WORKSHOP ON CORAL TROUT ASSESSMENT TECHNIQUES

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INTRODUCTION

The first Workshop on Fish Asssessment Techniques in November 1978 (G.B.R.M.P.A., 1978) concluded that, of the techniques investigated for estimating populations of commercially and recreationally important species of bottom reef fish, the intensive search technique was the only feasible technique for realistic estimates of these populations. However a number of questions concerning the technique remained to be answered. A second Workshop on Fish Assessment Techniques was therefore conducted to determine:

1. the distance or time period which would provide a statistically valid population assessment;
2. the number of replicate swims necessary to provide a statistically valid population estimate over the fixed time period or fixed transect distance;
3. whether the number of replicates required makes this technique feasible for relatively rapid reef assessment;
4. the relationship between time of day and state of tide and the population estimate;
5. the relationships of between observer and within observer variability;
6. a feasible method for consistently estimating size classes to reduce between observer variability;
7. whether the technique would reveal differences in fish populations between an 'unfished' reef (e.g. Heron) and a 'fished' area (e.g. Masthead).

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The Workshop was conducted for two weeks from 21 April to 4 May at Heron Island and was attended by four biologists from various organisations (Appendix 1). This report, which reflects the Workshop program, is essentially divided into three parts:

1. Underwater length estimation

In this Section variability in underwater length estimation was examined and standard techniques for improving accuracy and reducing variability were developed and employed.

2. Coral Trout Censusing

This Section involved diving censuses to determine the required transect time/length, required number of replicates, observer, tidal and time variability factors, usefulness of the method, differences between areas etc. and the relationship of results found in this study to other studies.

3. Proposed action and recommendations

A brief outline of the action proposed as a result of the Workshop findings is presented. Several Recommendations are also provided.

STATISTICAL TESTS

The major aim of both the length estimation work and the coral trout censusing was to compare size class distributions, the comparison of total numbers of coral trout observed being of secondary importance. Although the expected distribution of the stick lengths was known, the expected distribution of fish in the 'unfished' area was unknown. Moreover, a test was required which permitted comparison of samples obtained by different observers, where again there was no 'expected' distribution. The kind of test required to compare distributions needs to be particularly sensitive to skewness. For these reasons, the non-parametric Kolmogorov-Smirnov test (Siegel, 1956) was chosen. This test permits comparison of two independent samples by comparisons of the cumulative distributions and is sensitive for any kind of differences between distributions. Although the χ^2 test would have been appropriate for comparison of the observed and expected 'stick' distributions, the Kolmogorov-Smirnov test is believed to be more powerful and was therefore used for all comparisons of size class distributions.

In the examination of the appropriateness of the Kolmogorov-Smirnov test, the size class distribution of coral trout in the 'unfished' area observed in the First Workshop (G.B.R.M.P.A., 1978) was reversed to approximate the size class distribution of a 'fished' population.

Size class (cm)	0-20	20-40	40-60	60-80	80-100
'Unfished'	0	30	130	155	47
'Fished'	47	155	130	30	0

Under the Kolmogorov-Smirnov test, the two distributions were significantly different ($p > .05$).

The test is not sensitive simply to the added presence of a smaller size class in the population. This smaller size class may merely reflect recruitment. This was shown when the following distributions were compared and were found to be not significantly different ($p > .05$):

Size class (cm)	0-20	20-40	40-60	60-80	80-100
'Unfished	0	30	130	155	47
'Fished'	20	47	155	130	47

Dividing the 'unfished' population by two and comparing it with 'unfished' population shows that low numbers will not by themselves produce a significant difference ($p > .05$) since the test is based on proportions:

Size clas (cm)	0-20	20-40	40-60	60-80	80-200
'Unfished'	0	30	130	155	47
'Unfished x ½'	0	15	65	78	24

Thus the test appears to be entirely appropriate for the intended purpose, since it will tolerate some variability between distributions, but regards as significantly different, distributions which would approximate 'fished' and 'unfished' populations.

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UNDERWATER LENGTH ESTIMATION

Underwater fish length estimation is a necessary part of several kinds of comparative studies which require knowledge of the fish population size structure: environmental studies frequently require 'before' and 'after' assessments of fish populations to determine the effects of particular pollutants for example; many studies require comparisons to be made on a seasonal basis where changes in the size structures of the population may be evident; and investigations of the effects of fishing on populations require assessment of the size structures of populations. These and other reasons for the necessity for fish length estimation are discussed more fully in a paper by Pollard (in prep.)

However before undertaking studies involving length estimation it is essential that the accuracy of such estimations is known. To test the ability of divers to consistently estimate fish length underwater, a game (henceforth called 'fiddle sticks') was designed using lengths of orange 17 mm (O.D.) P.V.C. electrical conduit (the 'sticks') as simulated 'fish'. These sticks were cut into lengths of between 0 and 100 cm so that when grouped into five 20 cm length classes they formed a histogram approximating a normal curve with the parameters $\bar{x}$ = 50 cm and s.d. = 20 cm. The sticks were thus cut to the following lengths:

0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm
6	22	41	61	82
12	24	42	62	88
18	26	43	63	94
(3)	28	44	64	(3)
	30	45	66	
	32	46	68	
	34	47	70	
	36	48	72	
	37	49	74	
	38	50	76	
	39	51	78	
	40	52	80	
	(12)	53	(12)	
		54		
		55		
		56		
		57		
		58		
		59		
		60		
		(20)		

To test the ability of divers to estimate lengths, several methods were used:

1. Underwater the sticks were selected randomly from a pile, held up by a diver approximately three metres away from the test subject divers who scored the lengths into size classes, and the sticks were placed in the second pile. On completion of the 50 sticks, they were transferred back to the first pile, repeating the process. The actual lengths of the sticks in cm. were estimated on several trials. In some trials, the sticks were held against a 'standard: an 80 cm stick marked into 10 cm intervals.
2. On land, a procedure identical to that above was conducted: with and without the standard. Additionally several attempts at actual length estimation in centimetres were made.

3. Underwater the sticks were threaded in random order onto a 100 m rope. Each stick was separated from the next by at least its own length. The rope was laid out across the reef slope at a depth of between 9-12 m, depending on the location. The 'standard' stick was located at one end of the 'transect'. The divers swam along the 'stick transect' and recorded the sticks in size classes or made an actual length estimation recorded in centimetres.

The results of each diver were tested against the 'expected' distribution using the Kolmogorov-Smirnov test. The test statistic (Dmax) was compared with the critical value (Dcrit) for p = .05. The greater the difference between Dmax and Dcrit i.e. the smaller the difference between the two distributions, the better the length estimation.

In experiments in which actual length estimations were made, the mean deviation (in centimetres) and initially the mean negative and the mean positive deviations were calculated. The standard deviation and variance were also calculated.

Divers were informed of their results relative to the expected distribution or length estimations, and the various training exercises were repeated until a criterion developed over the course of the exercise was attained by all divers.

The results of a variety of trials of this technique are reported below.

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Experiment 1

This experiment was conducted in Jervis Bay on 8 April 1979 with three divers, two of whom (M.C., D.P.,) were experienced in estimating fish lengths underwater and one (J.M.) who was less experienced. Only one of the experienced observers (D.P.) knew the actual length distribution. In this test sticks were held up by another diver and were classified into five size classes on two occasions.

In all cases there was overestimation of the number of sticks in the smallest size groups and underestimation of the numbers in the larger size groups (Appendix 2, Table 1). Examining the test statistics for the Kolmogorov-Smirnov tests shows that only one observer showed much improvement between the first and second trials. None of the distributions is significantly different from the expected distribution.

Experiment 2

This experiment was conducted on 19 April 1979 in Botany Bay with three different divers one of whom was 'experienced' (J.B.[1]) one moderately experienced (J.B.[2]) and one naive (P.M.). The sticks were held up by another diver and classified into five size classes in each of two attempts.

Again all divers classified too many sticks in the smaller size classes and too few in the larger size classes. All observers deteriorated between the first and second trials (Appendix 2, Table 2). None of the distributions is significantly different from the expected distribution.

For the remaining experiments, the Kolmogorov-Smirnov test statistics are presented together in Appendix 2, Table 28.

Experiment 3

This experiment was conducted on 22 April 1979 in the boat harbour at Heron Island with two divers, one of whom was moderately experienced (B.R.) and one naive (W.C.). The sticks were held by a third diver. Both divers showed the same trend as previously observed, i.e. recording too many sticks in the smaller size classes and too few in the larger size classes (Appendix 2, Table 3). Both divers showed considerable improvements from the first to the second trial (Table 28).

Experiment 4

The above experiment was repeated on 22 April 1979 at Heron Island with four observers, three of whom (W.C., S.R., D.P.) were aware of the expected distribution and one of whom was completely naive (K.W.). Each observer participated in two trials except one (B.R.) who undertook four trials. Improvement over the previous trials was shown by all non-naive observers, who also showed considerably better performances than the naive observer (Appendix 2, Tables 4 and 28). The observer undertaking four trials showed improvement between the first and second two pairs of trials.

Experiment 5

The above experiment was repeated on 22 April 1979 on land at Heron Island with the same four observers, with the sticks held against the marked standard. The results (Appendix 2, Tables 5 and 28) showed considerable further improvement. The differences between Dmax and Dcrit increased generally to greater than 0.2.

Experiment 6

In this experiment on land at Heron Island on 22 April 1979, the three practised observers estimated the actual stick lengths (to the nearest centimetre). The results (Appendix 2. Table 6) show that all observers still had a strong tendency towards underestimation of stick lengths.

Experiment 7

The above experiment (estimating actual stick lengths) was repeated on 22 April 1979 underwater, in the boat harbour at Heron Island with the three practised observers. Underestimation underwater was greater than on land with all observers recording increased mean negative deviations (Appendix 2, Table 7).

Experiment 8

In this experiment on 22 April 1979 in the boat harbour at Heron Island, the sticks were held by another diver against a marked standard and the same three observers showed reasonable results (Appendix 2, Tables 8 and 28) although one observer showed a tendency to overestimate.

Experiment 9

In this experiment, on 22 April 1979, in the boat harbour at Heron Island, the same three observers classified the sticks held by another diver into five size classes without the assistance of a standard.

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All three observers showed considerable accuracy (Appendix 2, Tables 9 and 28) in classifying sticks, the observed distributions coming close to the expected distribution.

Experiment 10

In this experiment on 23 April 1979 on Northwest Wistari Reef, four divers, the three practised and one naive (J.H.), swam over the stick transect and estimated the actual length of the sticks. All practised observers showed an improvement in length estimation and a reduction in the number of length underestimations (Appendix 2, Table 10). The naive observer demonstrated a surprising degree of accuracy, although the tendency to underestimate was evident.

Experiment 11

In this experiment on 23 April at Northwest Wistari Reef, the same four divers swam over the stick transect twice each (except for one observer, J.H.) and classified the sticks into five size classes. All observers shows good ability to correctly classify the sticks; the differences between Dcrit and Dmax were all 0.2 or greater (Appendix 2, Tables 11 and 28).

Experiment 12

In this experiment on 24 April 1979, the same four divers swam over the stick transect on Northwest Wistari Reef and estimated actual stick lengths. The mean deviations were again quite low. The least practised observer (J.H.) still demonstrated the greatest tendency to underestimate and one of the practised observers (B.R.) had overcompensated to show many more overestimations than underestimations (Appendix 2, Table 12).

Experiment 13

In this experiment on 24 April 1979 at Northwest Wistari Reef the same four divers swam over the stick transect and classified the sticks into five size classes. The lowest differences between Dcrit and Dmax was 0.19 for the least practised observer (Appendix 2. Tables 13 and 28).

Experiment 14

This experiment, on 25 April 1979, was carried out on the north side of Heron Island Reef in an area to the east of the 'no fishing' area and referred to as the 'fished' area. The same four observers swam over the stick transect, estimating actual stick lengths.

Apart from one observer who appeared to be deteriorating with practice and considerably underestimated lengths, there appeared to be something of a stabilisation in estimating fish lengths for the other two practised observers with mean deviations of about 3-4 cm and only a slight tendency to underestimate (Appendix 2, Table 15).

Experiment 15

In this experiment on 25 April 1979 in the 'fished' area on the north of Heron Island, the same four observers swam over the stick transect and classified the sticks into five size classes. Three practised observers (including the observer worst at length estimation) showed extremely

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good results and the least practised observer again showed reasonable results (Appendix 2, Tables 16 and 28), showing reasonable approximations to the expected distribution.

Preliminary coral trout counts, made swimming in transects perpendicular to the stick transect from the reef crest to the sand area at the bommie zone, for the length of the stick transect had been made at Northwest Wistari Reef on 24 April (Appendix 2, Table 14) and to the east of the 'no fishing' area at Heron on 25 April (Appendix 2, Table 17). It was evident from these counts that coral trout fell primarily into three size classes. Because the power of the Kolmogorov-Smirnov test increases with a greater number of size classes, and three size classes give a rather gross population size structure, it was decided to examine the population in 10 cm rather than 20 cm size classes. Prior to this however it was necessary to determine diver accuracy and between diver variability in placing sticks into a greater number of smaller size classes. As an initial test, the actual length estimates from 25 April from the Heron 'fished' area were put into both 20 cm and 10 cm size classes (Appendix 2, Tables 20 and 21) and the distributions tested to see if they were significantly different from the expected distributions. None was significantly different from the expected distribution (Appendix 2, Table 22).

All further experiments involving sticks involved classifying sticks with ten 10 cm size classes.

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Experiment 16

In this experiment, conducted in the 'no fishing' area of the Marine Park on the north side of Heron Reef on 26 April 1979, the same four observers classified the sticks on the stick transect into ten 10 cm size classes. Each observer swam three or four times over the transect. All observers showed good ability to classify the sticks (Appendix 2, Tables 23 and 24), the difference between Dmax and Dcrit approaching or exceeding 0.2 in the vast majority of cases.

Experiment 17

The introduction of another observer (J.B.) who had participated in Experiment(2) necessitated testing his length estimation abilities. All tests with this observer involved placing the sticks into ten size classes, except for his first test, which required actual length estimation in the boat harbour at Heron Island.

Although this observer showed the same tendency for underestimation as all other observers, the mean deviation was relatively low (Appendix 2, Table 25). Placing these length estimates into size classes confirmed the accuracy of this observer (Appendix 2, Table 26).

All subsequent tests for this observer are grouped in Appendix 2, Table 27. These tests were made over a period of four days and showed steady improvement, so that in the last three trials his classifications were extremely close to the expected distribution.

