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Reef Faunal Assemblages & Seagrass-associated Echinoderm Populations in Oil Spill-affected Waters in Southern Guimaras, Philippines: A Comparison between Pre-spill and Post-spill Years

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Abstract

Data on reef and seagrass bed assemblages from previous surveys (2000-02) in the TINMAR are compared with similar data collected after the oil spill in August 2006 (2006-08). Sea urchin densities showed a large reduction from levels observed in 2000-02, while sea stars showed a 50% increase in abundance from observed levels in 2000-01. The opposing trends may reflect long term natural fluctuations of grazer populations in seagrass beds and may not necessarily be the effect of a specific disturbance. It is within the context of natural seasonal and between year patterns in variability that any meaningful impact of events such as the oil spill should be assessed. Observed abundance levels of reef fish assemblages from 2006-07 were 60% lower than levels observed in previous surveys. Overall abundance remained low even twenty (20) months after the oil spill, although reef habitat quality (live hard coral cover and macroepifaunal assemblages) did not show any difference from pre-spill (2000-02) conditions. This suggests that the reduction in reef fish abundance may have been caused by or in addition to other factors. The need for coordination with other monitoring studies, e.g. capture fisheries, is stressed.

The immediate impact of oil spills is typically recognizable in intertidal habitats where contaminants are repeatedly brought in and deposited by the tides. The extent of the impact will vary depending on hydrographic and topographic features specific to a given area, and on the kind and amount of oil contaminant. Subtidal habitats (e.g., coral reefs and seagrass beds) may be affected by oil spills if conditions lead to the physical mixing (thru waves) above the shallow subtidal portions or to the settling of deposits formed at the surface.

This study was conducted to determine the possible impact of the oil spill off the southern Guimaras on subtidal portions of coral reef habitats within the vicinity of the Taklong Island National Marine Reserve.

Materials and Methods

Seagrass Beds

The location of seagrass bed stations surveyed in previous studies (2000-02) of starfish[1)] and sea urchin[2)] populations in the vicinity of the reserve are shown in Fig. 1. From these,

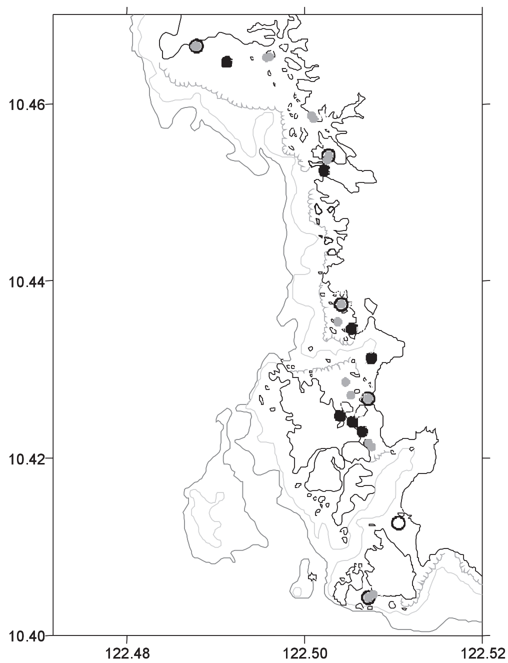

Fig. 1. Map showing location of transect stations surveyed in previous (2000-01= grey) and recent (2006=open; 2007=black) surveys in the vicinity of Taklong Island National Marine Reserve.

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monitoring stations for studies conducted from 2006-08 were chosen. However, because of very low echinoderm densities in a few of the stations surveyed in late 2006, additional sites were added while some of the original sites were dropped in the more recent surveys to optimize sampling time in the field. The location of the original, revised and additional stations are shown in Fig. 1. At each grassbed station at least one 50m X 1m (2 sides) belt transect was censused. All individuals of Protereaster nodosus, Tripneustes gratila and other sea star and urchin species within the $100m^2$ belt were counted and measured to the nearest millimeter. The test diameter of sea urchins was measured with the use of vernier calipers. For sea stars, the distance from the center of the oral disc (mouth) to the tip of the longest arm was measured.

