

REPORT

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PROJECT TITLE: RELATIONSHIPS BETWEEN PISCIVORE ABUNDANCE AND PREY MORTALITY.

INTRODUCTION and AIMS

In the development of models to account for the patterns of abundance of reef fish populations it is fundamental to assess the relative importance of presettlement processes that contribute to variable recruitment of fishes to the reef and subsequent postrecruitment processes that may modify these patterns. A number of studies focusing on the postrecruitment demography of coral reef fishes, characteristically demonstrate high juvenile mortality rates during this phase (Doherty and Sale, 1985; Victor, 1986; Eckert, 1987; Shulman & Ogden, 1987; Sale & Ferrell, 1988, Mapstone, 1988). Such a demographic event may have the potential to modify patterns of recruitment and thereby assist in explaining variations in adult numbers.

Concern for the source of mortality has led to a great deal of speculation on the role of predation. My work which is based on One Tree Island, Capricorn Bunker Group, Great Barrier Reef, has four objectives: (1) Identify piscine piscivores. (2) Evaluate whether the abundance of known piscine piscivores are uniform among locations separated by 10's of meters and 100's of meters. (3) Relate spatial patterns of prey mortality to the piscivore abundances found in (2). (4) Assess whether predation is the main source of mortality.

MAJOR FINDINGS AND APPLICATIONS TO MANAGEMENT

(1) IDENTIFICATION OF PISCIVORES AND THEIR PREY

Low numbers of recruits were found in the gut contents of piscivorous fish. This may be related to the small sample sizes, a more rapid rate of digestion for smaller fishes and low encounter rates of prey. Major problems have been encountered with the utility of gut content analysis for the purposes of identifying predators and their prey. The crucial one being that if the prey of interest makes up a small proportion of the predators diet, extremely large sample sizes are needed to detect that prey. The utility of gut content analysis may be restricted to little more than evaluating whether a piscivore is capable of consuming a certain type of fish. This has important implications in that researchers should be more aware of the relationship between sample size and probability of detecting specific items of prey. Researchers planning on using a small sample size to detect whether a suspected predator consumes a prey of interest may not be making a major contribution if they fail to detect the prey.

(2) PISCIVORE ABUNDANCE

Predators were defined as those fish that have been previously suspected or identified as piscivores. A large number of these predators were serranids, lutjanids and lethrinids. Since commercial and recreational fisheries target a number of piscivorous species, information on their temporal and spatial patterns and the consequences of altering these patterns are essential to management. To count predators, I used 5 replicate, 5x25m transects, after a pilot study showed they gave sufficiently precise estimates of abundance. The counts did not appear to be influenced by the time of the day or state of the tide within two locations. Non-cryptic species were counted as the tape was laid out while cryptic species were counted in a thorough search when returning along the same tape.

The counts found great differences in the abundance of predators between and within locations on the edge than centre of the lagoon (Table I). Locations on the edge of the lagoon had greater mean abundance than locations in the centre of the lagoon. Locations were separated by 100's of meters, which suggest that the abundance of predators may not necessarily be random at this spatial scale.

To determine whether predator abundance was uniform among locations separated by 10's of meters, maps of individual predators within different locations were plotted for different states of the tide, at different times of the day, within different days over a two week period. Three species (Plectropomus leopardus, Lutjanus carponotatus and Lutjanus fulviflamma) were chosen on the basis that they consumed the largest numbers of reef fish as identified by the gut content analysis.

It appears that regardless of tide, time of day and days, fish were highly aggregated in locations of high predator abundance. This information is exemplified in (Fig. 1a). Although a test for non-randomness is needed, it is quite clear that at this time for low tide, most of the coral trout are aggregated in one small part of the study area. At high tide, they were more scattered throughout the study area than at low tide but still appear not to have a random distribution (Fig. 1b).

(3) RELATIONSHIPS BETWEEN PISCIVORE ABUNDANCE AND PREY MORTALITY

Given the observations that (1), predator abundances vary on spatial scales of 10's and 100's of meters and (2), that juvenile prey mortality rates are high and variable, I proposed the following hypothesis: the mean mortality rates of juvenile fishes are greater in locations of high predator abundance than in locations of low predator abundance.

