Great Barrier Reef Marine Park Authority
Effects of Fishing Programme

INTER-REEF MOVEMENTS OF LARGE REEF FISHES

FINAL REPORT
INITIAL TAGGING EXERCISE

Campbell R. Davies
Department of Marine Biology
James Cook University of North Queensland

Summary

- The initial tagging exercise of a study of the inter-reef movement of large reef fish was performed on the Southern Cluster of the Effects of Fishing Experimental reefs in the Cairns Section of the Great Barrier Reef marine Park between the 1st and 12th of April, 1992.

- Commercial coral trout fishermen were employed to capture the fish which were tagged by personnel from James Cook University and the Great Barrier Reef Marine Park Authority. The perimeter of each reef was divided into blocks and the total effort distributed as evenly as possible between the blocks on each reef. Due to bad weather conditions only 54% of the total number of blocks were fished.

- A total of 2, 153 fish of 48 species were caught with a total fishing effort of approximately 560 man.h. This included 1,136 coral trout, *Plectropomus leopardus*, which were tagged and successfully released. Catch composition was dominated by serranids which accounted for 76% of the catch, with *P.leopardus* accounting for 53%.

- There was no significant difference in the CPUE of *P.leopardus* between reefs. However, CPUE of *P.leopardus* was significantly different among blocks within reefs.

- Results indicated the effectiveness of the sampling design and the use of commercial fishermen to catch and tag large numbers of large reef fish while satisfying the major assumptions of capture-recapture models.

Introduction

The spatial extent of movements of large reef fish (serranids, lutjanids and lethrinids) has not been investigated on the Great Barrier Reef (G.B.R.) on an experimental scale appropriate to the fisheries they support or the zoning plan by which they are managed. Within the current zoning plans for the G.B.R. there are numerous cases of adjacent reefs with opposing zoning status (e.g. General Use B/Marine Park B). In many instances the distance separating the reefs is less than a kilometer. At present there is no documented information on the extent of fish movements across these management boundaries.

The sampling design for the Great Barrier Reef Marine Park Authority (G.B.R.M.P.A.) "Effects of Fishing Experiment" (EoFE) makes the assumption that there is not significant movement of fishes among reefs within experimental clusters (Walters and Sainsbury, 1990). As individual reefs constitute the experimental treatments in each location, significant movement between reefs will confound the results obtained. Walters and Sainsbury (1990) suggested that inter-reef movements exceeding 25% of an individual reef's population could mask any potential difference in adult fish abundance resulting from the line fishing treatment. It was strongly recommended that a large scale study of the patterns of movement of the principle target species (*Plectropomus leopardus*& *Lethrinus miniatus*) be undertaken as part of the EoFE pilot study to quantify the extent of movements between the reefs selected for the experiment (Walters and Sainsbury, 1990).

Recent studies at Orpheus and Pelorus Is. indicate that fish do transverse these boundaries (Davies, unpubl.data). Several other studies have demonstrated that large reef fishes have the potential to move substantial distances within and between reefs (Beinssen, 1989a&b; Craik and Mercer,1981; Samoilys, 1986). However, there is no quantitative information available on extent of immigration or emigration of fishes from an individual reef, the temporal patterns of any movements or the particular biological mechanism(s) which may be driving any movements.

The aggregation of coral trout to spawn has long been known to fishermen and scientists on the G.B.R.. This is one of the most likely biological mechanism to drive inter-reef movements of individual fishes. However, there is little or no documented information on the distances moved by individual fish to spawning aggregations or the patterns of dispersion following spawning events. In order to comprehensively address the question of inter-reef movement it is essential that the tagging study is carried out over a time frame which incorporates periods of both non-spawning and spawning activity of coral trout.

Objectives

The objective of this study is to quantify the extent of movement of large reef fish, principally *Plectropomus leopardus*, between reefs and determine the possible effects of inter-reef movement on the experimental design for the EoFE experimental design. More specifically it aims to answer the following questions over a 12 month sampling period:

i) What is the level of exchange of large reef fish among individual reefs within the experimental cluster?

ii) What proportion of each individual reef's population does the exchange constitute?

iii) Is the level of movement constant between different reefs?

iv) Is there a temporal pattern to movement related to spawning activity?

Sampling design and Methodology

Sampling Design

The southern cluster for the EoEE Pilot study includes 6 reefs (Beaver, Taylor, Farquharson, Eddy, 17-060 and Potter Reefs) adjacent to the southern boundary of the Cairns Section of the Great Barrier Reef Marine Park, south of Innisfail. In order to make the most effective use of the available resources, it was decided at the EoFE meeting (18th Nov. 1991) that the pilot study for the movement study would be carried out on this cluster only. The reefs within the southern cluster may be subject to three different fishing regimes following the implementation of the new Cairns section zoning plan, which will provide three experimental treatments : a) Closed -> continued closure (Beaver Reef); b) Partial protection -> manipulation of fishing effort (Taylor and Farquharson Reefs): c) Open -> remaining open (Eddy, Potter and 17-060 Reefs) (Figure 1). Figure 2 provides estimates of the shortest distances between adjacent reefs within the southern cluster. The proposed manipulation of fishing effort (and presumably fish density) and the positions of the individual reefs may provide the opportunity to examine the effect of density and distance between reefs on the rate of movement of fish between reefs.

The perimeter of each reef will be divided into a number of blocks using temporary marker buoys. This will facilitate even distribution of fishing effort across each reef and analysis of patterns of movement within reefs. Each block shall be defined as a strip parallel to the reef crest extending vertically down the reef from the reef crest to the bottom of the reef slope (e.g. Beinssen, 1989a). The exact position of the boundaries of individual blocks shall be permanently recorded using Global Positioning Systems (G.P.S.). The number of blocks per reef shall be a function of the total area of crest-slope habitat for each individual reef. Hence, the total sampling effort will be divided evenly between the total number of blocks within the cluster, rather than allocating the same total level of sampling effort to each individual reef.

The initial tagging exercise was performed between the 1-12 April. This consisted of 10 days tagging and 2 days travelling. The 10 commercial trout fishermen and 10 taggers were divided into 4 teams. Three teams of 3 dories and one team on the 'Nancy E', the smaller of the two commercial mother vessels. Each fishermen was assigned a tagger at the beginning of the exercise and these teams remained the same for the duration of the trip.

