WORKSHOP ON REEF FISH ASSESSMENT AND MONITORING

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<u>C O N T E N T S</u>

GREAT BARRIER REEF MARINE PARK AUTHORITY WORKSHOP

'REEF FISH ASSESSMENT AND MONITORING'

Introduction to Workshop Objectives

The Great Barrier Reef Region contains some 2,000 species of fishes. Most of these are not unique to the region but represent approximately two-thirds of the entire fish faura of the Indo-Pacific.

The Authority considers that the single most important impact in the Great Barrier Reef Region is the effect of fishing (both recreational and commercial) and that one of the most important recreational activities for reef visitors is 'fish watching'. In view of the historical evidence in other areas of the Indo-Pacific, the Authority is concerned with managing the Great Barrier Reef's resources and minimising the impact of man's activities (as outlined in detail by Dr. Baker's introductory speech Appendix I).

The Authority invited a group of thirteen leading reef biologists to address the questions most pertinent to management or reef fish resources, namely:

- Is it possible to devise a method to adequately monitor stocks of fished reef-fish species, and how?

- Do all reefs have similar fish assemblages, and if not, how do we determine the differences; which of these assemblages warrants special protection?

- Does the Authority at present have all the necessary information for adequate management of the fish resources in the Capricornia area of the Great Barrier Reef, and if not, what additional information is necessary; how may it be obtained?

The working party successfully developed and tested:

- A technique that may be used to gather baseline data to assess the current populations of 'fished' species for zoning purposes and subsequent monitoring of the effect of management regulations.

- A technique to discriminate the differences in coral reef fish assemblages around one reef and between different reef systems as baseline data for zoning, management and monitoring.

The working party, as requested, also devised a sampling strategy for Capricornia which was considered the minimum biological input on reef fish populations necessary for rational management planning.

METHODS FOR ASSESSMENT OF CORAL REEF FISH ASSEMBLAGES

Introduction

The objective of the working group concerned with non exploited reef fishes, was to devise a rapid method of assessing such populations of fishes to answer the following questions:

- Can reef fish assemblages from different areas of the same reef be objectively characterised?
- Do reef fish assemblages differ from one reef to another within a group of reefs at approximately the same latitude (for example: Do inshore and offshore reefs of Capricornia differ?).
- Are there latitudinal differences in reef fish assemblages in the Great Barrier Reef Region?

The answer to such questions were considered by the working party to be essential for the rational zoning of reefs and delineation of marine parks from a biological viewpoint, and subsequently monitoring is expected to identify changes in the system.

The techniques adopted were dictated by the following constraints:

- that the methods should be rapidly executed and be carried out using a minimum of man power and specialised equipment;
- that the information obtained be directly relevant to management and zoning problems.

With regard to the latter, two major requirements were identified:

- the need for at least semiquantitative assessment of diversity (i.e. an assessment of the species abundance and occurrence) which could be used to obtain a comparison between assemblages;
- the need to assess localised reef areas in terms of their 'special' values.

The working party recognised a number of major difficulties in assessing whole assemblages of reef fishes, and these are:

- The sheer diversity of species. There are some 2,000 species of reef fishes in the Great Barrier Reef Region (as compared to less than 400 species of coral).

- The small size and cryptic habit of many species, and the enormous numbers in which they occur.

- The mobility of many species, and patchy distribution.

Bearing these factors in mind the working party considered their approach to the method.

Methods

Available methods of assessing reef fish assemblages (see Table 1) were examined (Russell *et al* 1978, Jones and Thompson 1978, Summerhays m.s.).

TABLE 1

Possible methods of assessing reef fish assemblages

Method	Advantages	Disadvantages
Quantative explosive	Precise estimates of nos. of spp. abundances, and sizes at wt's	Time consuming, destructive
Poison (rotenone) station	Gives good collections	Hard to delineate area of samples. Time consuming, destructive.
Underwater T.V. or film	No diver disturbance on remote method.	Resolution depend on visibility & terrain, inapplicable to small fishes. Expensive complex technology.
Visual transects (quantitative) counts	Moderately accurate	Problems of sp. identification. Very time consuming in rich areas. Problems with small numerous reef fishes.
Free-swimming visual (Semi-quantitative assessment)	Rapid, moderately accurate	Problems of identification and small bottom living fishes difficult to assess.

It was considered by the working group that such methods were unsuitable, because they either did not meet the requirements of large scale surveys, or were inapplicable in areas of high diversity. A modified semi-quantitative method of assessing reef fish assemblages was therefore considered most appropriate, by limiting the number of species to a 'core group'. Techniques developed by recording species observed along a fixed transect (Brock 1954), or in a fixed swim duration (Jones and Thompson 1978, Summerhays m.s.) were assessed, but due to the problems of identifying and counting such fishes in areas of high diversity even in a small area it was decided to restrict the list to selected species.

The species in Table 2 were chosen from species lists from One Tree Island and Lizard Island prepared by the Australian Museum using the following criteria:

- ease of identification underwater;
- their non-cryptic behaviour and ease of counting;
- their characteristic association with particular coral reef habitats;
- visually dominant species;
- widespread distribution in some regions of the Great Barrier Reef;
- restriction to certain parts of the Great Barrier Reef.

Where possible, whole groups of congenerics were included, because it is easier for the observer to remember and record all members of few genera rather than a few members of many genera. Secondly, because congenerics might also be expected to show habitat segregation on some scale. The list is considered to provide a basis of comparing fish assemblages in the Great Barrier Reef Region.

TABLE 2

ASSESSMENT OF CORAL REEF FISH ASSEMBLAGES - 'THE LOOKERS'

A. Species List

CHAETODONTIDAE:

Chaetodon aureofasciatus
C. auriga
C. chrysurus
C. citrinellus
C. ephippium
C. ulietensis
C. flavirostris
C. kleini
C. lineolatus

CHAETODONTIDAE (CONT).

C. lunula
C. melanotus
C. ornatissimus
C. pelewensis/punctatofasciatus
C. plebeius
C. rainfordi
C. semeion
C. speculum
C. trifascialis

TABLE 2 (CONT).

CHAETODONTIDAE (CONT).

Chaetodon trifasciatus
C. unimaculatus
C. vagabundus
C. bennetti
C. mertensi
C. rafflesi
C. reticulatus
C. baronessa
C. meyeri
Chelmon rostratus
C. morginalis
Forcipiger longirostris
F. flavissimus
Hemitaurichthys polylepis
Coradion altivelis
C. chrysozonus

ACANTHURIDAE

Naso unicornis
N. lituratus
N. annulatus
N. brevirostris
N. vlamingii
N. tuberosus
Zanclus canescens
Zebrasoma scopas
Z. flavescens
Z. veliferum
Acanthurus lineatus
A. dussumieri
A. hepatus
A. olivaceous
A. pyroferus
A. triostegus
A. glaucopareius
A. gahm/mata/xanthopterus

SIGANIDAE

Lo vulpinus
Siganus doliatus
S. puellus
S. lineatus
S. corallinus

LABRIDAE

Epibulus insidiator
Gomphosus varius
Lienardiella fasciata
Thalassoma amblycephalus
T. lunare
T. hardwicki
T. janseni
Thalassoma lutescens
Halichoeres centriquadrus
H. trimaculatus
Hemigymnus fasciatus
H. melapterus
Coris variegata *
C. gaimard
C. aygula

POMACENTRIDAE

Acanthochromis polyacanthus
Abudefduf coelestinus
A. whitleyi
A. saxatilus
A. sordidus
A. bengalensis
Chromis atripectoralis
C. caeruleus
C. atripes
C. lepidolepis
C. weberi (=opercularis)
C. nitida
C. retrofasciata
C. ternatensis

* Due to the difficulty in censusing this species and its ubiquitous habits, it is suggested that this species be dropped from future lists.

TABLE 2 (CONT).

POMACENTRIDAE (CONT.)

Dascyllus reticulatus
D. aruanus
D. trimaculatus
D. melanurus
Glyphidodontops cyaneus
G. rex
G. talboti
G. flavipinnis
G. rollandi
G. biocellatus

POMACENTRIDAE (CONT.)

Neopomacentrus azysron
N. cyanamos
N. anabatoides
Pomacentrus amboinensis
P. australis
P. pavo
P. moluccensis (=popei)
P. coelestis
P. lepidogenys

TABLE 2B

ADDITIONAL SPECIES SUGGESTED FOR THE 'LOOKERS' LIST

MULLIDAE

Mulloidichthys samoensis
M. auriflamma
Parupeneus barbarinus
P. barbarinoides
P. bifasciatus
P. trifasciatus
P. indicus
P. porphyreus

SERRANIDAE

Anthias squamipinnis
Mirolabrichthys tuka

GOBIIDAE

Valenciennes longipinnis
V. strigatus
Ptereleotris evides
P. microlepis

POMACENTRIDAE

Amblyglyphidodon aureus
A. curacao
A. leucogaster
Chromis iomelas

POMACENTRIDAE (CONT.)

Chromis margaritifer
C. lineata
C. vanderbilti
C. xanthura
Dischistodus perspicillatus
P. pseudochrysopocoelius
Paraglyphiododon melas (=melanopus)
P. nigrosis (=behni)
Plectroglyphidodon dickii
P. johnstonianus
Pomacentrus 'melanochir'
P. brachialis (=melonopterus)

LABRIDAE

Cheilinus chlorurus
C. diagrammus
C. fasciatus
C. trilobatus
Choerodon anchorago
C. schoenleini
C. venustus
C. transversalis
C. albigena
Cirrhilabrus temmincki

Assessment of Abundance

Having chosen a restricted list of species, a compromise between presence/absence data and counting all individuals in an areas was obtained. Using quantitative data obtained from explosive stations at Yonge Reef, a system of semi-quantitative abundance ranking were applied using different logarithmic abundance classes for which Log_5 was considered most applicable; this proved in practice both manageable and desirable (Table 3).

TABLE 3

Effect of using different abundance classes on explosive station samples from Yonge Reef.

Raw Data

Species	Sample No. 1	2	3	4	5		Rank	Rank Σxn	Rank Log_3 Σxn	Rank Log_5 Σxn
Acanthochromis polyacanthus	18	22	4	19	19	82	3	2	1.5	1.5
Glyphidodontops rollandi	5	Ø	Ø	Ø	Ø	5	6	6	6	6
Amblyglyphidodon lacrymatus	25	15	Ø	1	39	80	4	4	5	3
Pomacentrus amboinensis	5	17	1	23	1	47	5	5	4	5
Chromis atripes	17	25	1Ø	48	0	100	2	3	3	4
Chromis ternatensis	1	101	4	50	15	171	1	1	1.5	1.5

Abundance Intervals

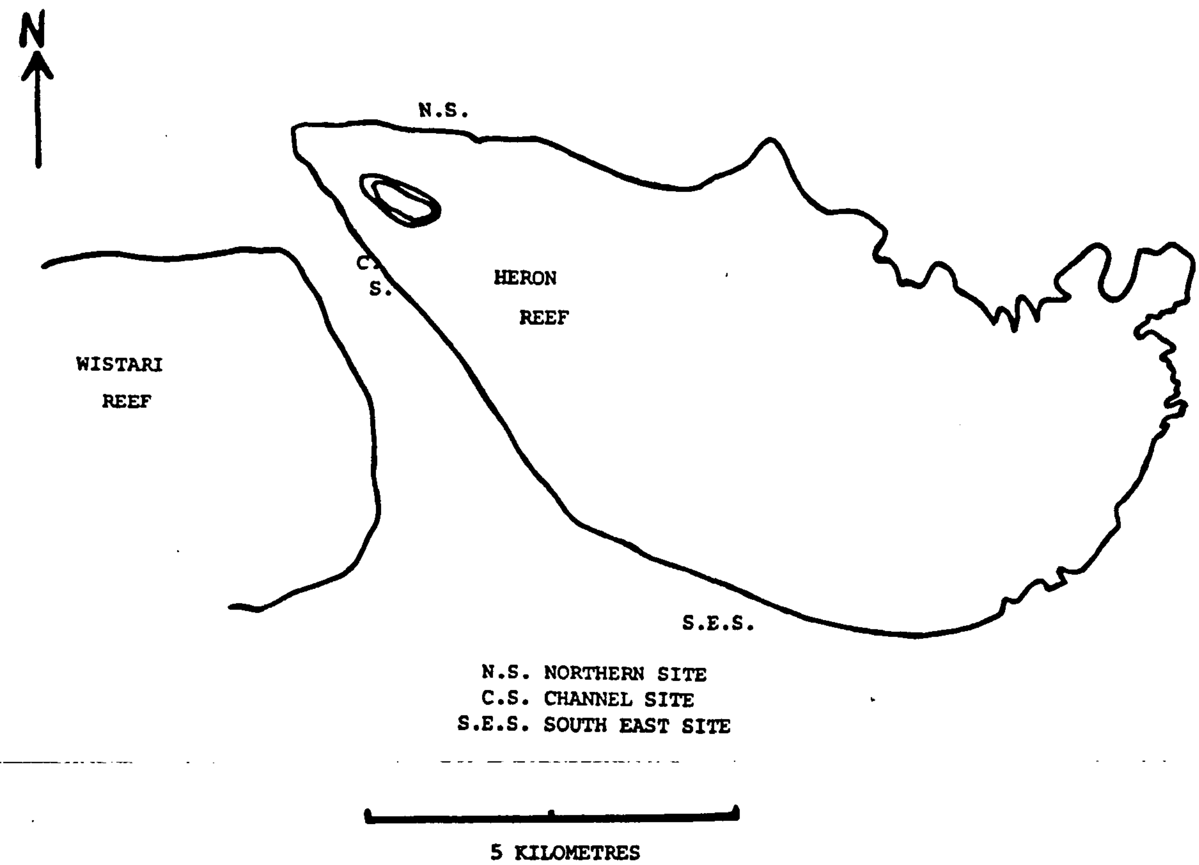
Abundance Classes

Log bases	1	2	3	4	5	6	7
Log_3	1	2-3	4-9	10-27	28-81	81-243	244
Log_5	1	2-5	6-25	26-125	126-625	626-3125	>3126

Sampling Methods and Sites

The working group considered that for the initial survey, sampling would be carried out in the outer reef slopes at Heron Island reef from the crest to a maximum depth of 40 feet (dictated by constraints of physiological factors affecting observers on multiple dives). Initially, two relatively similar sites were chosen on the northern and channel faces of Heron Reef. Subsequently samples were also taken on the south-east aspect of the reef slope (see Fig. 1). A zig-zag pattern of search up and down the reef slope in oblique transects of ten metres width was adopted; those species present were noted and their abundance classed.

