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The Effect of Community-Managed Marine Reserves in the Philippines on their Associated Coral Reef Fish Populations

A.T. WHITE

Coastal Resources Management Project
International Center for Living Aquatic Resources Management
MC P.O. Box 1501, Makati, Metro Manila, Philippines

Abstract

This study measures changes over two years in the species richness and abundance of fish on three coral reefs associated with new community-managed marine sanctuaries in the Visayas, Philippines.

The monitoring of species richness and abundance of fish was accomplished by a rapid visual census technique. A total of 126 species of coral reef fish in 19 families were censused simultaneously in areas of $750m^2$ by: (1) estimating the abundance of large numbers of visually obvious species of fish, and (2) counting those species known to be highly favored targets of fishermen, usually occurring in relatively low densities. Four to six nonoverlapping censuses were made at each sanctuary site during each of two periods separated by at least one year. Both census periods occurred within the first two years of management of the sanctuary.

The abundance of fish censused over the study period showed mean increases of 173% for sanctuaries in Apo, 89% for Pamilacan and 45% for Balicasag Islands. Of 19 families of fishes sampled, 12 showed significant increases in numbers on at least one of the study islands. There was an absolute increase in the mean number of species of 15 (40%) on Apo; 10.8 (25%) on Pamilacan; and 1.6 (3%) on Balicasag Islands. The quality of benthic habitats at the islands was either maintained or improved slightly during the period.

By means of effective community-managed reserves/sanctuaries, it is possible to maintain coral reef habitat and improve the species richness and abundance of coral reef fish dramatically in heavily fished areas. This may be accomplished in less than two years if protective management is effective. Such improvements may have implications for potential fish yields harvested outside the sanctuary areas.

Introduction

The Marine Conservation and Development Program (MCDP) of Silliman University, Philippines, was designed to promote the conservation of coral reefs in the Central Visayas, through community-based management. The formation of local management plans and groups to enforce these plans lay at the heart of MCDP. Other aspects of the program, such as agroforestry measures and income augmentation, supported the central theme (White and Savina 1987a).

The general objective of the marine management component of MCDP was to establish an integrated marine conservation program through the participation of fishing communities. The approach was to initiate local programs of marine management, in the form of marine reserves, in three fishing communities: Apo Island, Negros, and Pamilacan and Balicasag Islands, Bohol (Fig. 1). Community organization and education were the main methods used to stimulate community activity at these sites (White and Savina 1987a).

Destruction of coral reef habitats, overfishing and a consequent decline in fish catches affect small-scale fishermen throughout the Visayas. The 88, 168 and 62 households on Apo, Pamilacan and Balicasag Islands, respectively, suffered from these problems.

The marine reserve/sanctuary system as a management plan is based on maintenance of the environment with immediate and long-term benefits to the people who use the environment and the immediate ecosystem. These benefits include: (1) maintenance and possible increase in species richness and abundance of fish; (2) provision of an undisturbed breeding ground for fish; (3) export of fish biomass by adult emigration; (4) export of fish biomass over a wider area by larval dispersal; and (5) maintenance of the coral reef habitat (Alcala 1981; Russ 1984, 1985; White 1984).

Each site now has a sanctuary in which fishing is excluded and a surrounding buffer or reserve area available for ecologically sound fishing. Table 1 gives an overview of the three marine reserves in terms of coral reef habitat, sanctuary and reserve areas, and the dates on which the various phases of reserve management began.

It has been shown by Russ (1984, 1985) that the abundance and species richness per unit area of fish within the sanctuary area at Sumilon Island, which is near the present study sites, were significantly higher than outside the sanctuary in fished areas. Further, it has been suggested by Alcala (1981) and Alcala and Luchavez (1981) that marine sanctuaries may improve fish yields on adjacent reefs.

In this study, three environmental variates were monitored during the course of MCDP to evaluate the effect of the marine