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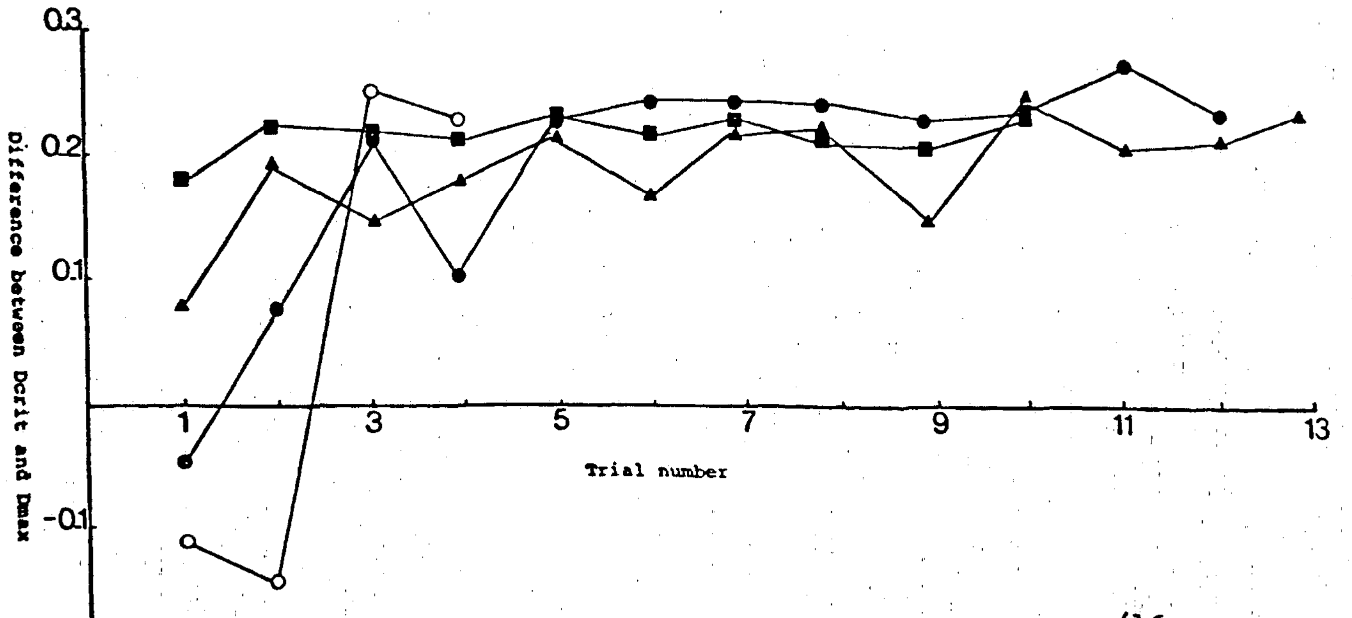
Discussion

The foregoing experiments underline the need for training of even 'experienced' fish length estimators in correctly estimating lengths while underwater. Presumably the observer's awareness that objects are larger underwater results in overcompensation and hence underestimation. It is evident however, that observers can be trained to correctly estimate length underwater with repeated practice, feedback on the kinds of errors being made and the use of a marked standard.

Although very few of the observed classifications were significantly different from the expected distribution, examination of the differences between Dcrit and Dmax over a series of trials demonstrates the improvement which can be achieved relatively quickly. This is shown (Appendix 2, Table 28 and Figure 1) where the difference between Dmax and Dcrit has been plotted against the trial number of observers.

Figure 1

Improvement in length estimation over a series of trials (Difference between Dcrit and Dmax from Kolmogorov-Smirnov test).



It is evident that fairly rapid improvement can be made to a level where the observed distribution closely approximates the expected distribution.

As a result of this exercise, the Workshop considers:

1. that observers classifying 50 sticks should be trained to where the differences between Dmas and Dcrit are 0.2 or greater;
2. that fish models, in addition to or instead of sticks should be used since sticks have no depth;
3. that, most desirably, real fish should be used, either by taking caught fish underwater or by estimating the length of a live fish underwater, then spearing it.

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STUDY SITES

Two major sites were used. Both were on the north side of Heron Reef. One was in the Heron-Wistari Reefs Marine Park area in which all fishing has been prohibited since 1974, the 'unfished' area; the other was to the east of the Marine Park area, where line fishing only is permitted and where several pieces of tangled line provided evidence of some fishing (Figure 2). The 'unfished' area was staked out along the reef crest in 50 m intervals over 200 metres and the 'fished' area over 150 m. Weighted ropes were laid perpendicular to the reef crest from each stake to a depth of about 17 m so that divers were aware of the end of each 50 metre section.

The selection of the 'fished' area was made as a result of being unable to locate, in the short time available, an area of comparable habitat to the 'unfished' area, but which was known to be heavily fished. In the absence of this information and after several spot dives at various locations on the north side of Heron Reef, the designated site was chosen.

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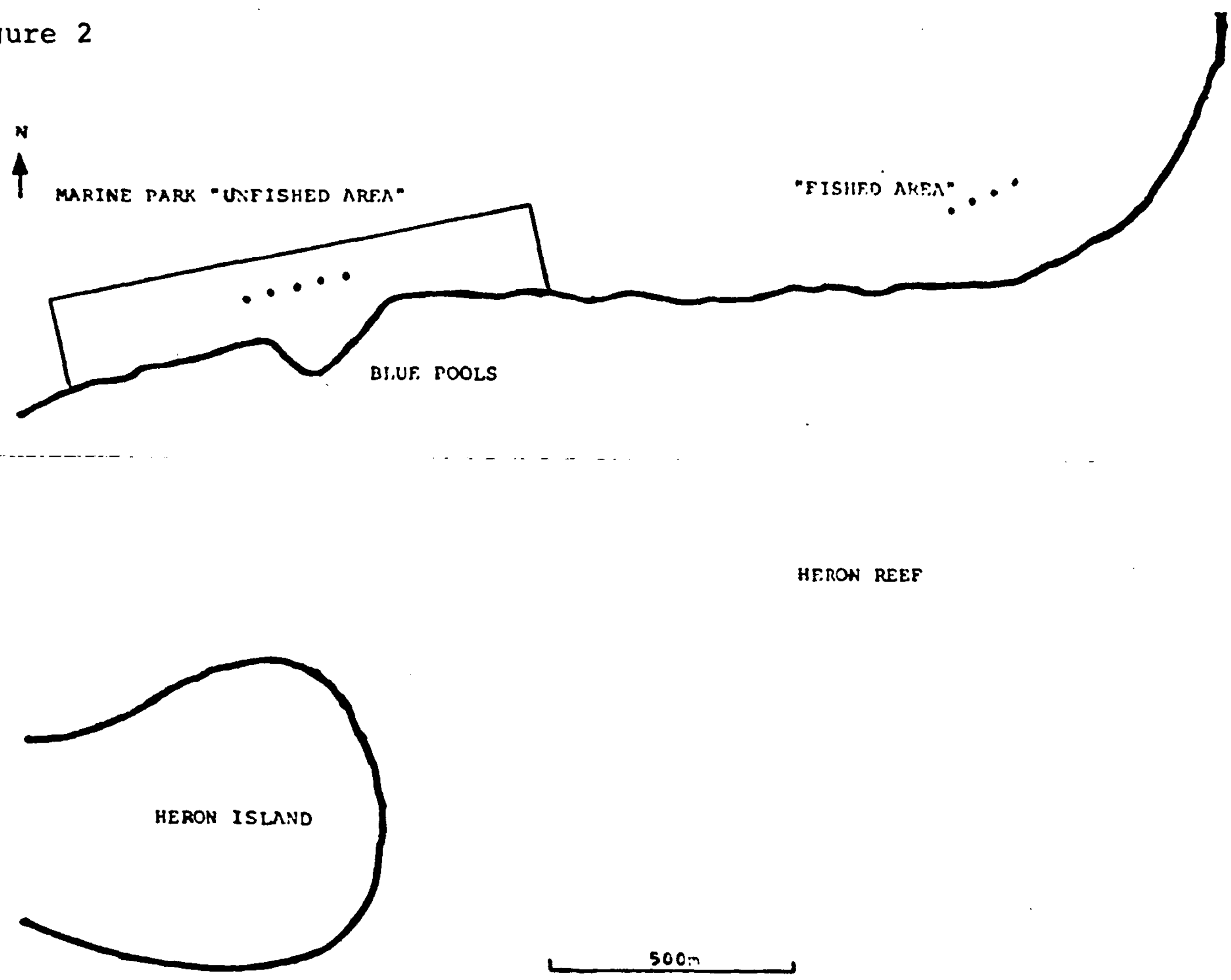
Figure 2


N
MARINE PARK "UNFISHED AREA"
"FISHED AREA"
BLUE POOLS
HERON REEF
HERON ISLAND
500m

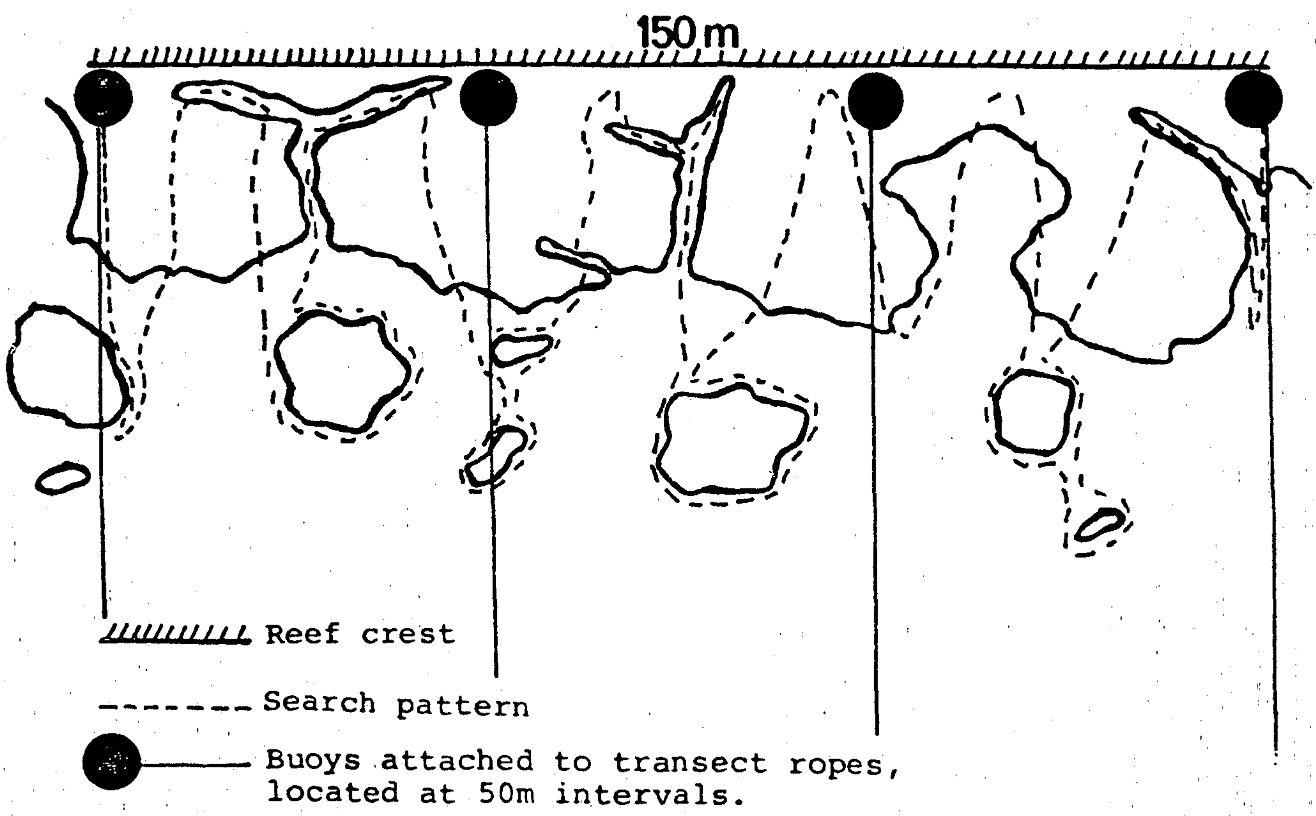
CORAL TROUT CENSUSING

Following the method established in the Fish Workshop (GBRMPA, 1978), several preliminary coral trout censuses were undertaken. The following is a brief outline of the census method.

Divers enter the water at one end of the transect (the end chosen depending on the prevailing current) and proceeded to swim up and down the reef slope searching gullies, caves, under ledges etc., swimming around bommies at the seaward end and returning to within 3 metres of the surface at the shorewards end. (Figure 3).

Figure 3

Search pattern over reef slope



As earlier counts at northwest Wistari (Table 14) and in the 'fished' area at Heron (Table 17) had made it clear that with five 20 cm size classes, only three size classes were present in the population in any numbers, counts were based on 10 cm size classes.

Several preliminary swims counting coral trout and determining the search area which could be feasibly covered in one tank of air were conducted. The time taken to complete each 50 metres was recorded and trout were recorded separately for each 50 metres. It was evident after two trials (Appendix 2, Tables 29 and 30) that three 50 metre sections could be fairly comprehensively searched in about 30 minutes or one tank of air, giving about 10 minutes to each 50 metre section. In these two trials comparisons of between observer variability over 2 x 50 metre sections (i.e. 100 m) showed some significant differences between observers, although all but one significant difference involved comparisons between one observer (D.P.) and all other observers. Since that observer departed shortly afterwards his results were no longer included in the analysis.

Subsequently, data used for analysis were derived from three divers who participated in each dive (J.B., B.R., W.C.). On two occasions (28, 29 April) totally naive observers also conducted censuses to provide a comparison between experienced and naive observers. The following dives were undertaken:

Heron Island 'unfished' area		Appendix 2
4 divers over 150 m	28 April	Table 31
6 divers over 150 m	28 April	Table 32
5 divers over 150 m	29 April	Table 33
3 divers over 150 m	30 April	Table 34
Heron Island 'fished' area		
3 divers over 150 m	1 May	Table 35
3 divers over 150 m	1 May	Table 36
3 divers over 150 m	2 May	Table 37
3 divers over 150 m	2 May	Table 38
Heron Island West of 'unfished' area		
3 divers over 150 m	3 May	Table 39
Heron Island east of 'unfished' area		
3 divers over 150 m	3 May	Table 40

i. Variability between Observers

To determine the variability between observers in the population size structure recorded from each dive, the distributions obtained were compared using the Kolmogorov-Smirnov test for each dive over 150 m of reef crest. As can be seen from Table 1 over ten dives with three practised observers, there were only four out of thirty comparisons showing significant differences, i.e. 13%. When naive observers are involved, of the 12 comparisons of their results with those of practised divers, 75% of the comparisons show a significant difference.

On this basis, the mean value for each dive that is, the mean value of three practised observers was used to provide values for comparisons required in this study.

