capricornia section.

4.2 Each strategy should be compatible with the objects of the Authority as defined in the Great Barrier Reef Marine Park Act 1975.

4.3 The report of Phase 2 shall consist of maps illustrating each strategy accompanied by a documentation of relevant points and schedules for capital works and broad estimates of management costs.

REQUIREMENTS FOR PHASE 3

5.1 The consultant shall evaluate the strategies developed in Phase 2 using recognized multi-criteria procedures which will assist in identifying the outcomes of the strategies relative to each other and relative to the 'do-nothing' situation.

5.2 The methodology to be used in the evaluation will be agreed by the Study Group during discussions preceding this phase of the study.

5.3 The report of Phase 3 will consist of a detailed evaluation of the strategies developed in Phase 2.

FINAL REPORT

6.1 It is envisaged that the final report will consist of the revised drafts of the reports of Phases 1 to 3.

6.2 The form of presentation of the final report shall be similar to that of the draft reports, maps, illustrations, figures and schedules arising from Phases 1 to 3.

APPENDIX B

PHYSIOGRAPHY

The physiographic characteristics of the reefal shoals, reefs and islands are documented by Steers (1938), British Admiralty (1973), Maxwell (1968), Fairbridge (1950), Flood (1974, 1976 & 1977), Jell & Flood (1978), and Mather & Bennett (1978). The salient features are summarized in this appendix. Illustrations are from Mather & Bennett (1978) and Flood (1977). The areas documented are from the following sources: Division of National Mapping, Canberra (numbers in roman type) and Queensland Department of Lands (numbers in italic type).

1. KARAMEA BANK

   A small, reefal shoal 18.3 m below low water.
   Approximate area <60 ha.

2. MORESBY BANK

   A small, reefal shoal 17.1 m below low water at the eastern end.
   Approximate area <60 ha.

3. EDGELL BANK

   A small, reefal shoal 15.5 m below low water.
   Approximate area <60 ha.

4. GOODWIN SHOAL

   A small, reefal shoal 8.2 m below low water.
   Approximate area <60 ha.

5. INNAMINCKA SHOAL

   A reefal shoal 9.4 m below low water.
   Approximate area 60 ha.

6. HABERFIELD SHOAL

   A reefal shoal 9.8 m below low water.
   Approximate area 60 ha.

7. <u>GUTHRIE SHOAL</u>

A reefal shoal 9.4 m below low water.
Approximate area 60 ha.

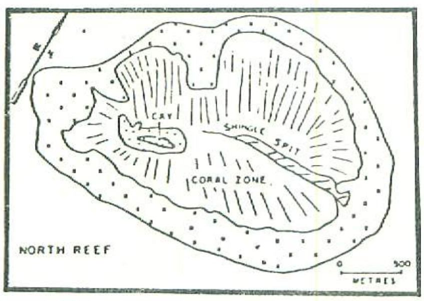
8. <u>JOHNSON PATCH</u>

A small, reefal shoal 11.9 m below low water. It is steep-to and lies on western extremity of a bank.
Approximate area <60 ha.

9. <u>DOUGLAS SHOAL</u>

A reefal shoal 8.2 m below low water.
Approximate area 120 ha.

10. <u>NORTH REEF</u>



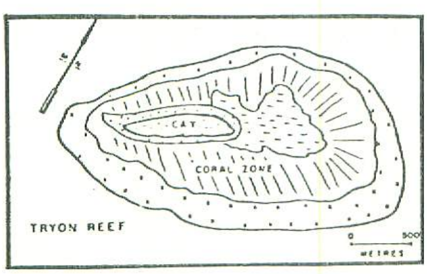
A small, drying, platform reef with a small, vegetated sand cay on the western end. This is the smallest island in the Capricornia Section.

Approximate area: Reef 295 ha
Cay 15 ha
4.5 ha

11. <u>BREW SHOAL</u>

A small, reefal shoal 9.4 m below low water, which lies on the outer end of a spit which extends 3.2 km WSW from Tryon Island Reef.
Approximate area 60 ha.

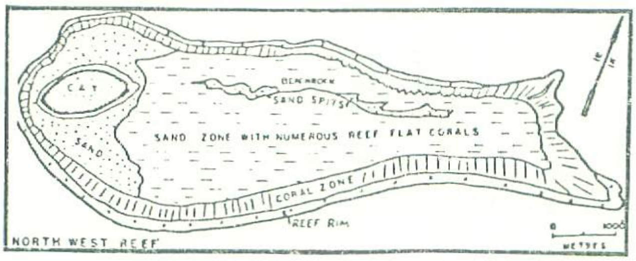
12. <u>TRYON ISLAND REEF</u>



A small, drying platform reef without a lagoon. The entire reef flat is subject to strong wave action and this has resulted in linear growth of the coral. There is a small elongated vegetated sand cay at the SW end of the reef. A spit extends 3.2 km WSW from this reef.