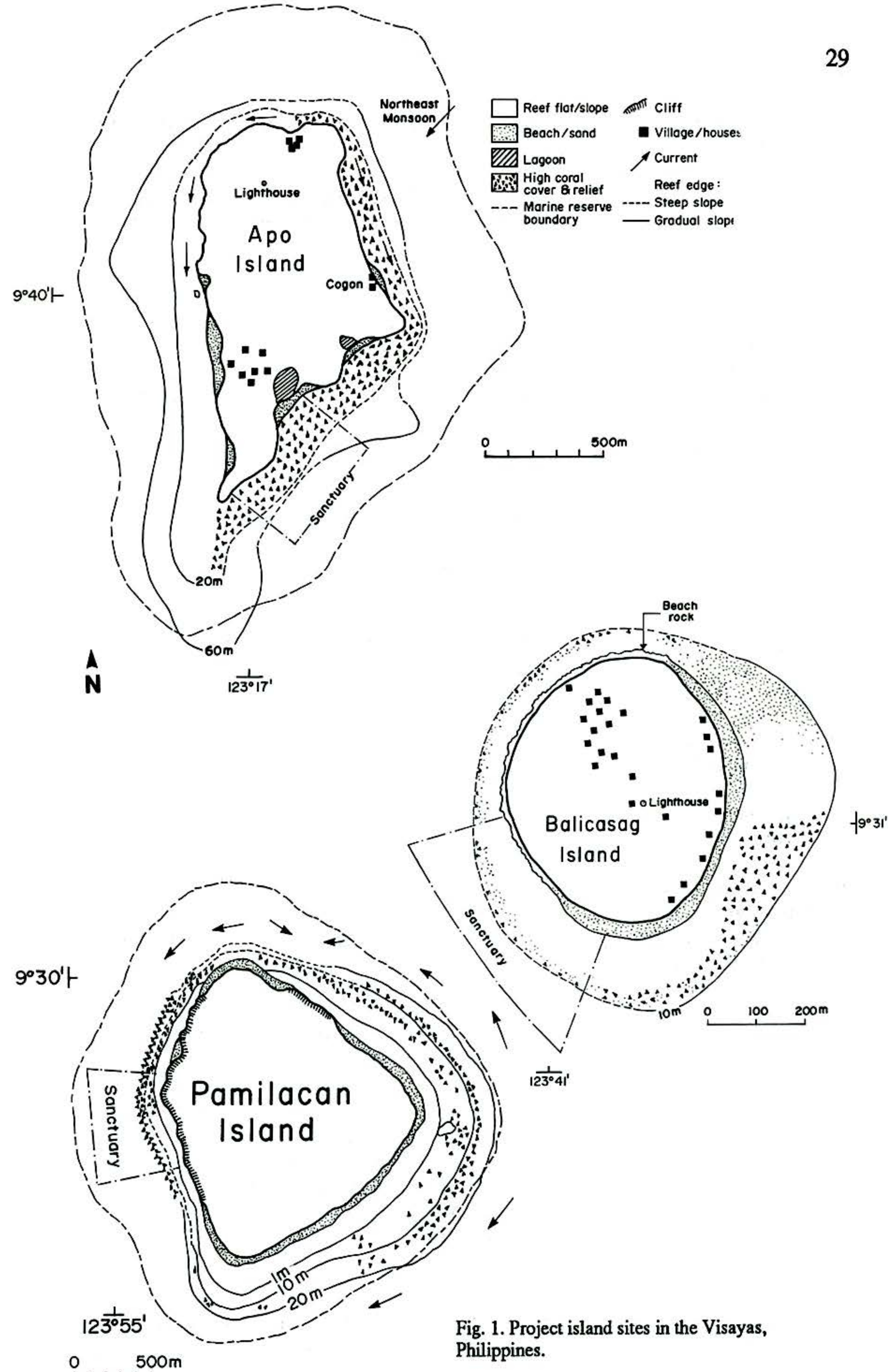

Fig. 1. Project island sites in the Visayas, Philippines.

Table 1. Description of habitat, area and management of marine reserves at the three project sites, Philippines.

	APO	PAMILACAN	BALICASAG
Habitat (%)			
substrate[a]	n = 6	n = 6	n = 6
Sediment	35.4	83.1	68.8
Hard coral	32.0	4.8	20.0
Soft coral	32.4	12.1	11.2
Total coral	64.3	16.9	31.2
Hard coral change over two years[b]	+2-3	+1-2	+2-3
Topography (m)[c]	2.9	2.1	3.7
Area (ha)			
Total reef to			
20 m isobath	53	180	31
60 m isobath	106	—	—
Marine reserve to 500 m offshore	284	339	147
Marine sanctuary to 250 m offshore	11.2	14	8[d]
Sanctuary per cent of total reef area	10.5	7.7	25.8
Reserve management			
Date of acceptance by community	*Apr 1985*	*Aug 1985*	*Aug 1985*
Date of municipal ordinance	Oct 1985	Dec 1985	Jul 1986
Date of enforcement	Oct 1985	Mar 1986	Dec 1985
Recorded violations	Sep 1986	Oct 1986	Jun 1986
Fish censuses			
First	Mar 1985	May 1985	Jul 1985
Second	Jul 1986	Sep 1986	Sep 1986

[a]Measured along 60-m line transects as described by White (1984).
[b]Estimated by snorkeling surveys on entire reef area.
[c]Additional surface area per horizontal 10 m.
[d]Area to 150 m offshore.

reserve/sanctuary on the coral reefs surrounding the island sites: the abundance of selected coral reef fish per unit area; the species richness of selected groups of coral reef fish per unit area; and the quality of the substratum cover on the reef.

Methods

The fish population census method is based on that of Russ (1984, 1985) who adapted methods similar to those used on the Great Barrier Reef in Australia to Philippine sites. Some modifications were made to Russ's methods in this study.