On any one reef, each team of 3 dories was assigned a block which they would fish. The effort from the 'Nancy E' was then distributed evenly between each of the 3 blocks. The advantage of the 'Nancy E' was that it could be used to fish deeper and more exposed areas more safely than the dories could. This procedure was repeated until each block on the reef had received the same level of fishing effort.

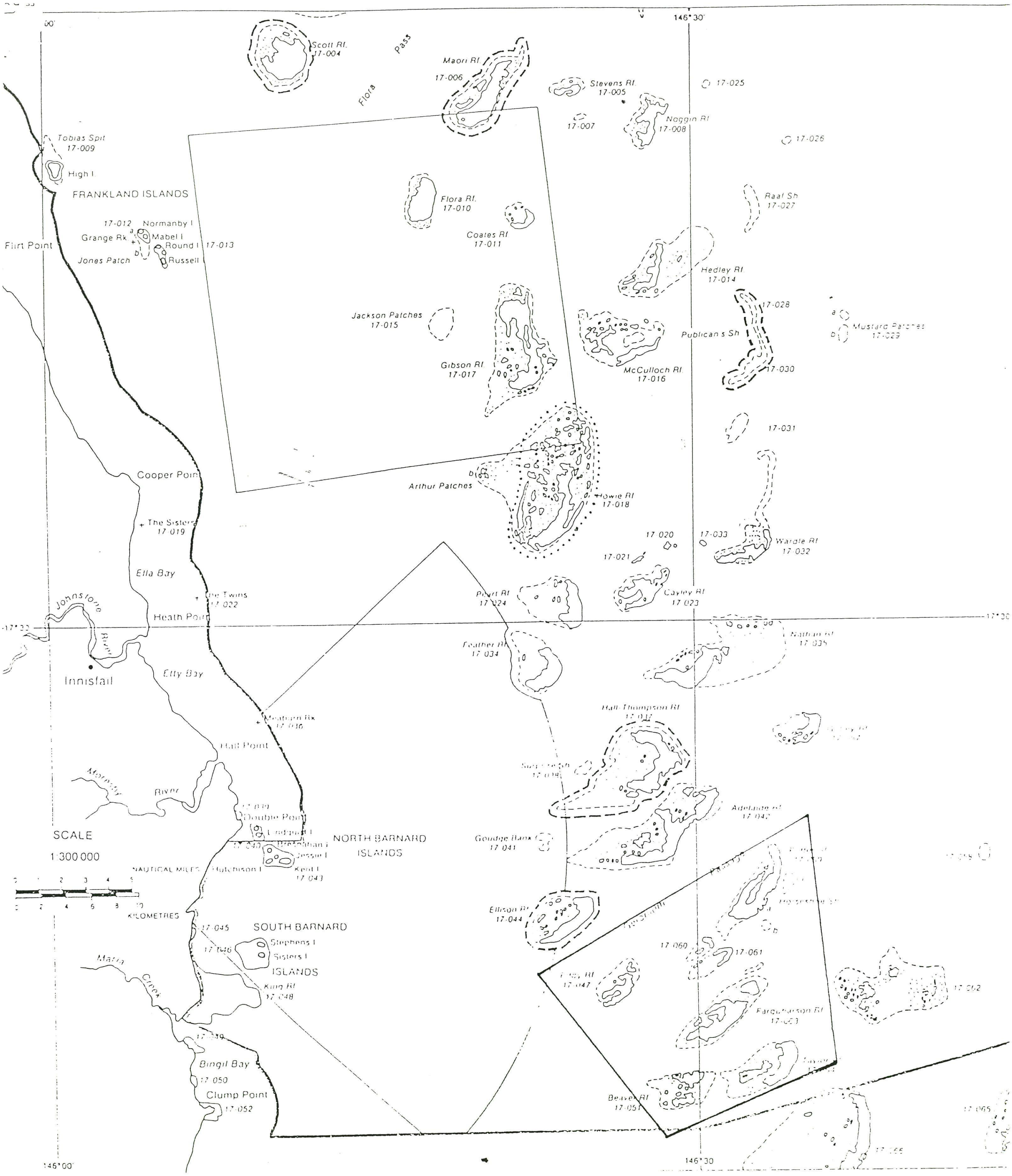

Figure 1: The location of the southern cluster of reefs (Beaver, Taylor, Farquharson, 17-060/061, Eddy and Potter) for the Effects of Fishing pilot study and site of the inter-reef movement study.