Approximate area: Reef 190 ha
Cay 30 ha
5.7 ha

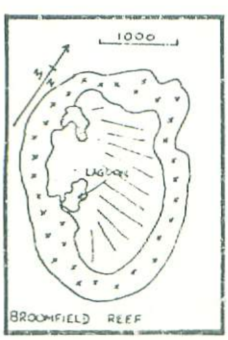
13. NORTH WEST ISLAND REEF



A large, drying, elongate platform reef approximately 11 km long and 3 km wide, running almost E-W. The reef displays irregular (not markedly linear) coral growth and has sand bank development along the north side. It is slightly depressed in the centre forming a lagoon, and has prolific coral growth at and behind its rim with good grooves and spurs development. There is a large, low, forested sand cay (1,700 m long x 800 m wide) at the western end of the reef. North West Island Reef is the largest reef and has the largest island in the Capricornia Section.

Approximate area: Reef 3,000 ha
Cay 125 ha
93.9 ha

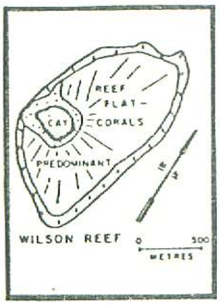
14. BROOMFIELD REEF



A drying, platform reef with a small intertidal sand body, 0.3 m high near the NW end. This sand body represents a cay in the early stages of development. It remains emergent at high tide. This reef has a very small lagoon. Between Broomfield Reef and North West Island Reef there is an extensive shoal (submarine

platform) less than 11 m below low water.
Approximate area 720 ha.

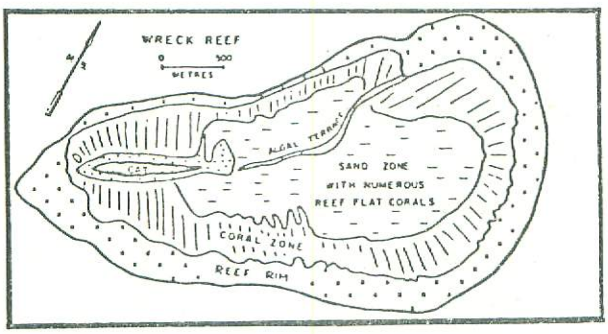
15. WILSON ISLAND REEF



A small, drying, platform reef about 1,700 m long x 1,000 m wide with a small vegetated sand and shingle cay (about 300 m in diameter) in the western corner of the reef.

Approximate area: Reef 145 ha
Cay 10 ha
4.9 ha

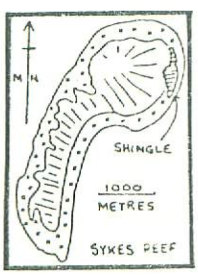
16. WRECK ISLAND REEF



A triangular-shaped, drying, platform reef about 4.5 km long and 2.5 km wide at the widest point. There is a narrow vegetated sand cay about 800 m long x 100 m wide on the SW corner of the reef flat.

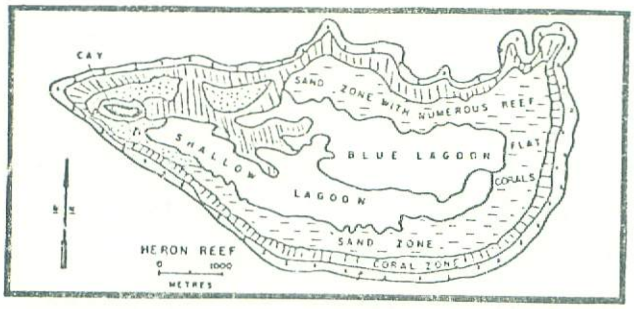
Approximate area: Reef 470 ha
Cay 30 ha
10.1 ha

17. SYKES REEF



A drying, wall reef. There is a submarine platform between Sykes Reef and Heron Island Reef (Flood, 1976).
Approximate area 630 ha.

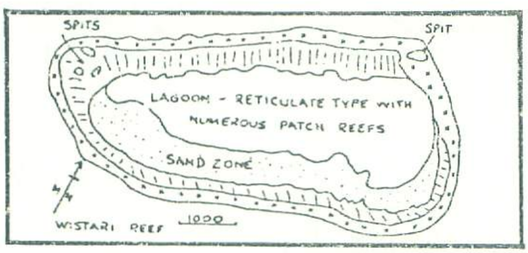
18. HERON ISLAND REEF



A large, drying, lagoonal platform reef some 8 km long x 3.5 km wide at the widest point. This reef has a true lagoon which is up to 3.5 m deep and surrounded by rich coral. A small, forested sand cay (700 m x 300 m) is located at the eastern end of the reef. There is a submarine platform between Heron Island Reef and Sykes Reef. (Jell & Flood 1978.)