A total of 126 species of coral reef fish in 19 families were censused simultaneously using two techniques. The first was a rapid visual technique to estimate the abundance of common and visually obvious species of fishes. The second was a technique to count those species known to be highly favored targets of fishermen, usually occurring in relatively low densities. The composition of the species list was determined accordingly. Those families of fishes considered visually obvious in this method were the chaetodontids, labrids, anthiids, balistids, pomacentrids, pomacanthids and zanclids. Those considered here to be target species or important food fishes are the acanthurids, caesionids, serranids, lutjanids, carangids, lethrinids, haemulids, kyphosids, mullids and scarids. The list of species censused within each of these families remained flexible throughout the study so that additional species could be added as they were seen. Some groups were estimated or counted only at the family level and numbers of particular species were ignored.

The abundances of "visually obvious" species within an individual census area (defined below) were estimated cumulatively on a log 4 abundance scale from 0 to 8 (Russ 1984, 1985). The abundances of "target" species (except for those with large numbers, i.e., caesionids and acanthurids) within a census area were determined by counting each individual.

An individual census area was demarcated by laying out a 60-m tape on and parallel to the area defined as the "reef crest" at 6 to 7 m depth. A single observer (the author) would begin 5 m from the end of the tape and swim down the reef slope to a depth of approximately 14 m. The abundances of all species were estimated or counted within 5 m either side of and above the observer and recorded onto a prepared data sheet. At a depth of about 14 m, the observer would turn 90° and swim at this depth for 10 m along the reef slope, parallel to the tape. The observer then swam up the slope, toward the tape, again recording abundance of fishes within 5 m either side of and above him until reaching the tape. This procedure was repeated along the entire length of the tape and back to the starting end to check for fishes which were missed the first time. The bottom depth of 14 m was adjusted in some cases by measuring the 12.5 m distance between the tape and bottom turn necessary to make 750 m^2. The 14m depth was generally a good estimate of this distance on 30° to 60° slopes. About 60 minutes were normally required to complete one census.

Four to six (depending on the site), nonoverlapping censuses were made at each sanctuary site during each of two separate periods. The first set of censuses was made in early 1985 and the second set during July, August and September 1986. These two sets, separated by more than a year, were compared. All the sanctuary areas on Apo, Pamilacan and Balicasag are in comparable steep slope habitats. In addition, at least five censuses were made in steep slope habitats and five in the gradual slope habitats outside the sanctuary areas at each site. The data from these censuses outside the sanctuaries are not presented here because no changes were observed over a one-year period in the fished areas.

Data on the benthic habitat of the reef were collected in the baseline study (MCDP 1985, 1986). The methods are described there and by White (1984). Monitoring during the course of the project was accomplished by numerous snorkeling surveys over much of the reef to check for major changes in cover of different types of substratum. Systematic line transects have not been made as in the baseline survey because periodic snorkel observations noted no obvious changes.

Results

At the completion of the surveys, 43 "target" species in 12 families were recorded. Mean species richness per unit area increased for most families of fish between the sample periods. Table 2 summarizes the changes in species richness for those families sampled and gives the percentage increase detected from 1985 to 1986. There were large percentage increases for most families but only some were significant using a non-paired t-test. Among the visually obvious groups, only chaetodontids showed significant increases in Apo and Pamilacan sanctuary areas and only pomacentrids in the Apo sanctuary.

Those groups which were favorite targets of fishermen showed more dramatic increases in numbers of species. Acanthurids, serranids and lutjanids showed statistically significant increases on at least one of the project sites. The large percentage increases in

Table 2. Comparison of the species richness of selected reef fish for 1985 and 1986 in the sanctuaries at the three project sites. The percentage change is indicated with decreases in brackets.

	APO			PAMILACAN			BALICASAG		
	1985 n = 4	1986 n = 5	% change	1985 n = 5	1986 n = 5	% change	1985 n = 4	1986 n = 6	% change
Mean no. of species per 750 m^2 for:									
Acanthurids*	7.3	10.2	40**	10.2	12.6	24	13.0	13.0	0
SE++	0.5	1.2		0.9	0.9		1.5	0.4	
Chaetodontids	8.3	11.8	43*	8.2	12.0	46**	9.8	8.3	(15)
SE	1.6	0.6		0.6	1.0		0.6	0.6	
Labrids	4.3	6.6	53	5.2	6.4	23	5.5	6.0	9
SE	0.9	0.2		0.8	0.8		0.7	0.7	
Caesionids+	2.0	2.8	40	2.8	2.4	(14)	2.8	2.8	0
SE	0.4	0.2		0.5	0.2		0.3	0.2	
Serranids+	0.25	0.4	60	0.4	2.2	450**	1.5	2.3	53*
SE	0.25	0.2		0.2	0.2		0.3	0.2	
Ballistids	1.5	2.4	60	1.2	1.4	17	2.3	2.8	24
SE	0.3	0.4		0.5	0.2		0.6	0.5	
Pomacentrids	10.5	12.6	20*	11.0	12.4	13	10	9.3	(7)
SE	1.2	0.4		1.4	0.5		1.1	0.3	
Lutjanids and Lethrinids+	1.3	2.4	92	1.2	2.4	100	1	3.5	250**
SE	0.8	0.4		0.5	.9		0.5	0.6	
Pomacanthids	2.0	3.2	60	3.6	2.8	(22)	3.3	2.7	(17)
SE	0.4	0.2		0.4	0.4		0.3	0.5	
Total	37.4	52.4	40	43.8	54.6	25	49.1	50.7	3