(a) *Artificial Reefs:*

To test a prediction of this hypothesis, I monitored natural recruitment and subsequent losses of sedentary pomacentrids from artificial reefs in locations of high and low predator abundance at two scales. At the local scale of meters, replicate artificial reefs were constructed close to and far away from continuous reef where predators were most abundant. Each reef was separated by at least 8m from each other and the continuous reef. At the broader scale of 100's of meters this design was repeated in two locations of high predator abundance (the edge of the lagoon) and two locations of low predator abundance (the centre of the lagoon). Patch reefs therefore, were separated by 10's and 100's of meters in a partially hierarchical design.

Evidence to reject the null hypothesis of no difference, would require the loss rates of juveniles to be greater on reefs constructed close to locations of high predator abundance. Correspondingly, this was tested at the scale of 10's of meters where it was predicted that there would be greater mean loss of fish from reefs constructed in closer proximity to continuous reef. At the scale of 100's of meters it was predicated that there would be greater mean loss in locations adjacent to reefs supporting high predator abundance.

Reefs were visited daily for two observation periods. It was necessary to pool the data for both periods which consisted of 21 and 29 days. Since fish settled at various times during the summer I rearranged the data matrix to generate a cohort of equal-aged individuals. Recruitment was found to vary between locations separated by 100's of meters (Table IIa). Since the test for 'proximity' was weak ($df=1,2$), the factors (LagxProx, ProxLoc{lag}) were pooled with the residual ($p>0.25$; Winer, 1971). Proximity remained non-significant ($p>0.25$) when tested over this pooled value ($df=1,19$). No differences in percentage loss between locations or proximity of reefs were found (Table IIb). Again, since the factors 'lagoon' and 'proximity' are a weak test, the interactions were pooled with the residual ($p>0.25$; Winer, 1971), to test both 'lagoon' and 'proximity' over this pooled value (Lagoon, $df=3,9$; Proximity, $df=1,19$). Both factors remain non-significant ($p>0.25$) after pooling.

Given that this design adequately tested the model, the results suggest that high mortality rates of pomacentrids are unlikely to be well explained by high predator abundances. More precisely it suggests that mortality rates of pomacentrids on *artificial reefs* are unlikely to be well explained by high predator abundances on continuous reef. Concurrent with these observations, the data of mapped individual predators within these locations suggest that they are highly associated with continuous reef and were not found to be more than a couple of meters away on the open sand (Fig. 2). Similarly, I was unable to document predators on or near the patch reefs. The assumption that reefs constructed on sand adjacent to a location of high predator abundance would be representative of high predator abundance may be false. Therefore, this test may not have been an appropriate test of the hypothesis. These results have interesting implications in that mortality observed on the extensively utilised artificial reefs may not be representative of natural reef. A comparison of mortality between patch reefs and natural reefs require study.

(b) *Natural Reef:*

An appropriate test therefore, may be one that monitors loss rates of prey on continuous reef within locations of high and low predator abundance. There have been a great deal of problems associated with monitoring mortality on continuous reef. The major problem is associated with ensuring that losses of individuals represent mortality and not emigration. On continuous reef it is necessary to individually recognise each fish (e.g., through tagging or natural markings). On isolated patch reefs losses of territorial fishes are assumed to be mortality. The use of both patch reefs and identifying individual fish for the purposes of quantifying mortality have major problems in that they require high and logistically difficult replication in order to detect differences in mortality. Hence studies have low power and concern for type II errors notoriously dominate mortality studies (e.g., Doherty and Sale, 1985; Sale and Ferrell, 1988; Mapstone, 1988 and Caley, 1991).

Acanthochromis polyacanthus juveniles were chosen as a study species so as to overcome these problems. The loss of individuals is almost certainly mortality rather than migration due to the initial dependence of the juveniles on the parents for survival. Potentially powerful tests are logistically possible since there are large numbers of juveniles which live in broods with their parents. Although this is not a typical fish in the way that it lacks a dispersive larval stage, it is an ideal species to address questions related to the early demography of juvenile fishes.