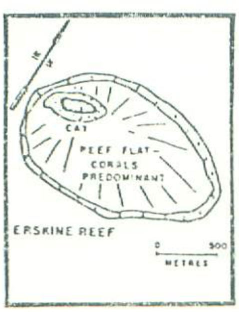
Approximate area: Reef 2,700 ha
Cay 20 ha
17 ha

19. WISTARI REEF



A large, drying, lagoonal platform reef which is separated from Heron Island by a narrow channel. This reef has a true lagoon. There is a small intertidal sand body on the SW end of the reef. Approximate area 2,250 ha.

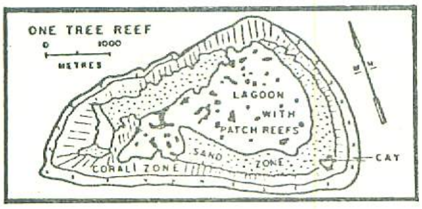
20. ERSKINE ISLAND REEF



A small, oval, drying, platform reef about 1.6 km long x 1.0 km wide. The coral is well developed and there is no lagoon. There is a small, vegetated shingle/sand cay (about 400 m x 100 m) on the western edge of the reef.

Approximate area: Reef 95 ha
Cay *2 ha*

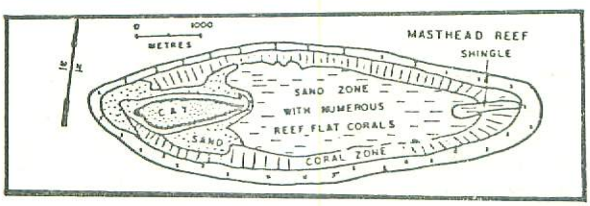
21. ONE TREE ISLAND REEF



A drying, lagoonal platform reef about 6 km long x 3 km wide at the widest point, with a central lagoon (divided into three) averaging 3 to 4 m in depth. The reef, particularly to the south and east has strongly aligned coral and the lagoon has many patch reefs and reticulate reefs. A small, shingle cay (approximately 250 m x 150 m) which has a central saline pool, lies on the SE corner of the reef.

Approximate area: Reef 1,290 ha
Cay 20 ha
2.4 ha

22. MASTHEAD ISLAND REEF



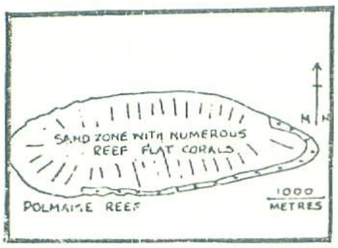
A drying, elongate platform reef about 6 km long by 2 km wide at the widest point. It is slightly dished and has strongly developed spurs and grooves at its edges. A vegetated, sand cay (1,200 m long x 400 m wide) lies north of the western end of the reef. This is the second largest island in the Capricornia Section.

Approximate area: Reef 640 ha
Cay 40 ha
64.8 ha

23. IRVING REEF (SHOAL)

A platform reef which remains submerged at all times, 3 m below low water. It lies in the middle of a spit which extends 5.2 km WNW from Polmaise Reef. Approximate area 190 ha.

24. POLMAISE REEF

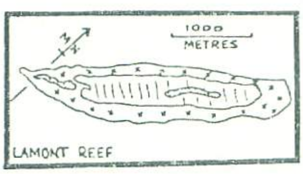


A drying, elongate platform reef. A spit extends 5.2 km WNW from Polmaise Reef to Irving Reef. Approximate area 820 ha.

25. ROCK COD SHOALS

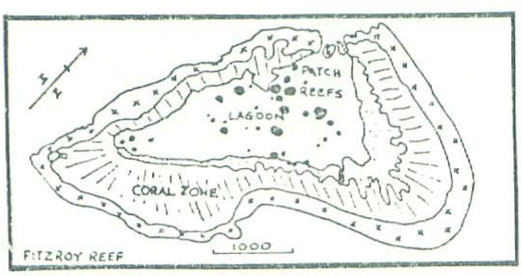
A reefal shoal 6.1 m below low water. Approximate area 625 ha.

26. LAMONT REEF



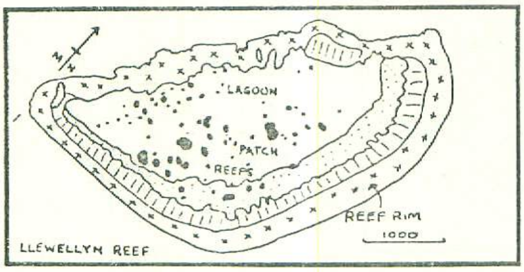
A drying, wall reef with a small intertidal sand body on the SW end of the reef.
Approximate area 310 ha.