Table 1

Comparison between divers on each dive over 150 m

	Dive	Area	Comparison	Dmax	Dcrit	Significance p = 0.5
	1	Unfished	WC vs BR	.14	.23	ns
	1	Unfished	WC vs JB	.15	.22	ns
	1	Unfished	BR vs JB	.28	.20	sig
	2	Unfished	JB vs WC	.20	.22	ns
	2	Unfished	JB vs BR	.12	.21	ns
	2	Unfished	WC vs BR	.32	.23	sig
*	2	Unfished	LT vs JB	.15	.24	ns
*	2	Unfished	LT vs WC	.24	.25	ns
*	2	Unfished	LT vs BR	.18	.24	ns
*	2	Unfished	LO vs JB	.57	.28	sig
*	2	Unfished	LO vs WC	.43	.30	sig
*	2	Unfished	LO vs BR	.60	.29	sig
	3	Unfished	WC vs JB	.05	.21	ns
	3	Unfished	WC vs BR	.06	.21	ns
	3	Unfished	JB vs BR	.11	.20	ns
*	3	Unfished	LO vs WC	.43	.23	sig
*	3	Unfished	LO vs JB	.39	.22	sig
*	3	Unfished	LO vs BR	.50	.22	sig
*	3	Unfished	LT vs WC	.23	.22	sig
*	3	Unfished	LT vs JB	.23	.21	sig
*	3	Unfished	LT vs BR	.28	.21	sig
	4	Unfished	JB vs BR	.26	.18	sig
	4	Unfished	BR vs WC	.13	.18	ns
	4	Unfished	WC vs JB	.17	.18	ns
	W	Unfished	JB vs BR	.07	.15	ns
	W	Unfished	BR vs WC	.08	.15	ns
	W	Unfished	JB vs WC	.15	.15	ns
	E	Unfished	WC vs BR	.07	.15	ns
	E	Unfished	WC vs JB	.17	.15	sig
	E	Unfished	BR vs JB	.12	.15	ns
	1	Fished	BR vs JB	.13	.26	ns
	1	Fished	BR vs WC	.05	.26	ns
	1	Fished	JB vs WC	.13	.27	ns
	2	Fished	BR vs JB	.09	.21	ns
	2	Fished	BR vs WC	.10	.24	ns
	2	Fished	JB vs BR	.01	.24	ns
	3	Fished	BR vs JB	.16	.23	ns
	3	Fished	BR vs WC	.26	.27	ns
	3	Fished	JB vs WC	.23	.26	ns
	4	Fished	BR vs JB	.03	.22	ns
	4	Fished	BR vs WC	.03	.20	ns
	4	Fished	JB vs WC	.19	.20	ns

* naive observers

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To determine whether between-diver variability is reduced when mean values from two consecutive dives are used, pairs of consecutive dives were compared between observers, using the Kolmogorov-Smirnov test. These results (Table 2) showed that using the mean value of two dives tends to reduce the variability to where there are no significant differences between observers.

The mean value of four dives reduces variability between observers even further; low Dmax values (Table 2).

Table 2

Variability between observers using mean from two consecutive dives

Dive	Area	Comparison	Dmax	Dcrit	Signifance p = .05
1+2	Unfished	WC vs JB	.07	.22	ns
1+2	Unfished	WC vs BR	.23	.23	ns
1+2	Unfished	BR vs JB	.21	.21	ns
3+4	Unfished	WC vs BR	.06	.19	ns
3+4	Unfished	WC vs JB	.12	.19	ns
3+4	Unfished	BR vs JB	.12	.19	ns
1+2	Fished	WC vs BR	.06	.25	ns
1+2	Fished	WC vs JB	.03	.25	ns
1+2	Fished	BR vs JB	.09	.24	ns
3+4	Fished	WC vs BR	.13	.22	ns
3+4	Fished	WC vs JB	.17	.22	ns
3+4	Fished	BR vs JB	.16	.22	ns

Variability between observers using mean from four consecutive dives

Dive	Area	Comparison	Dmax	Dcrit	Significance p = .05
1+2+3+4	Unfished	WC vs JB	.08	.21	ns
1+2+3+4	Unfished	WC vs BR	.18	.21	ns
1+2+3+4	Unfished	BR vs JB	.13	.20	ns
1+2+3+4	Fished	WC vs JB	.11	.24	ns
1+2+3+4	Fished	WC vs BR	.09	.24	ns
1+2+3+4	Fished	BR vs JB	.13	.24	ns

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ii. Determination of number of dives required

Given that there is very little variability between divers, a comparison of the mean values (of three observers) obtained from 1, 1+2, and 1+2+3 dives against the mean values obtained over 1+2+3+4 dives was made to determine the number of dives necessary to give a population size structure equivalent to that produced as a result of four dives. Four dives was regarded as adequate to provide a mean value. The results (Table 3) show that one dive (three observers) produced a population size structure not significantly different from that produced after four dives, at either area. In fact the low Dmax values show that there is almost no difference between the distributions.

Table 3

Determination of number of dives required

Comparison	Dmax	Dcrit	Significance (p = .05)
Unfished area			
1 vs 1+2+3+4	.01	.21	ns
1+2 vs 1+2+3+4	.01	.21	ns
1+2+3 vs 1+2+3+4	.02	.21	ns
Fished Area			
1 vs 1+2+3+4	.02	.25	ns
1+2 vs 1+2+3+4	.03	.24	ns
1+2+3 vs 1+2+3+4	.01	.24	ns

iii. Determination of Transect Length

To determine the length/time required to survey a particular 'habitat' the population size structure over a 450 m reef crest (deemed to provide a sufficiently large sample) in the 'unfished' area was determined. This area was made up of three adjacent 150 m sections of reef crest. The population size structure found in 150 m and 300 m were then compared with that over 450 m to determine how many 150 m sections were required to provide an adequate sample.

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The three 150 m sections from east to west are labelled, E, C and W and comparisons are made on mean results from three observers calculated for the last dive in each section, or combined sections.

Initially each of three 150 m sections were compared (Table 4) and no significant differences were found between them using the Kolmogorov-Smirnov test.

Table 4

Comparison of population size structure between three adjacent 150 m of reef crest.

Test	Dmax	Dcrit	Significance (p = .05)
E vs C	.04	.17	ns
E vs W	.07	.15	ns
C vs W	.06	.17	ns

There is no significant difference between 150 m sections in population size structures. Differences would not be expected between the 150 m and 300 m vs 450 m comparisons (Table 5).

Table 5

Comparison of population size structures from 150 m and 300 m vs 450 m of reef crest

Test	Dmax	Dcrit	Significance (p = .05)
E vs E+C+W	.04	.15	ns
E+C vs E+C+W	.02	.15	ns

To determine whether shorter reef crest distances than 150 m were a suitable survey distance (although low numbers and the smallness of the area suggest they are not) comparisons of the various 50 m mean values with 150 m mean values were made. Comparisons of between diver variability were made initially and showed surprisingly little difference between divers even over as short a distance as 50 m (Table 6).

Table 6

Between diver variability over 50 m sections

50 m Sect.	Area	Comparison	Dmax	Dcrit	Significance p = .05
1	Unfished	BR vs WC	.24	.32	ns
1	Unfished	WC vs JB	.19	.32	ns
1	Unfished	BR vs JB	.17	.29	ns
2	Unfished	BR vs WC	.15	.36	ns
2	Unfished	BR vs JB	.12	.35	ns
2	Unfished	WC vs JB	.14	.34	ns
3	Unfished	BR vs WC	.32	.29	sig
3	Unfished	BR vs JB	.18	.29	ns
3	Unfished	WC vs JB	.26	.30	ns
1	Fished	JB vs WC	.11	.32	ns
1	Fished	JB vs BR	.26	.39	ns
1	Fished	WC vs BR	.15	.30	ns
2	Fished	JB vs WC	.35	.48	ns
2	Fished	JB vs BR	.34	.49	ns
2	Fished	WC vs BR	.08	.48	ns
3	Fished	JB vs WC	.28	.31	ns
3	Fished	JB vs BR	.42	.32	sig
3	Fished	WC vs BR	.06	.30	ns

Comparing mean 50 m population size structure shows that there can be significantly different size structures over short distances (Table 7), and that surveying a distance as short as 50 m of reef crest could give a misleading picutre of the population size structure in the larger areas (Table 8).

Table 7

Comparisons of adjacent mean 50 m values over 150 m

Comparison	Area	Dmax	Dcrit	Significance p=.05
1st 50 m vs 2nd 50 m	Unfished	.04	.33	ns
1st 50 m vs 3rd 50 m	Unfished	.12	.30	ns
2nd 50 m vs 3rd 50 m	Unfished	.11	.32	ns
1st 50 m vs 2nd 50 m	Fished	.31	.42	ns
1st 50 m vs 3rd 50 m	Fished	.49	.33	sig
2nd 50 m vs 3rd 50 m	Fished	.16	.41	ns

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Table 8

Comparison of mean 50 m values with 150 m values containing 50 m sections

Comparison	Area	Dmax	Dcrit	Significance p = .05
1st 50 m vs 150 m	Unfished	.05	.25	ns
2nd 50 m vs 150 m	Unfished	.04	.28	ns
3rd 50 m vs 150 m	Unfished	.07	.24	ns
1st 50 m vs 150 m	Fished	.44	.29	sig
2nd 50 m vs 150 m	Fished	.13	.37	ns
3rd 50 m vs 150 m	Fished	.05	.30	ns

Thus 150 m of reef crest (one tank of air or approximately 30 minutes) appears to be the appropriate 'diver survey unit' which should be used. Using this distance or time period overcomes the natural variability inherent if smaller sections are surveyed, provides a statistically equivalent population size structure to a 450 m survey unit and can be easily completed in one tank of air.

iv. Factors affecting coral trout population size structure estimates

The factors which might be suspected of having most effect on the population size structure estimate are the state of the tide and the time of day. To determine the importance of these on both the number of fish seen in each dive and the population size structure, two analyses were undertaken for each factor. Ideally, at some future date, sufficient data should be collected to determine whether there is an interaction effect of tide and time, but from this study there are insufficient data to undertake such a comparison. All comparisons utilised mean values calculated over three observers for each dive.

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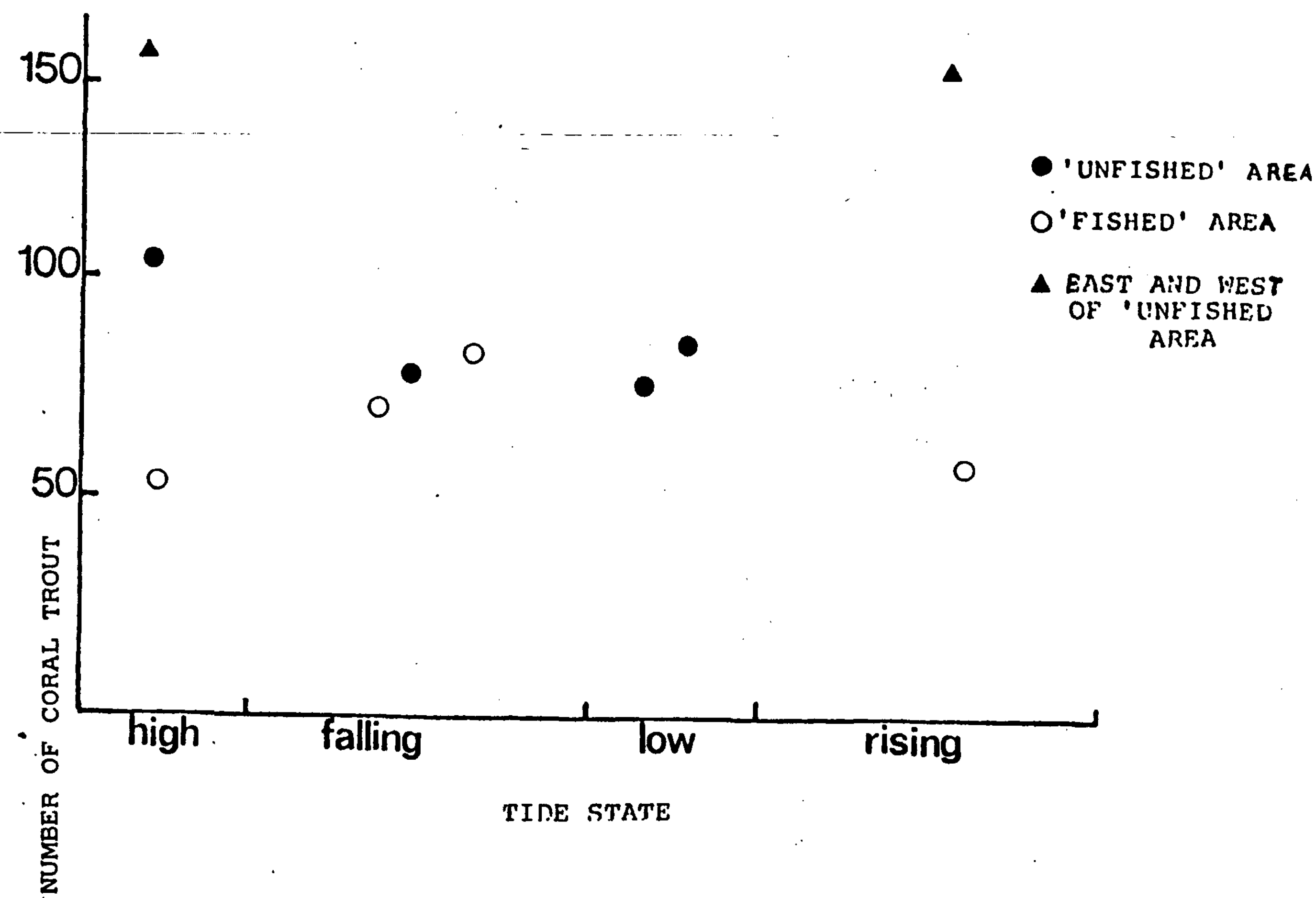
State of the tide

The tidal rhythm was arbitarily divided into four periods: high tide (two hours around predicted high tide, falling tide (the following four hours), low tide (two hours around predicted low tide) and rising tide (the four hours following low tide). Examination of the mean total number of coral trout observed against the state of the tide for each area suggests that there is no relationship between these factors (Figure 4).

Figure 4



Comparison of the population size structure found during each dive (mean of three observers) shows no significant difference between dives, i.e. certain size classes are not more 'visible' at certain state of the tide (Table 9).

Table 9

Comparison of population size structures at different tide sites.

Comparison	Dmax	Dcrit	Significance p = .05
Unfished area			
Falling tide vs low tide 1	.04	.21	ns
Falling tide vs low tide 2	.03	.21	ns
Falling tide vs high tide	.19	.20	ns
Low tide 1 vs low tide 2	.04	.21	ns
Low tide 1 vs high tide	.17	.20	ns
Low tide 2 vs high tide	.16	.19	ns
E&W of Unfished area			
Rising tide vs high tide	.07	.15	ns
Fished area			
High tide vs falling tide 1	.09	.25	ns
High tide vs rising tide	.02	.25	ns
High tide vs falling tide 2	.03	.24	ns
Falling tide 1 vs rising tide	.09	.24	ns
Falling tide 1 vs falling tide 2	.11	.22	ns
Rising tide vs falling tide 2	.02	.23	ns

Time of day

Examination of mean total number of coral trout seen against the time of day for each area fails to show any clear or consistent relationship (Figure 5). In addition the observed population size structure is not significantly different at different times of day (Table 10).