Fig. 1 - MAP OF HERON REEF SHOWING SAMPLING SITES CHOSEN FOR REEF FISH ASSEMBLAGE TESTING



Assessment of reef areas for visual value

Selected species (see Table 4) whose presence in a locality made it particularly appealing to snorkellers and skin divers etc., and which added to the overall 'impact' of an area would also be recorded.

TABLE 4

AESTHETIC APPEAL RATING

The families and species listed below provide an index of aesthetic appeal used in conjunction with the 'Reef Fish Assemblage' sampling techniques. Both are listed by the observer at the end of each 'Reef Fish Assemblage' sample and scored on a three point scale.

Exceptional Events	Appeal Value
Mantas	Serranids
Sharks	Fistularids
Giant Gropers	Aulostomids
Dolphins	Anthiids
Dugongs	Scorpaenids
Large Pelagic's	Pomacanthids
Turtles	Lutjanids
	Amphiprions
	Scarids
	Caesioids
	Ostraciontids

Listed on a scale: -

1	2	3
Rare	Abundant	Common

At the end of each sampling period, these species would be noted as 'rare', 'common' or 'abundant'. Areas of special topographic or other v.sual interest would also be noted. This information, in addition to the quantitative assessment of the fish assemblages, would be of value in the overall zoning and planning decision.

RESULTS

Initially, the method was tested to evaluate a time base, using presence/absence data only, and species-time counts graph constructed (Fig. 2). On the basis of this evidence, where an asymptote is reached after 40 minutes, a sample time of 45 minutes was identified.

Between site cumulative species were polotted against replicate number, in order to determine the necessary number of replicate samples at any one station. From these results (Figure 2) it was found the 95% of those species present on the list had been noted during five subsamples. Therefore it was considered that five subsamples should be used at each station.

FIGURE 2

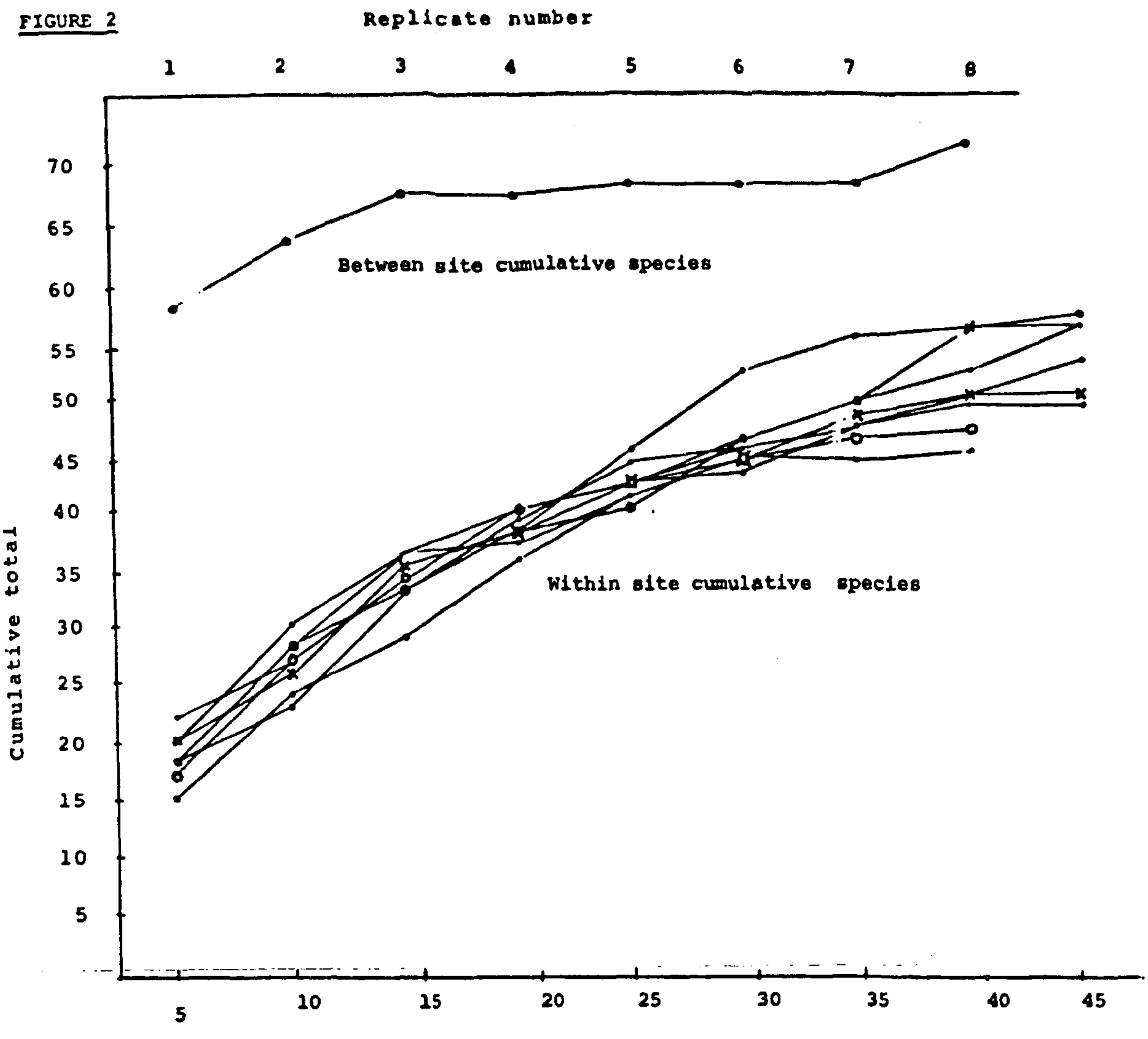


FIGURE 2

To test the feasibility of this method two sites were chosen for comparison, on the northern side of Heron Reef and the rather atypical situation on the southern side on the Heron-Wistari channel. Two sets of five replicates were obtained on the northern side, and one set of five replicates from the channel side (results shown in Tables 5, 6, 7) which allowed comparison with the northern face habitat and between the north and south face habitats. Wilcoxon matched pairs, signed ranks test, and Spearman rank correlation co-efficients were used in the comparison (Table 8). The Wilcoxon matched pairs, signed ranks test showed that the two samples from the north face of Heron Reef were not significantly different ($p > .18$) and the Spearman rank correlation tests gave a highly significant correlation ($r_s = 0.88$ $p < .001$). Comparing the north face with the channel, the Spearman rank correlation gave a value of $r_s = 0.58$ which is also highly significant ($p < .001$) but less well correlated than the two north face samples.

TABLE 5

HERON ISLAND - NORTH FACE - 24.11.78 - 27.11.78

	24/11			27/11				
Species	BR	GS	HS	GA	GA		Occ.	Rank
Chaetodon aureofasciatus	2	2	2	4	3	13	65	18.5
C. auriga			1		1	2	4	61.5
C. citrinellus		3	2	3	2	10	40	36.5
C. ulietensis	2					2	2	65
C. flavirostris	2	3	3	3	2	14	70	16
C. kleini	1		3	3		7	21	44
C. lineolatus		1		2	1	4	12	51
C. melanotus	2	2	3	2		9	36	38
C. ornatissimus			2			2	2	65
C. pelewensis/punctatofasciatus		2		2		4	8	57.5
C. plebeius	3	3	1	3	2	12	60	22.5
C. rainfordi	4	3	4	4	5	20	100	10
C. speculum	1	1			1	3	9	54
C. trifascialis	2	2	4	3	1	12	60	22.5
C. trifasciatus	2	2		3	3	10	40	36.5
C. unimaculatus	2	1	2	2		7	28	41
C. vagabundus	2		2	2		6	18	46.5
C. baronnessa	2	2	2		2	8	32	40
Chelmon rostratus	2	2	1	1	1	7	35	39
Forcipiger flavissimus			2	2	2	6	18	46.5
Coradion chrysozonus	1			1	1	3	9	54
Naso unicornis	2	2	3	3	2	12	60	22.5
N. brevirostris	2	2			1	5	15	48.5
N. annulatus					1	1	1	69
N. tuberosus	2	2				4	8	57.5
Zanclus canescens	2	2	3	2	3	12	60	22.5
Zebrazoma scopas	2	3	3	3	4	15	75	14
Z. veliferum				2	2	4	8	57.5

TABLE 5 (CONT)

Species	BR	GS	HS	GA	GA		Occ.	Rank
		24/11			27/11			
Acanthurus dussumieri		2				2	2	65
A. gahm (group)		1			3	4	8	57.5
A. lineatus		1				1	1	69
Siganus doliatus	2	2	3	2	2	11	55	28
S. puellus		1				1	1	69
S. lineatus					3	3	3	63
S. corallinus	1	2			2	5	15	48.5
Epibulus insidiator	1	2	1	2		6	24	43
Gomphosus varius	2	3	3	3	4	15	75	14
Lienardella fasciatus	3	1	3	3	3	13	65	18.5
Thalassoma amblycephalus	4	3	4		1	12	48	32.5
T. lunare	4	3	6	6	6	23	115	7.5
T. hardwicki	4	3	2	3		12	48	52.5
T. janseni	3	2	2	2	2	11	55	28
T. lutescens	4	3	4	3	3	17	85	12
Halichoeres centriquadrus	3	2	3	3	2	13	65	18.5
Hemigymnus fasciatus	3	3	4	3	2	15	75	14
H. melapterus	3	3	4	4		14	56	25.5
Coris variegata	3	2	4		4	13	52	30.5
C. gaimardi		1	1		1	3	9	54
C. aygula	1	1	2		1	5	20	45
Acanthochromis polyacanthus	4	4	4	4	3	19	95	11
Abedufduf coelestinus	2	1	2	4	2	11	55	28
A. whitleyi	5	5	5	6	3	24	120	5.5
A. saxatilus	3			4	2	9	27	42
Chromis atripectoralis	3	5	5	4	5	22	110	9
C. caeruleus		1	5			6	12	51
C. atripes	1	1	2			4	12	51
C. weberi			5			5	5	60
C. nitida	6	6	6	6	6	30	150	1
C. retrofasciatus	1	1				2	4	61.5
Dascyllus reticulatus		2	5	4	3	14	56	25.5
Glyphidodontops rex	1					1	1	69
G. talboti	4	2	1	3	3	13	65	18.5
G. flavipinnis	2	3	5		3	13	52	30.5
G. rollandi	4	1	4		2	11	44	34.5
Neopomacentrus azysron	6	5	6	6	4	27	135	3.5
Pomacentrus amboinensis	5	4	5	5	4	23	115	7.5
P. australis		2	2	3	4	11	44	39.5

TABLE 5 (CONT).

Species	BR	GS	HS	GA	GA		Occ.	Rank
Pomacentrus pavo				1		1	1	69
P. molluccensis	5	5	6	6	5	27	135	3.5
P. coelestis	5	5	6	6	6	28	140	2
P. lepidogenys	5	5	5	5	4	24	120	5.5

NORTH FACE NOT LISTED PREVIOUSLY (25/11/78 - 27/11/78)

Chaetodon ephippium
Naso lituratus
Acanthurus pyroferus
Chromis ternatensis
Dascyllus trimaculatus

TABLE 6

HERON ISLAND - NORTH FACE - 25.11.78 - 27.11.78

Species	BR	GS	HS	GA	BR		Occ.	Rank
Chaetodon aureofasciatus	2	2	3	2	1	10	50	38.5
C. auriga		2	2			4	8	56
C. citrinellus	2	2	3	3	3	13	65	27.5
C. ephippium			1			1	1	66.5
C. ulietensis		2				2	2	63.5
C. flavirostris	2	3	3	4	3	15	75	19
C. kleini	1		3	2		6	18	51
C. lineolatus	2	2	2	3	2	11	55	35
C. melanotus	2	2	4	2	3	13	65	27.5
C. pelewensis/punctatofasciatus				1	2	3	6	59
C. plebeius	3	3	2	3	3	14	70	22.5
C. rainfordi	4	4	4	5	4	19	95	9.5
C. speculum	1		2	1	1	5	20	49.5
C. trifascialis	2	2	4	3	2	13	65	27.5
C. trifasciatus	3	3	2	3	2	15	65	27.5
C. unimaculatus	2		2	3	2	9	36	44
C. vagabundus			1			1	1	66.5
C. baronnessa	2		2	3	2	9	36	44
Chelmon rostratus	2	3	2	2	2	11	55	35
Forcipiger flavissimus	2	2	2		2	8	32	46.5
Coradion chrysozonus		1	1			2	4	61.5

TABLE 6 (CONT).

	BR	GS	HS	GA	BR		Occ.	Rank
Naso unicornis	2	3	3	3	3	14	70	22.5
N. lituratus		1	1	1	2	5	20	49.5
N. annulatus	2					2	2	63.5
N. brevirostris	3	2	3			8	24	48
N. tuberosus	3	2	2	3	2	12	60	32
Zanclus canescens	2	3	2	3	3	13	65	27.5
Zebrazoma scopas	3	3	4	3	4	17	85	15
Z. veliferum	2				2	4	8	56
Acanthurus dussumieri			1	2		3	6	59
A. pyroferus			1			1	1	66.5
A. gahm (group)	3	2	3	3	3	14	70	22.5
Siganus doliatus	2	2	2	2	2	10	50	38.5
S. puellus		2	1			3	6	59
S. corallinus	2		2	2	2	8	32	46.5
Epibulus insidiator				2	2	4	8	56
Gomphosus varius	2	3	3	3	3	14	70	22.5
Leinardella fasciatus	3	2	2	4	1	12	60	32
Thalassoma amblycephalus	2	3	4	3	5	17	85	15
T. lunare	5	4	5	4	5	23	115	7.5
T. hardwicki	3	3	2	2	3	13	65	27.5
T. janseni	2	2	1	2	3	10	50	38.5
T. lutescens	4	4	4	4	3	19	95	9.5
Halichoeres centriquadrus	2	3	2	2	2	11	55	35
Hemigymnus fasciatus	3	3	4	3	4	17	85	15
H. melapterus	3	3	4	3	4	17	85	15
Coris variegata	4	3	4	3	4	18	90	11.5
C. gaimardi			2	1	1	4	12	52.5
C. aygula		1		1	2	4	12	52.5
Acanthochromis polyacanthus	3	3	3	4	3	16	80	18
Abedufduf coelestinus	4	3	2	1	2	12	60	32
A. whitleyi	6	5	6	6	6	29	145	3
A. saxatilus	2	2	2	3		9	36	44
Chromis atripectoralis	6	5		3	4	18	72	20
C. weberi	1		4			5	10	54
C. nitida	6	6	6	6	6	30	150	1.5
C. ternatensis		1				1	1	66.5

TABLE 6 (CONT).