27. FITZROY REEF



A drying, closed ring reef with a large enclosed lagoon with an opening to the sea. There is a small intertidal sand body on the SW end of the reef.
Approximate area 1,380 ha.

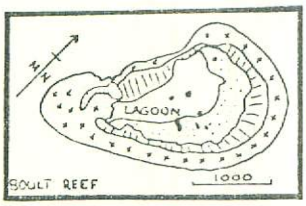
28. LLEWELLYN REEF



A drying, closed ring reef with a large enclosed lagoon. There is a small intertidal sand body on the SW end of the reef.

Approximate area 1,440 ha.

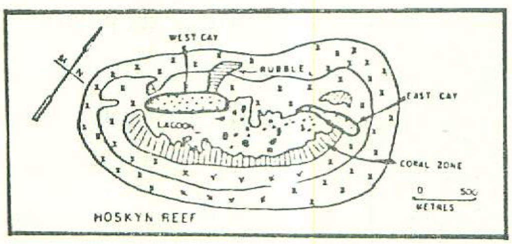
29. BOULT REEF



A drying, closed ring reef with a small intertidal sand body on the SW end which is nearly covered at high tide.

Approximate area 600 ha.

30. HOSKYN ISLANDS REEF

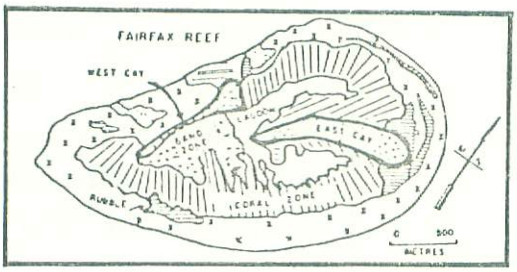


A drying, ingrown closed ring reef about 1.6 km long with strong, radially aligned pattern of reef growth, typical of the smaller platforms. It is slightly depressed, forming a very shallow lagoon. This reef has two small, vegetated islands, the eastern one is a shingle cay and the larger western one is a sand cay.

Approximate area: Reef 285 ha

Cays 25 ha
Eastern cay *3 ha*
Western cay *9 ha*

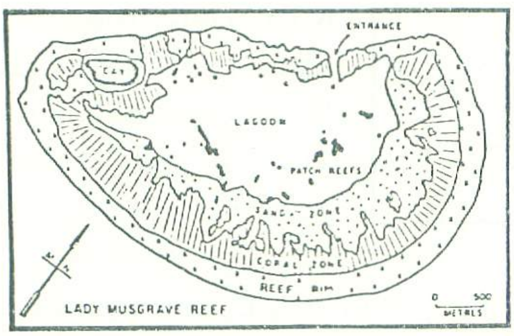
31. FAIRFAX ISLANDS REEF



A drying, ingrown closed ring reef about 3 km long, with a shallow lagoon and three islands. The eastern island is a vegetated shingle cay, the western island is a vegetated sand cay and the small sand cay located to the west of the western island is bare. There are two brackish pools located toward the eastern end of the eastern island.

Approximate area: Reef 315 ha
Cays 60 ha
Eastern cay *16 ha*
Western cay *3 ha*

32. LADY MUSGRAVE ISLAND REEF



A large, drying, closed ring reef about 5 km long. It has a true lagoon up to 7 m deep with an opening to the sea. Reef growth is radial. There is a small, wooded shingle/sand cay (about 500 m long x 300 m wide, with a small brackish pool) located on the SW (leeward) end of the reef.

Approximate area: Reef 1,050 ha
Cay 60 ha
20.3 ha

33. LADY ELLIOTT ISLAND

A drying platform reef with a vegetated shingle cay, which is 800 m wide at the widest point, on the southern end of the reef. The coral shingle of the island is arranged in ridges which run more or less concentrically.

Approximate area: Reef 70 ha
Cay 60 ha
36.4 ha

34. HERALD PATCHES

A number of small reefal shoals composed of sand and coral, about 18.3 m below low water.

Approximate area 1,910 ha.

APPENDIX C

PRINCIPAL DEMERSAL FISHES CAUGHT IN THE CAPRICORNIA SECTION

Source: Great Barrier Reef Marine Park Authority (n.d.)

Many of the common names cover a number of species. Some refer to more than one family.