Figure 5

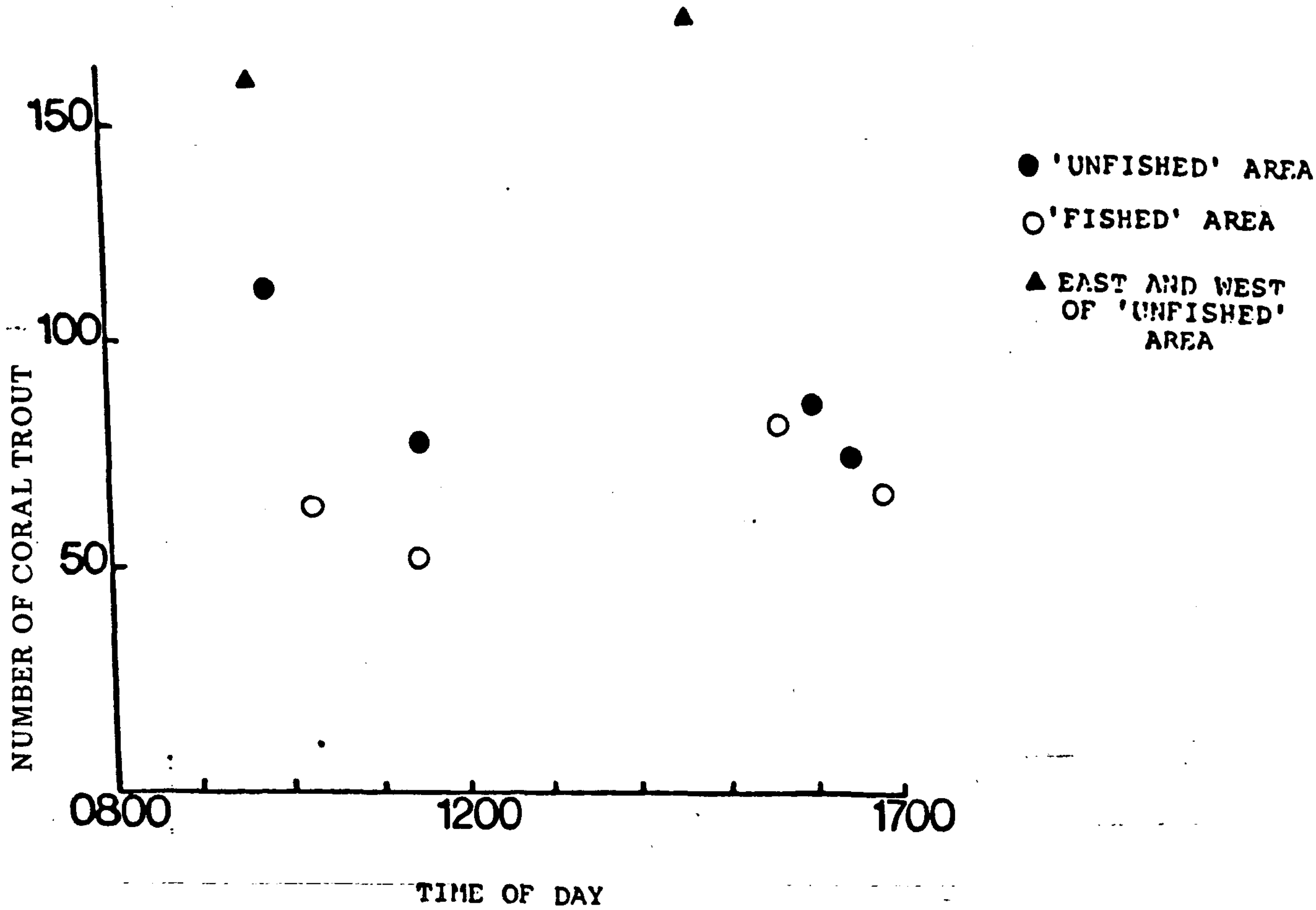


Table 10

Comparison of population size structure at different times of day

Comparison	Dmax	Dcrit	Significance p = .05
Unfished area			
1000 vs 1115	.19	.20	ns
1000 vs 1600	.16	.19	ns
1000 vs 1605	.17	.20	ns
1115 vs 1600	.03	.21	ns
1115 vs 1605	.04	.21	ns
1600 vs 1605	.04	.21	ns
E & W. of unfished area			
1005 vs 1415	.07	.15	ns
Fished area			
1015 vs 1115	.02	.25	ns
1015 vs 1527	.02	.23	ns
1015 vs 1620	.09	.24	ns
1115 vs 1527	.03	.24	ns
1115 vs 1620	.09	.25	ns
1527 vs 1620	.11	.22	ns

v. Comparison of a 'fished' area with an 'unfished' area

One of the objectives of this Workshop was to make a comparison between a 'fished' and 'unfished' area of similar habitat, to determine whether the technique developed revealed differences in the population size structure i.e. whether the 'fished' population was weighted in favour of the smaller size classes.

Using the mean values from three observers over four dives at each area, the population size structure for each of the two areas was determined (Figure 6). The mean, variance and standard deviation for each size class are shown in Table 11. These population size structures were compared using the Kolmogorov-Smirnov test and were found to be not significantly different ($p > .05$).

Table 11

Statistics of 'unfished' and 'fished' population
Mean of three observers over four days

Size classes (cm)	Unfished Area mean	va.	s.d.	Fished Area mean	va.	s.d.
0-10	0			0		
10-20	0			0		
20-30	0.16	0.13	0.37	2.0	1.3	1.15
30-40	19.25	47.35	6.88	13.08	13.07	6.08
40-50	40.66	202.2	14.22	32.66	99.38	9.96
50-60	18.66	39.38	6.27	13.08	19.4	4.4
60-70	5.66	9.05	3.0	3.16	4.47	2.11
70-80	1.25	3.02	1.73	0.5	0.41	0.64
80-90	0			0	0	0
90-100	0			0	0	0
TOTAL	86.66	271.8	16.48	65.25	234.85	15.32

Kolmogorov-Smirnov test

Dmax =0.04; Dcrit = 0.22 (p =0.05).

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Figure 6a Heron Reef "unfished" area coral trout population structure

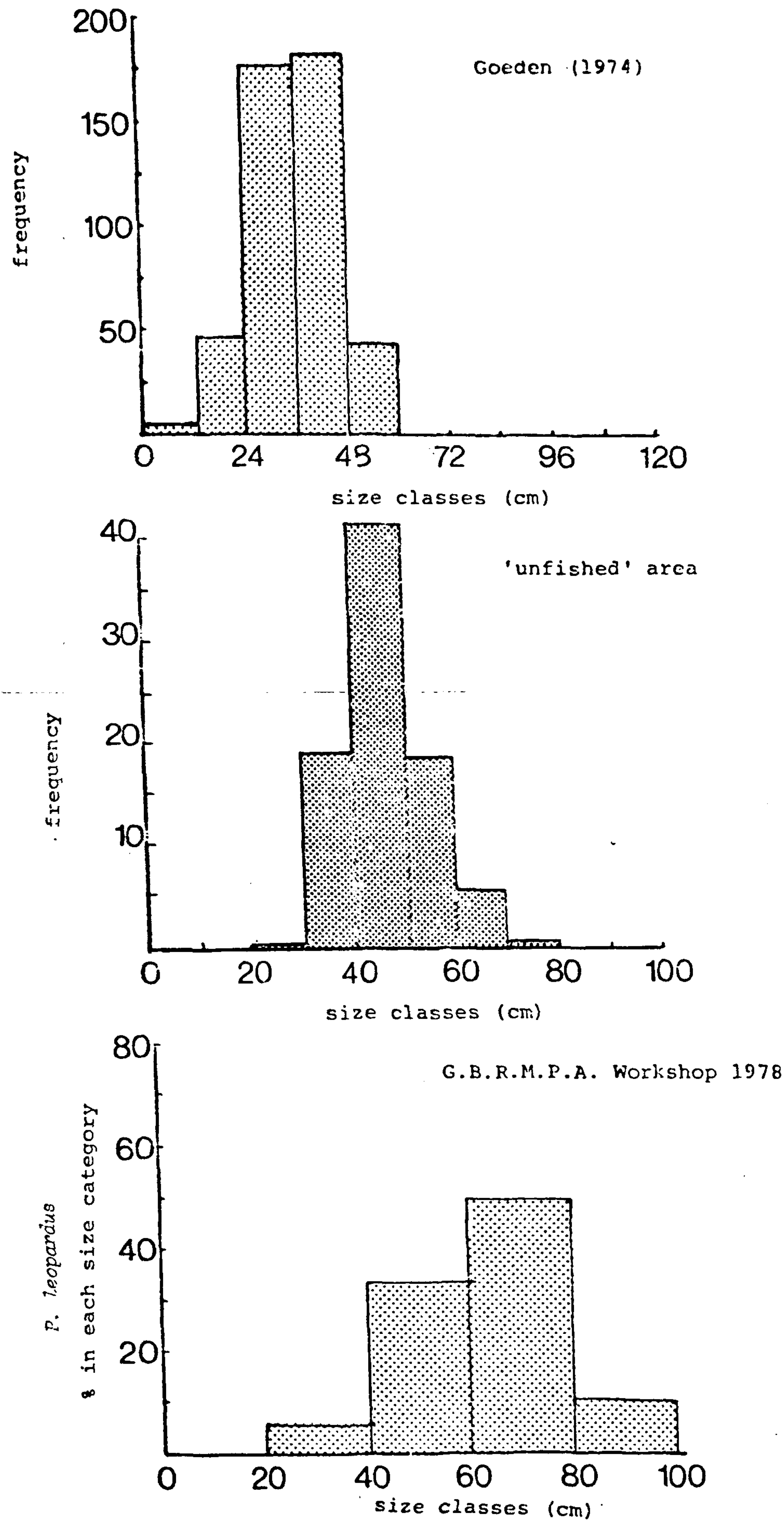
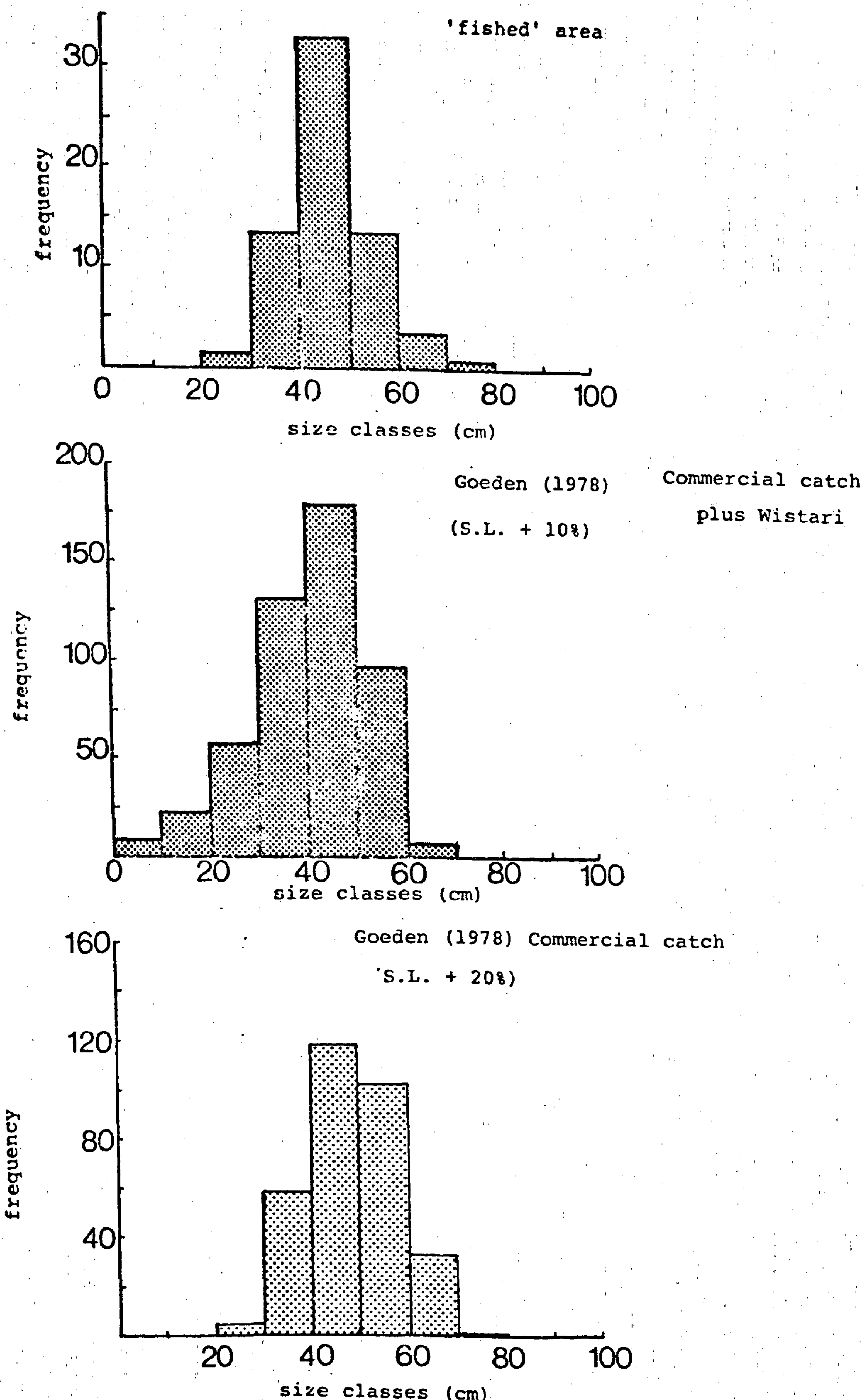


Figure 6b Heron Reef "fished" area, and commercial catches (Goeden, 1978) of coral trout population structure



Comparing the size structure resulting from this workshop of the coral trout population (based on five 20cm size classes), with that recorded by the previous workshop (G.B.R.M.P.A. 1978) shows a highly significant difference between the two populations (Dmax = 0.52, Dcrit = 0.19, p = 0.05) (Figure 6a). This suggests that the two groups of observers made substantially different length estimations. Curiously, despite the fact that untrained observers underestimate length, as shown by the stick experiments, the 1978 workshop observers apparently overestimated length, assuming that the 1979 observers are correct.

Goeden (1974) studied the coral trout population in the "unfished" area at Heron Island and the population size structure recorded by him is also shown in Figure 6a. It cannot be statistically compared with the Kolmogorov-Smirnov test because of size class differences but it does show that the average fish size has increased in the last five years.

In his monograph on coral trout, Goeden (1978a) presents a length-frequency distribution for trout taken largely from the commercial catch in the Capricorn-Bunker and Swain Reefs area added to a small number from Wistari Reef. The values from his length-frequency distribution (in 5mm size classes) were read off his graph, corrected to total length from standard length (adding 10% of standard length), then consolidated into 10 cm size classes, (Figure 6b) for comparison with the distribution for the Heron Island 'unfished' population. The distributions were significantly different (Dmax = 0.22, Dcrit = 0.15, p = .05).

However, since adding 10% of standard length to achieve total length may be an underestimate, 20% was added to Goeden's figures for the commercial catch (Swains) only and the distributions were again compared. This resulted in no significant difference between the Heron "unfished" and the commercial catch distribution (Dmax = 0.14, Dcrit = 0.16, $p = 0.05$). However, Goeden's two distributions were found to be significantly different (Dmax = 0.25, Dcrit = 0.09, $p = 0.05$). The resolution of these population differences awaits the final determination of a correct conversion (probably non-linear) from standard length to total length.

Virtually no fish in the 20 to 30 cm size class were observed during this workshop at Heron Island although Goeden observed a considerable number in this size class at Wistari (Goeden, 1976a). An even more noticeable difference is his observation of coral trout less than 20 cm at Wistari and the complete absence of this size group at Heron Island.

Comparison between the 'fished and 'unfished' areas, of the total number of coral trout observed over 150 m by three divers over four dives using the median test (Siegel, 1956) shows that in the fished area there are significantly fewer fish ($\chi^2 = 4.819$, $p < .05$). This suggests that the slight habitat differences which were apparent may result in fewer trout.

Some comparisons of coral trout numbers found in this study with those reported by Goeden are possible. Of particular interest is his "density" estimate for the Heron Island Marine Park area in which this study was conducted. Values from a number of sources (Table 12) show considerable differences between areas if such 'density' estimates are reliable.