The major findings were that although there was no difference in newly hatched juveniles (Table IIIa), by the time the brood had reached a total mean size of 19mm there were significant differences between the edge and centre of the lagoon (Table IIIb). Broods on the edge had significantly less juveniles at 19mm. This can essentially be explained by higher mortality rates experienced by juveniles in locations of higher predator abundance (Table IIIc).

Although I accept the hypothesis that on continuous reef, juvenile *Acanthochromis polyacanthus* suffer higher mortality rates in locations of high predator abundance, the interpretation of these observations are hampered. This is because they do not establish the main cause of mortality. The observed mortality rates may be the result of any number of differences between the locations. An experiment is required to unconfound spatial differences.

In summary, this research has identified; (1) That there needs to be more awareness with respect to the relationship between sample size and the probability of detecting specific types of prey when gut content analysis is used to identify predators and prey; (2) That artificial reefs may not be representative of natural reefs; (3) How piscivore abundance relates to differences in prey mortality. This information has been a useful contribution to help refine the design of meaningful manipulative experiments for the coming year. It is hoped that this combination of approaches will be an effective approach to increasing our knowledge on the potential influence of predation on coral reef fishes.

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Figure 1(a).

The distribution of individual predators are plotted within a location of high predator abundance. The lines represent the depth isobars of this location. The procedure used to map individuals, involved four divers who swam together down one of four marked lanes, while plotting the positions of individual fish within their lane on a map. In this example each dot represents an individual coral trout.