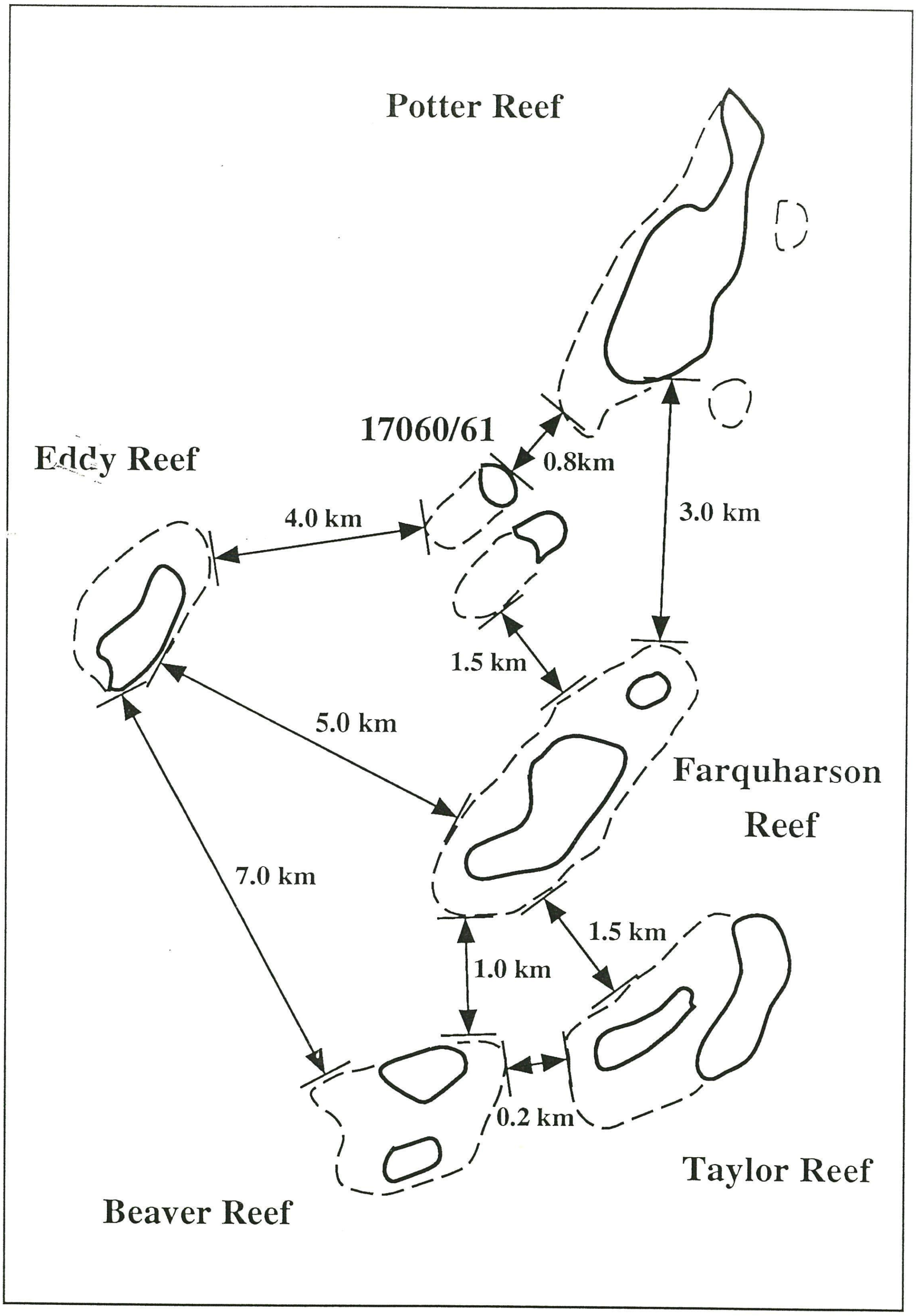

Figure 2: Estimated minimum distances between adjacent reefs within the southern EoFE cluster.

Within each of the teams of 3 dories, 2 dories tagged with T-bar anchor tags only and 1 dory tagged with T-bar anchor tags and Dart tags. In order to distribute the total effort evenly over the whole block and at the same time distribute the Dart /T-bar tagged fish evenly among the T-bar anchor tagged fish, each team fished the blocks in the following way. The 2 dories using only T-bar anchor tags were assigned to opposite ends of the block and systematically worked towards the center of the block. Hence, each "T-bar" dory only fished one half of the area of the block. The single dory using Dart and T-bar anchor tags worked the entire length of the block over the same period, thus distributing the Dart/T-bar tagged fish evenly between the T-bar only tagged fish. Furthermore, as the fishermen rarely fished a "rock" (coral bombie) which had been fished by another dory, this ensured a large proportion of the habitat within each block was fished.

In a further attempt to distribute the effort evenly over the blocks, minimum and maximum time intervals were set for any one fishing position (hang). Each dory fished for a minimum of 10 min and a maximum of 30 min at any one hang. All commercial fishermen used 70-80lb hand lines with 9/0 hooks. Taggers, also fished when possible to maximize the available effort.

Due to extremely rough seas (winds averaging 25 - 30 kts with 2-2.5m seas) during the trip, it was not possible to fish the blocks located on the front (S.E. aspect) of Potter (4 blocks), Farquharson (4 blocks) or Taylor (3 blocks) reefs and, as a result of the time lost, Eddy reef was not fished at all. (Table 2, Figure 3).

It was only feasible to deploy marker buoys to delineate the sampling blocks at Beaver and Potter reefs. The rough sea conditions made it time consuming to deploy the buoys before fishing could begin and, even when deployed, the buoys were seldom visible from distances greater than 100 m. As a result, deployment of the buoys was abandoned after fishing Potter reef and major features of the individual reefs were used to divide the reef into sampling blocks.