COMMON LOCAL NAME	FAMILY	GENUS
Coral Trout	Serranidae	*Plectropoma*
Sweetlip Emperor	Lethrinidae	*Lethrinus*
Sweetlip Thick-lipped Bream	Pomadasyidae	*Plectorhynchus*
Sea Perch Red Emperor Snapper	Lutjanidae	*Lutjanus*
Cod	Serranidae	*Epinephelus*
Parrot Tusk-fish	Labridae	*Choerodon*

APPENDIX D

PERMITS TO COLLECT MARINE ORGANISMS IN THE HERON-WISTARI MARINE PARK

Source: Queensland Fisheries Service

During the 1978 calendar year permits to collect the following numbers of marine organisms from the Heron-Wistari Marine Park were issued by Queensland Fisheries Service.

ORGANISM	TOTALS PERMITTED TO BE TAKEN (1978)
Molluscs	728
Fishes	715
Algae (Colonies)	345
Crustaceans	250
Coral (Colonies)	319
Echinoderms	100
Ascidians	60
Holothurians	200
Asteroidea	50
Invertebrates (species were not indicated in permit application)	390
Crinoids	40

Permits to collect various other organisms were also issued but in general these were not quantifiable, e.g. oligochaetes, polychaetes, isopods, arthropods etc.

APPENDIX E

LIST OF HUMAN ACTIVITIES IN THE GREAT BARRIER REEF REGION

Supplied by Great Barrier Reef
Marine Park Authority, Oct. 1978.

(i) <u>Indirect</u>

Shipping
Aviation

(ii) <u>Direct non-extractive</u>

Visual/photographic recreation
Visual/photographic tourism
Film making
Scientific survey studies

(iii) <u>Direct extractive</u> - exploiting renewable resources

Professional line fishing
Professional trawling
Professional shell collecting
Professional aquarium fish collecting
Professional spear fishing
Professional coral collecting
Professional boat charter for amateur line fishing
Professional boat charter for amateur spear fishing
Professional charter for amateur shell collecting
Amateur line fishing
Amateur spear fishing
Amateur shell collecting
Amateur aquarium fish collecting
Amateur coral collecting
Scientific experimental research

(iv) <u>Destructive</u>

Shipwrecks - physical impact
Shipwrecks - spillage of pollutants
Explosions
Military exercises

APPENDIX F

MARKET PRICES

Market prices used in the evaluation were:

ITEM	MARKET PRICE
Higher cost resort	\$50/person-day
Lower cost resort	\$25/person-day
Camping	\$4/person-day
Charter boats	\$35/person-day
Scenic flight	\$30/person-trip
Research station	\$12/person-day
Pelagic fish	\$3.00/kg whole fish
Demersal fish	\$4.00-\$5.00/kg whole fish
Scallops	\$9.00-\$10.00/kg scallop meat

APPENDIX G

Operational forecasts

This appendix contains forecasts of activity levels, management inputs and private resort development to the year 2000 under each strategy. The forecasts are an important input into the economic evaluation and are based on many factors including:

. the definition of the strategies;
. existing use patterns;
. constraints and opportunities in the Section;
. estimated population growth;
. changing economic circumstances; and
. changes in available leisure time.

Some caution should be exercised in the interpretation of the forecasts since they have been estimated in the absence of quantitative demand studies and in many cases from base data of questionable reliability.

(i) Future activity levels

Projections of future activity levels under each strategy are summarized in Tables G 1-3. For several of the activities, such as resort visits, camping and commercial fishing, the maximum use levels have been set by the definition of the strategies and the only area of uncertainty is when maximum use levels would be reached.

(ii) Management costs

Management costs have been derived in accordance with the definitions of the strategies contained in Phase 2 of the study. The following assumptions have been made in arriving at these costs:

(a) The management authority would be responsible for the construction and operation of camping facilities in the Section. Some of these costs would be recouped by the imposition of a camping fee set at $4.00/person-day for the purpose of this evaluation.

TABLE G-1. PROJECTED ACTIVITY LEVELS - FISHING INDUSTRY STRATEGY

YEAR	RESORT VISITS (guest-days)	RESEARCH STATION VISITS (visitor-days)	CHARTER BOAT USE (person-days)	SPEED BOAT USE (person-days)	SCENIC FLIGHTS (person-days)	YACHTS & SEAPLANES (person-days)	CAMPING (person-days)	COMMERCIAL FISHING CATCH (kg)		
								Scallops	Demersal	Pelagic
1980	37,000	8,000	12,000	9,000	200	2,000	16,000	100,000	225,000	100,000
1985	46,000	10,000	17,000	12,000	800	2,500	16,000	100,000	225,000	100,000
1990	65,000	11,000	26,000	15,000	1,800	3,000	17,000	100,000	225,000	100,000
1995	90,000	11,000	36,000	17,000	2,800	3,500	17,000	100,000	225,000	100,000
2000	90,000	11,000	51,000	17,000	4,000	4,000	17,000	100,000	225,000	100,000