Table 12

'Density' estimates for coral trout in different areas (and obtained using different methods).

Reef	Trout/ha	S.d.	Source
Heron 'unfished'	87	16	Workshop (1979)
Heron 'fished'	65	15	Workshop (1979)
Heron 'unfished' approx.	71		GBRMPA (1978)
Wistari	67.8	25.0	Goeden (1978a)
Heron 'unfished'	87.7		Goeden (1974)
'Unfished' (Heron?)	39.2		Goeden (1979)
Swain Reefs	22.7		Goeden (1979)
Wreck	13.5		Goeden (1979)
Capricorns	4.3		Goeden (1979)
Wheeler	15.6		Goeden (1979)
Cairns, Innisfail	5.6		Goeden (1979)

Some of these values, particularly those from Goeden (1979) are means based on a number of reefs. The methods used also differ between studies. The method used in this study, GBRMPA (1978) and Goeden (1974) was previously outlined. Goeden (1978a) swam transects seawards from the reef crest down to the reef slope at six different locations on Wistari.

The other values (Goeden 1979) are derived from

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manta towing around reefs. The first GBRMPA Fish Workshop (1978) found that using the manta snorkel technique, about 5% of the number of coral trout observed using the intensive search technique were observed. While this value (5%) could be expected to alter with habitat, it suggests that Goeden's manta-towing values may be somewhat low.

SUMMARY OF TECHNIQUE

Training

1. Divers are trained using sticks, fish models, live and/ or dead fish to estimate length underwater until (on the basis of distribution with a frequency of 50), the difference between the observed and expected distributions as revealed by the difference between Dmax and Dcrit, using the Kolmogorov-Smirnov test, is greater than 0.2.

Reef Surveying

1. Locate four or five 'habitat' areas on reef on basis of coral survey work.
2. Divers test current - especially on bottom.
3. Divers enter water and following intensive search pattern of swim, swim together and with current for duration of one tank of air or 30 minutes recording end of each 10 minute interval.
4. Coral trout are classified into 10 cm size classes and mean of pair of dives is taken as population size structure for that habitat.
5. Population size structure in Capricorn-Bunker area is compared with 'unfished' area at Heron Reef using Kolmogorov-Smirnov test. As a secondary consideration, mean number of trout are compared using median test.
6. Under the constraints of decompression tables, and since this survey work usually requires diving to 60' each diver can only dive twice per day.

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PROPOSED ACTION

1. That a pilot survey of two to three weeks be conducted in which this technique is applied over a series of reef habitats in the Capricorn-Bunker area. At this stage it is recommended that a team of biologists undertake the survey. A budget is attached. In view of the flexibility it would provide, chartering a boat e.g. 'Sea Hunt' and operating from it seems the most feasible approach.

Five divers and two inflatables so that four divers (in two teams) are always available is envisaged as the most productive approach, so that preferably four areas could be surveyed each day with two dives/day. This would enable six reefs in the Capricorn group and five in the Bunker group to be surveyed. The time at Heron Island would be spent in retraining for length estimation underwater and surveying Heron and Wistari Reefs. Once on the 'Sea Hunt' the following reefs would be surveyed: Masthead, Rock Cod Shoals, Northwest and One Tree in the Capricorn group.

In the Bunker Group, Lady Elliot, Lady Musgrave, Boult, Llewellyn and Fitzroy would be surveyed.

Budget for Coral Trout survey Capricorn-Bunker Groups	$
Heron Island	
Accommodation 6 @ $15/night for 6 nights	450 00
Food $20/person and extras	150 00
Charter of Boat 'Sea Hunt' 8 days @ $300/day	2 400 00
Air Fares - 3 ex Sydney return @ $150	450 00
- 3 ex Townsville return @ $200	600 00
Helicopter - 6 @ $41/head	250 00
Salaries - Payment to two diving participants @ $250/week	1 000 00
Incidentals	
Air at Heron Island	70 00
Fuel at Heron Island	30 00
	$4 500 00

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2. That bimonthly surveys be commissioned at Heron Island, One Tree Island and Lizard Island so that seasonal variation in coral trout numbers can be monitored. This should also provide some information on recruitment. A budget is attached. The budget allows for a five days training period for the divers at Heron and One Tree Islands.

Budget for surveys of coral trout at Heron Island, One Tree Island and Lizard Island

Payment for surveying	12 months
	$
2 divers at Heron Island (2 dives one day/month)	1 200
2 divers at One Tree Island (2 dives one day/month)	1 200
2 divers at Lizard Island (2 dives one day/month)	1 200
	3 600
(Pay at the rate of base-grade clerk i.e. @ $24/day)	
Training	
Accommodation - 3 people 5 days at Heron Island	225
Food - 5 people 5 days	120
Air at Heron	30
Fuel at Heron	10
(2 air-fares ex Sydney return	300)
1 air-fare ex Townsville	200
(2 helicopter fares	164)
1 Helicopter fare	82
T.A. and incidentals	100
	1 231
GRAND TOTAL	4 800

RECOMMENDATIONS

1. The major recommendation from the Workshop was the need for a comprehensive study of the biology of coral trout specifically for age and growth, reproduction and recruitment information. Of lesser importance, but worthy of consideration, are movement and feeding studies. Although Goeden (1978a) has conducted a study of coral trout biology, insufficient sampling and analysis make it more of a preliminary study requiring further work for substantiation of conclusions.

In any fishery the factors resulting in increase in the fishable stock are growth and recruitment while those factors resulting in a reduction in the fishable stock are natural mortality and fishing mortality. Thus it is necessary for management to have accurate information on these factors. The following indicates the management uses of the various kinds of information.

Age and growth

- knowing longevity of species
- constructing age-length and weight-length curves since length and weight are much more readily determined for large samples than age
- identifying year-classes
- determining survival and whether size selective mortality exists (both natural and fishing)
- determining growth
- using growth parameters in yield equations
- determination of the effect of fishing on the age structure of the population determining age at recruitment
- in coral trout, age and sex reversal.

Reproduction

The information is necessary particularly in this species which undergoes sex-reversal

- age at maturity
- spawning period
- age/size at which sex reversal occurs
- is this age lowered by fishing
- is fishing eliminating the males in the population

Recruitment

Since recruitment is one of two major inputs to the fishable stock the following information is necessary

- size/age at recruitment
- time of recruitment

Movements Other information which would be of value is data on the movement of these fish. A start can be made on this with the tagging program but more specific studies may be part of a comprehensive biological study.

Budget A budget for such a study of coral trout over three years is attached. In view of the importance of coral trout to both the commercial and amateur fishery (in 1976 coral trout made up 29% of total Queensland landings passing through the Queensland Fish Board), obtaining financial assistance from the Fishery Industry Research Trust Account is suggested. A proposal which involves FIRTA paying salaries and GBRMPA paying other costs (or vice versa) is suggested. Alternatively, since GBRMPA is not an established fisheries organisation, a request for funds might be more successful if GBRMPA funded the first year and applied for FIRTA assistance for subsequent years.

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Budget for Coral Trout Study

(Based in Sydney, with field work out of Heron Island)

	$
SALARIES	
Principal Investigator - 3 yrs @ $16 000 p.a. (plus 10% p.a.)	53 000
Research Assistant 3 yrs @ $9 000 p.a. (+ 10% p.a.)	30 000
Payroll tax etc. 20%	16 600
	100 000
FIELD EXPENSES	
Bench fees ($100/week) 18 months in field P.I.	7 200
Bench fees (" " " " " " R.A.	7 200
	14 400
TRAVEL	
6 return airfares/yr (2½ years) P.I.	3 000
6 " " " " " R.A.	3 000
	6 000
+ Inflation (15%)	900
	6 900
EQUIPMENT	
Diving Gear x 2	2 000
Boat (14ft with 25hp motor)	3 000
Microscope & equipment accessories	5 000
Miscellaneous equipment	2 000
	12 000
+ Inflation (10%)	1 200
	13 200
MAINTENANCE	
Boat running costs & maintaining engines	3 000
General	2 000
	5 000
+ Inflation (10%)	500
	5 500
THREE YEAR TOTAL	$140 000

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2. The coral trout tagging program commencing later this year should be pursued and become part of a program aimed at obtaining catch records for all coral trout caught at Heron Island. Heron Island is one of the few places on the coast where a fairly 'closed' system exists i.e. most of the fish are landed on the island by relatively few people. With the co-operation of these people, length measurements and location of all fish landed could be recorded. This information will be of assistance to a study of coral trout biology.

As a further step it is recommended that a fishing competition be held at Heron Island in conjunction with one of the Fishing Expo's (possibly this November), in which after an intensive tagging survey program a limited area is opened for a week or two for intensive fishing where prizes are awarded and subsequnetly the area is surveyed and then regularly monitored to determine how rapid the recovery is.

3. The third recommendation which relates to coral trout surveys is that stocks of coral trout probably differ between areas, even if they belong to the same species. For these reasons it will be necessary to have an 'unfished' area as representative for each area. Thus asspon as the Authority can proceed with Declaration, representative areas in each general area should be closed to fishing as at Heron Island.

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APPENDIX 1

Participants in Second Fish Assessment Workshop

21 April - 4 May 1979

Dr David Pollard	New South Wales State Fisheries
Mr Johann Bell	New South Wales State Fisheries
Mr Barry Russell	Department of Environmental Studies, Macquarie University.
Dr Wendy Craik	Great Barrier Reef Marine Park Authority
Mr Jim Halvorsen	
Mr Koko Wigness	Great Barrier Reef Marine Park Authority provided field assistance.

APPENDIX 2

TABLE 1

Fiddlesticks Experiment 1 - 8.4.79
Plantation Point, Jervis Bay 1430

	Size Classes (cm)					
Observer	0-20	20-40	40-60	60-80	80-100	Total
M.C. 1.	10	14	15	6	5	50
2.	8	17	17	5	3	50
J.M. 1.	6	14	17	10	4	51
2.	5	13	19	10	3	50
D.P. 1.	7	19	14	8	2	50
2.	4	13	21	10	2	50

Kolmogorov-Smirnov Test of difference between observed and expected distribution (D crit at p = .05)

Observer	D. max	D. crit	Difference
M.C. 1.	.18	.27	.09
2.	.20	.27	.07
J.M. 1.	.09	.27	.18
2.	.06	.27	.21
D.P. 1.	.22	.27	.05
2.	.06	.27	.21

The larger the difference between D max and D crit, the closer the observed distribution to the expected distribution

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TABLE 2

Fiddlesticks Experiment 2 - 19.4.79
Botany Bay 1330

	Size Classes (cm)					
	0-20	20-40	40-60	60-80	80-100	Total
J.B.[1] 1.	8	16	19	4	3	50
2.	8	18	18	4	2	50
J.B.[2] 1.	10	12	14	9	5	50
2.	11	15	12	10	4	52
P.M. 1.	8	11	15	8	7	49
2.	8	20	14	5	3	50

Kolmogorov-Smirnov test of difference between observed and expected distribution (D crit. at p=.05)

Observer	D. max	D. crit	Difference
J.B.[1] 1.	.16	.27	.11
2.	.22	.27	.05
J.B.[2] 1.	.14	.27	.13
2.	.15	.27	.12
P.M. 1.	.09	.27	.18
2.	.26	.27	.01

The larger the difference between D max and D crit, the closer the observed distribution to the expected distribution.

TABLE 3.

Fiddlesticks Experiment 3 - 22.4.79
Boat Harbour, Heron Island 1000

	Size Classes					
	0-20	20-40	40-60	60-80	80-100	Total
W.C. 1.	14	17	6	7	7	51
2.	9	15	12	7	5	48
B.R. 1.	13	12	9	12	4	50
2.	5	13	13	13	6	50

TABLE 4

Fiddlestocks Experiment 4 - 22.4.79
On land Heron Island 1100

	Size Classes					
	0-20	20-40	40-60	60-80	80-100	Total
W.C. 3.	4	14	18	10	4	50
4.	3	10	20	14	3	50
B.R. 3.	8	14	15	10	3	50
4.	5	15	17	10	3	50
5.	3	9	25	10	3	50
6.	3	6	25	14	3	51
D.P. 1.	3	16	21	7	3	50
2.	3	12	22	10	3	50
K.W. 1.	19	14	10	5	2	50
2.	16	20	10	2	2	50

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TABLE 5

Fiddlesticks Experiment 5 - 22.4.79
On land Heron Island 1200
Sticks held against marked standard

	Size Classes					
	0-20	20-40	40-60	60-80	80-100	Total
W.C. 5.	3	10	20	14	3	50
6.	3	12	19	13	3	50
B.R. 7.	3	9	25	11	2	50
8.	5	12	19	11	3	50
D.P. 3.	3	13	22	10	2	50
4.	3	12	23	9	3	50
K.W. 3.	3	12	19	11	4	49
4.	4.	13	16	13	4	50

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TABLE 6

Fiddlesticks Experiment 6 - 22.4.79
On land, Heron Island 1400

Estimation of Actual Stick Length

Actual length (cm)	W.C.	dev.'n	B.R.	dev.'n	D.P.	dev.'n
82	88	+ 6	85	+ 3	72	-10
28	28	0	15	-13	28	0
63	62	- 1	52	-11	52	- 9
38	35	- 3	35	- 3	32	- 6
64	64	0	60	- 4	56	- 8
24	22	- 2	22	- 2	24	0
12	12	0	10	- 2	12	0
78	78	0	78	0	76	- 2
66	60	- 6	56	-10	62	- 4
58	56	- 2	53	- 5	54	- 4
57	54	- 3	48	- 9	52	- 5
53	50	- 3	45	- 8	48	- 5
94	84	-10	100	- 6	94	0
54	52	- 2	(54	0)	50	- 4
46	46	0	45	- 1	42	- 4
41	38	- 3	32	- 9	40	- 1
48	42	- 6	46	- 2	46	- 2
22	20	- 2	18	- 4	22	0
6	6	0	4	- 2	6	0
52	46	- 6	50	- 2	48	- 4
88	74	-14	95	+ 7	82	- 6
44	40	- 4	33	-11	44	0
51	48	- 3	48	- 3	48	- 3
62	50	-12	52	-10	62	0
70	56	-14	75	+ 5	70	0
56	52	- 4	49	- 7	50	- 6
59	60	+ 1	50	- 9	52	- 7
30	28	- 2	25	- 5	32	+ 2
32	30	- 2	25	- 7	36	+ 4
34	34	0	30	- 4	34	0
47	44	- 3	45	- 2	38	- 9
74	66	- 8	65	- 9	68	- 6
50	46	- 4	45	- 5	48	- 2
50	50	0	45	- 5	50	0
36	34	- 2	30	- 6	40	+ 4
43	40	- 3	42	- 1	44	+ 1
55	52	- 3	52	- 3	48	- 7
37	30	- 7	30	- 7	34	- 3
45	42	- 3	33	-12	42	- 3
26	24	- 2	21	- 5	28	+ 2
68	68	0	58	-10	64	- 4
40	38	- 2	31	- 9	38	- 2
42	34	- 8	35	- 7	44	+ 2
18	16	- 2	11	- 7	18	0
72	66	- 6	62	-10	60	-12
49	40	- 9	42	- 7	46	- 3
76	74	- 2	75	- 1	68	- 8
60	52	- 8	53	- 7	54	- 6
61	54	- 7	43	-18	58	- 3