+Important food fish.
++Standard error of the mean.
*Probability of increase due to chance alone less than .05.
**Probability less than .01.

Note: One or two of the significant increases (*) may have occurred by chance alone.

species of serranids and lutjanids resulted from the very small number censused in 1985. Serranids, especially, are considered a prime target group of fishes. Fig. 2 shows the mean change in species richness per 750 m^2 for each family of fish. Mean percentage increases for species of those families censused for species richness were 40% in Apo, 25% in Pamilacan and 3% in Balicasag sanctuaries (Table 2).

Table 3 summarizes the changes in mean number of individual fish per 750 m^2 over the sample period. Among the visually obvious groups, chaetodontids, labrids and zanclids showed significant increases in numbers at one site, while anthiids, pomacentrids and pomacanthids significantly increased in two of the three sites. Factors which may have contributed to the increase in numbers of these "nontarget" fish include lack of fishing and a general lack of disturbance, which may make them less timid and more obvious to the observer.

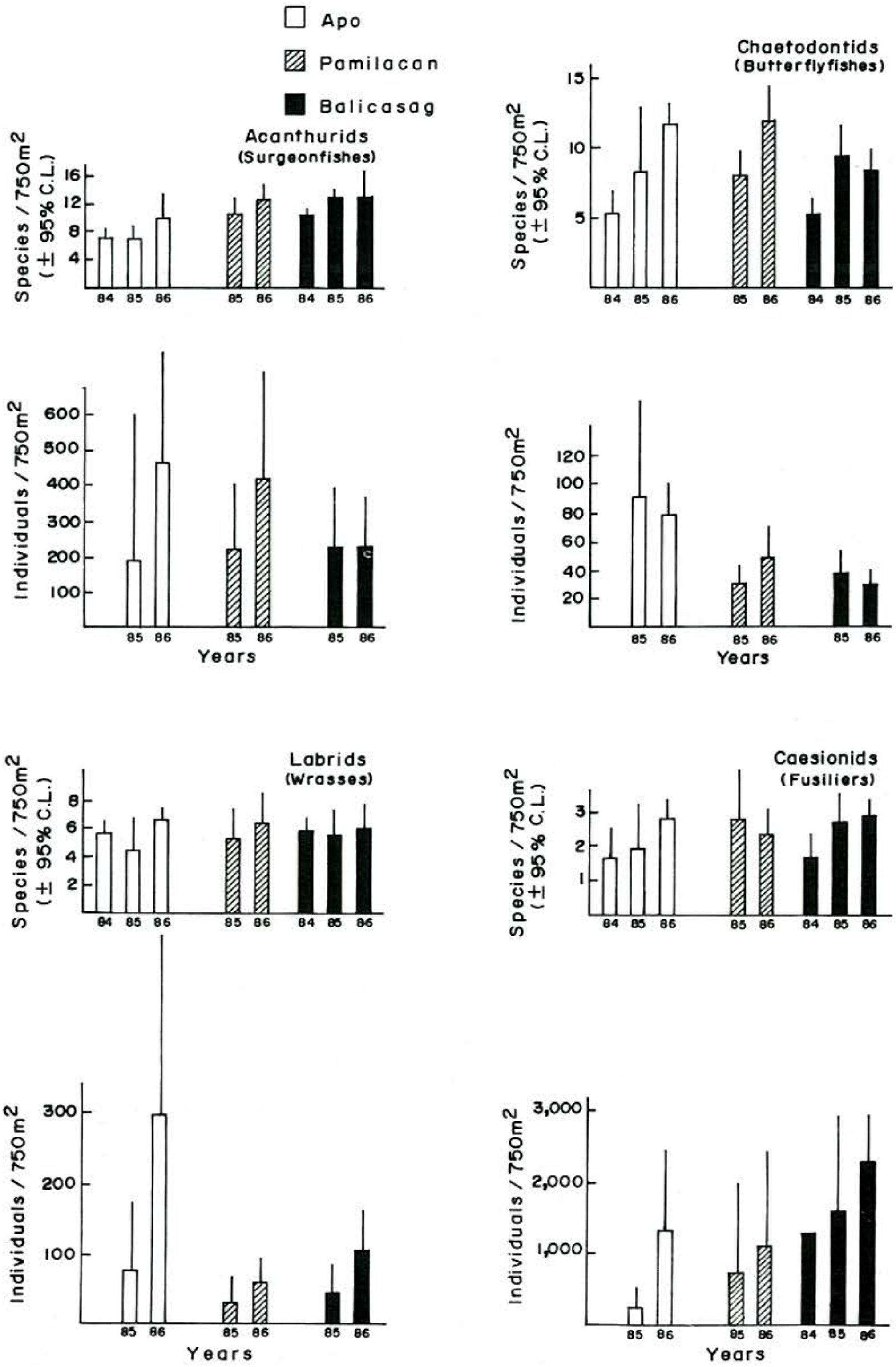

Fig. 2. Comparison of diversity (species/750 m^2) and abundances (individuals/750 m^2) between 1985 and 1986 for each family of fish censused in the sanctuaries at Apo, Pamilacan and Balicasag Islands. (Data for 1984 provided by Russ.)

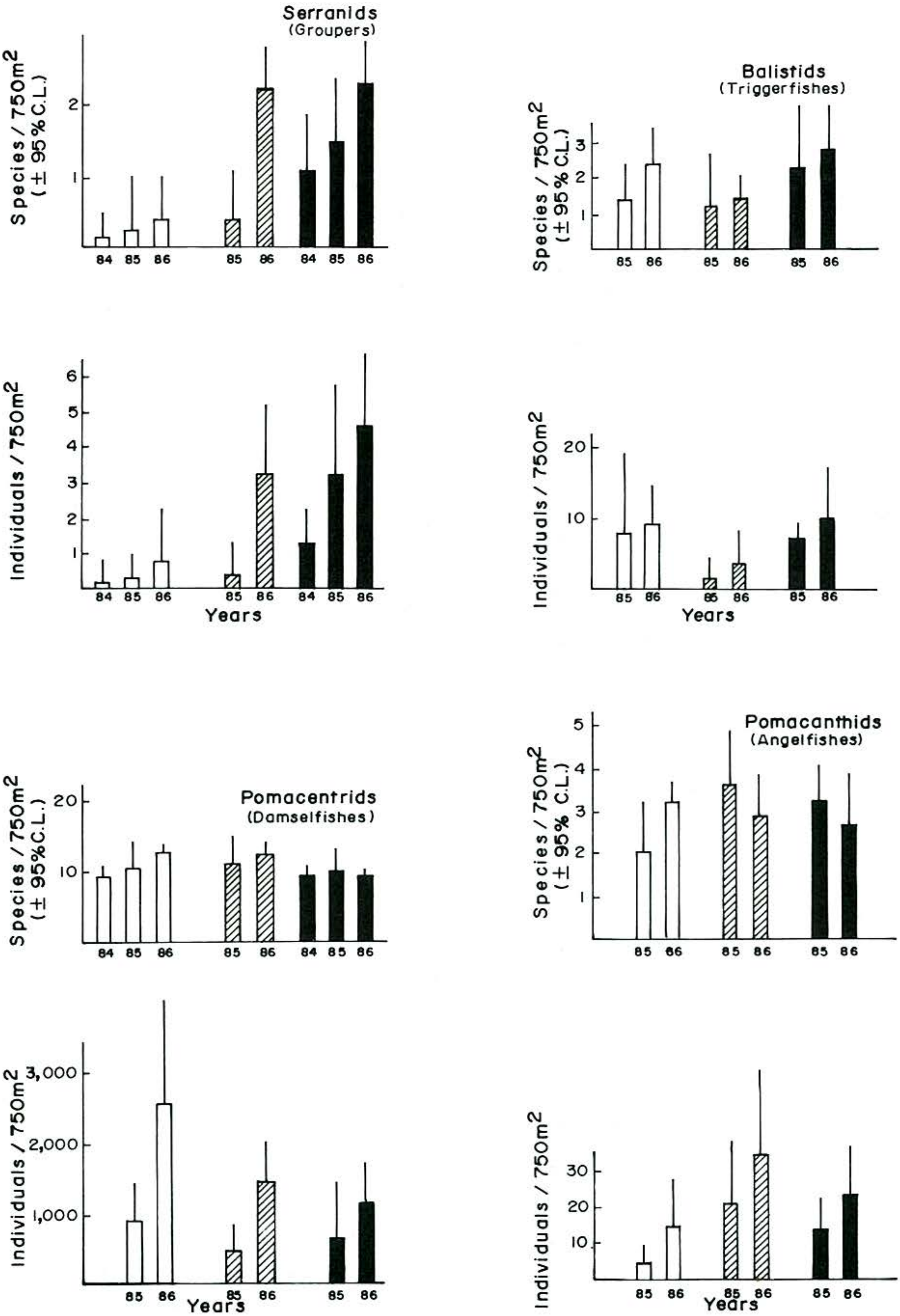

Fig. 2. Continued. Comparison of diversity (species/750 m^2) and abundances (individuals/750 m^2) between 1985 and 1986 for each family of fish censused in the sanctuaries at Apo, Pamilacan and Balicasag Islands. (Data for 1984 provided by Russ.)