TABLE G-2. PROJECTED ACTIVITY LEVELS - TOURISM/RECREATION STRATEGY

YEAR	RESORT VISITS (guest-days)	RESEARCH STATION VISITS (visitor-days)	CHARTER BOAT USE (person-days)	SPEED BOAT USE (person-days)	SCENIC FLIGHTS (person-days)	YACHTS & SEAPLANES (person-days)	CAMPING (person-days)	COMMERCIAL FISHING CATCH (kg)		
								Scallops	Demersal	Pelagic
1980	37,000	8,000	12,000	9,000	200	2,000	16,000	100,000	225,000	100,000
1985	46,000	10,000	17,000	11,000	800	2,500	17,000	75,000	120,000	100,000
1990	90,000	11,000	26,000	13,000	1,800	3,000	19,000	75,000	120,000	100,000
1995	90,000	11,000	39,000	15,000	2,800	3,500	20,000	75,000	120,000	100,000
2000	200,000	11,000	60,000	16,000	4,000	4,000	20,000	75,000	120,000	100,000

TABLE G-3. PROJECTED ACTIVITY LEVELS - PRESERVATION STRATEGY

YEAR	RESORT VISITS (guest-days)	RESEARCH STATION VISITS (visitor-days)	CHARTER BOAT USE (person-days)	SPEED BOAT USE (person-days)	SCENIC FLIGHTS (person-days)	YACHTS & SEAPLANES (person-days)	CAMPING (person-days)	COMMERCIAL FISHING CATCH (kg)		
								Scallops	Demersal	Pelagic
1980	37,000	8,000	12,000	9,000	200	2,000	16,000	100,000	225,000	100,000
1985	46,000	10,000	17,000	13,000	1,000	2,500	4,500	0	50,000	50,000
1990	70,000	13,000	22,000	14,000	2,000	3,000	4,500	0	50,000	50,000
1995	70,000	13,000	27,000	15,000	3,500	3,500	4,500	0	50,000	50,000
2000	70,000	13,000	32,000	15,000	5,000	4,000	4,500	0	50,000	50,000

(b) Private enterprise would construct and operate all resorts.

(c) Unit costs for boats would be (in present day values):

	CAPITAL COST ($)	RUNNING COST (ex.crew)($/yr)	USEFUL LIFE (yrs)	REPLACEMENT COST($)
15 m boat	350,000	50,000	15	150,000
9 m boat	50,000	12,000	10	20,000
10 m barge	80,000	10,000	10	30,000

(d) Unit costs for campground development would be (in present day values):

Toilet block	$40,000
Developed campground & facilities	$2,000/tent site

(e) Annual salaries of management staff would be (in present day values):

CATEGORY	ANNUAL SALARY ($)
Manager	25,000
Clerks/Secretary	9,000 (av)
Education Officers	14,000 (av)
Rangers/Masters	12,500 (av)
Technical Assistants/Workmen	9,000 (av)
Research Staff	15,000

An overhead factor of 100% has been used in each case.

A summary of management costs (in present day values) under each strategy is contained in Tables G 4-6. No attempt has been made to apportion management costs amongst the various Commonwealth and State agencies which may be involved in the management program.

TABLE G-4. MANAGEMENT COSTS - FISHING INDUSTRY STRATEGY

5 YEAR PERIOD	ACTIONS	CAPITAL COST ($)	RECURRING COST ($)	LESS CAMPING FEES ($)	NET MANAGEMENT COST ($)
1981 to 1985	Purchase 2 x 9 m boats Purchase 1 x 15 m boat Purchase 2 vehicles Toilet facilities on North West, Lady Musgrave, Tryon & Masthead Islands Purchase radio comm. equipment Temporary ranger accommodation on Heron Island Appoint manager, secretary, 3 clerks, 5 rangers/masters, 9 assistants & 2 education officers	694,000	2,332,000	300,000	2,726,000
1986 to 1990	Purchase 1 x 9 m boat Purchase 1 x 10 m landing barge Temporary ranger accommodation on Lady Elliott, Lady Musgrave & North West Islands Replace 2 vehicles Campground on North West Island Appoint 1 ranger/master, 2 assistants & 1 clerk	339,000	3,708,000	324,000	3,723,000
1991 to 1995	Replace 2 x 9 m boats Replace 2 vehicles Install computer terminals Appoint 1 clerk	59,000	3,900,000	340,000	3,619,000
1996 to 2000	Replace 1 x 9 m boat Replace 1 x 15 m boat Replace 2 vehicles	174,000	3,900,000	340,000	3,734,000