This report includes updated information on seagrass-associated echinoderm populations within the survey area up to June 2008.

Coral reefs

Six dive stations were chosen for the study and their locations are shown in Fig.2. Baseline information on these six (6) reef stations is available from quarterly surveys conducted in 2001 and 2002[3)]. The same six sites were surveyed once after the oil spill, two of them on 03 Sep and the rest on 30-31 Oct 2006. In both baseline and post-spill surveys, benthic lifeform cover, epibenthic macro-invertebrates and reef fish were censused over 50m transects laid on the slope parallel to the crest using the same standard techniques.

Benthic life form cover was determined using the standard line intercept technique. Percent cover was determined by getting the ratio of the total distance covered by a given life form over the total length of the transect (50m). Epibenthic macro-invertebrates (mainly mollusks, crustaceans and echinoderms) within a belt of 50m X 2m were identified and counted. Reef fish were censused by identifying, counting and estimating the size of fish within a 50m X 5m (wide) X 5m (high) volume. Fish biomass was derived by using length-weight relationships published in the literature.

This report includes information on reef associated assemblages up to Dec 2007. Data on reef assemblages for surveys conducted in February and May 2008, as well as some information for December 2007 are still being processed and are not included in this report.

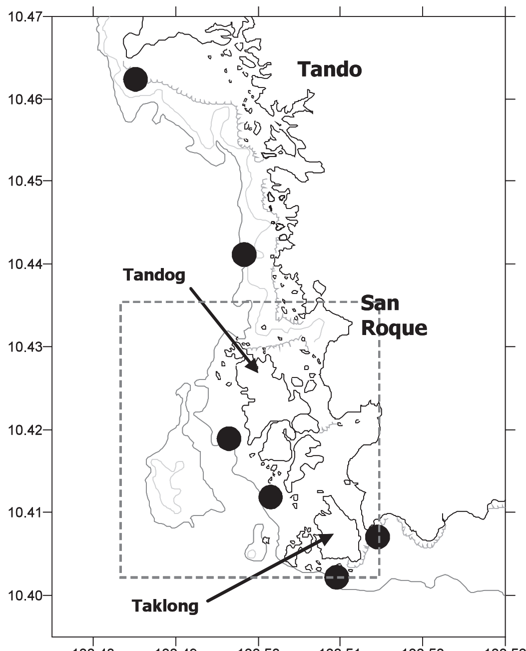

Fig. 2. Map showing the location of dive stations surveyed in 2006 and 2007 in the vicinity of the Taklong Island National Marine Reserve.

Results and Discussion

Echinoderm populations in seagrass beds

Mean monthly densities of *Protereaster* nodosus from Aug 2006 to June 2008 ranged from 10.7 to 30.4 individuals per $100m^2$ across 5-7 sites in the vicinity of the reserve. A plot of monthly densities covering the years 2000-01, 2006-07 and 2007-08 is shown in Fig. 3. Highest densities were recorded in June 2001 and in January and February 2008.

It appears that densities are high during the NE monsoon (Jan-Feb) and during the early SW monsoon months as suggested by data from recent surveys. The latter peak, however, was not observed in 2000. Unfortunately, monitoring of den-

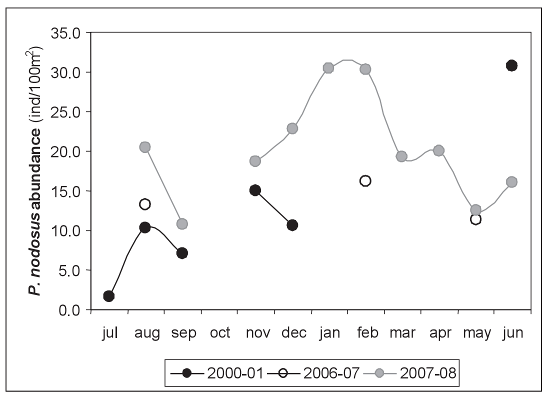

Fig. 3. Mean abundance estimates of *Protereaster nodosus* in seagrass beds surveyed in different months for 2000-01, 2006-07 and 2007-08 in the vicinity of the Takong Island National Marine Reserve.