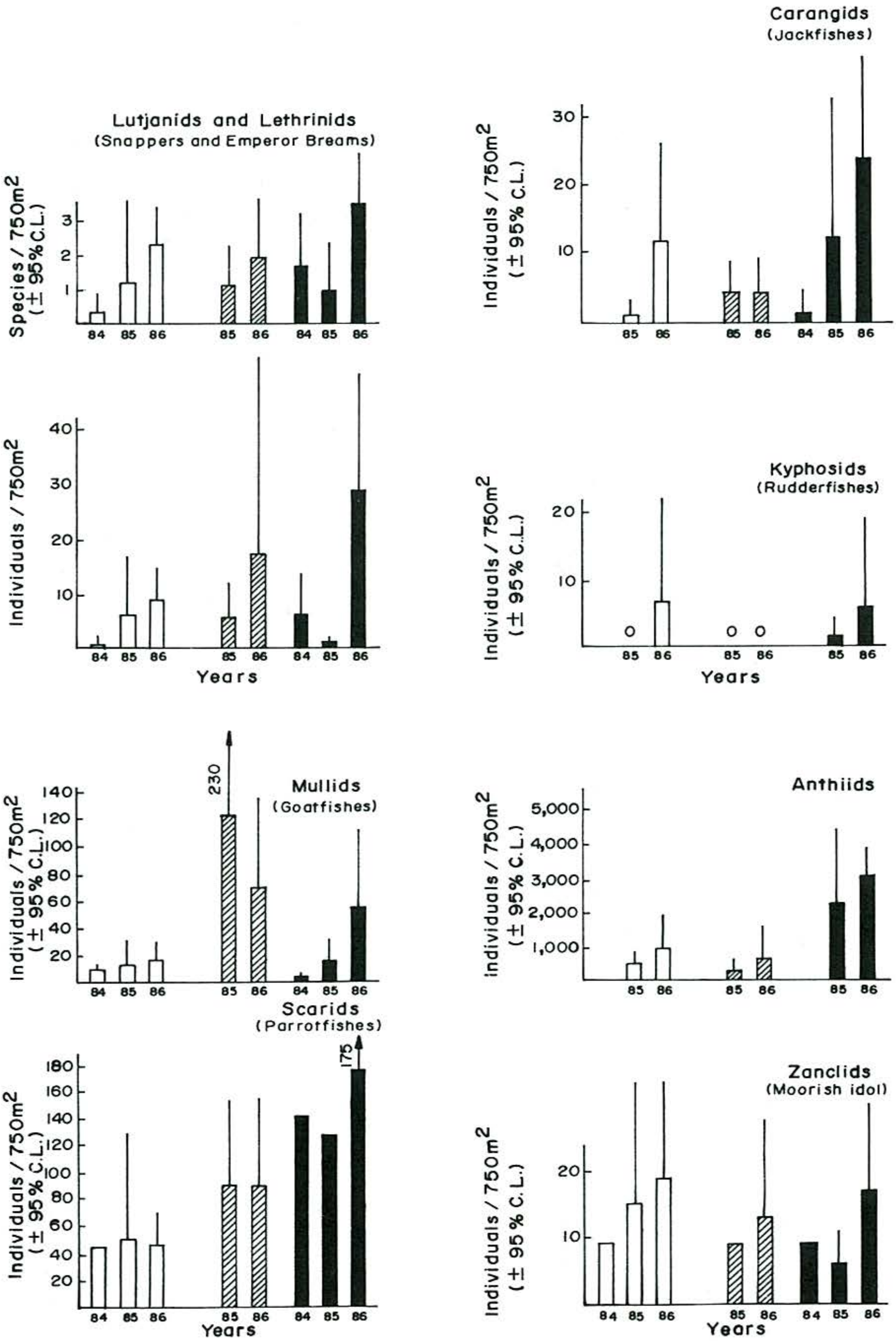

Fig. 2. Continued. Comparison of diversity (species/750 m^2) and abundances (individuals/750 m^2) between 1985 and 1986 for each family of fish censused in the sanctuaries at Apo, Pamilacan and Balicasag Islands. (Data for 1984 provided by Russ.)

Table 3. Comparison of the abundance of selected reef fish for 1985 and 1986 in the sanctuaries at the three project sites. The percentage change is indicated with decreases in brackets.