TABLE G-5. MANAGEMENT COSTS - TOURISM/RECREATION STRATEGY

5 YEAR PERIOD	ACTIONS	CAPITAL COST ($)	RECURRING COST ($)	LESS CAMPING FEES ($)	NET MANAGEMENT COST ($)
1981 to 1985	Purchase 2 x 9 m boats Purchase 1 x 15 m boat Purchase 3 vehicles Toilet facilities on North West, Lady Musgrave, Tryon & Masthead Islands Temporary ranger accommodation on Heron Island Purchase radio comm. equipment Appoint manager, secretary, 4 clerks, 5 rangers/masters, 9 assistants, 2 education officers	701,000	2,350,000	316,000	2,735,000
1986 to 1990	Purchase 2 x 9 m boats Purchase 1 x 10 m landing barge Replace 3 vehicles Temporary ranger accommodation on Lady Elliott, Lady Musgrave & North West Islands Stage 1 campground on North West Island Appoint 4 rangers/masters, 4 assistants, 1 clerk & 1 education officer	341,000	4,121,000	340,000	4,122,000
1991 to 1995	Replace 2 x 9 m boats Replace 3 vehicles Install computer terminals Permanent ranger accommodation & interpretive centres on Lady Elliott & North West Islands Stage 2 campground on North West Island Appoint 2 rangers/masters, 2 assistants 1 clerk & 1 education officer	201,000	4,894,000	380,000	4,715,000
1996 to 2000	Replace 2 x 9 m boats Replace 1 x 15 m boat Replace 3 vehicles	196,000	5,315,000	400,000	5,111,000

TABLE G-6. MANAGEMENT COSTS - PRESERVATION STRATEGY

5 YEAR PERIOD	ACTIONS	CAPITAL COST ($)	RECURRING COST ($)	LESS CAMPING FEES ($)	NET MANAGEMENT COST ($)
1981 to 1985	Purchase 1 x 9 m boat Purchase 1 x 15 m boat Purchase 2 vehicles Toilet facilities on Lady Musgrave Island Temporary ranger accommodation on Heron Island Purchase radio comm. equipment Upgrade One Tree Island Research Station Appoint manager, secretary, 2 clerks, 3 rangers/masters, 9 assistants & 2 education officers	554,000	1,921,000	112,000	2,363,000
1986 to 1990	Purchase 1 x 15 m boat Replace 2 vehicles Upgrade Heron Island Research Station Appoint 1 ranger/master & 4 assistants	504,000	2,989,000	90,000	3,404,000
1991 to 1995	Replace 1 x 9 m boat Replace 2 vehicles	24,000	3,480,000	90,000	3,414,000
1996 to 2000	Replace 1 x 15 m boat Replace 2 vehicles	154,000	3,480,000	90,000	3,544,000

(iii) Resort development program

The program for resort development which has been employed under each strategy is summarized in Table G-7.

TABLE G-7. RESORT DEVELOPMENT PROGRAM

5 YEAR PERIOD	STRATEGY		
	FISHING INDUSTRY	TOURISM/RECREATION	PRESERVATION
1981 to 1985	Upgrade Heron Island Resort Stage 1 Low Cost Resort on Lady Elliott Is. (100 beds)	Upgrade Heron Island Resort Stage 1 Low Cost Resort on Lady Elliott I. (100 beds)	Upgrade Heron Island Resort Low Cost Resort on Lady Elliott Island (100 beds)
1986 to 1990	Upgrade Heron Island Resort Stage 2 Low Cost Resort on Lady Elliott Is. (+100 beds)	Upgrade Heron Island Resort Stage 2 Low Cost Resort on Lady Elliott Is. (+100 beds)	Upgrade Heron Island Resort
1991 to 1995	-	Stage 1 High Standard Resort on Lady Elliott Is.(200 beds) Upgrade airstrip on Lady Elliott Island Stage 1 Low Cost Resort on North West Island (200 beds)	-
1996 to 2000	-	Stage 2 High Standard Resort on Lady Elliott Is.(+200 beds) Stage 2 Low Cost Resort on North West Island (+200 beds) Underwater Observatory on Wilson Island	-

GLOSSARY

All terms/words in this glossary are defined in the context in which they are used in this report.