Deviations:

Total	$\bar{x}$ = 3.9 s.d. = 3.5 va. =12.5	$\bar{x}$ = 5.96 s.d. = 3.75 va. =14.1	$\bar{x}$ = 3.56 s.d. = 3.02 va. = 9.12
Negative	N =39 $\bar{x}$ = 4.80 s.d. = 3.37 va. =11.37	N =45 $\bar{x}$ = 6.28 s.d. = 3.70 va. =13.70	N =32 $\bar{x}$ = 5.09 s.d. = 2.59 va. = 6.70
Positive	N = 2 $\bar{x}$ = 3.50 s.d. = 2.5 va. = 6.25	N = 3 $\bar{x}$ = 5.00 s.d. = 1.63 va. = 2.66	N = 6 $\bar{x}$ = 2.5 s.d. = 1.11 va. = 1.25

TABLE 7

Fiddlesticks Experiment 7 - 22.4.79
Boat Harbour, Heron Island 1630

Estimation of Actual Stick Length

Actual length (cm)	W.C.	dev'n	B.R.	dev'n	D.P.	dev'n
78	82	+ 4	75	- 3	66	-12
58	62	+ 4	65	+ 7	48	-10
66	74	+ 8	68	+ 2	58	- 8
72	72	0	72	0	68	- 4
60	62	+ 2	53	- 7	52	- 8
94	94	0	95	1	88	- 6
82	88	+ 6	75	- 7	78	- 4
68	70	+ 2	62	- 6	64	- 4
88	72	-16	85	- 3	82	- 6
76	68	- 8	65	-11	66	-10
74	68	- 6	58	-16	64	-10
70	66	- 4	50	-20	72	+ 2
64	46	-18	48	-16	56	- 8
61	56	- 5	45	-16	56	- 5
50	42	- 8	38	-12	50	0
53	48	- 5	42	-11	54	+ 1
57	50	- 7	45	-12	52	- 5
63	56	- 7	48	-15	54	- 9
59	46	-13	45	-14	58	- 1
51	42	- 9	38	-13	50	- 1
54	44	-10	35	-19	48	- 6
62	34	-28	43	-19	46	- 6
49	44	- 5	32	-17	44	- 5
45	50	+ 5	28	-17	42	- 3
56	44	-12	35	-21	44	-12
48	38	-10	28	-20	40	- 8
46	42	- 4	26	-20	38	- 8
44	38	- 6	25	-19	36	- 8
52	54	+ 2	33	-19	48	- 4
47	44	- 3	28	- 19	46	- 1
41	40	- 1	25	-16	38	- 3
38	38	0	22	-16	36	- 2
40	42	+ 2	20	-20	40	0
37	34	- 3	21	-16	34	- 3
34	36	+ 2	18	-16	32	- 2
55	52	- 3	30	-25	44	-11
50	44	- 6	32	-18	42	- 8

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Actual length (cm)	W.C.	dev'n	B.R.	dev'n	D.P.	dev'n
32	30	- 2	18	-12	30	- 2
30	16	-14	12	-18	28	- 2
36	38	+ 2	15	-21	30	- 6
24	22	- 2	12	-12	22	- 2
39	40	+ 1	20	-19	32	- 7
22	20	- 2	11	-11	24	+ 2
6	6	0	6	0	6	0
42	40	- 2	23	-19	38	- 4
48	42	- 6	24	-24	40	- 8
18	18	0	15	- 3	18	0
12	12	0	8	- 4	12	0
28	30	+ 2	18	-10	24	- 4
26	28	+ 2	16	-10	22	- 4

Deviations:

	W.C.	B.R.	D.P.
Total	N = 50	N = 50	N = 50
	$\bar{x}$ = 5.38	$\bar{x}$ = 13.44	$\bar{x}$ = 4.9
	s.d. = 5.32	s.d. = 6.52	s.d. = 3.39
	va. = 28.35	va. = 43.12	va. = 11.53
Negative	N = 30	N = 45	N = 42
	$\bar{x}$ = 7.5	$\bar{x}$ = 14.71	$\bar{x}$ = 5.71
	s.d. = 5.73	s.d. = 5.56	s.d. = 3.07
	va. = 32.9	va = 31.00	va = 9.44
Positive	N = 14	N = 3	N = 3
	$\bar{x}$ = 3.14	$\bar{x}$ = 3.33	$\bar{x}$ = 1.66
	s.d. = 1.92	s.d. = 2.62	s.d. = 0.47
	va. = 3.69	va. = 6.88	va. = 0.22

TABLE 8

Fiddlesticks Experiment 8 - 22.4.79
Boat Harbour, Heron Island 1650

Sticks held against marked standard

Observer		Size classes				
	0-20	20-40	40-60	60-80	80-100	Total
W.C. 7	3	11	20	12	3	49
B.R. 9	2	6	23	15	4	50
D.P. 5	3	14	20	10	3	50

TABLE 9

Fiddlesticks Experiment 9 - 22.4.79
Boat Harbour, Heron Island 1715

Observer		Size classes				
	0-20	20-40	40-60	60-80	80-100	Total
W.C. 8	3	11	20	12	4	50
B.R. 10	3	11	22	10	3	49
D.P. 6	3	11	24	10	2	50

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TABLE 10

FIDDLESTICKS EXPERIMENT 10 - 23.4.79 14.30

N.W. WISTARI -
STICKS STRUNG ON 100 m TRANSECT LINE

ESTIMATION OF ACTUAL STICK LENGTHS

Actual length (cm)	J.H. dev'n	B.R. dev'n	W.C. dev'm	D.P. dev'n
68	70 + 2	58 - 10	78 + 10	72 + 4
48	48 0	47 - 1	50 + 2	50 + 2
52	50 - 2	50 - 2	60 + 8	48 - 4
64	60 - 4	56 - 8	66 + 2	60 - 4
45	42 - 3	40 - 5	50 + 5	44 - 1
59	50 - 9	54 - 6	56 - 3	48 - 11
57	45 - 12	42 - 15	54 - 3	52 - 5
53	50 - 3	55 + 3	50 - 3	50 - 3
58	50 - 8	58 0	60 + 2	52 - 6
60	52 - 8	52 - 8	64 + 4	50 - 10
24	30 + 6	25 + 1	24 0	24 0
36	30 - 6	35 - 1	36 0	34 - 2
87	70 - 17	70 - 17	90 + 3	74 - 13
32	30 - 2	30 - 2	34 + 2	32 0
42	40 - 2	38 - 4	46 + 4	40 - 2
46	45 - 1	45 - 1	54 + 8	42 - 4
41	45 + 4	43 + 2	42 + 1	38 - 3
40	35 - 5	34 - 14	46 + 6	40 0
50	45 - 5	45 - 5	54 + 4	48 - 2
56	50 - 6	58 + 4	60 + 4	54 - 2
62	60 - 2	70 + 8	70 + 16	66 + 4
38	35 - 3	48 + 10	42 + 4	46 + 8
78	80 + 2	85 + 17	74 - 4	82 + 4
55	55 0	65 + 10	62 + 13	60 + 5
43	35 - 8	58 + 15	42 - 1	46 + 3
61	50 - 9	70 + 9	58 - 3	60 - 1
37	28 - 9	45 + 8	38 + 1	38 + 1

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TABLE 10 (cont.)

Actual length (cm)	J.H. dev'n	B.R. dev'n	W.C. dev'n	D.P. dev'n
50	45 - 5	55 + 5	54 + 4	48 - 2
51	42 - 9	58 + 7	52 + 1	56 + 5
28	27 - 1	30 + 2	32 + 4	34 + 6
63	60 - 3	62 - 1	66 + 3	68 + 5
34	32 - 2	36 - 2	42 + 8	28 - 6
76	70 - 6	75 - 1	78 + 2	66 - 10
44	45 + 1	45 + 1	44 0	40 - 4
70	62 - 8	72 + 2	56 - 14	56 - 14
26	26 0	30 + 4	0	22 - 4
74	75 + 1	95 + 19	0	78 + 4
54	58 + 4	56 + 2	62 + 12	56 + 2
42	40 - 2	48 + 6	46 + 4	44 + 2
94	90 - 4	95 + 1	74 - 20	88 - 6
6	7 + 1	7 + 1	6 0	6 0
30	28 - 2	32 + 2	32 + 2	26 - 4
22	19 - 3	28 + 6	28 + 6	22 0
66	70 + 4	60 - 6	64 - 2	64 - 2
88	75 - 13	88 0	98 + 10	88 0
18	18 0	20 + 2	18 0	18 0
49	45 - 4	60 + 11	46 - 3	44 - 5
39	35 - 4	40 + 1	42 + 3	36 - 3
12	13 + 1	12 0	12 0	12 0
72	60 - 8	75 + 3	68 - 4	70 - 2

Deviation				
Total	x = 4.48	x = 5.2	x = 4.28	x = 3.8
	s.d. = 3.6	s.d. = 4.73	s.d. = 4.44	s.d. = 3.27
	va = 13.20	va = 22.4	va = 19.72	va = 10.72
Negatives	N = 37	N = 19	N = 11	N = 28
Positives	N = 10	N = 28	N = 29	N = 14

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TABLE 11

FIDDLESTICKS EXPERIMENT 11 — 23.4.79

N.W. WISTARI — 15.00

STICKS STRUNG ON 100m TRANSECT LINE

OBSERVER	SIZE CLASSES (cm)					TOTAL
	0-20	20-40	40-60	60-80	80-100	
B.R. 11	1	10	23	6	3	43
12	1	9	20	11	3	44
D.P. 7	2	9	21	10	3	45
8	1	9	23	8	3	44
W.C. 9	2	14	17	9	2	44
10	1	10	17	13	2	43
J.H. 1	1	14	16	13	2	46

TABLE 12

FIDDLESTICK EXPERIMENT 12 24.4.79

N.W. WISTARI 11.30

Sticks strung on 100m transect line

ESTIMATION OF ACTUAL LENGTH

ACTUAL LENGTH (cm)	B.R. (dev'n)	D.P. (dev'n)	J.H. (dev'n)	W.C. (dev'n)
68	72 + 4	68 0	70 + 2	70 + 2
48	65 + 17	42 - 6	45 - 3	50 + 2
52	68 + 16	50 - 2	45 - 7	52 0
64	85 + 21	64 0	58 - 6	60 - 4
45	58 + 13	46 + 1	40 - 5	46 + 1
59	68 + 9	60 + 1	45 - 14	54 - 5
57	72 + 15	58 + 1	45 - 12	50 - 7
53	62 + 9	50 - 3	41 - 8	40 - 13
58	63 + 5	52 - 6	53 - 5	48 - 10
60	65 + 5	54 - 6	52 - 8	49 - 11
24	28 + 4	22 - 2	20 - 4	22 - 2
36	38 + 2	32 - 4	30 - 6	28 - 8
82	92 + 10	82 0	75 - 7	72 - 10
32	40 + 8	30 - 2	30 - 2	28 - 4
42	55 + 8	46 + 4	40 - 2	32 - 10
46	58 + 12	48 + 2	50 + 4	46 0
41	55 + 14	44 + 3	35 - 6	38 - 3
40	54 + 14	46 + 6	33 - 7	30 - 10
50	62 + 12	54 + 4	40 - 10	42 - 8
56	65 + 9	56 0	52 - 4	44 - 12
62	75 + 13	60 - 2	58 - 4	56 - 6
38	52 + 14	36 - 2	38 0	34 - 4
78	88 + 10	76 - 2	75 - 3	64 - 14
55	68 + 13	52 - 3	45 - 10	60 + 5
43	57 + 14	40 - 3	40 - 3	34 - 9
61	74 + 13	62 + 1	53 - 8	52 - 9
37	55 + 18	38 + 1	35 - 2	26 - 9
50	64 + 14	50 0	42 - 8	38 - 12
51	58 + 7	48 - 3	42 - 9	56 + 5
28	32 + 4	26 - 2	25 - 3	18 - 10
63	65 + 2	62 - 1	55 - 8	50 - 13
34	38 + 4	34 0	30 - 4	28 - 6

ACTUAL LENGTH (cm)	B.R.	dev'n	D.P.	dev'n	J.H.	dev'n	W.C.	dev'n
76	85	+ 9	70	- 6	75	- 1	76	0
44	56	+ 12	48	+ 4	30	- 14	40	- 4
70	70	0	68	- 2	65	- 5	64	- 6
26	28	+ 2	34	+ 8	20	- 6	18	- 8
74	70	- 4	66	- 8	60	- 14	60	- 14
54	58	+ 4	52	- 2	55	+ 1	52	- 2
42	56	+ 14	48	+ 6	40	- 2	50	+ 8
94	96	+ 2	94	0	85	- 9	90	- 4
6	6	0	6	0	7	+ 1	6	0
30	35	+ 5	32	+ 2	25	- 5	24	- 6
22	26	+ 4	27	+ 5	20	- 2	16	- 6
66	66	0	64	- 2	65	- 1	68	+ 2
88	85	- 3	88	0	85	- 3	72	- 16
18	20	+ 2	18	0	20	+ 2	18	0
49	58	+ 9	46	- 3	45	- 4	40	- 9
39	54	+ 15	42	+ 3	43	+ 4		
12	15	+ 3	12	0	15	+ 3	12	0
72	72	0	72	0	60	- 8	70	- 2

	B.R.	D.P.	J.H.	W.C.
DEVIATIONS				
TOTAL	x = 8.22	x = 2.48	x = 5.38	x = 6.34
	s.d. = 5.35	s.d. = 2.20	s.d. = 3.52	s.d. = 4.33
	va = 28.65	va = 4.84	va = 12.39	va = 18.75
NEGATIVES	N = 2	N = 22	N = 42	N = 36
POSITIVES	N = 45	N = 16	N = 6	N = 7

TABLE 13

FIDDLESTICKS EXPERIMENT 13

24.4.79
12.00

N.W. WISTARI

STICKS STRUNG ON 100m TRANSECT LINE

	SIZE CLASSES (cm)					
OBSERVER	0-20	20-40	40-60	60-80	80-100	TOTAL
B.R. 13	3	11	23	12	2	51
D.P. 9	3	12	23	10	3	51
W.C. 11	4	11	20	12	3	50
J.H. 2	2	16	24	11	1	54

TABLE 14.