	APO			PAMILACAN			BALICASAG		
	1985 n = 4	1986 n = 5	% change	1985 n = 5	1986 n = 5	% change	1985 n = 4	1986 n = 6	% change
Mean no. of individuals per 750 m² for:									
Acanthurids+	188	467	148	221	419	90*	225	229	2
SE++	137	133		65	107		57	49	
Chaetodontids	92	79	(14)	32	51	60**	39	31	(21)
SE	23	9		4	8		4	4	
Labrids	79	299	279**	31	64	105	44	108	145
SE	34	105		12	11		14	23	
Caesionids+	231	1,369	493**	787	1,149	46	1,621	2,325	43
SE	95	446		453	514		459	258	
Serranids+	0.25	0.80	220	0.40	3.2	700**	3.25	4.7	45
SE	0.25	0.58		0.24	0.7		0.85	0.8	
Anthiids	515	943	83*	280	669	139*	2,282	3,112	36
SE	128	411		130	366		754	318	
Ballistids	8.0	9.2	15	1.6	3.8	137	7.3	10.2	41
SE	3.7	2.3		0.9	1.5		1.7	2.8	
Pomacentrids	935	2,554	173**	529	1,449	174*	666	1,173	76
SE	176	533		143	256		256	205	
Lutjanids and Lethrinids+	6.3	9.2	47	6.0	18.8	213*	1.0	29.5	2,850**
SE	4.0	2.6		2.7	13.7		0.5	8.4	
Pomacanthids	4.0	14.8	270**	20.4	34.4	69	13.8	23.3	69*
SE	1.5	5.8		7.0	8.9		2.9	5.6	
Carangids+	1.3	12.0	860**	4.2	4.0	(5)	12.3	24.0	95
SE	0.6	5.5		2.0	2.0		7.3	5.7	
Kyphosids+	0	7.8	—	0	0	0	1.5	6.5	333**
SE		6.3					0.9	5.3	
Mullids+	14	17	29	124	71	42	15	56	270**
SE	7	7		97	24		6	24	
Haemulids+	0.75	0.80	7	0	7.2	—	0	0.17	—
SE	0.75	0.58			1.8			0.17	
Scarids+	51	47	7	91	91	0	129	177	37
SE	27	21		24	24		0	69	
Zanclids	15	19	24	9	13	40	6	17	183**
SE	6	6		0	5		2	5	
All fishes	2,140	5,849	173	2,136	4,046	89	5,066	7,326	45
*Important food fish	492	1,931	293	1,233	1,763	43	2,008	2,851	42

+Important food fish.
++Standard error of the mean.
*Probability of increase due to chance alone less than .05.
**Probability less than .01.
(blank) — Not significant.

Note: 2 to 3 of the significant increases (*) may have occurred by chance alone.

The most dramatic increases in abundance of fish were seen in the groups of target species (Table 3 and Fig. 2). Acanthurids, caesionids, serranids, lutjanids and lethrinids, carangids, kyphosids and mullids showed significant increases in at least one of the sanctuaries studied. All the target or important food fish showed an