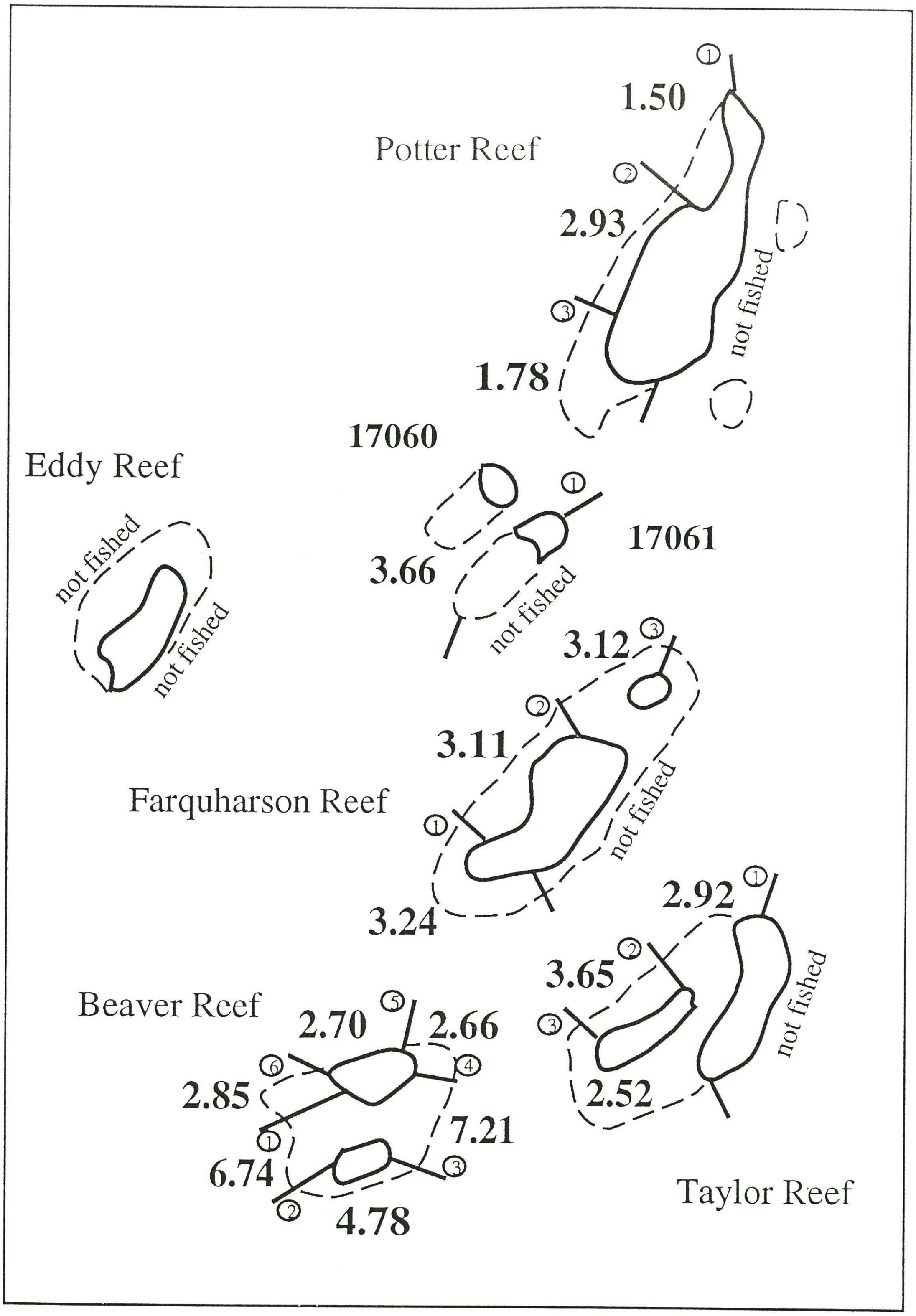

Figure 3: Mean CPUE (fish.man.h) of *Plectropomus leopardus* for each block(individual block numbers are circled) within each reef of the cluster. Areas of reefs which were not fished are indicated ("not fished").

Analysis

Catch Per Unit Effort (CPUE) data were analyzed using each individual hang as a replicate. Thus, the CPUE for a hang is equivalent to the total catch at the hang divided by the duration of the hang. The unit of CPUE is fish.man.h. This definition of effort does not include the time spent travelling between hangs, only the time between setting and hauling of the anchor. It is thought that this provides the best standardization of effort between fishermen.

The fishing effort of the taggers has not been included in this analysis, due to the lack of effort data recorded by individual taggers and the extreme variation in the fishing skill and time spent fishing between taggers. The catch by taggers for all reefs was 297 fish which included 121 *P.leopardus*. This represents 14% of the total catch and 10% of the total *P.leopardus* caught for the trip. As this effort has not been included in the analysis, the estimates of CPUE provided are likely to be overestimates.

ANOVA's were performed on the CPUE and length frequency data for *Plectropomus leopardus* to determine whether CPUE or the mean fork length differed significantly between reefs or among blocks within reefs. The models for the ANOVA's are presented in Tables 1a-c.

The 2-way nested ANOVA's of CPUE and fork length for *P.leopardus* have been performed using the data from the three back reef blocks of Beaver, Taylor, Farquharson and Potter Reefs. The three reef front blocks at Beaver Reef and the single block at 17060/61 have been omitted in order to balance the design.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Reef	F	4	B(A)
B(A)	Blocks	R	8	Residual

Table 1a: 2-way nested Model III Anova used in analyses for differences in the CPUE and mean size of *P.leopardus* between reefs and among blocks(back reef) within reefs. 17060/61 and blocks (reef front) 1, 2 and 3 of Beaver reef were omitted.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Reefs	F	4	Residual

Table 1b: 1-way ANOVA used in analyses for differences in the mean size of *P.leopardus* .between reefs.

Factor	Source of Variation	Fixed/Random	df	Denóminator
A	Blocks	F	5	Residual

Table 1c: 1-way ANOVA used in analyses for differences in the CPUE and mean size of *P.leopardus* among blocks within Beaver Reef.

Results

Catch Composition

A total of 2,153 fish of 48 species from 8 families were caught over the 10 days sampling. 2,123 of these were tagged and successfully released. This included 1,136 coral trout, *Plectropomus leopardus*. The total effort by the commercial fishermen over this period was approximately 560 man.h. The distribution of effort between reefs is provided in Table 2.

	Beaver	Taylor	Farquharson	17-060/061	Potter
Date	2/4-3/4:9/4	8/4-9/4	9/4-11/4	7/4	4/4-6/4
Effort	132	108	120	60	140
% Fished	100	57	55	57	55

Table 2: The dates when each of the five reefs were fished, the total fishing effort from the commercial fishermen (man.h) and the proportion of the blocks fished on each reef. The proportion of the blocks fished is equivalent to the percentage of the total perimeter of each reef that was fished.

The catch was dominated by three families, the Serranidae, Lutjanidae and Lethrinidae (Table 3). The Serranidae (19 species) accounted for 76% of the total catch while the Lutjanidae (11 species) and Lethrinidae (12 species) constituted 12% and 11% of the total catch, respectively (Table 3). Nine species accounted for 89% of the total catch (Table 4). *Plectropomus leopardus* was the most abundant species accounting for 54% of the total catch. *Cephalopholis cyanostigma* (13%), *Lutjanus carponotatus* (6%), *Lethrinus atkinsoni* (4%) and *Lethrinus miniatus* (4%).were the other dominant species (Table 4).

	Serranidae	Lutjanidae	Lethrinidae	Others	Total
No.Species	19	11	12	6	48
Total Catch	1630	257	242	24	2153
% Total Catch	76	12	11	1	100

Table 3: Summary of catch composition, by family, for all reefs with number of species given for the dominant families and the percentage of the total catch each family constitutes.

Species	Beav.	Tayl.	Farq.	060/061	Pott	Total
Cephalopholis cyanostigma	7	16	13	14	27	13
Epinephelus fuscoguttatus	3	1	1	1	1	2
E.merra	0	2	2	3	3	2
Plectropomus leopardus	57	55	53	57	46	54
Lutjanus bohar	1	4	4	3	2	3
L. carponotatus	7	4	7	6	3	6
Lethrinus atkinsoni	4	3	5	4	6	4
L.lentjan	2	1	1	1	2	1
L.miniatus	5	2	4	4	3	4

Table 4: The percentage of the total catch (by number) represented by the nine dominant species for each reef and for all reefs combined.

Catch Per Unit Effort

CPUE was seen to vary for different species between reefs. The CPUE for the nine most abundant species in the catch for each of the reefs are given in Table 5. CPUE for *P.leopardus* was highest at Beaver reef and lowest on Potter reef (Figure 4). This pattern was evident also for *Epinephelus fuscoguttatus*, *Lutjanus carponotatus*, *Lethrinus atkinsoni* and *L.miniatus* (Table 5). In contrast, CPUE for *Cephalopholis cyanostigma* and *Epinephelus merra* was highest on Potter reef and lowest on Beaver reef.