	BR	GS	HS	GA	BR		Occ.	Rank
Dascyllus reticulatus	3	2	5	3	4	17	85	15
D. trimaculatus			1		1	2	4	61.5
Glyphidodontops talboti	2	1	4	1	2	10	50	58.5
G. flavipinnis	4	3	5	3	3	18	90	11.5
G. rollandi	2		4	3	3	12	48	41.5
Neopomacentrus azysron	6	6	6	6	6	30	150	1.5
Pomacentrus amboinensis	4	4	5	5	5	23	115	7.5
P. australis	2		4	3	3	12	48	41.5
P. moluccensis	5	5	5	5	5	25	125	5.5
P. coelestis	5	5	6	5	6	27	135	4
P. lepidogenys	6	5	4	5	5	25	125	5.5

SPECIES (NORTH FACE) 24 & 27.11.78 NOT IN LIST ABOVE

Chaetodon ornatissimus
Acanthurus lineatus
Chromis caeruleus
C. atripes
C. retrofasciatus
Glyphidodontops rex
Pomacentrus pavo

TABLE 7

HERON ISLAND CHANNEL - SATURDAY 25.11.78 & MONDAY 27.11.78 (1 dive)

	BR	GS	HS	GA	BR			Rank
Chaetodon aureofasciatus	4	4	4	4	4	20	100	10.5
C. auriga	2	1		2	1	6	24	43.5
C. ephippium		2				2	2	66
C. ulietensis	3		1	1	2	7	28	40.5
C. flavirostris	4	2	3	3	3	15	75	20.5
C. kleini		2				2	2	66
C. lineolatus	3	2	2	3	2	12	60	31.5
C. melanotus	3	3	4	2	3	15	75	20.5
C. ornatissimus	1				2	3	6	59
C. pelewensis/punctatofasciatus		2	1			3	6	59
C. plebeius	4	4	4	3	4	19	95	14
C. rainfordi	4	4	4	3	4	19	95	14

TABLE 7 (CONT.)

Series	BR	GS	HS	GA	BR			Rank
Chaetodon speculum	2				2	4	8	56
C. trifascialis	2			3	3	8	24	43.5
C. trifasciatus	3	3	4	4	4	18	90	16
C. unimaculatus	2		2		2	6	18	49
C. vagabundus	2					2	2	66
C. bennetti		1	1		2		4	62
C. baronnessa	3	2	2	3	3	13	65	27.5
Chelmon rostratus	3	3	3	2	2	13	65	27.5
Forcipiger flavissimus	2		2		2	6	18	49
Coradion chrysozonus	3	1	2	1	2	9	45	35.5
Naso unicornis	4	4	4	3	4	19	95	14
N. lituratus	2	2	2	1		7	28	40.5
N. brevirostris	2		2	2		6	18	49
N. tuberosus	2	4	2	1	3	12	60	31.5
Zanclus canescens	3	2	3	2	3	13	65	27.5
Zebrazoma scopas	3	3	3	2	4	15	75	20.5
Z. veliferum	3	3	3	3	3	15	75	20.5
Acanthurus gahm (group)	2	2		1		5	15	51
Lo vulpinus	3	3	3	3	3	15	75	20.5
Siganus doliatus	2	2				4	8	56
S. puellus	3	3	2	1	2	11	55	34
S. corallinus	2	2	3	2	3	12	60	31.5
Epibulus insidiator	3	2	2	3	3	13	65	27.5
Gomphosus varius	2	2	1	1	2	8	40	38.5
Leinardella fasciatus	2	1	3	3	3	12	60	31.5
Thalassoma amblycephalus				2	3	5	10	54
T. lunare	5	3	4	4	4	20	100	10.5
T. hardwicki	2	2				4	8	56
T. janseni	1		2	1	1	5	20	47
T. lutescens	2	2	1	2	2	9	45	35.5
Holichoeres centriquadrus			2			2	2	66
Hemigymnus fasciatus	4	3	4	3	3	17	85	17
H. melapterus	4	4	4	4	4	20	100	10.5
Coris variegata	3	4	2		2	11	44	37
C. gaimardi	2		1			3	6	59
C. aygula		1	1			2	4	62
Acanthochromis polyacanthus		3	2	2	3	10	40	38.5
Abedufduf whitleyi	5	5	6	6	5	27	135	5

TABLE 7 (CONT).

Series	BR	GS	HS	GA	BR			Rank
Abedufduf coelestinus		4	2		1	7	21	45.5
A. saxatilis	1		1			2	4	62
Chromis atripectoralis	6	6	6	6	6	30	150	2.5
C. caeruleus			5	2		7	14	52
C. nitida	6	6	6	6	6	30	150	2.5
C. ternatensis	4	5	6	4	6	25	125	7
D. reticulatus	2	3	3	3	3	14	70	24.5
D. aruanus	2		2		3	7	21	45.5
D. trimaculatus	2					2	2	66
Glyphidodontops talboti		1	1		2	4	12	53
G. flavipinnis		2		4	3	9	27	42
G. rollandi	5	3	3	5	4	20	100	10.5
Neopomacentrus azysron	6	6	6	6	6	30	150	2.5
Pomacentrus amboinensis	5	5	6	5	5	26	130	6
P. australis	5	2		5	3	15	75	20.5
P. moluccensis	6	6	6	6	6	30	150	2.5
P. coelestis		4	2	3	5	14	70	24.5
P. lepidogenys	5	4	4	4	5	22	110	8

TABLE 8

COMPARISON OF DATA FROM TABLES 5, 6, 7

SPEARMAN RANK ANALYSIS

(1) x (2) Spearman $r_s = 0.88$ $p < 0.001$ highly significant

(2) x (3) Spearman $r_s = 0.58$ < 0.001 highly significant

N.B. Correlation between (2) x (3) while highly significant is less than within habitat comparison of (1) x (2).

WILCOXON MATCHED-PAIRS SIGNED RANKS TEST

(1) x (2) = −0.895 $p > .18$ not significantly different

∴ The two sets of replicates do not differ significantly in rankings of abundance and occurrence.

WHERE:

(1) - Heron Island Census North Face, 5 replicates (4 on 24.11.78 + 1 on 27.11.78).

(2) - Heron Island Census North Face, 5 replicates (4 on 25.11.78 + 1 on 27.11.78)

(3) - Heron Island Census Channel, 5 replicates (4 on 25.11.78 + 1 on 27.11.78).

In addition to the northern and southern sites at Heron Island reef, five samples were taken at a station 1,000 metres from the southern tip of the reef on the S.E. side on December 1 1978 (Table 9). These samples were compared with northern and southern sites using *Simple Matching Coefficients* (Sokal and Sneath 1963) which utilises only presence or absence information and, *Morisita's Index of Overlap* as modified by Horn (1966). This method of analysis compares the similarity between two habitats with respect of the distribution of individuals among the species present. With both these indices the minimum and maximum values are 0 and 1 respectively; the higher the value, the greater the similarity between the faunas of any two habitats. (See Table 10A and 10B). In terms of both species presence/absence (Table 10A) and the respective abundance of these species (Table 10B) it can be seen that the fish fauna of the *South-East Face* is substantially less similar to the *channel* fauna than to the *Northern Face* fauna.

TABLE 9	Observer			Observer	
SOUTH EAST FACE	G. Stroud			S. Summerhays	
Sample No.	1	2	3	4	5
Chaetodon aureofasciatus	2				1
C. auriga	1	3	2		2
C. chrysurus					
C. citrinellus		2			
C. ephippium					
C. ulietensis					
C. flavirostris	3	3	3	3	3
C. kleini	2	2	2		2
C. lineolatus	2		2		3
C. lunula					
C. melanotus	2	3	3	3	3
C. ornatissimus					
C. pelewensis/punctatofasciatus	1	2		2	
C. plebeius	1	2	2	3	2
C. rainfordi	2	3	4		3
C. semeion					
C. speculum			1		
C. trifascialis		1		1	
C. trifasciatus	2		2		2
C. unimaculatus	1	2		2	2
C. vagabundus	1		2		2
C. bennetti					
C. mertensi	2				

TABLE 9 (CONT.)	Observer G. Stroud			Observer S. Summerhays	
Sample No.	1	2	3	4	5
Chaetodon rafflesi					
C. reticulatus					
C. baronessa				2	
C. meyeri					
Chelmon rostratus	2	2	2	3	2
C. marginalis					
Forcipiger longirostris					
F. flavissimus		2			1
Hemitaurichthys polyepis					
Coradion altivelis					
Coradion chrysozonus	2		1		
Naso unicornis	2	3	3	2	3
N. lituratus			1		
N. annulatus	2				
N. brevirostris		3	3	3	3
N. vlamingii					
N. tuberosus	2			3	
Zanclus canescens		2	3	3	
Zebrazoma scopas			2		2
Z. flavescens					
Z. veliferum			1		2
Acanthurus lineatus					
A. dussumieri	2	2	2		
A. hepatus					
A. olivaceous	2				
A. pyroferus					
A. triostegus			2		
A. glaucoparieus	2				
A. gahm/mata/xanthopterus	2	3	3	3	3
SIGANIDAE					
Lo vulpinus		2			
Siganus doliatus		2		2	
S. puellus					2
S. lineatus	2				
S. corallinus	1	2	2	3	2

TABLE 9 (CONT.)

	Observer G. Stroud			Observer S. Summerhays	
Sample No.	1	2	3	4	5
LABRIDAE					
Epibulus insidiator	3				
Gomphosus varius	2	2	1	1	3
Lienardiella fasciata	2				1
Thalassoma amblycephalus	2		4		2
T. lunare		3	4	3	4
T. hardwicki		2	3	3	2
T. janseni	3	2	3		
Thalassoma lutescens	3	3	3	4	3
Halichoeres centriquadrus	2	2	2	3	2
H. trimaculatus					
Hemigymnus fasciatus	2	3	3	3	4
H. melapterus	2	3	3	4	4
Coris variegata		2	3		
C. gaimard					
C. aygula		1			
POMACENTRIDAE					
Acanthochromis polyacanthus		2	2	4	4
Abudefduf coelestinus		1	2		2
A. whitleyi		3	4	2	5
A. saxatilus				1	
A. sordidus					
A. bengalensis					
Chromis atripectoralis	5				
C. caeruleus				1	
C. atripes					
C. lepidolepis					
C. weberi (=opercularis)			2		2
C. nitida		6	5	6	6
C. retrofasciata				1	
C. ternatensis					
Dascyllus reticulatus	2	2	2	3	3
D. aruanus					
D. trimaculatus				1	
D. melanurus	2				
Glyphidodontops cyaneus			1		

TABLE 9 (CONT.)

	Observer G. Stroud			Observer S. Summerhays	
Sample No.	1	2	3	4	5
POMACENTRIDAE (CONT.)					
Glyphidodontops rex	5	2	2		2
G. talboti					
G. flavipinnis					
G. rollandi	4	3	3	4	3
G. biocellatus					
ADDITIONAL SPECIES					
MULLIDAE					
Mulloidichthys samoensis					
M. auriflamma					
Parupeneus barbarinus					
P. barbarinoides					
P. bifasciatus					
P. trifasciatus					
P. indicus					
P. porphyreus					
SERRANIDAE					
Anthias squamipinnis					
Mirolabrichthys tuka					
GOBIIDAE					
Valenciennes longipinnis	2				
V. strigatus					
Ptereleotris evides		3		3	4
P. microlepis				2	
POMACENTRIDAE					
Amblyglyphidodon aureus					
A. curacao		2	2	1	
A. leucogaster					
Chromis iomelas	3				
C. margaritifer					
C. lineata	1				
C. vanderbilti					
C. xanthura					

TABLE 9 (CONT.)

Sample No.	Observer G. Stroud 1	2	3	Observer S. Summerhays 4	5
POMACENTRIDAE (CONT.)					
Dischistodus perspicillatus					
Pomacentrus pseudochrysopocoelius					
Paraglyphidodon melas (=melanopus)			2	1	2
P. nigrosis (=behni)					
Plectroglyphidodon dickii					1
P. johnstonianus					
Pomacentrus "melanochir"		2		2	1
P. brachialis (=melonopterus)	4	3			
Dischistodus prosopotaenia	2				
Neopomacentrus azysron		5	5	5	6
N. cyanamos					
N. anabatoides					
Pomacentrus amboinensis	5	4	4	3	3
P. australis		2	1		
P. pavo	2			1	
P. moluccensis (=popei)		5	5	5	5
P. coelestis		6	6	6	6
P. lepidogenys		5	5	5	5
LABRIDAE					
Cheilinus chlorurus		2	2	3	2
C. diagrammus		2	2		
C. fasciatus	2				
C. trilobatus	1		1		
Choerodon anchorago	4				
C. schoenleini		1			
C. venustus	3				
C. transversalis		3	3	3	3
C. albigena	4		1		1
Cirrhilabrus temmincki		5	4	5	4

TABLE 10

MEASURES OF SIMILARITY BETWEEN HABITAT-CHARACTERISTIC FAUNAS

TABLE 10a

Simple matching coefficients of association (MC)

Location	Channel	Northern Face*	South-east Face
Channel	-	0.79	0.76
North. Face	-	-	0.86

Table 10b

Morisita's indices of overlap (MO)

Location	Channel	Northern Face*	South-east Face
Channel	-	0.86	0.74
North. Face	-	-	0.81

* 24, 27.11.78 sample

This suggests that while there are grounds for distinguishing such assemblages, the methods need to be refined. Such modifications as adding a seventh abundance class may resolve very abundant species. Additional species to the proforma list (Table 2B) may give more chance of detecting differences, and with experience some species may be eliminated.