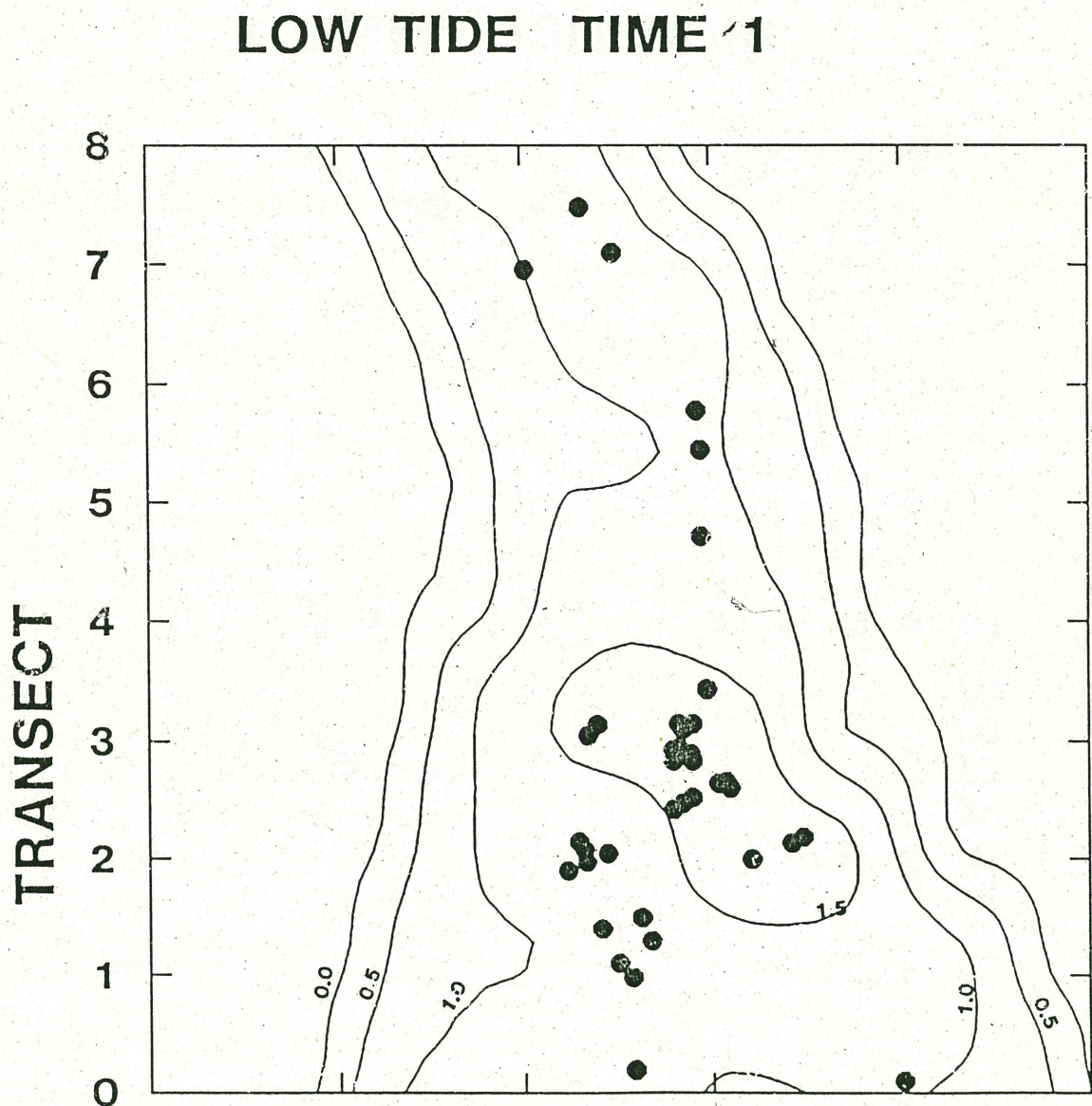


Figure 1(b).