CORAL TROUT PRELIMINARY COUNT
N.W. WISTARI
COVERING REEF SLOPE OVER STICK TRANSECT LENGTH

24.4.70
12.15
Falling Tide

	SIZE CLASSES (cm)					
B.R. (15 mins)	1	3	1	1	0	6
D.P. (30 mins)	1	4	5	0	0	10
W.C. (20 Mins)	1	3	3	0	0	7

TABLE 15

FIDDLESTICK EXPERIMENT 14

N.W. HERON 'FISHED' AREA. 25.4.79

STICKS STRUNG ON 100m TRANSECT LINE 11.00

ESTIMATION OF ACTUAL LENGTHS

ACTUAL LENGTH (cm)	B.R. dev'n	W.C. dev'n	D.P. dev'n	J.H. dev'n
68	65 - 3	72 + 4	64 - 4	65 - 3
48	42 - 6	58 + 10	54 + 6	42 - 6
52	46 - 6	64 + 12	60 + 8	45 - 7
64	50 - 14	66 + 2	64 0	52 - 12
45	35 - 10	44 - 1	50 + 5	40 - 5
59	48 - 11	52 - 7	56 - 3	50 - 9
57	52 - 5	54 - 3	60 + 3	50 - 7
53	46 - 7	56 + 3	58 + 5	45 - 8
58	48 - 10	58 0	62 + 4	50 - 8
60	54 - 6	78 + 18	66 + 6	53 - 7
24	21 - 3	24 0	26 + 2	28 + 4
36	26 - 10	38 + 2	38 + 2	35 - 1
82	62 - 20	84 + 2	74 - 8	62 - 20
32	25 - 7	32 0	30 - 2	38 + 6
42	29 - 13	38 - 4	40 - 2	39 - 3
46	32 - 14	38 - 8	44 - 2	43 - 3
41	24 - 17	40 - 1	40 - 1	38 - 3
40	30 - 10	40 0	38 - 3	38 - 2
50	41 - 9	56 + 6	52 + 2	42 - 8
56	46 - 10	62 + 6	54 - 2	48 - 8
62	48 - 14	70 + 8	64 + 2	55 - 13
38	30 - 8	44 + 6	40 + 2	37 - 1
78	70 - 8	72 - 4	72 - 6	60 - 18
55	50 - 5	50 - 5	60 + 5	55 0
43	38 - 5	40 - 3	46 + 3	40 - 3
61	45 - 16	58 - 3	64 + 3	50 - 11
37	25 - 12	36 - 1	34 - 3	38 + 1
50	27 - 23	60 + 10	48 - 2	47 - 3
51	28 - 23	54 + 3	50 - 1	47 - 3
28	15 - 13	32 + 4	26 - 2	32 + 4
63	33 - 30	68 + 5	60 - 3	55 - 13

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TABLE 15 (CONT)

ACTUAL LENGTH (cm)	B.R. dev'n	W.C. dev'n	D.P. dev'n	J.H. dev'n
34	15 - 19	32 - 2	36 + 2	35 + 1
76	42 - 34	74 - 2	72 - 4	70 - 6
44	28 - 16	38 - 6	48 + 4	48 + 4
70	54 - 16	72 + 2	62 - 8	57 - 13
26	21 - 5	24 - 2	24 - 2	25 - 1
74	58 - 16	74 0	64 - 10	52 - 22
54	48 - 6	50 - 4	50 - 4	40 - 14
42	45 + 3	52 + 10	46 + 4	37 - 5
94	82 - 12	96 + 2	94 0	78 - 24
6	6 0	6 0	6 0	6 0
30	24 - 6	28 - 2	30 0	29 - 1
22	18 - 4	20 - 2	22 0	22 0
66	65 - 1	56 - 10	64 - 2	50 - 16
88	70 - 18	82 - 6	88 0	85 - 3
18	15 - 3	22 - 4	18 0	18 0
49	48 - 1	44 - 54	48 - 1	45 - 4
39	36 - 3	34 - 5	38 - 1	38 - 1
12	10 - 2	12 0	12 0	10 - 2
72	62 - 10	68 - 4	78 + 6	75 + 3

DEVIATIONS				
TOTAL	x = 10.46	x = 4.18	x = 3.0	x = 6.4
	s.d. = 7.25	s.d. = 3.60	s.d. = 2.36	s.d. = 5.93
	va = 52.60	va = 13.02	va = 5.6	va = 35.4
NEGATIVE	N = 48	N = 24	N = 22	N = 38
POSITIVE	N = 2	N = 19	N = 19	N = 6

25.4.79
12.00

TABLE 16

FIDDLESTICK EXPERIMENT 15

N.W. HERON 'FISHED' AREA

STICKS STRUNG ON 100m TRANSECT LINE

OBSERVER		(SIZE CLASSES cm) 0-20	20-40	40-60	60-80	80-100	TOTAL
B.R.	14	2	9	21	10	3	45
	15	3	13	22	9	3	51
	16	3	12	21	12	2	50
D.P.	10	3	12	19	14	2	50
W.C.	12	3	12	18	12	4	49
J.H.	3	3	18	20	9	1	50

TABLE 17

CORAL TROUT PRELIMINARY COUNT — 25.4.79

N.W. HERON 'FISHED' AREA — 12.30

COVERING REEF SLOPE OVER STICK TRANSECT LINE — Falling tide

OBSERVER	SIZE CLASSES (cm) 0-20	20-40	40-60	60-80	80-100	TOTAL
B.R.	0	2	8	5	0	15
D.P.	0	6	10	4	0	20
W.C.	0	0	4	1	0	5
J.H.	0	7	10	3	1	21

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23.4.79

TABLE 18

ACTUAL LENGTH MEASUREMENTS FROM N.W. WISTARI
PUT INTO SIZE CLASSES (20cm).

OBSERVER	SIZE CLASSES					TOTAL
	0-20	20-40	40-60	60-80	80-100	
B.R.	2	11	23	10	4	50
J.H.	4	12	25	8	1	50
W.C.	3	7	25	12	2	49
D.P.	3	12	23	9	3	50

TABLE 19

ACTUAL LENGTH MEASUREMENT FROM N.W. WISTARI 24.4.79
PUT INTO SIZE CLASSES (20cm)

	0-20	20-40	40-60	60-80	80-100	TOTAL
B.R.	2	8	16	18	6	50
D.P.	3	10	23	12	3	51
J.H.	2	15	24	7	2	50
W.C.	6	12	21	9	1	49

TABLE 20

ACTUAL LENGTH MEASUREMENTS FROM 25.4.79 N.W. HERON 'FISHED' AREA PUT INTO SIZE CLASSES (20cm).

OBSERVER	SIZE CLASSES 0-20	20-40	40-60	60-80	80-100	TOTAL
B.R.	6	18	20	5	1	50
W.C.	2	16	16	12	3	49
D.P.	3	11	20	14	2	50
J.H.	3	16	25	6	0	50

TABLE 21

ACTUAL LENGTH MEASUREMENT FROM N.W. HERON 'FISHED' AREA PUT INTO SIZE CLASSES (10cm)

OBSERVER	SIZE CLASSES 0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
B.R.	2	4	13	5	14	5	4	2	1	0	50
W.C.	1	2	4	13	5	9	6	7	2	1	49
D.P.	1	3	5	8	8	7	12	4	1	1	50
J.H.	2	1	4	13	15	8	5	2	0	0	50
Exp.	1	2	5	7	10	10	7	5	2	1	50

25.4.79

TABLE 22

KOLMOGOROV - SMIRNOV TEST OF ACTUAL ESTIMATES PUT INTO FIVE SIZE CLASSES vs ACTUAL SIZE CLASSES FOR TABLE 20

OBSERVER	D MAX.	D crit (p=.05)	Diff	
B.R.	0.18	.28	.10	n.s.
W.C.	0.07	.27	.20	n.s.
D.P.	0.02	.28	.26	n.s.
J.H.	0.18	.28	.10	n.s.

KOLMOGOROV - SMIRNOV TEST OF ACTUAL ESTIMATES PUT INTO 10 SIZE CLASSES vs ACTUAL SIZE CLASSES FOR TABLE 21

25.4.79

OBSERVER	D MAX	D crit (p=.05)	Diff	
B.R.	0.26	.28	.02	n.s.
W.C.	0.10	.27	.17	n.s.
D.P.	0.06	.28	.22	n.s.
J.H.	0.20	.28	.08	n.s.

26.4.79

TABLE 23

FIDDLESTICKS EXPERIMENT 16

N.W. HERON 'UNFISHED' AREA

STICKS STRUNG ALONG 100m TRANSECT LINE.

OBSERVER	SIZE CLASSES										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
D.P.1	1	2	4	6	13	11	6	4	2	1	50
2	1	2	5	8	11	11	6	3	3	0	51
3	1	2	6	7	12	11	6	3	2	0	50
4	1	2	4	9	10	12	7	3	2	0	50
W.C.1	1	3	3	6	8	10	8	5	4	2	50
2	1	2	3	6	10	11	8	4	3	2	50
3	1	2	4	4	8	12	8	5	3	1	48
4	1	1	3	9	8	11	5	7	4	1	50
B.R.1	1	4	2	4	11	12	8	4	2	2	50
2	1	2	3	5	12	15	7	2	1	2	50
3	1	3	3	3	9	9	9	8	4	1	50
J.H.1	2	2	3	10	12	14	9	4	0	0	56
2	1	2	4	7	9	12	6	5	0	0	46
3	1	2	3	9	9	12	6	3	1	0	46
ACTUAL	1	2	5	7	10	10	7	5	2	1	50

TABLE 24

KOLMOGOROV - SMIRNOV TEST OF SIZE CLASS ESTIMATES AGAINST ACTUAL SIZE CLASSES.

26.4.79

OBSERVER		D. max	(p=.05) D crit	Diff.	Significance
D.P.	1	.04	.27	.23	n.s.
	2	.05	.27	.22	n.s.
	3	.08	.27	.19	n.s.
	4	.06	.27	.21	n.s.
W.C.	1	.08	.27	.19	n.s.
	2	.06	.27	.21	n.s.
	3	.10	.27	.17	n.s.
	4	.08	.27	.19	n.s.
B.R.	1	.08	.27	.19	n.s.
	2	.08	.27	.19	n.s.
	3	.14	.27	.13	n.s.
J.H.	1	.07	.26	.19	n.s.
	2	.06	.27	.21	n.s.
	3	.08	.27	.19	n.s.

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TABLE 25 28.4.79

FIDDLESTICK - NEW OBSERVER 12.00

BOAT HARBOUR, HERON ISLAND
STICKS STRUNG OUT OVER 100 m TRANSECT

ESTIMATION OF ACTUAL LENGTH

ACTUAL LENGTH	J.B. dev'n	Actual	J.B.	devn.
68	64 - 4	61	59	- 2
48	48 - 0	37	36	- 1
52	53 + 1	50	48	- 2
64	70 + 6	51	50	- 1
45	43 - 2	28	23	- 5
59	58 - 1	63	62	- 1
57	50 - 7	34	33	- 1
53	43 - 10	76	85	+ 9
58	52 - 6	44	44	0
60	54 - 6	70	81	+ 11
24	23 - 1	26	25	- 1
36	33 - 3	74	78	+ 4
82	85 + 3	54	54	0
32	32 - 1	42	49	+ 7
42	41 - 1	94	100	+ 6
46	45 - 1	6	7	+ 1
41	42 + 1	30	28	- 2
40	38 - 2	22	22	0
50	47 - 3	66	64	- 2
56	51 - 5	88	94	+ 6
62	55 - 7	18	17	- 1
38	37 - 1	49	46	- 3
78	67 - 11	39	39	0
55	52 - 3	12	12	0
43	43 0	72	77	- 5

Deviations

Total x = 3.14 Negative N = 32

s.d. = 2.99 Positive N = 8

va = 8.96

TABLE 26

FIDDLESTICKS. NEW OBSERVER
ACTUAL LENGTH ESTIMATES PUT INTO
10 SIZE CLASSES

28.4.79

OBSERVER	SIZE CLASSES										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
J.B.	1	2	3	10	11	9	7	4	1	2	50

D. max = 0.04 Dcrit = .27 n.s. p .05
Diff. = .23

TABLE 27

FIDDLESTICKS NEW OBSERVER
BOAT HARBOUR HERON ISLAND
STICKS STRUNG ALONG 100 m transect

30.4.79
1.5.79
2.5.79 am
2.5.79 pm
3.5.79

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-200	TOTAL
J.B.	1	3	2	5	11	12	8	5	2	1	50
3	1	3	4	8	11	12	5	3	2	1	50
4	1	3	4	7	11	10	7	4	2	1	50
5	1	3	3	8	11	11	6	4	2	1	50
6	1	3	4	6	10	9	8	6	2	1	50

	D max.	Dcrit.	Diff.	Signif.
2	.08	.27	.19	n.s.
3	.08	.27	.19	n.s.
4	.02	.27	.25	n.s.
5	.04	.27	.23	n.s.
6	.04	.27	.23	n.s.

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Table 28

Summary of fiddlesticks experiments excluding actual length estimations.
Experiments in chronological order to show improvement with training.
Difference between Dmax and Dcrit using Kolmogorov-Smirnov Test.

			W.C.			B.R.			D.P.			J.H.			K.W			J.B		
Date	Test	No.	Dm	Dc	Diff	Dm	Dc	Diff	Dm	Dc	Diff	Dm	Dc	Diff	Dm	Dc	Diff	Dm	Dc	Diff
1979	W-	1	.32	.27	-.05	.20	.27	.07												
22.4	W-	2	.20	.27	.07	.08	.27	.19												
	L-	3	.06	.27	.21	.14	.27	.14	.10	.27	.17				.36	.27	-.11			
	L-	4	.16	.27	.11	.10	.27	.17	.04	.27	.23				.42	.27	-.15			
	L-	5				.06	.27	.21												
	L-	6				.12	.27	.16												
	LS	7	.04	.27	.23	.06	.27	.21	.06	.27	.21				.02	.27	.25			
	LS	8	.02	.27	.25	.04	.27	.23	.06	.27	.21				.04	.27	.23			
	WS	9	.02	.27	.25	.14	.27	.14	.04	.27	.23									
	W-	10	.02	.27	.25	.02	.27	.25	.06	.27	.21									
23.4.	W-	11	.06	.29	.23	.09	.29	.20	.06	.29	.23	.04	.29	.25						
	W-	12	.05	.29	.24	.07	.29	.22	0.07	0.29	.22									
24.4.	W-	13	0	.27	.27	.03	.27	.24	.05	.27	.22	.08	.27	.19						
25.4.	W-	14	.03	.27	.24	.06	.28	.22	.02	.27	.25	.11	.27	.18						
	W-	15				.05	.27	.22												
	W-	16				.02	.27	.25												
28.4	W-	17																.01	.27	.26
30.4	W-	18																.08	.27	.19
1.5	W-	19																.08	.27	.19
2.5	W-	20																.02	.27	.25
2.5	W-	21																.04	.27	.23
2.5	W-	22																.04	.27	.23

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TABLE 28 (cont.)

Note 1. All observers except J.B. were placing sticks into 5x20 cm size classes; J.B. was placing sticks into 10x20 cm size classes.

2. W = water, L = land, S = with standard, - = without standard

3. Although in only three cases were the observed distributions significantly different from the expected distribution (p .05). The size of the difference between Dcrit and Dmax is inversely proportional to the difference between the observed and expected distributions.

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TABLE 29

CORAL TROUT

N.W. HERON 'UNFISHED AREA

CORAL TROUT INTO 10 SIZE CLASSES IN TRANSECTS A & B

TIME FOR EACH 50 m IN PARENTHESIS

27.4.79

10.50

Falling tide

	Size Classes (cm)										Total
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
W.C.											
A.(15)	0	0	4	6	5	6	4	2	0	0	27
B.(10)	0	1	0	8	12	4	3	1	0	0	19
	0	1	4	14	17	10	7	3	0	0	46
D.P.											
A.(15)	0	0	0	3	10	15	6	2	1	0	37
B.(15)	0	0	0	0	3	1	2	1	1	0	7
	0	0	0	3	13	16	8	3	2	0	44
B.R.											
A.(20)	0	0	0	18	20	8	2	0	0	0	48
B.(15)	0	0	1	8	12	4	1	0	0	0	26
	0	0	1	26	32	12	3	0	0	0	74
J.H.											
A.(35)	0	1	0	11	13	14	8	7	3	1	58

KOLMOGOROV - SMIRNOV TEST COMPARING BETWEEN OBERSVERS A + B

Test	Dmax	Dcrit	Significance (p = .05)	
D.P. vs W.C.	0.28	0.27	sig	p .05
D.P. vs B.R.	0.44	0.26	sig	p .05
B.R. vs W.C.	0.16	0.24	n.s.	p .05

TABLE 30

27.4.79
16.00
Low tide

CORAL TROUT

N.W. HERON 'UNFISHED' AREA

CORAL TROUT INTO 10 SIZE CLASSES IN TRANSECTS C + D (100 m). TIME FOR EACH 50 m in PARENTHESIS.