In place of Spearman Rank statistical analysis, the above data are amenable to taxonometric analysis such as *Clustan and Taxon* which provide a classification of sites based on their similarity. The use of these types of analytical techniques have been advocated for selecting and allocating terrestrial areas for nature conservation purposes in Australia (Webb *et al* 1973).

Conclusions and Recommendations

A number of available censusing techniques were considered by the working group, none of which were fully applicable to the constraints of such a diverse system as the Great Barrier Reef. A modified Rapid Visual Technique was chosen as being most suitable in terms of the speed with which it may be conducted; the minimum requirement of equipment and manpower, and the adequate biological information which may be obtained for management planners of the Great Barrier Reef Marine Park.

A semi-quantitative method of assessing reef fish assemblages was adopted based on a proforma list of species chosen on the following basis:

- Ease of identification and non-cryptic habit.
- Characteristic association with particular reef types.
- Their visual dominance.
- Their widespread, or restricted geographic distribution.

The initial list drawn up was considered by the working party to have value, as collective 'indicators' of different biological or environmental conditions. However, such is the present inadequacy of our knowledge on reef fish assemblages and the factors affecting them, that the eventual listing which will be progressively developed may include as many as 200 species. Despite such a large number of species on the list, only 60-70 would be expected to occur in any sample.

The sampling technique devised was a compromise between such constraints as: time available to carry out a major survey, safe working limits for divers, and the minimum adequate biological information upon which to base rational planning of park usage.

It is recommended that in areas of heavy human impact, an adequate system of sampling reef fish assemblages is set up as baseline information for park planning, zoning and monitoring. The working party has formulated such a proposal for Capricornia on the Great Barrier Reef.

When planning a survey it is recommended the objectives be carefully identified. In delineation of marine parks, random spot checks in the area proposed using the reef fish assemblage technique will provide some indication of the comparative aspects of the fish fauna within the Great Barrier Reef Region.

A second stage in the development of a marine park is the zoning procedure, for which baseline information on the nature of the biological resource is obtained. In regions most heavily used surveys may have to be conducted on the most important reefs. In addition it is recommended that such surveys are also conducted on reefs strategically placed in terms of their expected faunal assemblages. Subsequent monitoring of reefs should be continued to assess what changes may be caused by human impact.

Each reef should be surveyed on the outer reef slopes in all the major habitat zones. It is expected that about 4-5 stations at each reef would provide adequate information for the above purposes. Each station should be sampled five times at adjacent sites in order to even out the patchiness in distribution of fishes, and to account for approximately 95% of the species present on the proforma list.

Such a sampling strategy should provide the Great Barrier Reef Marine Park Authority with sufficient information to make an adequate assessment of the biological resources and consequently, an ability to control human impact on that resource in a rational manner.

Summary

- The working party was able to develop a reliable rapid method for sampling and analysing reef fish assemblages by trained observers.

- Insufficient is known about coral reef fish assemblages at the moment to isolate individual so called 'indicator' species.

- The method of sampling was standardised using a number of tests, but it was concluded that the initial species listing will be progressively refined as it is tested in different parts of the Great Barrier Reef Region in the future.

- It was conceived that the assemblages identified using this technique might be limited to coral assemblages, which may facilitate easier sampling in the future.

- It is believed that interpretation of the results collected in this way will enable marine park planners to identify areas such as adult spawning grounds, nursery areas, critical marine habitats (sensu Carlton Ray 1975). 'unique' sites or areas of particular scientific importance.

Summary of Technique

1. Sampling sites are selected on the basis of morphological or biological characteristics of the reef.

2. Each site is sampled five times at adjacent stations.

3. Observers note the species occurring in their sample site, that are included on their species list.

4. A zigzag pattern of search is made from the reef crest to a depth of 12m. along the reef slopes.

5. Sampling continues for 45 minutes.

6. The observations are made over a 10m. transect width and numbers of each species estimated progressively on Log_5 abundance ratings.

7. Aesthetic appeal ratings and exceptional events are recorded at the end of each sample.

8. The data is classified according to taxometric analysis packages like *Clustan* or *Taxon*, and different sites compared.

METHODS OF ASSESSMENT OF 'FISHED' REEF FISH POPULATIONS

Introduction

The Great Barrier Reef Marine Park Authority has a responsibility under Section 32(7) of its Act, to regulate the activities that exploit the resources of the Great Barrier Reef Region so as to minimise the effect of those activities on the Great Barrier Reef. Of all the activities, both recreational and commercial, that affect the Reef today there is little doubt that fishing has the greatest impact. In order to comply with the requirements of the Act, (Section 32 (7)), the Authority needs to initiate baseline studies on the effects of fishing pressures on fish populations and monitor the effects of management objectives. In certain sectors of the region, closest to centres of human habitation, fishing pressures have reduced coral trout populations to less than one-tenth of their original abundance (Goeden 1977), and has reduced the size of fish caught in other species.

The Authority initiated the workshop primarily to devise a technique to adequately survey the populations of 'fished' reef fish species so as to implement appropriate zoning regulations and to institute monitoring procedures in the future.

Methods

Initially, a list of species which come under greatest pressure from fishing was drawn up using data obtained from experienced anglers, fish catch records and spearfishing competitions (Bundaberg Skin Diving Club, P. Saenger Table 11).

The demersal 'fished' species considered most affected by fishing pressures were then identified (Table 12) and various behavioural and ecological characteristics which may have had a bearing on censusing techniques were listed.

The most important consideration for the working group in estimating 'fished' reef fish populations was to devise rapid methods which could be carried out with the minimum of equipment and manpower, and which would provide an accurate index of populations.

Apart from assessing absolute numbers, the ratio of size classes in a population may provide a far more sensitive technique for indicating stress (Thompson & Munroe 1978). It was therefore decided that in any technique devised, where possible the ratio of size classes should be estimated.

TABLE 11a

IMPORTANT FAMILIES AND GENERA FOR LINE AND SPEAR FISHING
(REEF ASSOCIATED)

FAMILY/GENUS	LINE	SPEAR
SERRANIDS		
Plectropoma spp.	5	5
Cephalopholis ppp.	3	4
Epinephelus spp.	4	4
Variola louti	1	0
Cromileptes altivelis	1	4
Anyperodon leucogrammicus	1	0
LUTJANIDS		
Lutjanus spp.	4	4
Aprion virescens	1	0

TABLE 11a (CONT.)

FAMILY/GENUS	LINE	SPEAR
NEMIPTERINAE		
Gymnocranius spp.	1	0
POMADASYIDS		
Plectorhynchus	3	2
Spilotichthys pictus	1	1
LETHRINIDS		
Lethrinus nebulosus		
L. chrysostomus	5	2
L. spp. (ther)		
LABRIDS		
Cheilinus spp.	1	0
Choerodon spp.	3	1
Coris cyanea	0	1
SCARID		
Scarus spp.	0	1
KYPHOSIDAE		
Kyphosus spp.	0	1

TABLE 11b IMPORTANT SPECIES FOR LINE & SPEAR FISHING (SUPPLEMENTARY LIST)

A list of families and genera of demersal reef associated fish species of importance in the Capricorn/Bunker group for handlining (commercial and recreational) and spearfishing; and a supplementary list of pelagic and bait fishes that are also important in the Great Barrier Reef Region have been identified below.

FAMILY/GENUS	NET	LINE	SPEAR	
CARANGIDS				
Caranx spp.		X	X	Pelagic fish
Seriola spp.		X		Pelagic fish
Gnathanodon sp.		X	X	Pelagic fish
Chorinemus sp.		X	X	Pelagic fish

TABLE 11b (CONT.)

FAMILY/GENUS	NET	LINE	SPEAR	
SCOMBRIDAE				) Pelagic fish
Scomberomorus spp.		X		)
SPHYRAENIDAE				)
Sphyraena spp.		X	X	)
HEMIRHAMPHIDAE	X			) Bait fish
ATHERINIDAE	X			)
ENGRAULIDAE	X			)

TABLE 12

IMPORTANT SPECIES AND SPECIES GROUPS IN THE ASSESSMENT OF DEMERSAL 'FISHED' SPECIES POPULATIONS

SPECIES	Social Behaviour			Diurnal Activity			Zones of Occurrence							Sampling Time			
	S	SG	Sch	N	D	C	DR	ORF	WOR	LOR	RF	LF	LPR	7-9am 4-6pm	9-4 p.m.	Ad. of Vis. Cen.	
Plectropoma leopardus A.	x				1	2		2	2	2	1	0	1	2	1	2	*
(Large blue spots) B.	x				1	2		2	2	2	1	0	1	2	1	2	*
" " " C.	x				1	2		2	2	2	1	0	1	2	1	2	*
P. melanoleucas	x				1	2								2	1	1	
Cephalopholis miniatus	x				1	2		0	1	2	0	0	1	2	1	1	*
C. argus	x					2				2				2		1	
C. cyanostigma	x					2				2				2	1	1	
C. spp.	x					2	x		x	2	x		x	2	1		
Epinephelus undulostriatus	x					2	2	2						2	1	2	
E. fascoguttatus	x					2				2	1		2	2	1	1	*
E. merra (complex)	x					2			1	2	2		2	2	1	1	
E. fario	x					2				2	2		2	2	1	2	
E. tauvina	x					2	2	2		2		1		2	1	1	
E. tukula	x					2	2	2	2					2	1	1	
E. spp.	x					2	x	x	x	x	x	x	x	2	1		
Cromileptes altivelis	x			2	0	1			1	2			1	2	1	1	
Variola louti	x					2	2	2	2	1				2	1	2	

TABLE 12 (CONT.)

	Social Behaviour			Diurnal Activity			Zones of Occurrence							Sampling Time			
	S	SG	Sch	N	D	C	DR	ORF	WOR	LOR	RF	LF	LPR	7-9 a.m. 4-6 pm.	9-4 pm.	Ad. of Vis. Cen.	
Anyperodon leucogrammicus	x					2			1	2			2	2	1	1	
Lutjanus sebae		x		2	2		2	2	1	1				1	1	1	*
L. carponotatus		x				2				2	2		2	1	2	2	*
L. bohar	x	x			2	2	2		2	2				2	2	2	
L. gibbus			x	2		2	2		2	2				1	1	1	
L. amabilis			x	2			2		2		2			1	2	2	
L. monostigma	x	x			1	2				2			2	1	2	2	
L. spp.																	
L. nematophorous	x	x		1	1	1	1	1					1	1	1	1	
S. pictus	N	D	D		2							1	1	1	2	2	
Plectorhynchus spp.	x				2					2	1		1				
Lethrinus nebulosus	N	D	D	2		1						2	1	1	2	1	*
L. chrysostomus	C	D		2		2	1	1	1	2	1	1	1	2	1	2	*
L. spp.																	
Cheilinus undulatus		D		2	1	1	1	1		2			1	1	2	1	
C. fasciatus		D		2	1	1	1	1		2			1	1	2	1	
C. trilobatus		D		2	1	1	1	1		2			1	1	2	1	
Choerodon spp.	D/N		D	1	2		2	2		1			1	2	2	1	*
Coris aygula	D			2						2	1		1	2	2	1	

* Commonly fished in C/B

N.B. Only adults considered

TABLE 12 (CONT.)

COMMENTS

Social Behaviour :

x	Most common grouping
D	Grouping found in daytime
N	Grouping found in night-time
C	Grouping found at dawn & dusk
S	Solitary
S.G.	Small group
Sch.	School

Diurnal Activity:

N	Nocturnal
D	Diurnal
C	Crepuscular

Numbers indicate visibility at these times

0	very difficult to count
1	sometimes seen
2	easy to see

Zones of Occurrence:

DR	Deep Reef
ORF	Off reef floor
WOR	Windward outer reef
LOR	Leeward outer reef
RF	Reef flat
LF	Lagoon floor
LPR	Lagoon patch reef

Numbers indicate abundance

2	abundant in that zone
1	often in that zone
0	rarely in that zone

Sampling time:

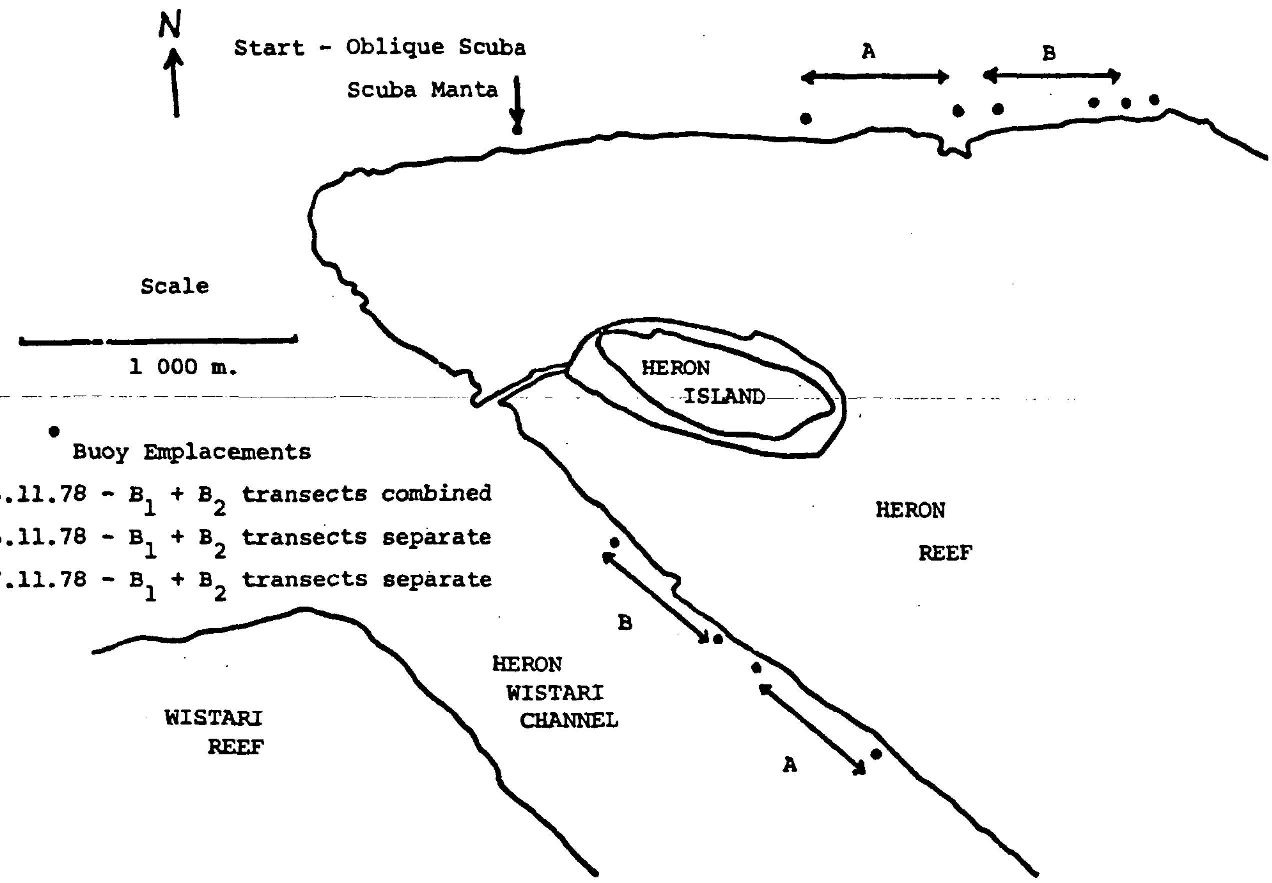
Numbers indicate adequacy of sampling at time state

2	easily sampled
1	difficult to sample

Sampling sites

Two sample sites were selected on both the northern and southern reef slope of Heron Reef (Fig. 3) each of which was approximately 500 metres in length. All sites were selected for their relative uniformity in habitat and structure, and the desirability of comparing combined northern (sites A and B) and southern site (sites A & B). Sample sites for fish assemblages also occurred in these areas.