HIGH TIDE TIME '1

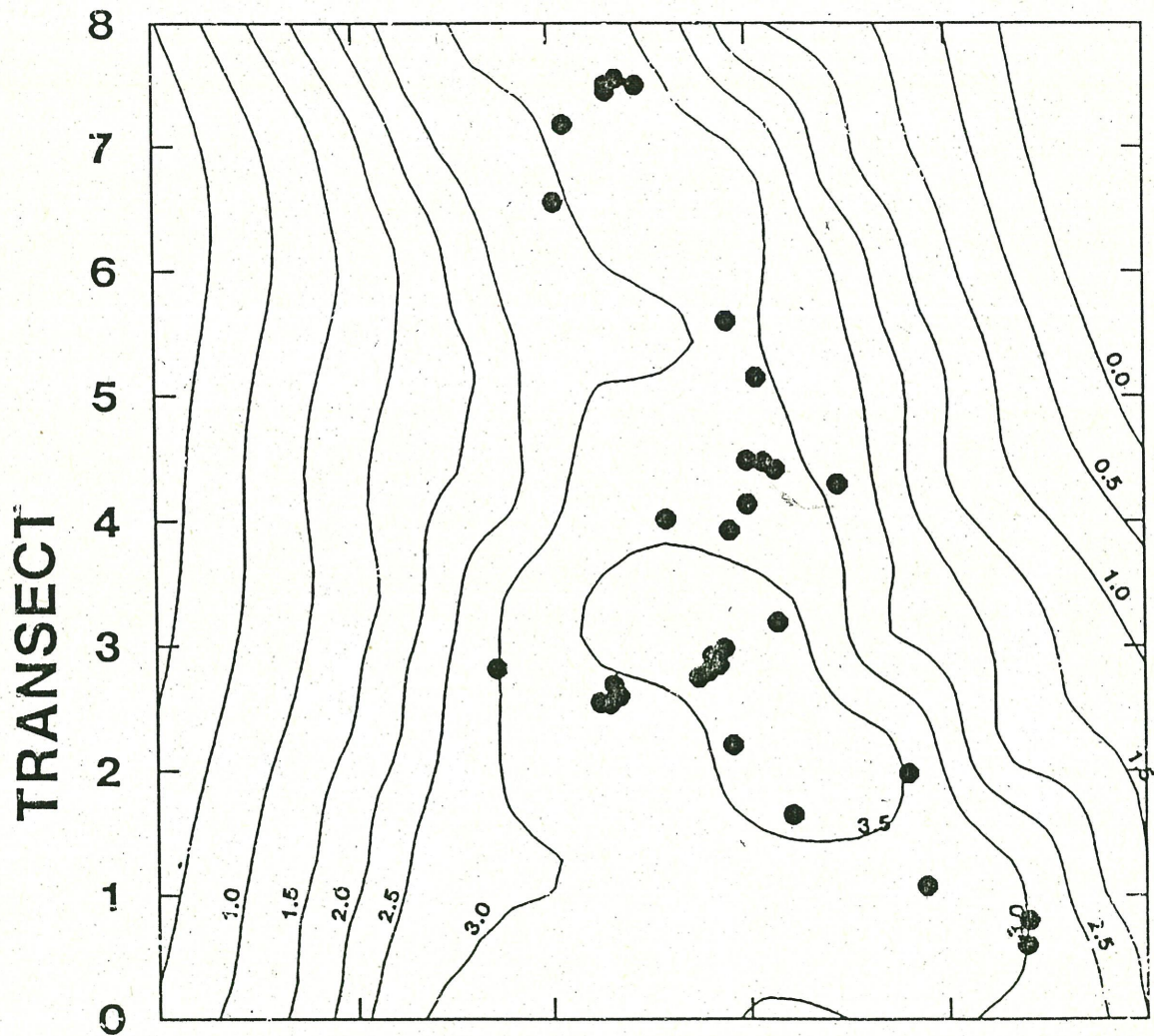


Figure 2.

The distribution of individual predators are plotted within a location of high predator abundance where patch reefs were constructed close to and far from continuous reef. The lines represent depth. These start at 0m (low tide) and increase in depth by 2m intervals towards the patch reefs. The patch reefs are constructed over barren sand flats. Each dot represents a piscine piscivore.