Species	Beav.	Tayl.	Farq.	060/061	Pott	Total
Cephalopholis cyanostigma	0.42	0.50	0.53	0.43	0.61	0.51
Epinephelus fuscoguttatus	0.17	0.04	0.03	0.02	0.04	0.07
E.merra	0.02	0.06	0.07	0.08	0.08	0.06
Plectropomus leopardus	4.35	3.06	3.16	3.33	2.26	3.25
Lutjanus bohar	0.08	0.12	0.18	0.10	0.06	0.11
L. carponotatus	0.38	0.13	0.28	0.18	0.10	0.22
Lethrinus atkinsoni	0.21	0.10	0.18	0.13	0.17	0.17
L.lentjan	0.13	0.04	0.03	0.03	0.06	0.06
L.miniatus	0.29	0.07	0.16	0.13	0.08	0.15

Table 5: CPUE (fish.man.h) for each of the nine dominant species for each reef and for all reefs combined.

Maximum CPUE of *P.leopardus* for the back reef blocks occurred at Taylor Reef, block 2 (3.65 fish.man.h.+/- 0.57 S.E) with a minimum of 1.50 fish.man.h.(+/-0.46 S.E.) recorded for Block 3 of Potter Reef. The observed difference in CPUE for *P.leopardus* was not significant between reefs ($p>0.2359$, d.f.= 3, 8) but was significantly different among blocks within reefs ($p<0.0003$, d.f.= 8, 643). SNK *a posteriori* multiple comparisons of means failed to detect significant differences between the mean CPUE of the different blocks.

CPUE *P.leopardus* was found to be significantly different between blocks within Beaver Reef ($p<0.001$, d.f.= 5, 220). SNK *a posteriori* multiple comparisons of means failed to detect significant differences between the mean CPUE of the different blocks.

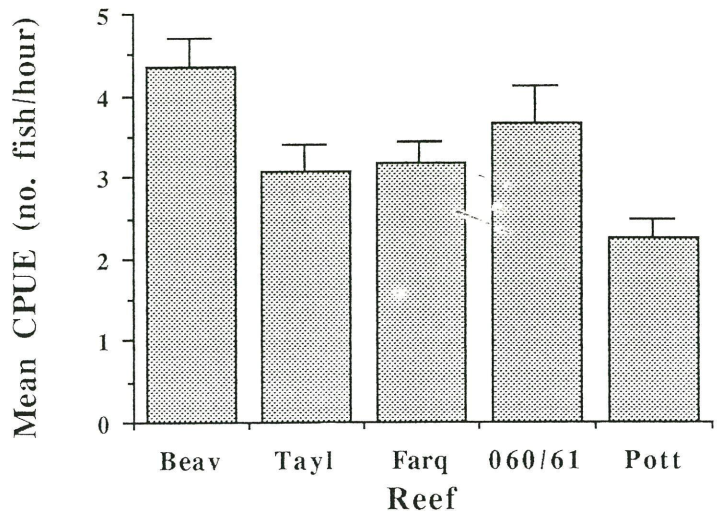

Figure 4: Mean CPUE (fish.man.h.) for *Plectropomus leopardus* for each reef within the cluster. Error bars represent one standard error.

The highest levels of CPUE for the study were obtained for blocks 1, 2 and 3 of Beaver Reef while the back reef blocks of Beaver Reef(4, 5, 6) had CPUE values similar to those of back reef blocks of the other reefs (Table 6). Blocks 1, 2 and 3 are located at the front (exposed) side of the Beaver Reef (Figure 3). These were the only reef front blocks fished during the study (Figure 3). Extremely rough conditions resulted in all subsequent fishing being confined to back reef blocks (Figure 3).

Length Frequency

The mean fork length of *P.leopardus* was significantly different between reefs ($p<0.0042$, d.f.= 4, 1151).with Taylor Reef having the largest mean size (435.16mm +/-

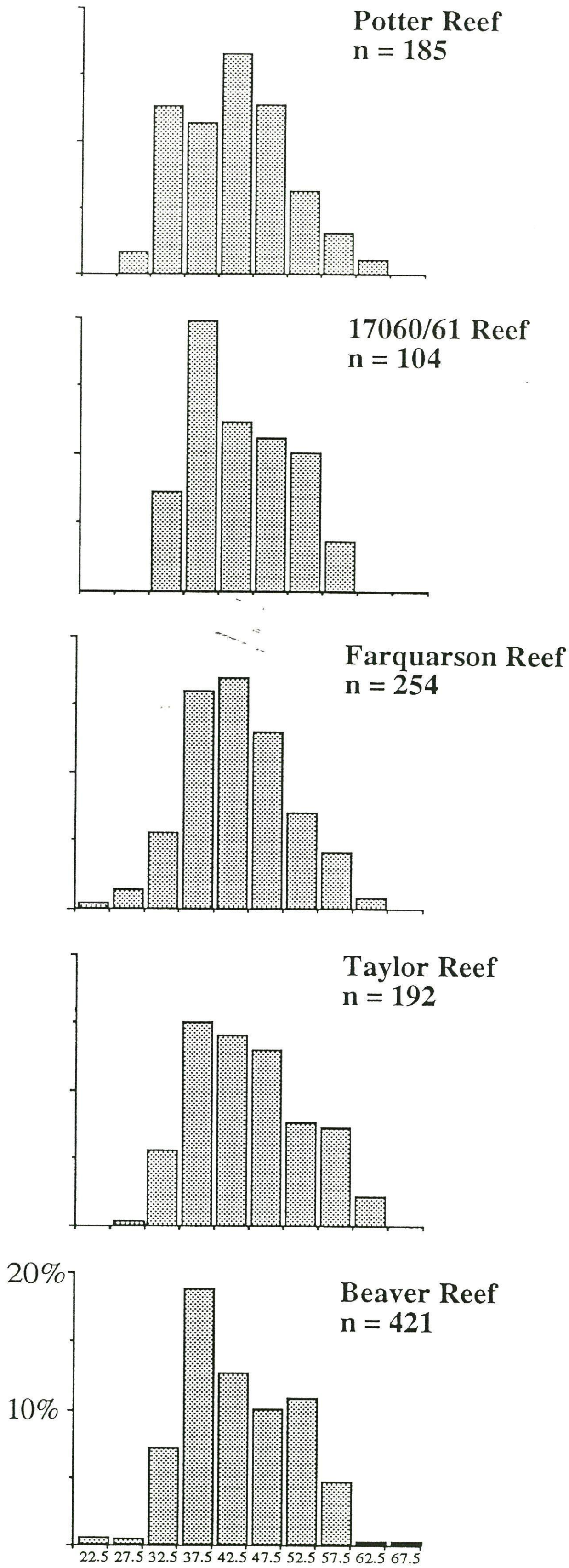

Figure 5 : Length frequency distributions (5cm size classes with mid-point given) of *Plectropomus leopardus* for each of the five reefs fished with number of fish per reef (n) given.