Fig. 3 MAP OF HERON ISLAND REEF SHOWING SAMPLING LOCATIONS



CENSUSING TECHNIQUES

A number of censusing techniques were tested and compared.

1. Snorkel Manta Transects:

Manta towed observers, equipped with mask, snorkel and flippers were towed at a speed of approximately two knots along the transect. Observers were instructed to maintain approximately 10 metre transect width, and they were permitted to dive towards the bottom to improve observation in deep water. Coral trout were alone enumerated, and divided into three size categories:

Small	Medium	Large
0.3m	0/3 - 0.6m	0.6m

The manta tow lasted approximately five minutes each at the end of which the observer recorded integrated information onto a data sheet. Each transect was sampled four times, twice in the afternoon and twice in the morning to obtain variation in observation at different times of the day and state of the tide.

2. SCUBA Manta technique:

The observer was equipped with a SCUBA tank, mask and flippers and towed on a manta board at a depth of approximately nine metres.

The observer was towed over a distance of approximately 2.5km. As with the snorkel manta technique, the coral trout were classified into three size categories. At two minute intervals, the towing boat halted for ten seconds to allow the observer to record numbers observed in the preceding two minute tow.

The two tows conducted lasted 90 minutes and 70 minutes respectively over identical distances and utilising different observers.

At a later stage this method was tested again with the observer towed at a depth of 12 metres (a depth chosen by physiological constraints) and beyond the base of the reef slope, over a distance of 1 000 metres.

3. SCUBA Transects:

Coral trout *(P. leopardus)* populations were evaluated by an observer equipped with SCUBA swimming the same transects as those used for the snorkel manta technique previously described. The observer swam at a depth of between six metres and three metres above the substrate. Sightings of coral trout were recorded in three size categories during sampling and the transect width was estimated at 10 metres.

Each transect was sampled four times, twice in the afternoon and twice in the morning, to test changes in observed populations with different time of day and state of tide.

4. Oblique SCUBA Transects:

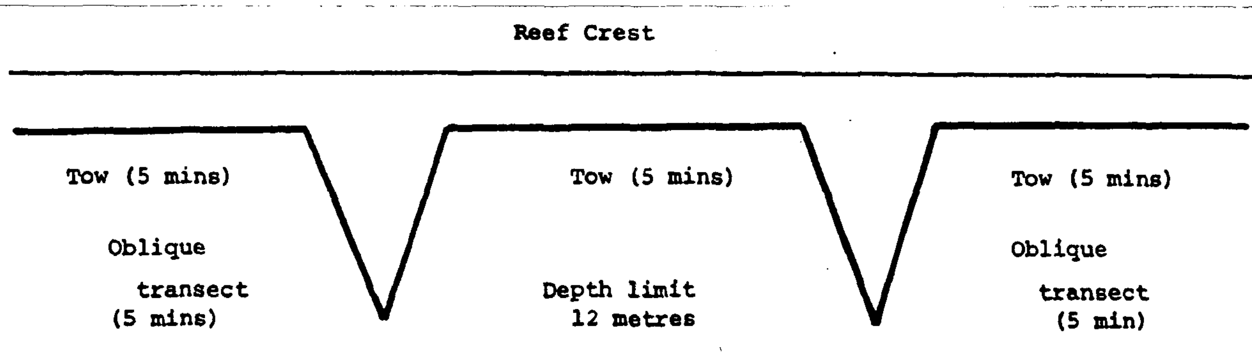
Coral trout populations were estimated using a SCUBA oblique transect technique along the northern section of Heron Island (position shown in Figure 4).

A SCUBA equipped diver made a swimming diagonal descent from the reef crest along the reef slope to a depth of 12 metres before returning diagonally to the reef crest. Coral trout numbers from within a 10 metre transect were recorded in three size categories. Upon surfacing the diver was towed for five minutes (approximately 200 metres) following which another diagonal transect was swum. Each diagonal transect lasted approximately five minutes. Only fishes seen in the oblique descent and ascent were recorded (on a data board). The oblique transects were repeated at 5 minute (approximately 200 m) intervals adjacent to the reef crest.

Below is a diagram showing the survey pattern.

Figure 4

OBLIQUE SCUBA TRANSECT TECHNIQUE



5. Intensive SCUBA Search:

For the intensive SCUBA search technique an estimate of total coral trout numbers in three size categories was first attempted over the entire length of Transect 'B" Northern side (see Figure 3). This was carried out by two observers; took approximately 70 minutes and covered an area from the reef crest to a depth of nine metres, and a distance of 500 metres.

Subsequently, the method was expanded to include all those species listed in Table 2 and initially tested by two observers at the Heron Island Bommie for observer accuracy and reliability. The divers recorded all species seen and classified them into five life history size classes based on maximum standard lengths (E.M. Grant) divided by five. For example, the coral trout *(Plectropoma leopardus)* was divided into the following size classes:

Small Juvenile	Juvenile	Small Adult	Adult	Large Adult
up to 20 cm	20-40 cm	40 - 60 cm	60-80 cm	80-100 cm (plus)

Where possible, individual fishes were enumerated and later recorded, however if a large school passed a numerical index could be substituted on a Log_3 scale:

1	=	1 fish	4	=	10-27 fish
2	=	2-3 fish	5	=	28-81 fish
3	=	4-9 fish	6	=	82-243 fish, etc.

In analysis of the numerical index a mean of the numerical range was taken.

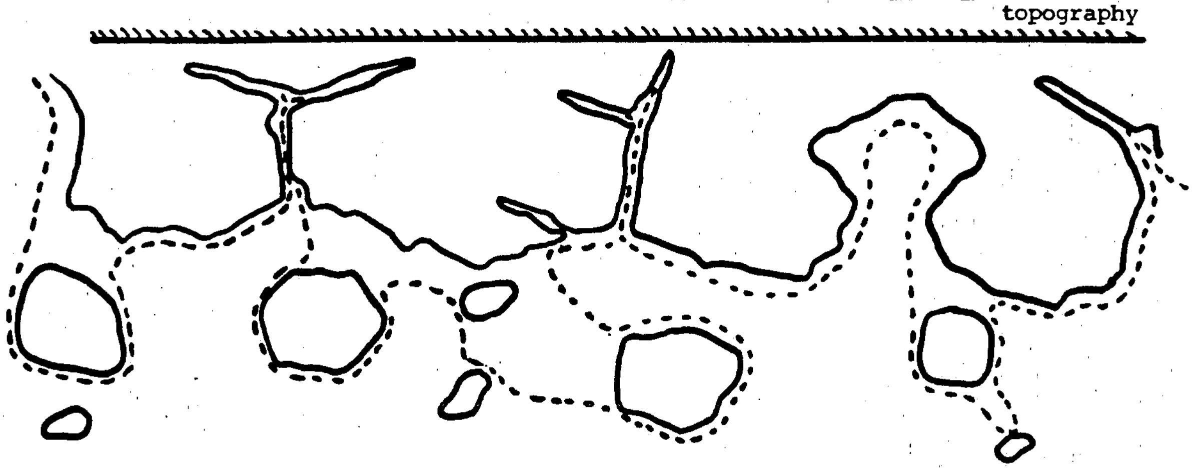
Two adjacent 100 metre sections (B_1 and B_2) were then delineated within Transect 'B' Northern Side and intensively searched for all species. As with the 'Bommie' trial, the fishes seen were divided into five size categories.

The intensive search technique involved a close examination of gutters, crevices, bommies, caves, etc. to a depth of approximately 12 metres which was considered most desirable as it encompasses the majority of coral trout habitat and also lay within contraints of multiple dives by individual observers.

This method was replicated in the same area of three days with a total of eleven dives involving five different observers.

Figure 5 - SCUBA Intensive Search, Search Pattern

-------- Search Patch Reef Crest ______ Outline of reef topography



Results:

The results of testing these different assessment techniques are summarised in the following tables:

TABLE 13	Snorkel/Manta Transect and SCUBA Transect
TABLE 14	Oblique SCUBA Transect
TABLE 15 (a & b)	SCUBA Manta Tow
TABLE 16	Intensive SCUBA Search
TABLE 17	Intensive SCUBA Search - 'Bommie'
	(a) Observer 1
	(b) Observer 2
	(c) Comparison of Totals - Observers 1 & 2
TABLE 18	Intensive SCUBA Search 25.11.78
	(a) All Numbers Counted, All Species
	(b) Comparison of Results, *P. leopardus* only
TABLE 19	Intensive SCUBA Search - 26.11.78
	(a) Total Numbers Counted, All Species.
	(b) Comparison of Results, *P. leopardus* only.
TABLE 20	Intensive SCUBA Search - 27.11.78
	(a) Total Numbers Counted, All Species
	(b) Comparison of Results, *P. leopardus* only.
TABLE 21	Intensive SCUBA Search - Compariosn of Results 25.11, 26.11, 27.11, *P. leopardus* only.

Comparison between the techniques tested appear in -

TABLE 22	SCUBA Transect, Comparison of Observed Numbers *P. leopardus*, morning and afternoon.
TABLE 23	Manta Snorkel Transect, Compariosn of Observed Numbers *P. leopardus*, morning and afternoon
TABLE 24	Coral trout observed over 200 m of Reef Front by various techniques.
FIGURE 6	Manta SCUBA Technique: Numbers of coral trout seen with time (30.11.78)
FIGURE 7	(a) Bar graph showing comparitive numbers of different size classes *(P. leopardus)*.
	(b) Shift in size classes (after Thompson & Munro) of *Epinephalus striatus*, with heavy fishing pressure.

TABLE 13

COMPARISONS OF SAMPLING STRATEGIES AND TIME OF DAY SCUBA TRANSECT AND MANTA/SNORKEL TRANSECTS A AND B. CHANNEL AND NORTHERN SIDES OF HERON REEF 20/21 NOV. 1978

TRANSECT	J	SA	A	TOT	TIME OF DAY	J	SA	A	TOT	APPROX. TIME OF DAY
AM 1	3	1	0	4	1441-1446	2	2	6	10	Afternoon 1400-1600
AM 2	2	7	0	9	1548-1553	0	1	0	1	
AM 3	1	7	0	8	0914-0924	5	11	7	23	Morning 0900-1030
AM 4	0	9	2	11	1022-1029	4	6	5	15	
Total	6	24	2	32		11	20	18	49	
BM 1	0	2	0	2	1354-1357	0	4	1	5	Afternoon 1400-1530
BM 2	0	3	0	3	1525-1530	3	2	2	7	
BM 3	0	4	1	5	0858-0901	2	3	8	13	Morning 0900-1000
BM 4	1	1	0	2	1000-1005	2	6	1	9	
Total	1	10	1	12		7	15	12	34	
AS 1	6	10	1	17	1346-1430	3	13	8	24	Afternoon 1350-1600
AS 2	6	14	1	21	1507-1600	3	18	4	25	
AS 3	6	40	4	50	0851-0958	4	11	5	20	Morning 0900-1100
AS 4	2	27	4	33	0958-1058	7	13	5	25	
Total	20	91	10	121		17	55	22	94	
BS 1	2	3	0	5	1429-1454	6	10	7	23	Afternoon 1430-1600
BS 2	1	11	2	14	1540-1600	6	15	9	30	
BS 3	1	14	5	20	0915-1010	3	12	5	20	Morning 0900-1130
BS 4	1	19	3	23	1010-1130	2	11	1	14	
Total	5	47	10	62		17	48	22	87	
GRAND TOTAL	32	172	23	227		52	138	74	264	

KEY: AM 1 = 'A' Transect, Manta Tow #1 (Snorkel)

BS 3 = 'B' Transect, SCUBA Contour Swim #3 - Second day

J = Juvenile; S.A. = Small adult; A. = Adult

* 20.11.78 : AM1, AM2, BM1, BM2, AS1, AS2, BS1, BS2.

21.11.78 : AM3, AM4, BM3, BM4, AS3, AS4, BS3, BS4.