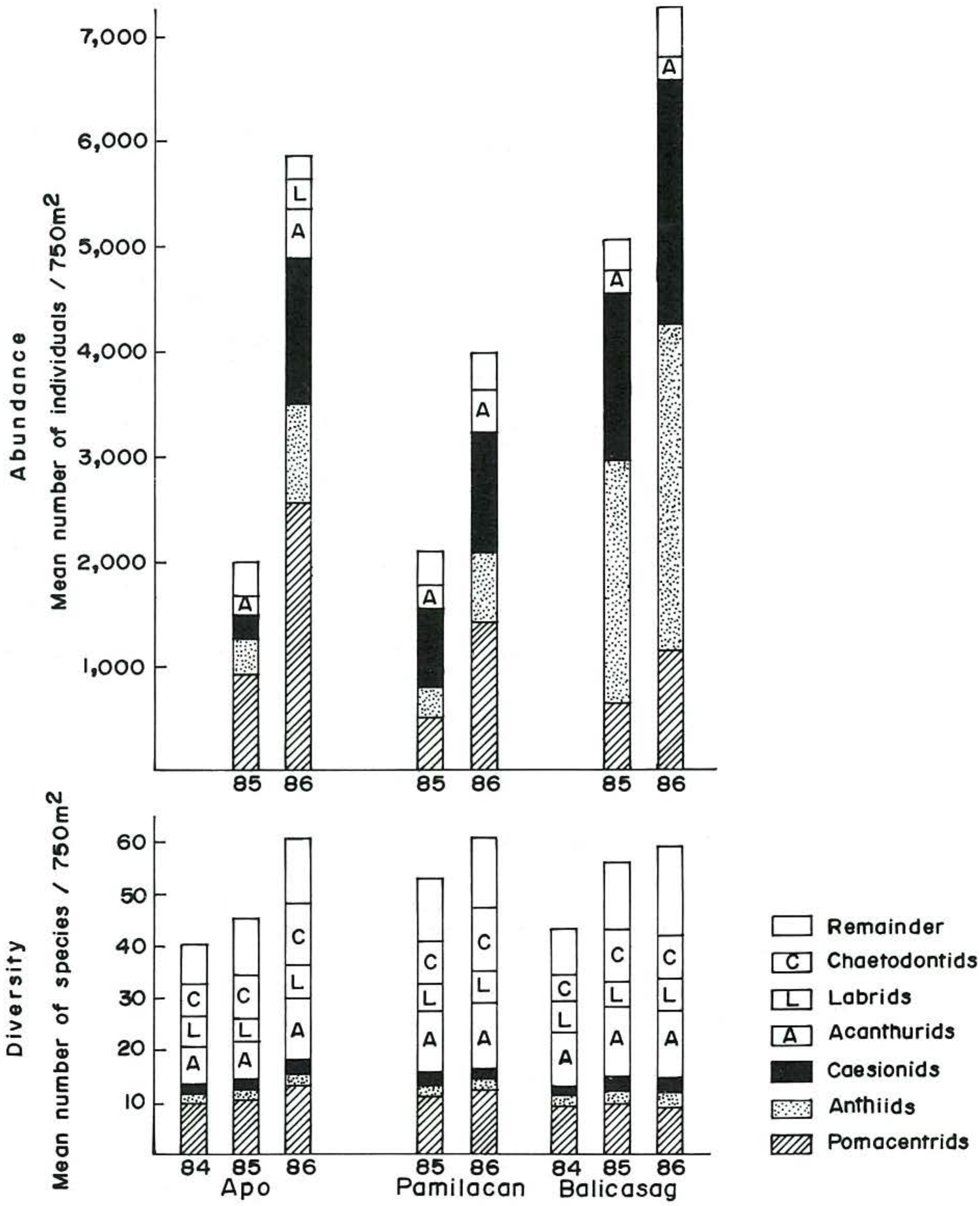

Fig. 3. Summary of the changes between 1984 and 1986 of fish diversity and abundances for all families censused at Apo, Pamilacan and Balicasag Island sanctuaries. (Data for 1984 provided by Russ.)

increase in numbers. Lutjanids and lethrinids, which are important in Pamilacan and Balicasag fisheries, showed sizeable increases. Carangids, important in the Apo fishery although not generally considered reef fish, were seen much more frequently in the sanctuary in 1986. These carnivorous fish may be attracted by the improved supply of prey in the sanctuary. Mean percentage increases in the numbers of all food fish were 293% for Apo, 43% for Pamilacan and 42% for Balicasag. The large increase in the Apo sanctuary was due primarily to the increase in numbers of caesionids observed (Table 3).

Fig. 3 compares the overall changes in species richness and abundance for all groups of fish censused. It shows that two visually obvious groups, pomacentrids and anthiids comprised most of the fish on the reefs. Among food fish, caesionids and acanthurids comprised the largest number of individuals. However, the dramatic increases in numbers of individual fish were not reflected in a parallel increase in the numbers of species.

Overall percentage increases in numbers were 173% for Apo, 89% for Pamilacan and 45% for Balicasag Islands (Table 3). Of the 19 groups of both visually obvious and target fish sampled, 12 showed significant increases in numbers in at least one of the project sanctuaries. There was a mean absolute increase in the number of species of 15 (40%) on Apo, 10.8 (25%) on Pamilacan and 1.6 (3%) in Balicasag sanctuaries (Table 2). Of the nine groups of fish censused for species richness, five showed significant increases in the number of species in one or more of the project sites.

Figs. 2 and 3 also include data from 1984 surveys by Russ (1984, 1985). These data are not included in the analyses due to differences between observers and observation techniques.

Periodic monitoring of the benthic habitat at each island indicated no noticeable decrease in the quality or cover of corals due to destructive fishing methods or natural events over a two-year period. General quality of the reef appeared to be improving on Pamilacan where there had been extensive dynamite fishing previously. Coral cover was estimated to have improved slightly in all sites (Table 1).

Discussion

The presence of the reserve/sanctuaries led to measurable changes in reef quality within them in less than two years.

In all three sanctuaries, there were significant increases in both the number of species and abundance of fish. This is most likely a direct response to decreased fishing pressure in the sanctuaries. It is assumed that over time the entire reef will benefit from improvements in the sanctuaries which will translate into improved fish yields on the fished portion of the reef. This would support Alacala's contention of improved yields for nearby Sumilon Island after seven years of sanctuary protection (Alcala 1981).

No measure of change in fish yields from the reefs could be made in one year, although a detailed one-year baseline record of yields has been made and is discussed separately for Apo Island by White and Savina (1987b) and for Pamilacan Island by Savina and White (1986). The subjective perception of fishermen selected at random was that their catches of fish had increased or remained the same, since implementation of the management system (MCDP 1986). This should not be interpreted as meaning an actual increase in fish catches. Rather, these perceptions are significant in that they indicate the reserve/sanctuary scheme does not seem to adversely affect catches, and thus, livelihood. Perhaps the positive experience with the current size of sanctuary will provide the confidence to expand the sanctuary areas in the future.

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