5.41 S.E.) and Potter Reef the smallest (408.93mm +/- 5.19 S.E.) (Table 7). However, SNK *a posteriori* multiple comparisons of means failed to detect significant difference in the mean size between reefs. The length frequency distribution of *P.leopardus* for each reef is illustrated in Figure 5.

Reef / Block No.	n	Mean CPUE	S.E.
Beaver 1	28	6.74*	0.95
Beaver 2	25	4.78*	0.86
Beaver 3	45	7.21*	0.93
Beaver 4	55	2.66	0.54
Beaver 5	26	2.70	0.80
Beaver 6	47	2.85	0.60
Taylor 1	34	2.92	0.66
Taylor 2	59	3.65	0.57
Taylor 3	52	2.52	0.50
Farquharson 1	71	3.24	0.42
Farquharson 2	78	3.11	0.46
Farquharson 3	53	3.12	0.60
17060/61 1	93	3.66*	0.45
Potter 1	43	1.78	0.39
Potter 2	102	2.93	0.39
Potter 3	62	1.50	0.46

Table 6: Number of "hangs" (n), mean CPUE (fish.man.h) and Standard Error(S.E.) for *Plectropomus leopardus* for all blocks. * indicates blocks which were omitted from the 2-way nested ANOVA.

The mean size of *P.leopardus* differed significantly ($p<0.0067$, d.f.= 5, 415) between blocks within Beaver Reef also. SNK *a posteriori* multiple comparisons of means failed to detect significant difference in the mean size between blocks. The mean size of *P.leopardus* was greatest for blocks 3 and 4 and least for blocks 5 and 6 (Table 8.and Figure 6).

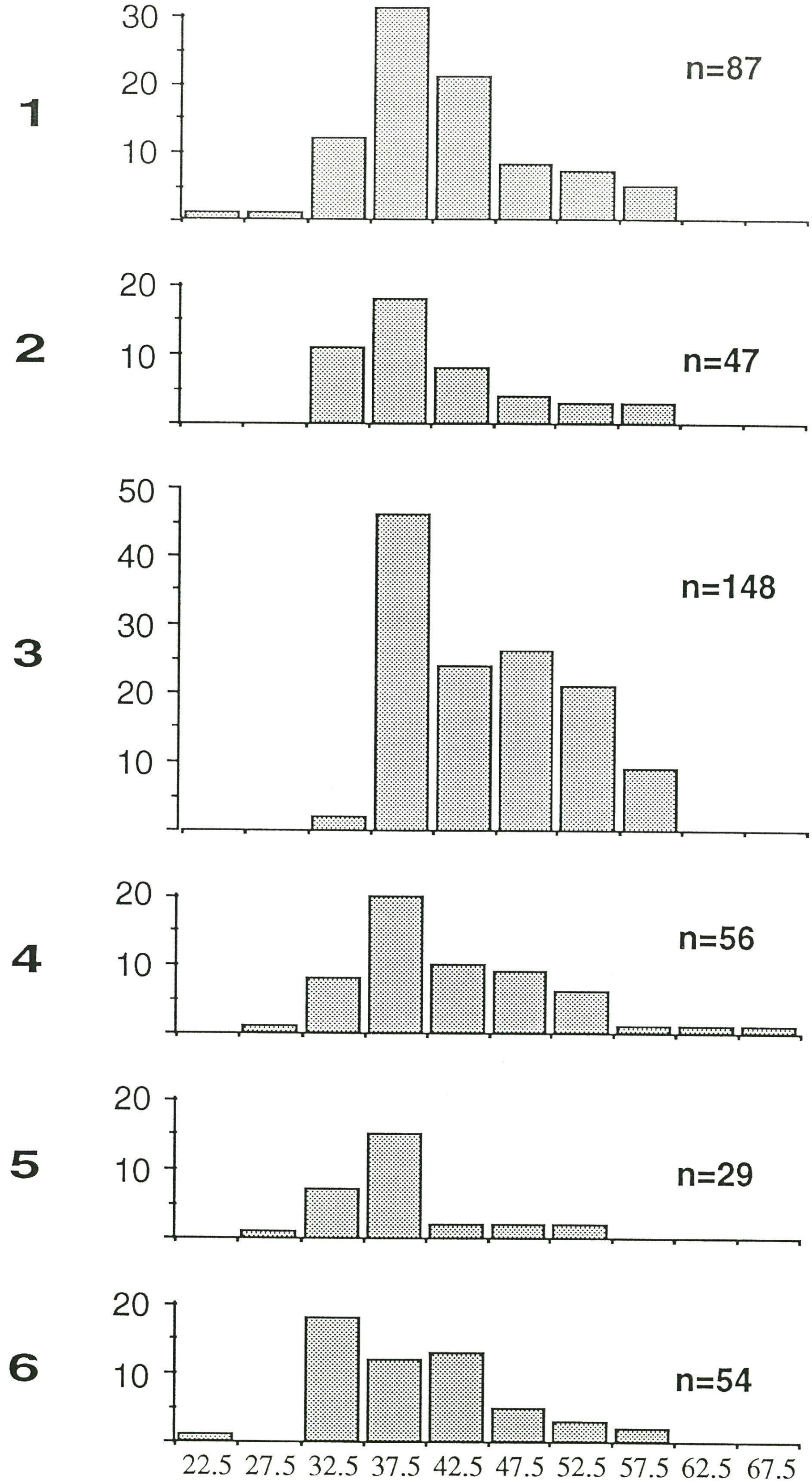

Figure 6: Size distribution (midpoint of each 5cm size class is given) of *Plectropomus leopardus* for each block within Beaver Reef. n = total number of fish / block.

Reef	Mean Fork Length (mm)	S.E.
Beaver	413.97	3.55
Taylor	435.16	5.41
Farquharson	419.70	4.39
17060/61	417.61	6.82
Potter	408.93	5.19

Table 7: Mean fork length (mm) and Standard Error (S.E.) for *Plectropomus leopardus* for each reef.

The presence of relatively few very large fish increased the mean size in block 4 (Figure 6). There were few large individuals captured in the back reef blocks (Figure 6) resulting in a lower mean size for blocks 5 and 6 (Table 8).