** For position of Transects 'A' and 'B' for both Channel & Northern face see Fig. 3.

TABLE 14

OBLIQUE SCUBA TRANSECT

Time: 14.00 - 15.41 | Time: 14.22 - 15.49

Diver 1 (H. Sweatman)				Diver 2 (B. Goldman)				Diver 3 (G. Anderson)				Diver 4 (S. Summerhays)			
J	SA	A	TOT	J	SA	A	TOT	J	SA	A	TOT	J	SA	A	TOT
0	1	1	2	4	2	0	6	2	3	0	5	0	3	1	4
0	9	3	12	9	2	2	13	0	0	0	0	0	0	0	0
0	5	0	5	1	2	0	3*	1	1	1	3	0	3	1	4
0	6	0	6	3	3	0	6	1	2	0	3	2	4	1	7
0	11	3	14	3	15	0	18	0	4	0	4	1	4	0	5
1	2	1	4	1	4	0	5	0	2	0	2	0	0	0	0
0	10	2	12	0	7	0	7(b)	3	4	0	7	0	0	0	0
2	9	1	12(B)	2	6	1	9	1	6	2	9	1	6	3	10
0	6	4	10	0	13	0	13								
0	8	1	9	2	7	1	10								
3	67	16	86	25	61	4	90	8	22	3	33	4	20	6	30

TABLE 15a.

SCUBA MANTA TOW - 22.11.78

2 Min. Sect.	Diver 1 (B. Russell) J	SA	A	TOTAL	Diver 2 (Greg. Stroud) J	SA	A	TOTAL
1	3	5	1	9	0	2	0	2
2	0	0	1	1	0	1	0	1
3	0	0	0	0	0	3	0	3
4	1	0	0	0	0	2	0	2
5	1	1	0	2	0	4	1	5
6	1	3	3	7	2	6	1	9
7	0	0	1	1	0	5	1	6
8	2	1	0	3	1	7	0	8
9	0	2	2	4	0	5	1	6
10	1	4	5	10	1	6	1	8
11	1	2	2	5	1	6	0	7
12	1	2	4	7	0	6	1	7
13	0	0	4	4	1	0	0	1
14	0	3	7	10	0	2	0	2
15	0	1	3	4	0	2	0	2
16	0	2	6	8	0	3	0	3
17	0	1	4	5	0	1	1	2
18	2	1	3	6	1	0	0	1
19	1	3	3	7				
20	0	4	0	4				
21	0	2	1	3				
22	0	2	0	2				
23	2	2	2	6				
24	0	4	0	4				
	16	45	52	113	7	61	7	75
	Time: 1 hr. 30 mins.				Time: 1hr. 30 mins.			

TABLE 15b

MANTA SCUBA TECHNIQUE 30.11.78 - NORTHERN TRANSECTS A + B HERON ISLAND

Observer - Greg Stroud				Observer - Soames Summerhays			
09.29- 09.54	11.04 - 11.30	15.39 16.04	17.03- 17.27	10.15- 10.47	11.40- 12.05	16.23- 16.48	17.58- 18.19
7	3	12	12	-	5	12	2
8	20	11	7	4	16	4	2
25	1	8	4	7	28	16	4
4	-	20	1	3	11	6	0
26	3	21	2	21	21	5	3
12	40	18	15	21	2	8	4
11	40	-	7	6	3	3	3
1	2	6	7	27	36	8	3
-	2	6	11	1	2	3	24
1	1		12	42	1	12	
-	2			0	50		
7	30			1			
				2			
102	144	102	78	135	175	77	45

$\bar{x}$ = 107.25; length of transect = 1,000 m.; low tide = 1.30 p.m.

Figure 6

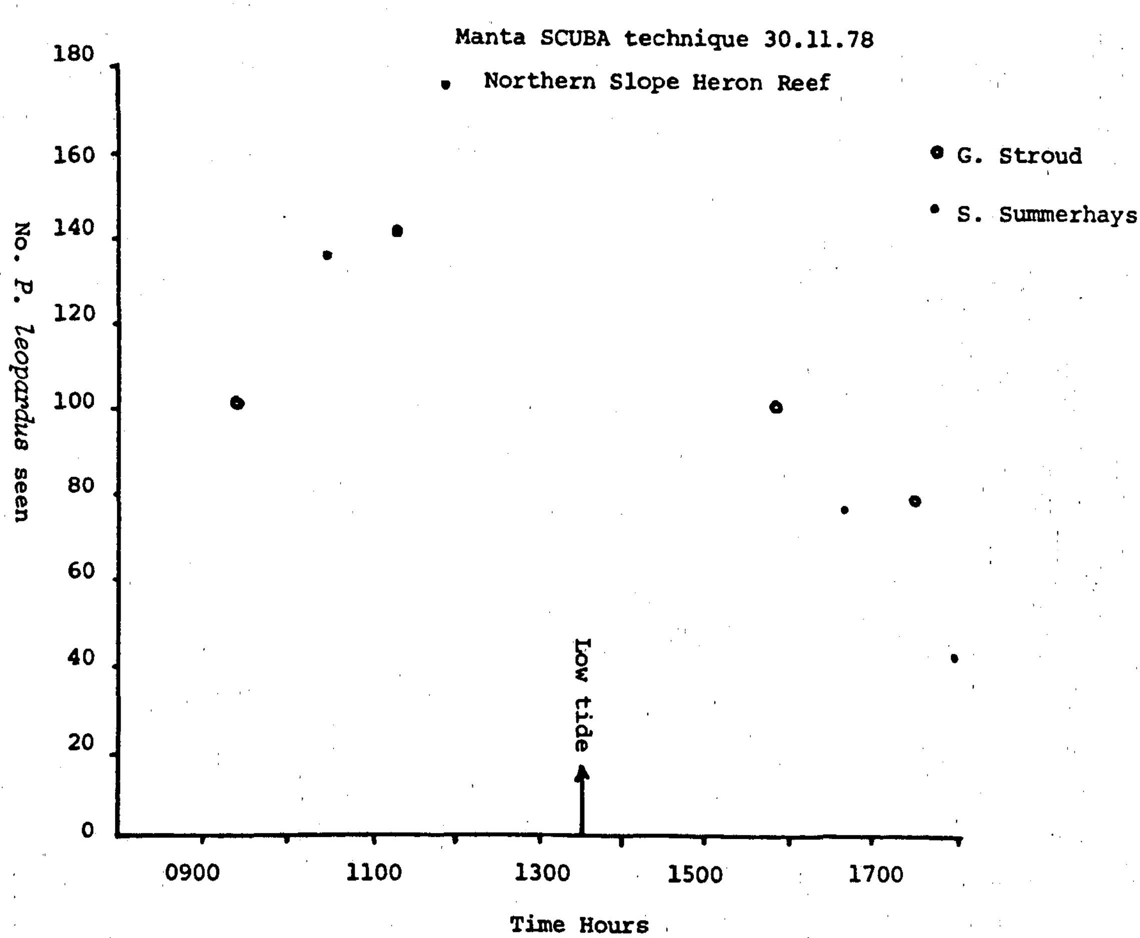


TABLE 16

9M. INTENSIVE SCUBA SEARCH

Date: 23.11.78 - Time: 9.20 - 10.30 a.m.

(Search carried out over Transect B Northern Side)

Observer	Small	Medium	Large	Total
P. Saenger	9	27	5	41
F. Talbot	15	28	3	46
Total	24	55	8	87

TABLE 17

INTENSIVE SCUBA SEARCH - 'BOMMIE

a. Observer 1 - P. Seanger

Species	Size category - SJ	J	SA	A	LA		TOTAL
Plectropomus leopardus	1	1	5	3			10
Cephalopholis miniatus		1	2	3			6
Epinephelus merra (complex)			1				1
Cromileptes altivelis			1	1			2
Lutjanus carponotatus			5	30-80		Av:	55
Plectorhynchus pictus		4	1	3			8
P. chaetodontoides			3	4	2		9
Lethrinus chrysotomus				30-80		Av;	55
Chelinus fasciatus			1				1
Choerodon venustus			2	1			3

b. Observer 2 - D. Pollard

Species	SJ	J	SA	A	LA	TOTAL
Plectropomus leopardus			6	5		11
Cephalopholis miniatus				2	5	7
Epinephalus merra (complex)			1			1
Cromileptes altiveles				1	1	2
Lutjanus carponotatus					51	51
Plectorhynchus pictus			2			2
P. chaetodontoides					7	7
Lethrinus chrysotomus			15	30		45
Choerodon venustus			3			3
C. transversalis			1			1

TABLE 17 (CONT.)

c. Comparison of Totals - Observers 1 and 2

Species	Observer 1	Observer 2
Plectropomus leopardus	10	11
Cephalopholis miniatus	6	7
Epinephelus merra	1	1
Cromileptes altivelis	2	2
Lutjanus carponotatus	55	51
Plectorhynchus pictus	8	2
P. chaetodontoides	9	7
Lethrinus chrysostomus	55	45
Choerodon venustus	3	3
C. transversalis	-	1
Chelinus fasciatus	1	-
	150	130

χ^2 = 1.3164 ; p = 0.20; d.f = 1; not significant

TABLE 18a

14M. INTENSIVE SCUBA SEARCH - 25.11.78 (MORNING)

a. Total Numbers counted, All Species

Species	Observer 1 P. Saenger	Observer 2 S. Summerhays	Observer 3 D. Pollard	TOTAL
Plectropomus leopardus	82	134	80	296
P. melanoleucus	1	3	0	4
Cephalopholis miniatus	6	31	20	57
C. argus	0	2	0	2
Epinephelus merra (complex)	3	6	2	11
E. fario	2	1	2	5
E. tauvina	0	1	0	1
Cromileptes altivelis	0	2	0	2
Lutjanus sebae	1	4	2	7
L. carponotatus	17	15	4	36
L. amabilis	54	59	88	201
L. monostigma	0	4	6	10
L. nematophorous	0	2	0	2
Plectorhynchus pictus	2	56	6	64
P. chaetodontoides	4	2	4	10
Lethrinus chrysostomus	7	9	2	18
L. nebulosus	0	0	4	4
Cheilinus undulatus	0	1	4	5
C. fasciatus	6	0	0	6
C. trilobatus	1	0	0	1
Choerodon venustus	0	0	2	2

TABLE 18b

Comparison of Results - *P. leopardus* only

Observer	SJ		J		SA		A		LA		
	Total	%	Total	%	Total	%	Total	%	Total	%	Total
1. P. Saenger	-	0	3	3.7	18	21.9	49	59.8	12	14.6	82
2. S. Summerhays	-	0	6	4.4	35	25.7	83	61	12	8.8	136
3. D. Pollard	-	0	2	2.5	30	37.5	38	47.5	12	12.5	80
	-	0	11	3.7	83	27.9	170	57.0	34	11.4	298

Standard Deviation of Totals = 17.9

χ^2 = 7.76

No significant difference between observers

TABLE 19a

14M INTENSIVE SCUBA SEARCH - 26.11.78 - (AFTERNOON)

a. Total Numbers counted, All species

Species	Transect B_1 Obs 1	Obs 2	Obs 3	Obs 4	Total	Transect B_2 Obs 1	Obs 2	Obs 3	Obs 4	Total	B_1+B_2 Total
Plectropomus leopardus	40	37	52	30	159	49	78	24	52	203	362
P. melanoleucus	1	1	1	1	4	-	-	-	-	0	4
Cephalopholis miniatus	4	1	25	8	38	12	12	4	12	40	78
C. argus	1		1		2		1		2		3
Epinephelus merra	5	10	4	3	22	6	14	10	6	36	58
Cromileptes altivelis	1	1		1	3	2			1	3	6
Variola louti	1			1	2					0	2
Lutjanus sebae	1		1	2	4					0	4
L. carponotatus	4	51*	42*	53*	150	8	8	4	7	27	177
L. bohar				1	1	2	1		2	5	6
L. amabilis		1	1	1	3	6	66*	3	65*	140	143
L. monostigma	1		2	2	5	3	6		11	20	25
Pleorhynchus pictus			12	7	19		3		8	11	30
P. chaetodontoides	1	1	2	3	7		2			2	9
Lethrinus chrysostomus	5	8	4	1	18	2	4		3	9	27
L. nebulosus				6	6				2	2	8
Chelinus undulatus			1		1					0	1
C. fasciatus	1				1					0	1
Choerodon venustus	1		2		3				1	1	4
Epinephelus undulostriatus		5	1	2	8		1	1		2	10
E. fuscoguttatus			15		15		1	2		3	18
Cephalopholis cyanostigma			1	1	2					0	2
Coris aygula	1	2		1	4					0	4

* Large differences explained by passage of schools of the species through area

TABLE 19b

Comparison of counts for *P. leopardus* only

Size category	SJ		J		SA		A		LA		
Observer	Total	%	Total	%	Total	%	Total	%	Total	%	Total
1. S. Summerhays	0	0	8	9.9	28	34.6	29	35.8	24*	29.6	89
2. G. Stroud	0	0	9	7.8	37	32.2	63	54.8	6	5.2	115
3. H. Sweatman	0	0	5	6.6	35	46.1	29	38.2	7	9.2	76
4. D. Pollard	0	0	8	9.7	30	36.6	34	41.5	10	12.2	82
TOTAL	0	0	30	8.5	130	36.7	155	43.8	47	13.3	362

Standard Deviation of Totals $\pm$ 31.7

χ^2(obs. 1, 2, 3) = 28.99 p = .001 Highly significant

χ^2(obs. 2, 3, 4) = 9.03 p = .05 Not significant

χ^2(obs. 1, 3, 4) = 13.01 p = .01 Significant

χ^2(total) = 8.89 3df $p < 0.05$ $> .01$ Differences just significant

* This reading is the one affecting the χ^2 analysis.