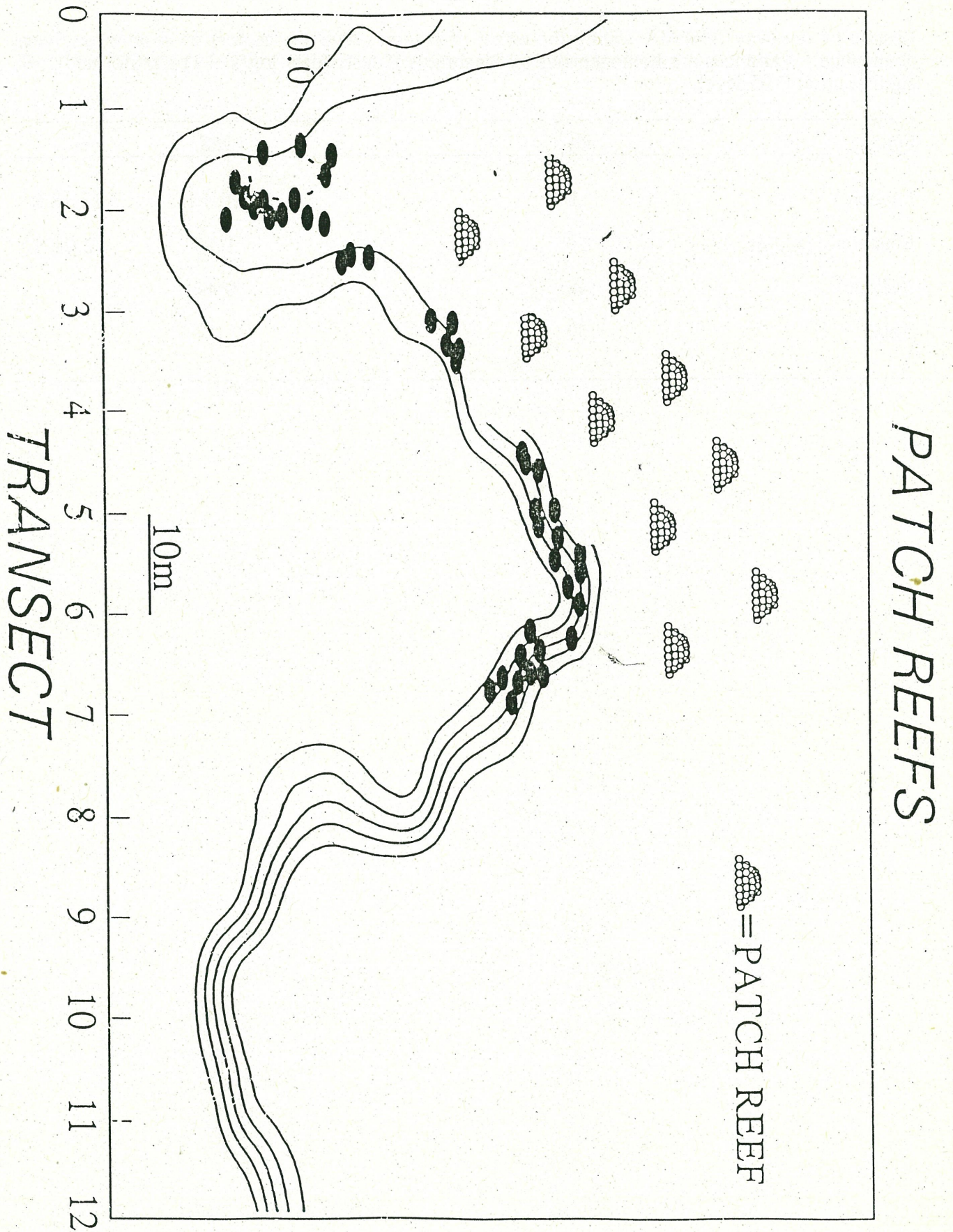


TABLE I

Results of one-way ANOVA testing the effect of lagoon (edge vs. center) on piscine piscivore abundance. Variances are homogeneous by Cochran's *C* test, (data $\log(x + 1)$ -transformed). S, significant at 0.05 level.

Source	df	MS	F
Lagoon	1	10.10	23.18 S
Location(LAGOON)	10	0.89	2.05 S
Residual	48	0.44	
Total	59		

TABLE IIa

Results of two-way ANOVA testing effect of locations and proximity on newly settled juveniles. Variances are homogeneous by Cochran's *C* test. NS, nonsignificant; S, significant at 0.05 level.

Source	df	MS	F
Lagoon	1	228.17	4.21 NS
Location(LAGOON)	2	54.17	5.58 S
Proximity	1	2.67	0.20 NS
Location ^X Proximity	1	10.67	0.08 NS
Proximity ^X Location(LAGOON)	2	13.33	1.37 NS
Residual	16	9.71	
Total	23		

TABLE IIb

Results of two-way ANOVA testing effect of locations and proximity on loss of newly settled juveniles. Variances are homogeneous by Cochran's *C* test. NS, nonsignificant.

Source	df	MS	F
Lagoon	1	5.04	0.03 NS
Location(LAGOON)	2	166.21	0.44 NS
Proximity	1	392.04	1.32 NS
Location ^X Proximity	1	92.04	0.31 NS
Proximity ^X Location(LAGOON)	2	297.38	0.78 NS
Residual	16	380.21	
Total	23		

TABLE IIIa

Results of two-way ANOVA's testing effect of lagoon (edge vs. center) and locations on juvenile *Acanthochromis polyacanthus*. Variances are homogeneous by Cochran's *C* test. NS, nonsignificant; S significant at 0.05 level.

<i>(a) Number of newly hatched juveniles</i>			
Source	df	MS	F
Lagoon	1	375.00	1.92 NS
Location	2	335.00	0.98 NS
Site (Location \times Lagoon)	6	341.67	0.91 NS
Lagoon \times Location	2	195.00	0.57 NS
Residual	48	375.00	
Total	59		

TABLE IIIb

<i>(b) Number of juveniles at TL=19mm</i>			
Source	df	MS	F
Lagoon	1	7661.40	60.14 S
Location	2	284.07	1.88 NS
Site (Location \times Lagoon)	6	150.97	0.34 NS
Lagoon \times Location	2	127.40	0.84 NS
Residual	48	442.90	
Total	59		

TABLE IIIc

<i>(c) Percentage survivorship</i>			
Source	df	MS	F
Lagoon	1	14075.01	105.68 S
Location	2	114.15	0.44 NS
Site (Location \times Lagoon)	6	257.39	0.89 NS
Lagoon \times Location	2	133.19	0.52 NS
Residual	48	290.34	
Total	59		