Reef / Block	n	Mean Fork Length	S.E.
Beaver 1	87	413.10	7.63
Beaver 2	47	404.89	10.49
Beaver 3	148	426.66	4.76
Beaver 4	56	424.34	10.17
Beaver 5	29	380.79	10.51
Beaver 6	54	378.19	9.45
Taylor 1	49	440.37	9.83
Taylor 2	81	420.27	7.40
Taylor 3	62	450.48	10.99
Farquharson 1	103	408.12	6.75
Farquharson 2	83	419.54	7.50
Farquharson 3	68	437.43	8.63
17060/61 1	104	416.76	6.81
Potter 1	36	422.00	11.89
Potter 2	106	409.65	6.96
Potter 3	43	398.05	10.33

Table 8: Number of individuals of *Plectropomus leopardus* (n), mean fork length (mm) and Standard Error(S.E.) for all blocks.

Tagging

One thousand one hundred and fifty-six *P.leopardus* were caught of which 20 died as a result of severe embolisms or being deeply hooked in the throat. Thus, a total of 1,136 *P.leopardus* were double tagged and successfully released. The number of *P.leopardus* caught, tagged and successfully released on each reef is given in Table 9, together with the number and proportion of individuals tagged with Dart and T-bar tags and T-bar tags only. The number of *P.leopardus* tagged and successfully released in each block of each reef is presented in Figure 7.

	Beav.	Tayl.	Farq.	060/061	Pott.	Total
Caught	421	192	254	104	185	1,156
Died	5	6	6	2	1	20
T-bar	272	133	175	76	129	785
Dart/T-bar	146	53	83	27	55	364
% Dart/T-bar	35	29	32	26	30	32
Total tagged	416	186	248	102	184	1136

Table 9: Number of coral trout, *Plectropomus leopardus*, caught, tagged and released for each reef and for all reefs combined. Number of individuals tagged with T-bar anchor tags only and Dart/T-bar combination is given also.

Eight tagged fish have been returned to date including, 6 *P. leopardus* (Table 10). Six of these fish have been recaptured on the same reef as they were originally tagged (Taylor Reef). Two of fish, one *P.leopardus* and one *Cephalopholis cyanostigma,* have been recaptured on a different reef (Potter Reef) to which they were tagged (17060/61) (Table 10).

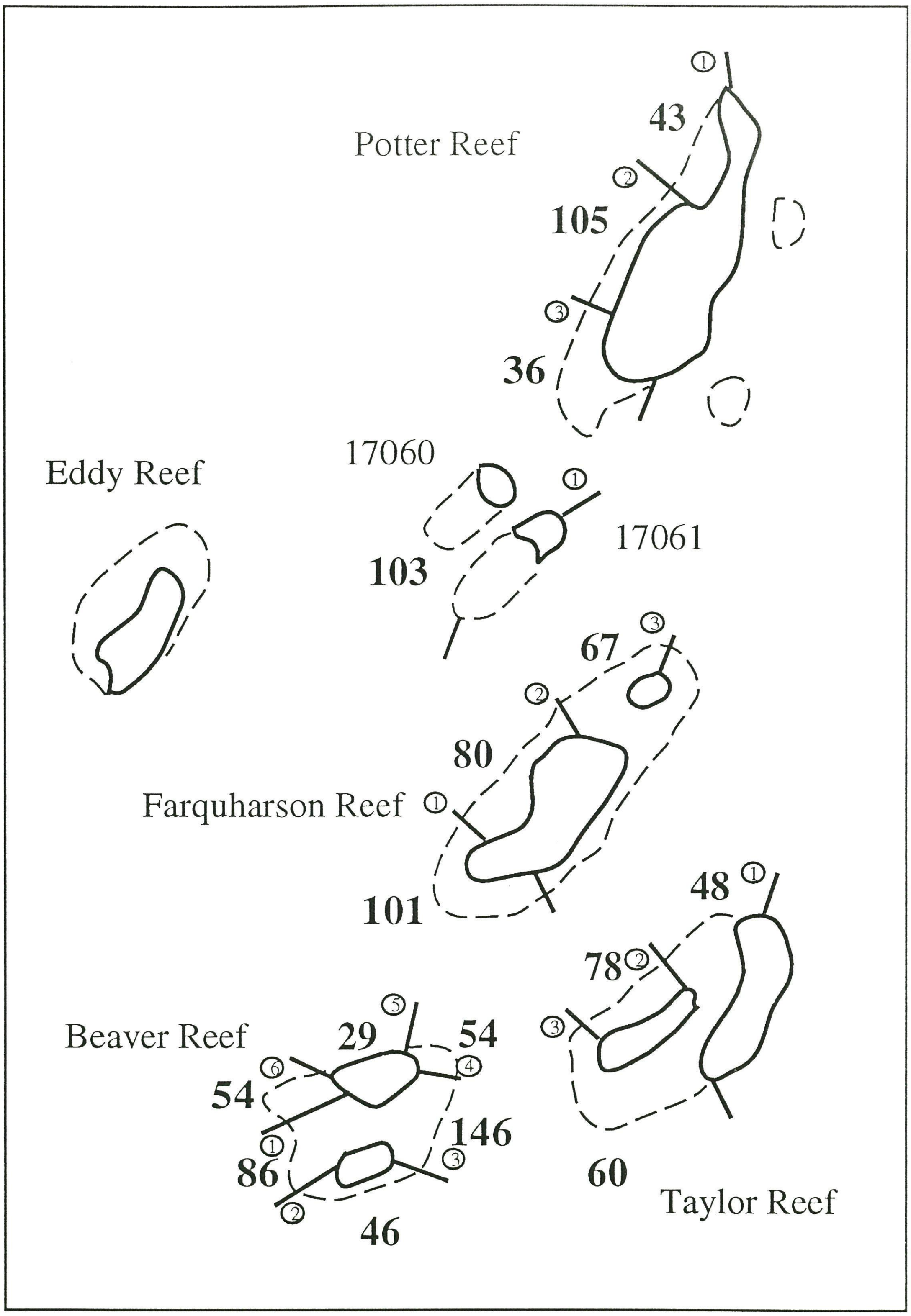

Figure 7: Number of *Plectropomus leopardus* tagged and successfully released in each block (individual block numbers are circled) for each reef.