χ^2 (all categories) = 29.7 12 df $p < .001$ ***

(categories - LA & A combined) = 5.312 9df P = > 0.05

TABLE 20a

14M INTENSIVE SCUBA SEARCH - 26.11.78 (MORNING)

a. Total Numbers counted, All Species

Species	Transect 1 Obs 1	Obs 2	Obs 3	Obs 4	Total	Transect 2 Obs 1	Obs 2	Obs 3	Obs 4	Total	B_1+B_2 Total
Plectropomus leopardus	23	27	30	59	139	45	48	35	17	145	284
P. melanoleucus	1	1	1	2	5		1			1	6
Cephalopholis miniatus	9		1	10	20	7	9	5	2	23	43
C. argus		1			1		1	1		2	3
Epinephelus undulostriatus		5			5						5
E. merra	6	5	5	4	20	4	9	5	5	23	43
E. fario				10	10	1					11
Cromileptes altivelis							1			1	1
Variola louti	1	1	1	1	4						4
Lutjanus sebae	1			1	2						2
L. carponotatus	15	16	27	1	59	8	7	5	4	24	83
L. bohar	1	1			2	7		1		8	10
L. gibbus						2				2	2
L. amabalis	7	2			9	66	4	3	24	97	116
L. monostigma	3	2	1		6	1	4	1		6	12
L. nematophorus								1		1	1
Plectorhynchus pictus	24			2	26	7	2		12	21	47
P. chaetodontoides		2	1	1	4	1	1	2		4	8
Lethrinus nebulosus			2		2		2	18		20	22
L. chrysostomus	2	3	2	3	10	7	3		8	18	28
Cheilinus undulatus				1	1		1			1	2
C. fasciatus				1	1				1	1	2
Choerodon venustus				1	1			1		1	2
Coris cyaneus (=aygula)	1				1	1				1	2
Epinephelus fascoguttatus			6		6						6

TABLE 20b

Comparison of Results, *P. leopardus* only $B_1 + B_2$

Observer	Size Category	SJ	J	SA	A	LA	TOTAL
1. S. Summerhays		0	7	38	22	1	68
2. G. Stroud		0	1	28	44	2	75
3. H. Sweatman		0	2	19	32	2	55
4. P. Saenger		0	3	16	41	16*	76
		0	13	101	139	21	274

$\chi^2 = 49.4$ 12 df $p = 0.001$ Differences are significant

* These readings are affecting the χ^2 analysis.

χ^2 (Total count) = 4.62, 3df, $p = > 0.05$ non significant.

TABLE 21

INTENSIVE SCUBA SEARCH - COMPARISON OF RESULTS

Location B_1/B_2 Northern Side

26.11, 27.11 - *P. leopardus* only

OBSERVER	26.11.78 Afternoon	27.11.78 Morning
1. S. Summerhays	89	68
2. G. Stroud	115	75
3. H. Sweatman	76	55
4. D. Pollard (26.11) P. Saenger 27.11)	82	76

^{2} (26.11, 27.11) = 2.699 3 d.f. p = 0 05

Differences non significant

FIGURE 7a. Size class distribution of *Plectropomus leopardus* Heron Island Reef - North Site

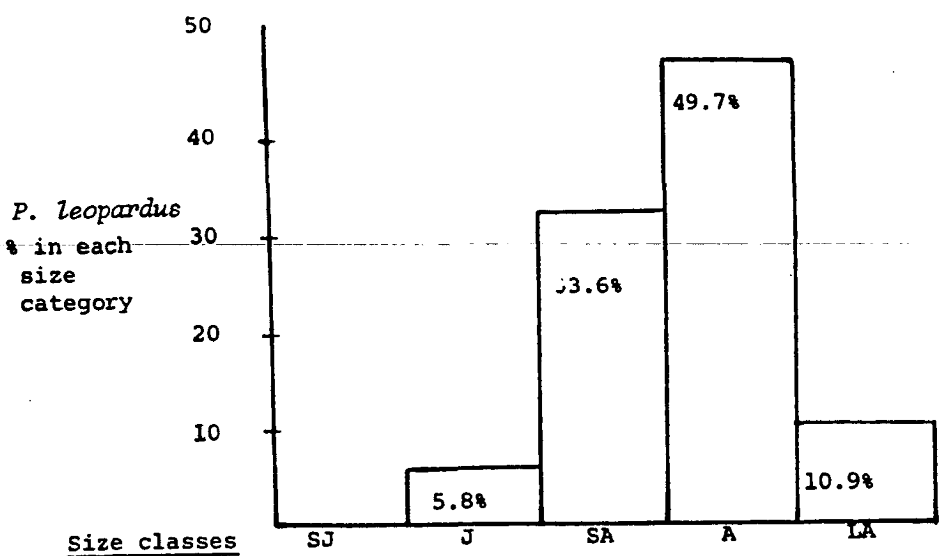
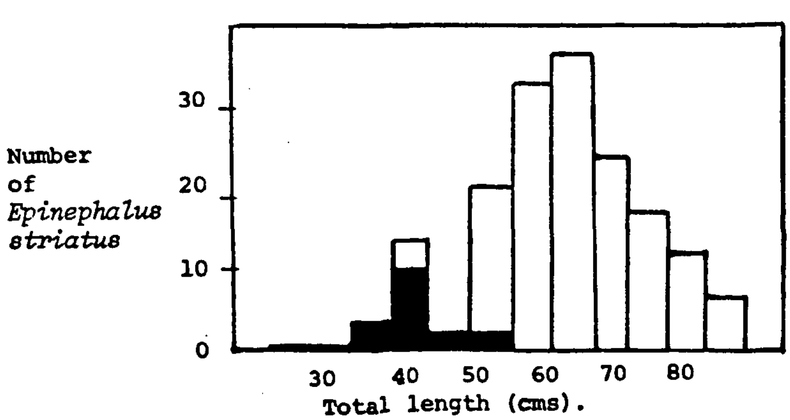


Figure 7b. Shift of size classes with increased fishing pressure on *E. striatus* Black denotes population sizes of heavily fished populations.



(after Thompson & Munro 1978).

TABLE 22

SCUBA TRANSECTS, COMPARISON OF OBSERVED NUMBERS, *P. leopardus*

MORNING AND AFTERNOON

	Channel				Northern Side			
	J	SA	A	TOTAL	J	SA	A	TOTAL
Afternoon: 13.30 - 16.00 hrs								
Average $AS_1 + AS_2$	6	12	1	19	3	15.5	6	24.5
Average $BS_1 + BS_2$	1.5	7	1	9.5	6	12.5	8	26.5
		TOTAL		28.5		TOTAL		51.0
Morning: 08.30 - 10.15 hrs								
Average $AS_3 + AS_4$	4	33.5	4	41.5	5.5	12	5	22.5
Average $BS_3 + BS_4$	1	16.5	4	21.5	2.5	11.5	3	17
				63.0				39.5

TABLE 23

MANTA, SNORKEL TRANSECTS, COMPARISON OF OBSERVED NUMBERS *P. leopardus*

MORNING AND AFTERNOON

	Channel				Northern Side			
	J	SA	A	TOTAL	J	SA	A	TOTAL
Afternoon: 13.30 - 16.00 hrs								
Average $AM_1 + AM_2$	2.5	4	0	6.5	1	1.5	3	5.5
Average $BM_1 + BM_2$	0	2.5	0	2.5	1.5	3	1.5	6
				9.0				11.5
Morning 08.30 - 10.15 hrs								
Average $AM_3 + AM_4$	0.5	8	1	9.5	4.5	8.5	6	19
Average $BM_3 + BM_4$	0.5	2.5	1	4	2	4.5	4.5	11
				13.5				30

Key: A/B = Sampling sites A/B; S = Scuba Transect; M = Manta Snorkel Transects

TABLE 24

COMPARISON OF THE AVERAGE NUMBERS OF CORAL TROUT PER 200 METRES ON THE NORTHERN REEF SLOPE OF HERON REEF OBTAINED BY DIFFERENT TECHNIQUES

	J	SA	A	TOTAL	%
Manta-snorkel	1.1.	2	1.8	4.9	5.17
Manta SCUBA 9 m.	0.8	4.6	1.4	6.8	8
Manta SCUBA 12 m.				16.98	20
SCUBA Transect	1.7	5.5	2.2	9.4	11.07
SCUBA Angles	1.1	6.5	1.3	7.9	9.41
SCUBA Search 9 m.	4.8	11	1.6	17.4	20.49
SCUBA Search 14 m.					

Mean number of *P. leopardus* seen over 200 m in 11 samples of intensive SCUBA search = 84.9 (SD $\pm$ 21.34).

N.B. J/SA/A are size categories, juveniles/small adults/adults.

Discussion of Results

Whereas, superficially, it may appear that the snorkel manta technique is most efficient (fish seen per unit time - Table 14 & 24) the snorkel manta system proved to assess only 5.7% of the best estimate obtained for coral trout populations in a 'back reef' area (using intensive SCUBA search). The percentage of the total populations observed on the reef front is expected to be greater due to the lack of available cover where the coral trout may hide. The index of 5.7% would therefore be unreliable as an estimate of the total population as it would expect to change in a non-quantifiable way according to the structure of the reef slope. Furthermore, in comparing abundances of coral trout between morning and afternoon, samples on the north side of Heron Reef (Tables 13 & 23) show that consistently more coral trout were observed in the morning than the afternoon, compared to a SCUBA transect sample at the same time when the opposite was the case (Tables 13 & 22). On the southern side of the reef in Transects A & B, the majority of coral trout were observed in the morning. These inconsistencies, it was agreed, were partly due to considerable and relatively consistent changes in cryptic habit during the day, or the course of a tidal cycle; and may also be due to the far ranging nature of these fishes. It was concluded that as the variation of coral trout seen when using a snorkel manta technique, could more than double the mean index observed by this method, that the snorkel manta technique was invalid.

The SCUBA manta technique was tested at depth of nine metres and 12 metres. The observers recorded approximately 8% and 20% of the best coral trout population estimate, at these respective depths. As indicated by an intensive search, up to four times the number of trout may be found between 9-14 metres as from 0-9 metres. Apart from recording only one-fifth of the coral trout population, at best, there were disturbing discrepancies occurring with the number recorded during the course of a day (or tidal cycle?) - see graph. This method also consistently underestimated the number in the smaller size classes.

The SCUBA manta technique at 9m is marginally more accurate than the snorkel manta technique (see above). The SCUBA manta to 12m returned a higher percentage of the best estimate as the observer is towed over the area where approximately 50% of *P. leopardus* are to be found. However, due to the fact that the majority of coral trout are located in high densities around bommies, the technique is subject to question. As the observer has little control over the area 'towed', any sample transect line may or may not cover the area with deep water bommies, resulting in considerable fluctuations between observers (see Table 15a and Figure 5).

The SCUBA transect method estimated a mean of approximately 11% of the best population estimate, but was subject to considerable variation in the number observed at different times of day or tidal cycles (see Table 22). Due to the variation in the number of fishes seen as a percentage of the best population estimate, the method was considered too inaccurate for assessing population indices or monitoring.

The oblique SCUBA search technique returned a mean of approximately 10% of the best estimate of population. This method was to test a compromise between assessment of large areas and intensive searches. Two pairs of divers over 9-10 such transects showed high correlation between the numbers of each pair, but variation between pairs was two to three times over the same transect (see Table 14). This technique was not considered valid for management.

An intensive search over a 500 metre transect down to nine metres proved to be the most consistent and probably the most reliable system of assessment among these methods (see Table 16). However, subsequent intensive searches down to 14 metres indicated that even an intensive search to nine metres estimated only one-fifth of the entire population (see Table 14), and that this fraction in addition was probably subject to variation according to time of day, tidal influences and the amount of cover.

Multi-species estimates using intensive search for 'fished' species of reef fishes

On the basis of the above results, it was decided to concentrate on intensive SCUBA search techniques over the full range of 'fished' species listed in Table 12.

In order to assess both the intensive search technique and any between-observer differences over a range of species, two observers attempted a complete count of 'fished' species around the Heron Island Bommie. It appears from Table 17 and the analysis of these results over the 12 species observed using a χ^2 test that there was no significant difference between observers in the case of this relatively isolated area.

Following this trial further studies was carried out over a 200 metre section of Transect 'B' - Northern Side (a much more complex habitat than the Heron Island Bommie). The results of these itensive SCUBA searches are presented in Tables 18. 19, 20. For the tests of 26.11 and 27.11, the 200 metre transect was divided into two 100 metre segments (B_1 and B_2), as 100 m of reef frontage requires approximately one full SCUBA tank to be adequately surveyed by the intensive SCUBA technique. The results for each observer are presented for each segment (Tables 19 & 20).

Comparison of samples taken in the morning and afternoon indicate that using this method there is no significant difference between observers caused by time of day or tide. However, poor visibility experienced on 27.11 caused recognisably lower numbers of coral trout observed, but not significantly different using χ^2 analysis.

On examination of data collected on coral trout *P. leopardus* data, it appeared that the results were more consistent between observers when summed over the 200 metre transect, and χ^2 analysis (Table 21) showed the differences in total counts between observers were non significant ($p < 0.05$).

With regard to two of *Lutjanus* species (those asterisked in Table 19a), observations of isolated schools of these species caused considerable discrepancies in between-observer results.

Abundance and size class distribution of *P. leopardus* during intensive searches (Transect 'B' Northern Reef).

The results (coral trout only) from the intensive SCUBA searches carried out on the 25.11, 26.11, 27.11 (a total of 11 replicates) are tabulated in Tables 18b, 19, 20, 21. χ^2 analysis of these results indicated some significant differences between observers. These discrepancies can be explained in terms of the following factors -

1. On critical analysis of the size group distribution at least two observers concluded that their estimates of adult fish (L.A. or S.A.) were much too high (see those asterisked in Tables 19b and 20b). By combining adjacent size categories some of these effects could be eliminated.
2. A number of observers commented on the problem of counting the same fish twice when the reef crest was criss-crossed; and large schools of fishes passing through an area might be missed by some observers.

Conclusions

A number of techniques were tested by the working party to attempt to assess the population of 'fished' reef fish species. Of the five methods only the intensive SCUBA Search could be considered as a viable technique. The Snorkel Manta technique proved to assess only a very small proportion of the actual population of just one species *(P. leopardus)* this was subject to considerable variations over the same transect during the course of the day. SCUBA Transect method produced good correlation between observers or with the same observer over the same transect at different times of the day. The oblique SCUBA technique resulted in considerable variations between two pairs of observers even when undertaken simultaneously in the same area, but following different transect lines.

The intensive SCUBA search also allowed sufficient time to estimate size classes of *P. leopardus*. It is expected that the population number in combination with the ratio of size classes should provide an index of the effect of fishing. It was recognised that these fishes may be migratory, but from the work that has been one *P. leopardus* appears to be homeranging.

Due to the fact that both 'Trout' *(Pleotropomus)* and Emperor *(Lethrinus* spp*)* occur on all sections of the Great Barrier Reef, and are therefore subject to fishing pressure (or being the most popular sport and food fishes) where they occur, the working party recommended that these species should be used for monitoring purposes and management of the 'fish' resource.