	SIZE CLASSES										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
W.C.											
C(20)	0	0	5	23	21	5	2	0	0	0	56
D(20)	0	0	0	22	23	5	0	0	0	0	50
C+D	0	0	5	45	44	10	2	0	0	0	106
J.B.											
C(15)	0	0	2	13	9	8	0	0	0	0	32
D(13)	0	0	0	13	15	5	0	0	0	0	33
D(15)	0	0	0	7	15	6	0	0	0	0	28
C+D	0	0	2	26	24	13	0	0	0	0	65
B.R.											
C(25)	0	0	2	15	18	12	7	2	0	0	56
D(18)	0	0	0	8	13	5	1	0	0	0	27
C+D	0	0	2	23	31	17	8	2	0	0	83
D.P.											
C(15)	0	0	0	5	6	12	6	6	1	0	36
D(10)	0	0	0	0	15	8	5	0	0	0	28
D(10)	0	0	0	4	10	9	4	1	0	0	29
C+D	0	0	0	5	21	20	11	6	1	0	64

TOTAL VALUES REPRESENT C+D TOTALS

KOLMOGOROV-SMIRNOV TEST COMPARING BETWEEN OBSERVERS C + D

TEST	Dmax	D crit	Sign.	(p = .05)
W.C. vs D.P.	0.48	0.22	Sig.	$p < .05$
J.B. vs D.P.	0.39	0.24	sig.	$p < .05$
B.R. vs D.P.	0.26	0.23	sig.	$p < .05$
W.C. vs B.R.	0.22	0.19	sig.	$p < .05$
B.R. vs J.B.	.13	.22	ns	$p > .05$
W.C. vs J.B.	.09	.22	ns	$p > .05$

TABLE 31 28.4.79
11.15

CORAL TROUT

N.W. HERON ISLAND 'UNFISHED' AREA Falling tide

TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS

	SIZE CLASSES (cm)										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
W.C.											
D(10)	0	0	0	7	8	5	1	0	0	0	21
C(10)	0	0	0	7	10	6	0	0	0	0	23
B(10)	0	0	0	5	7	5	1	0	0	0	18
A(6)	0	0	0	2	9	10	4	0	0	0	25
D+C+B	0	0	0	19	25	16	2	0	0	0	62
J.B.											
D(11)	0	0	0	12	9	6	4	3	0	0	34
C(13)	0	0	0	5	8	10	5	2	0	0	30
B(12)	0	0	0	7	11	8	2	1	0	0	29
A(10)	0	0	0	4	15	8	3	4	0	0	34
D+C+B	0	0	0	24	28	24	11	6	0	0	93
B.R.											
D(13)	0	0	1	4	13	2	1	0	0	0	21
C(18)	0	0	0	5	27	3	1	0	0	0	36
B(6)	0	0	0	3	13	6	0	0	0	0	22
D+C+B	0	0	1	12	53	11	2	0	0	0	79
D.P.											
D(10)	0	0	0	1	7	9	1	1	0	0	19
C(10)	0	1	0	0	7	8	5	1	0	0	22
B(10)	0	0	0	0	7	8	3	2	2	0	22
D+C+B	0	1	0	1	21	25	9	4	2	0	63

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TABLE 32 28.4.79

CORAL TROUT 16.05

N.W. HERON ISLAND 'UNFISHED' AREA

TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m in PARENTHESIS) Low tide

OBS.	SIZE CLASSES (cm)										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
J.B.											
A(13)	0	0	0	6	14	3	3	2	0	0	28
B(12)	0	0	0	1	4	2	0	0	0	0	7
C(12)	0	0	0	13	20	9	8	0	0	0	50
A+B+C	0	0	0	20	38	14	11	2	0	0	85
W.C.											
A(10)	0	0	0	3	3	5	1	2	0	0	14
B(10)	0	0	0	1	4	4	2	1	0	0	12
C(10)	0	0	0	5	14	13	4	0	0	0	36
D(9)	0	0	0	1	6	14	6	2	0	0	28
A+B+C	0	0	0	9	21	22	7	3	0	0	62
B.R.											
A(12)	0	0	0	4	15	3	1	0	0	0	23
B(15)	0	0	0	2	10	1	0	0	0	0	13
C( )	0	0	0	10	22	7	3	0	0	0	42
A+B+C	0	0	0	16	47	11	4	0	0	0	78
D.P.											
A(10)	0	0	0	2	9	2	2	1	1	0	17
B(10)	0	0	0	0	4	5	0	0	0	0	9
C(10)	0	0	0	3	5	8	5	2	1	0	24
D(10)	0	0	0	2	11	6	3	0	0	0	22
A+B+C	0	0	0	5	18	15	7	3	2	0	50
L.T.											
A.	0	0	8	5	6	3	0	0	0	0	22
B.	0	0	7	4	0	0	0	0	0	0	11
C.	0	0	4	5	6	2	0	0	0	0	17
	0	0	19	14	12	5	0	0	0	0	50
L.O.											
A.	0	2	5	4	0	0	0	0	0	0	11
B.	0	1	2	5	6	0	0	0	0	0	14
C.	0	1	1	3	0	0	0	0	0	0	5
D.	0	1	2	3	2	3	0	0	0	0	11
A+B+C	0	4	8	12	6	0	0	0	0	0	30

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TABLE 33

CORAL TROUT
N.W. HERON ISL. 'UNFISHED' AREA

29.4.79
16.00
Low tide

CORAL TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS).

	SIZE CLASSES (cm) 0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
W.C.											
A(11)	0	0	0	3	6	4	0	0	1	0	14
B(11)	0	0	0	7	8	2	2	0	1	0	20
C(9)	0	0	0	7	17	10	4	0	0	0	38
A+B+C	0	0	0	17	31	16	6	0	2	0	72
B.R.											
A(13)	0	0	1	6	17	2	1	0	0	0	27
B(10)	0	0	0	2	13	6	0	0	0	0	21
C( )	0	0	0	1	6	15	3	1	0	0	43
A+B+C	0	0	2	14	47	23	4	1	0	0	91
J.B.											
A(11)	0	0	0	8	9	2	1	1	0	0	21
B(11)	0	0	0	8	10	7	2	0	0	0	27
C(9)	0	0	0	10	13	15	4	0	0	0	42
A+B+C	0	0	0	26	32	24	7	1	0	0	90
L.O.											
A.	0	1	5	3	5	7	0	0	0	0	21
B.	0	0	3	4	6	5	0	0	0	0	18
C.	0	1	7	9	10	6	0	0	0	0	33
A+B+C	0	2	15	16	21	18	0	0	0	0	72
L.T.											
A.	0	0	4	8	1	1	0	0	0	0	14
B.	0	0	0	5	8	0	0	0	0	0	13
C.	0	0	6	20	9	2	0	0	0	0	37
A+B+C	0	0	10	33	18	3	0	0	0	0	64

TABLE 34

30.4.79
10.00

CORAL TROUT

N.W. HERON ISLAND 'UNFISHED' AREA

High tide

CORAL TROUT INTO SIZE CLASSES (TIME FOR EACH 50 m) IN PARENTHESIS.

	Size Classes (cm)										
OBS.	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
B.R.											
A(15)	0	0	0	12	25	4	1	0	0	0	42
B(12)	0	0	0	6	15	5	0	0	0	0	26
C(9)	0	0	0	4	35	6	1	0	0	0	46
A+B+C	0	0	0	22	75	15	2	0	0	0	114
W.C.											
A(12)	0	0	0	5	15	9	2	0	0	0	31
B(9)	0	0	0	6	13	7	2	1	0	0	29
C(9)	0	0	0	5	17	17	3	0	0	0	42
A+B+C	0	0	0	16	45	33	7	1	0	0	102
J.B.											
A(11)	0	0	0	15	15	12	0	0	0	0	42
B(10)	0	0	0	11	11	7	3	0	0	0	32
C(9)	0	0	0	10	20	5	2	1	0	0	38
A+B+C	0	0	0	36	46	24	5	1	0	0	112

TABLE 35

CORAL TROUT
N.W. HERON 'FISHED' AREA

1.5.79
11.15

CORAL TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS)

High tide

Size Classes (cm)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
B.R.											
A(13)	0	0	0	8	20	7	1	0	0	0	36
B(9)	0	0	0	0	4	3	0	0	0	0	7
C(9)	0	0	1	2	10	2	0	0	0	0	15
A+B+C	0	0	1	10	34	12	1	0	0	0	58
W.C.											
A(10)	0	0	0	3	14	4	1	1	0	0	23
B(11)	0	0	0	0	2	1	0	0	0	0	3
C(9)	0	0	1	5	11	6	1	0	0	0	24
A+B+C	0	0	1	8	27	11	2	1	0	0	50
J.B.											
A(10)	0	0	0	8	9	8	1	0	0	0	26
B(10)	0	0	0	0	2	0	2	0	0	0	4
C(10)	0	0	0	6	7	2	1	1	0	0	17
	0	0	0	14	18	10	4	1	0	0	47

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1.5.79

TABLE 36

16.20
Falling tide

CORAL TROUT

HERON 'FISHED' AREA CORAL TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS) Size Classes (cm)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
W.C.											
C(10)	0	0	1	4	9	2	0	0	0	0	16
B(10)	0	0	0	2	8	2	1	0	0	0	13
A(10)	0	0	0	6	13	5	1	0	0	0	25
C+B+A	0	0	1	12	30	9	2	0	0	0	54
J.B.											
C(11)	0	0	0	6	17	3	0	0	0	0	26
B(11)	0	0	0	3	8	5	2	0	0	0	18
A	0	0	1	7	16	3	1	1	0	0	19
C+B+A	0	0	1	16	41	11	3	1	0	0	73
B.R.											
C(15)	0	0	2	1	25	5	0	0	0	0	33
B(10)	0	0	0	4	14	3	0	0	0	0	21
A	0	0	0	4	16	3	1	0	0	0	24
C+B+A	0	0	2	9	55	11	1	0	0	0	78

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TABLE 37

CORAL TROUT

N.W. HERON ISLAND 'FISHED' AREA

CORAL TROUT IN 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS)

2.5.79

10.15

Rising tide

	Size Classes (cm)										Total
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
W.C.											
C(10)	0	0	0	2	8	4	1	0	0	0	15
B(10)	0	0	0	0	3	4	2	0	0	0	9
A(8)	0	0	1	2	7	4	2	0	0	0	16
C+B+A	0	0	1	4	18	12	5	0	0	0	40
B.R.											
C(10)	0	0	1	4	17	4	0	0	0	0	26
B(9)	0	0	1	0	11	2	0	0	0	0	14
A(10)	0	0	1	6	14	5	0	0	0	0	26
C+B+A	0	0	3	10	42	11	0	0	0	0	66
J.B.											
C	0	0	0	9	10	7	3	0	0	0	29
B	0	0	0	4	3	4	1	0	0	0	12
A	0	0	2	10	12	4	2	0	0	0	30
C+B+A	0	0	2	23	25	15	6	0	0	0	71

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TABLE 38

CORAL TROUT 2.5.79

N.W. HERON ISLAND 'FISHED' AREA 15.27

CORAL TROUT INTO 10 SIZE CLASSES (TIME FOR EACH 50 m IN PARENTHESIS) Falling tide

	Size Classes (cm)										TOTAL
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
J.B.											
A	0	0	2	10	14	6	1	0	0	0	33
B	0	0	0	6	6	2	1	0	0	0	15
C	0	0	1	10	19	4	0	0	0	0	34
A+B+C	0	0	3	26	39	12	2	0	0	0	82
W.C.											
A	0	0	3	6	15	6	4	1	0	0	35
B	0	0	0	1	7	7	1	1	0	0	17
C	0	0	1	9	18	13	2	0	0	0	43
A+B+C	0	0	4	16	40	26	7	2	0	0	95
B.R.											
A	0	0	0	2	10	4	2	1	0	0	19
B	0	0	1	1	5	7	1	0	0	0	15
C	0	0	3	6	18	6	2	0	0	0	35
A+B+C	0	0	4	9	33	17	5	1	0	0	69

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TABLE 39

3.5.79

10.05

CORAL TROUT

N.W. HERON ISLAND

Rising tide

CORAL TROUT W OF 'UNFISHED' AREA FOR 30 MINUTES (3x10 MINUTES INTERVALS

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	TOTAL
B.R.	0	0	1	9	25	7	1	0	0	0	43
	0	0	0	11	19	19	1	0	0	0	50
	0	0	0	17	21	13	6	1	0	0	58
TOTAL	0	0	1	37	65	39	8	1	0	0	151
J.B.	0	0	0	13	21	5	1	0	0	0	40
	0	0	0	9	18	12	1	0	0	0	40
	0	0	2	20	30	16	2	0	0	0	70
TOTAL	0	0	2	42	69	33	4	0	0	0	150
W.C.	0	0	0	7	23	14	7	0	0	0	51
	0	0	1	9	12	14	5	0	0	0	41
	0	0	0	20	29	19	7	0	0	0	75
TOTAL	0	0	1	36	64	47	19	0	0	0	167

COMPARISON BETWEEN OBSERVERS 150 m VALUES

TEST	Dmax	Dcrit	Significance (p = .05)
JB vs BR	.07	.15	n.s.
BR vs WC	.08	.15	n.s.
JB vs WC	.15	.15	n.s.

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TABLE 40

3.5.79
14.15
High tide

CORAL TROUT
N.W. HERON ISLAND
CORAL TROUT E. OF 'UNFISHED' AREA FOR 30 MINS. (3 x 10 MINUTE INTERVALS)

	Size Classes (cm)										Total
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
W.C.	0	0	1	12	25	15	3	0	0	0	56
	0	0	1	9	30	19	3	0	0	0	62
	0	0	0	10	15	18	5	(1)	0	0	49
TOTAL	0	0	2	31	70	52	11	1	0	0	167
B.R.	0	0	0	9	32	5	2	1	0	0	49
	0	0	1	7	30	14	7	1	0	0	60
	0	0	0	3	21	15	6	0	(1)	0	46
TOTAL	0	0	1	19	83	34	15	2	1	0	155
J.B.	0	0	2	21	29	5	1	0	0	0	58
	0	0	2	8	41	8	3	0	0	0	62
	0	0	0	8	26	16	3	0	(1)	0	54
	0	0	4	37	96	29	7	0	1	0	174

COMPARISON BETWEEN OBSERVERS 150 m VALUES KOLMOGOROV-SMIRNOV TEST

TEST	Dmax	Dcrit	Significance	
WC vs BR	.07	.15	n.s.	$p > .05$
WC vs JB	.17	.15	sig	$p < .05$
BR vs JB	,12	.15	n.s.	$p > .05$

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