Fishermen	Species	Reef Tagged	Reef returned
Recreational	*Plectropomus leopardus*	17060	Potter
	Cephalopholis cyanostigma	17060	Potter
Commercial	*Plectropomus leopardus*	Taylor	Taylor
	Plectropomus leopardus	Taylor	Taylor
	Plectropomus leopardus	Taylor	Taylor
	Plectropomus leopardus	Taylor	Taylor
	Epinephelus fasciatus	Taylor	Taylor
Recreational	*Plectropomus leopardus*	Taylor	Taylor

Table 10: Summary of tag recoveries to date with category of fishermen, individual species returned and reef on which each fish was tagged and recaptured.

Discussion

Catch Composition

The catch was dominated by serranids (76%) with the common coral trout, *Plectropomus leopardus,* by far the most common species (53%). The catch composition indicates the selectivity of the capture technique employed, with five species accounting for 81% of the total catch, particularly for targeting serranids such as *P.leopardus*

The small serranids,*Cephalopholis cyanostigma* and *Epinephelus merra,* comprised a greater percentage of the total catch at Potter Reef than any of the other reefs fished, while *P.leopardus* and the other commercial species represented a smaller proportion of the total catch at Potter Reef than the other reefs. A similar pattern is evident in the CPUE data. It may be that *C.cyanostigma* is more abundant on Potter reef than on the other reefs, or the catchability of *C.cyanostigma* is greater a Potter Reef due to a relative decrease in the density of *P.leopardus.* An independent estimate of abundance of the two species at the different reefs would be necessary to distinguish between the two processes.

CPUE was greatest at Beaver Reef (Closed) and least at Potter Reef (open) for 6 of the most dominant species, including *P.leopardus.* This difference was particularly marked for the large serranids with CPUE for *E.fuscoguttatus* being four times greater on Beaver Reef than on any other reef. The reverse pattern was evident for the smaller serranids *Cephalopholis cyanostigma* and *E. merra.* Although there is no replication of closed reef in this study, this suggests that CPUE of large serranids such as *E.fuscoguttatus, E. malabaricus and P.laevis,* which are much less abundant than *P.leopardus,* may be a more sensitive indicator of effects of fishing than the CPUE of *P.leopardus.*

CPUE for *P.leopardus* did not differ significantly between reefs but was found to differ significantly among blocks within reefs. However, the *a posteriori* multiple comparisons were unable to detect significant differences between the means of individual blocks. This is likely to be due to the unbalanced number of replicates within each level of the nested factor in the analysis.

There was a significant difference in CPUE and mean size of *P.leopardus* between blocks within Beaver Reef but again the *a posteriori* multiple comparisons were unable to detect significant differences between the means of individual blocks. However, it is apparent that CPUE was considerably, albeit not significantly, higher for the reef front blocks of Beaver Reef compared to the back reef blocks. If this pattern is the same for the other reefs within the cluster, it suggests that a large proportion of the populations of *P.leopardus* on these reefs have not been sampled. It will be a priority of the first recovery exercise to fish these reef front blocks.

It should be noted that the principle objective of this exercise was to tag as many fish as possible on the reefs within the cluster. Therefore, every effort was made to utilize all the fishing effort available to maximize total catch. If the major objective had been to obtain estimates of relative abundance of the target species from CPUE data, an alternative sampling design would have been employed incorporating more rigorous definition and stratification of fishing effort.

The failure of the *a posteriori* multiple comparisons to detect differences detected by the ANOVA's is likely to be the result of the unbalanced replication and the high level of zero values which result in a non-normal distribution of the data. *A posteriori* tests, such as the SNK, tend to be less powerful than ANOVA and more sensitive to unbalanced replication (Underwood, 1981). A more powerful test could be made if the hang time was set at a single time (e.g.20 min), rather than a 20 min range, and the number of replicates/block balanced.

Capture and Tagging

Two thousand one hundred and fifty-three fish were caught during the 10 days fishing. This included 1,156 *P.leopardus* of which 1,136 were tagged and successfully released. It was only possible to fish 54 % of the reef area within the cluster. This gives an average density of tagged *P.leopardus*. within each block of 71. It is essential that those reef front blocks which were not fished in this exercise are fished in the first recovery exercise. This will provide a sound basis for the analysis of movement patterns of *P.leopardus* within and between reefs. This will only be possible if sufficient numbers of returns are obtained and the information is accurate.

To date the rate of returns has been low from the commercial and recreational fishing communities. This may be a reflection of the fishing pressure on these reefs. Furthermore, there is considerable variation in the accuracy of data supplied with each return, particularly with regards to position of capture. For these reasons the proposed recovery exercises are essential to the success of this study by ensuring large numbers of recoveries, accurate data on position of recapture and the opportunity for multiple recaptures (as fish recaptured during the recovery exercises would be released again).

Recommendations for Future Research

The primary objective of the initial tagging exercise was to tag as many coral trout (*Plectropomus leopardus*) as possible in a manner which satisfied the major assumption of Capture-Recapture models. Namely, the even distribution of effort across the study area to ensure the tagged individuals are mixed through the population. Despite the weather conditions which prevailed for the majority of the field-work, this objective was achieved for approximately 54% of the reef area of the cluster. Eddy Reef was not fished as a result of the fishing time lost due to bad weather. It was decided that the effort would be more effectively used to maintain the required level of the effort (therefore the density of tagged fish) on the five other reefs rather than spread the reduced level of effort over all reefs.

The effectiveness of using commercial trout fishermen is evident from the high levels of CPUE obtained, the wide distribution of this effort over the reefs and their ability to work effectively under extremely difficult fishing conditions. It would be difficult to achieve similar results using charter vessels manned with recreational fishermen.

As a result of the extreme weather conditions the fronts of four of the five reefs were not fished. The fishermen suggest that had it been possible to fish these areas of the reefs the catch of *P.leopardus* would have been greater. This is supported by the results of the CPUE analysis for *P.leopardus* at Beaver Reef, where CPUE was higher on 2 of the 3 reef front blocks.

The size of the operation during this exercise (3 vessels and 20 personnel) meant that it was not cost-effective or logistically possible to stop the trip in response to bad weather conditions and continue at a later date. This is due to the availability of the tagging personnel (who all have personal research commitments) and the cost of steaming to and from the cluster in the charter vessel. A smaller operation would be more responsive, making it logistically feasible to re-schedule trips around favorable fishing periods (tides and weather). It would also reduce the field logistics and the variation in the skill level of individual fishermen. This is likely to substantially increase the overall

CPUE and thus the cost-efficiency of the exercises. It is suggested that subsequent exercises will take the form of 2 shorter trips, involving fewer personnel, which are timed to coincide with favorable fishing periods.

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