amateur catch	That part of the total fish catch (from the Capricornia Section) that is not sold but used by the fishermen for their own purposes.
amateur fisherman	A fisherman who does not sell or trade any part of his catch. He works from a speed boat, charter boat or yacht.
avifauna	Birdlife.
beach rock	Subtidally lithified sediments. Beach rock is formed by the cementing together of calcareous sand and accumulated debris of the reef under certain physical conditions.
benthic	Living on the sea bed.
boat fishing	Fishing from a boat as opposed to spearfishing: it includes line fishing (trolling and weighted line) and trawling.
calcareous	Composed of calcium carbonate of biological origin.
cay	A sand and/or shingle island on a coral reef; it is permanently above high water.
cay rock	Supratidally lithified sediments.
clastic	Composed of broken fragments. Usually applied to coarser sedimentary particles.
commercial catch	That part of the total fish catch (from the Capricornia Section) that is sold or traded.
crustaceans	A group of animals with hard, close-fitting shells which are shed periodically. Examples are lobsters, crabs, shrimps and prawns.
demersal	Refers to fishes that live on, or adjacent to the sea bottom.
drying reef	A coral reef which emerges at low tide. Examples are Wistari Reef, Fitzroy Reef.

echinoderms	A group of marine animals which includes starfish, sea-urchins and sea-cucumbers.
effluent	Discharged waste-water.
full-time equivalent	The equivalent of one person working full-time, e.g. 2 people working 50% of the time = 1 full-time equivalent.
gastropod	A mollusc with a snail-like shell. Examples are tritons, whelks, cone shells and cowries. Prized by shell collectors.
generalized cost	The total cost of travel between two points - generally calculated as a linear combination of monetary expenses and a cost derived from the time taken to make the trip.
Great Barrier Reef Region	As defined by the Great Barrier Reef Marine Park Act, 1975. Areas within the Region may be declared as parts of the Great Barrier Reef Marine Park.
guano	Natural manure composed chiefly of seabird excrement. Guano was removed from some of these islands around the turn of the century and used as fertilizer.
human metabolic waste	Human urine and faeces.
inorganic solid waste	Waste of a non-biological origin. It is not biologically degradable - for example, bottles and tins.
invertebrates	Animals without backbones. Examples are corals, molluscs, echinoderms and crustaceans.
isobath	A line drawn on a map of oceans connecting all points having the same depth.
molluscs	A group of marine animals including forms popularly called shellfish; all have soft bodies protected in most instances by calcareous shells. Examples with shells include gastropods and scallops. Examples without shells are squid and sea-slugs.

optimum sustainable yield	The annual catch that theoretically will retain a viable adult stock for breeding and hence ensure the continuation of the fishery in perpetuity.
organic solid waste	Waste of biological origin. It is biologically degradable - for example, food scraps, paper etc.
pelagic	Refers to fishes living in the open sea, free from direct dependence on the sea bed or shore.
person-day	The presence of one person for a whole day or a substantial part of a day. It includes both visitors to and residents in the Capricornia Section.
plankton	Masses of minute plants and animals, mostly microscopic, that float on or near the surface of the sea. Plankton includes algae, larvae, eggs, protozoa etc. Many fishes, birds and other marine animals feed on plankton.
pollution	The unfavourable alteration of the environment wholly or largely as a by-product of man's actions.
predatory	Habitually preying upon other animals.
pro-amateur fisherman	A fisherman who is basically an amateur fisherman but because he sells all or part of his catch is classed as a pro-amateur. He works from a speed boat or a charter boat.
professional fisherman	A fisherman who holds a master fisherman's licence and works from a registered fishing vessel. He fishes primarily to sell his catch.
Reef	The Great Barrier Reef.
reefal shoal	A submerged coral reef which rises to within 10 to 20 m of water surface at low spring tides. Examples are Douglas Shoal and Haberfield Shoal.
rookery	A breeding place or colony of birds or turtles.
Section	Capricornia Section.
siltation	The process whereby fine particles (sand, mud etc.) carried by moving water, fall from the water column to form a sediment.

sullage	Waste-water from kitchens, showers, laundries, campsites and charter boats etc.
town planning scheme	The mechanism for statutory control and regulation of the use of land within a defined planning scheme area. In Queensland schemes are prepared and administered by local authorities in pursuance of Section 33 of the Local Government Act.
turbidity	Reduced transmission of light in water and consequent reduced underwater visibility caused by sand, mud, silt or planktonic plant cells.
visitor-day	The presence of one visitor in the Capricornia Section for a whole day or a substantial part of a day. It does not include residents in the Section.
whole fish equivalents	Fishes are landed as either whole fish or fillets. The catch can be aggregated into whole fish equivalents by adding the weight (or number) of whole fish landed to the equivalent weight (or number) of whole fish which must have been caught to produce the fillets landed.
wind rose	A diagram summarizing the frequencies of winds of different strengths and directions as measured at a specific point over an extended period of time.
zoning plan	The mechanism for statutory control and regulation of human activities within the Great Barrier Reef Marine Park. A zoning plan must be prepared in pursuance of Section 32 of the Great Barrier Reef Marine Park Act, 1975.

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