<u>Summary</u>

1. Of all the methods used, the Intensive SCUBA Search was regarded as the closest approximation to reality;

2. To varying degrees all of the more rapid methods used tended to underestimate the relative proportion of the small size classes of coral trout in the population. (As stressed earlier, an accurate estimate of numbers of fish in the different size classes is regarded as critical in assessing the effects of fishing pressures on different reefs);**

3. With regard to the Intensive SCUBA Search technique for coral trout, the between-observer-differences encountered during the present study can largely be explained on the basis of counting the same fish twice; and also by assigning fish to the wrong size category, thereby overestimating the fish in some categories and underestimating in others. These errors should be reduced with experience on the part of the observer;

4. Differences observed in total numbers of fish counted in the Intensive Search tests conducted on different days were explicable on the basis of water clarity. Considerably lower numbers of coral trout were observed when the water was turbid (27.11) compared to clear conditions (25.11).

5. In order to improve on the Intensive SCUBA Search Technique as carried out in the coral trout population studies, it is suggested that the search be conducted using a horizontal criss-cross pattern facilitated by an underwater diver propulsion vehicle (D.P.V.). This search pattern should commence at the level of the deepest bommie adjacent to the reef slope (but shallower than 14 metres) and work upwards towards the reef crest.

** It should be pointed out that the area encompassed by Transect 'B' Northern Side is included in a preserve in which both spearfishing and angling are banned.

6. It was believed that fishing impact could be readily identified by only assessing the fluctuations on populations of Lethrinids and *Plectropomus* spp., on account of two factors.

Firstly, these two groups bear the brunt of exploitation on the Great Barrier Reef. In addition, they are represented over all sectors of the Great Barrier Reef in all coral reef habitats.

7. As a final conclusion, the group considered that with experience in relation to accurate enumeration and size class assessment, four diver replicates of a single 200 metre stretch of relatively uniform reef slope in a selected habitat, would give a reasonable estimate of both coral trout and Lethrinid populations, and thus an index of fishing pressure.

Recommendations

The working party recommends that when assessing reefs in the Great Barrier Reef Region for important demersal 'fished' species -

1. The Intensive SCUBA Search technique be used with four replicate samples of a 200 metre area being conducted at each geomorphologically or biologically distinct habitat type around a reef. This technique should be carried out on selected reefs only, to give an index of coral trout populations for zoning purposes, and any changes occurring for monitoring. The selecting of which reefs that should be surveyed in any area depends to some extent on the human impact on the area in question.

2. With regard to the species to be surveyed, it is essential that both coral trout *(Plectropoma leopardus)* and the two main Lehtrinid species *(Lethrinus chrysostomus L. nebulosus)* be included in these surveys. Except for two species of schooling Lutjanids *(Lutjanus carponotatus* and *L. amabilis*, the remaining species in Table 12 occurred in only small numbers over the 200 metre transect, and their relative abundance would therefore be difficult to assess with any statistical reliability. It is felt however that the presence of these less abundant 'fished' species could be noted during future surveys.

3. When considering the equipment which could be used to facilitate such surveys, it is recommended that:
   (a). the dive boat be fitted with an echo sounder so the nature of the reef profile and the depth at the edge of the 'bommie zone' can be assessed;
   (b) the divers be equipped with decompression meters in crder that they can determine their decompression status at any time during the surveys;
   (c) the use of an under-water D.P.V. in conjunction with an underwater tape-recorder system be investigated for more efficient utilisation of resources and man power;

Summary of Intensive Search Technique

1. A set 200 metre section of reef, from crest to outer reef floor (or a depth of 14 metres) is marked out with stakes and buoys. This transect will then be monitored at annual intervals in the future.

2. The transect is divided into two 100 metre sections.

3. Two divers search each section from reef crest to a depth of 14 metres. Two replicates are made of each section by both divers.

4. *Plectropoma leopardus* and *Lethrinus* spp. (*L. chrysostomus* and *L. nebulosus*) are enumerated separately, and the fish placed in size classes.

5. The results are analysed by comparing numbers of these two groups of fishes from areas of similar habitat; and by comparing the change in ratio of the age classes and absolute numbers with time, in that given transect.

APPENDIX I

INTRODUCTION TO WORKSHOP

by

J.T. Baker
(Member) G.B.R.M.P.A.

The Authority is in the business of managing a national natural resource.

It must recommend to the Minister on areas of the Great Barrier Reef Region which should be declared parts of the Marine Park, and it must establish regulations that will allow management of specific zones for different purposes within the Marine Park.

The Authority has *not* been established to wrap the Reef in cotton wool and prevent use of the region. Rather, it has been established to ensure the controlled development of the Great Barrier Reef Region as a resource to be enjoyed and utilised by today's generation and maintained, with a minimum of human disturbance to its natural state, for the enjoyment and utilisation of future generations.

To be effective and responsible in its functions, the Authority has a role to play in -

- planning and liaison
- research
- public participation
- management.

Within this functional role, factors of biology, ecology, hydrography, demography, economic development, transportation, recreation and impacts of island and mainland activity have to be better understood.

But, as in any business, we must make decisions now - not wait until every aspect in this complex situation is understood. We want to make decisions on the best possible advice available. That is why you are here for one specific aspect of the basics to be considered in the overall decision-making process.

You will know that the Authority is committed to early declaration of the Capricorn/Bunker region as the first Marine Park.

You should apply your consideration in this workshop first to the general Reef Region, but if difficulties arise, then your attention should be directed to specific requirements of this Capricorn/Bunker Region.

I *do* want to see clear objectives agreed to. Within these objectives, there can be searching questions but I would like to think that at the end of the period, we will have a set of recommendations for the Authority to assist it in its zoning and management role.

I will introduce several questions. Mr. Soames Summerhays will then centre on some basic definitions and on specific objectives.

With specific regard to fishing, there are many requests the Authority will have to answer, among these may be some apparently simple questions such as:

- What is the best place to see reef fish?
  - (a) in glass bottom boats?
  - (b) skin diving?
  - (c) SCUBA diving ?

Where can I catch a reef fish or a specific fish e.g. a red emperor?

Then there will be more extensive questions, such as:

(a) the reef is being overfished. I cannot get fish the way I used to. Why don't you do something about it? How can we responsibly answer that question?

What do we know about fish on the Great Barrier Reef or even, specifically, on Heron Island Reef? You are the people to whom we turn. Let me now give some general introduction and perhaps repeat myself a little - specifically on 'fish'.

The Great Barrier Reef Region is an area of major attractions for many reasons.

Overall, it has a considerable historic and romantic appeal in the challenge presented in the mastery of its waters, and the areas near reefs have great aesthetic value in the variety of colours presented, due not only to the living organisms, but also to the great variety of colour tones in the water themselves.

Many people are attracted to the reef simply for relaxation, for occasional viewing from glass-bottom boats, for diving among the corals and the fish, or for reef-walking.

Many others are attracted to collect different marine organisms and, although I do not have precise figures, I suspect that a high percentage of reef visitors *will* throw a line in the water at some time, hoping to 'catch a fish'.

Fish and fishing are major attractions to the region, fish being perhaps the most significant single publicised exploitative activity - and it is to the benefit of all if a management protocol could be established which enables maintenance of fish stocks at levels which are consistent with the overall ecosystem, and which allow a reasonable probability of visitors being able to refer, as one of the highlights of their visit to the Reef, that they saw all these beautiful fish and actually caught this 'beauty' (illustrated) on a fishing trip!

It may seem strange that I introduce the workshop topic of 'Reef Fish Assessment and Monitoring' in this way. I do it deliberately because the Authority exercises its functions over an area which is subject to increasing human presence. After declaration of a section of the Great Barrier Reef Region as a Marine Park, the Authority has the responsibility under s.32(1) of the Act to prepare, as soon as practicable, a zoning plan in respect of that Region.

The zoning plan shall make provision with respect to the purposes for which the zone is to be, or may be, used or entered.

In the preparation of this zoning plan, Section 32 (7) of the Act requires that regard shall be had 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 minimise the effect of those activities on the Great Barrier Reef;

(d) the preservation of some areas of the Great Barrier Reef in its natural state undisturbed by man except for the purposes of scientific research.

Objects (b) and (c) clearly relate to activities which exploit the resources of the Region. All five objects have a strong 'fish component'. One should note however that, apart from Authority approved research and investigations relevant to the establishment, care and development of the Marine Park, or for scientific research, no operations for the recovery of minerals shall be carried on in the Marine Park (Section 38).

One may therefore assume that all other forms of exploitation may be propose for the Authority's consideration.

Fishing, in my opinion, is a key aspect.

What do we mean by fish in this workshop? Fish as individuals or as assemblages? That topic will be addressed by Mr. Soames Summerhays in the next part of the opening session.

For me and the Authority, there are many questions to which we would eventually want to have the answers.

Some of these would be:

1. Is it possible to define reliable methods to evaluate populations of fished species?

2. Can these methods be made applicable to rapid assessment over relatively large areas e.g. around Heron Island?

3. How does one verify these methods?

4. Can one identify important components of an ecosystem for a stable fish population, e.g. currents, substrate, algae, corals, etc.

5. To what extent is there recruitment or exchange of fish populations from one section of the Reef to another?

6. Is it possible to define specific sections of reef areas which are important in the breeding season?

7. Is there a breeding season?

8. Is the breeding season the same for all species?

9. If one identifies the major species of fish or interest to the private (?) professional (?) fisherman, are all species distributed over the entire Barrier Reef Region?

10. If not, should certain species be specifically protected in specific areas?

11. What length of time is necessary to determine if a fish population is varying due to the influence of man (whether that influence be direct - e.g. fishing - or indirect - e.g. destruction of habitat, pollution etc.)?

12. Would it ever be possible to establish when a fish population is in jeopardy, prior to a 'point of no-return' being reached?

13. Can one identify evidence as to the presence of certain fish e.g. nocturnal feeders, even if they are not directly observable in a day-time survey?

14. How important are factors such as ; the time of day - weather conditions - tide - phase of moon, in applying fish population assessment methods? Many people claim that the best fishing is either early morning or late evening. Others say fish bite better on dull overcast days, still others claim fish bite best on a rising tide. Do these proposals relate to movement of fish from one region of the reef waters to another at certain times; are they indications of preferred feeding habits in a population always present in the same area; or are these popular theories not supportable anyhow?
(Whether they are or not, fishermen will always claim that their own theories always - or nearly always - apply.)

15. Is it possible that the demands in the Great Barrier Reef Region differ from those of other fisheries in that there is a significant non-destructive involvement with reef fishes e.g. glass bottom boat, SCUBA diving, for aesthetic pleasure?

16. The Great Barrier Reef Region encompasses regions from the Queensland coast to the reefs and beyond to the open Pacific Ocean waters. It also covers from 2,000 linear km in a north-south direction.

    (a) Are mangrove systems important to reef fish populations? Why?
    (b) Are the waters in the Region, not closely associated with reefs, significant in any 'reef' fish populations? Why?
    (c) Is there any consistent variation in species from outer reef to inner reef regions?
    (d) Is there a north-south variation in species?

17. What is a reef? Is it something containing coral at any depth or is it something containing coral, which is partly or wholly exposed at low tide?

18. What features of food chains are important to the different reef fish species?

19. Are any symbiotic (or related) relationships, important in any of the reef fish to be considered?

20. What fish are important to man in the Reef region (for viewing in their 'natural' habitat for sport, for sustenance, for sale)?

21. Are these the only fish populations which should be monitored?

22. Does one specific method of catching fish more than any other cause any significant change in habit of the remaining fish stock?

All these questions may be asked of an Authority which is seen to be responsible for the management of the Reef resources.

There are many more questions which may properly be proposed, but in this workshop I would hope that we can draw upon your individual areas of expertise to address ourselves to the fundamental questions which must be debated and resolved by you as experts, the answers translated to theories and the theories practised in the field so that a management body has methods to assess the impact of man on the presence of fished demersal fish in the Barrier Reef Region. It seems that the questions 1, 2, 3, 4, 13, 14, and 20 may be the first to assess.

I *wonder* if the methods perfected would only be applicable to Barrier Reef waters? Certainly I hope not. The reason for the Authority conducting the workshop is that we believe we have to find the methods of assessment of different species populations. Fish are but one group, but they do require special consideration. You people represent the most significant expertise in the general field of fish ecology - particularly reef fish ecology.

There is no place for politics or sectional interests in this workshop. There are problems; they need a solution. The results of your work, with your concurrence, will be made widely available through appropriate publications.

To ease the task of recording the decisions and major proceedings of each Section of the workshop, Ms. Hilary Jasper has been appointed rapporteur. She will need your help to ensure that the recordings are accurate. This will lead to an early publication of the workshop activities and decisions.

Mr. Soames Summerhays is the Authority staff member who has instigated this workshop. He will in the next presentation, pose some additional questions, and, with us, determine the realistic objectives and scope of this workshop, which I now formally declare open.

APPENDIX II

PARTICIPANTS FOR FISH METHODOLOGY WORKSHOP
GREAT BARRIER REEF MARINE PARK AUTHORITY
18 NOVEMBER - 28 NOVEMBER 1978

Mr. Gordon Anderson	Australian National Parks and Wildlife Service
Dr. J.T. Baker	Member of Great Barrier Reef Marine Park Authority
Dr. Wendy Craik	Great Barrier Reef Marine Park Authority
Mr. Peter Doherty	Department of Biological Sciences, University of Sydney
Dr. Barry Goldman	Director, Lizard Island Research Station
Miss Hilary Jasper	Australian National Parks & Wildlife Service
Dr. David Pollard	New South Wales Fisheries Service
Mr. Barry Russell	Department of Environmental Studies, Macquarie University
Dr. Peter Saenger	Australian Underwater Federation
Mr. Greg Stroud	Department of Biological Sciences, James Cook University of North Queensland
Mr. Soames Summerhays	Great Barrier Reef Marine Park Authority
Mr. Hugh Sweatman	Department of Environmental Studies, Macquarie University
Professor Frank Talbot	Department of Environmental Studies, Macquarie University
Mr. David Williams	Department of Biological Sciences, University of Sydney

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