sities was irregular even in the more recent surveys. The color-coded data points in Fig. 3 suggest that observed sea star densities from the more recent surveys in 2006-08 (mean = 18.6 ind/100m^2; sd = 6.42) are higher than earlier estimates from 2000-01 (mean = 12.6; sd = 9.94). In spite of relatively large but homogeneous (F = 2.40; df = 5,12; p = 0.099) variances, this apparent difference was still marginally significant (t = 1.607; p = 0.0.063).

On the other hand, recent (2006-08) estimates of *Tripneustes gratila* densities (mean = 14.8 ind/100m^2; sd = 9.10) are on average about 4 times lower than estimates from previous (2001-02) surveys (mean = 58.0; sd = 27.61) (Fig. 4). This large difference is statistically significant (t' = 5.687; df' ~18; p = 0.00001). It is unlikely, however, that this highly significant decrease resulted directly from the oil spill since overall urchin densities were already decreasing at least 4 years before the spill. Figure 4 shows from February to June 2002 densities decreased somewhat continuously, in contrast to the same periods in 2001 (pre-spill) and 2008 (post-spill), wherein urchin densities generally increased. It thus appears that the difference between observed densities in 2000-02 and 2006-07 may be caused by something that occurred 4 years before the spill. Whether this reflects long term natural fluctuations of grazer populations in seagrass beds or the effect of other disturbances is not certain. Interestingly, the opposite trend was observed for sea stars inhabiting the same grassbeds during the same time frame, although the difference (50% increase from 2000-01 levels) was of lesser magnitude.

It is not clear what the cause is for the observed differences between echinoderm populations in the survey area. The regular harvesting of sea urchins could result in a decline in their

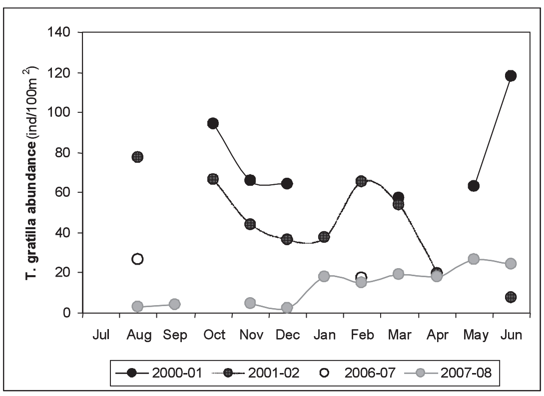

Fig. 4. Mean abundance estimates of *Tripneustes gratila* in seagrass beds surveyed in different months for 2000-01, 2001-02, 2006-07 and 2007-08 in the vicinity of the Takong Island National Marine Reserve.

abundance, but actual field observations during the monthly surveys as well as limited informal interviews with local fishers do not show any indications of a local fishery targeting sea urchins. On the other hand, it would also be unlikely for a disturbance such as the oil spill to result in the drastic decline in sea urchins on the one hand, and to conditions favoring an increase in sea stars in the same area on the other. More effort should be exerted to continue monitoring regularly so that parallel trends between years, if any, can be determined, and long term trends can be established. It is with reference to such seasonal and between year patterns in abundance that the impact of events such as the oil spill in August 2006 should be assessed.

Reef fish assemblages

Similarly, mean biomass of reef fish from recent surveys (mean = 8.9 mt/km^2; range = 2.2 – 18.4) showed a 60% decrease from what was observed in 2001-02 (mean = 21.9 mt/km^2; range = 1.3-60.9). This large decrease was significant (t' = 3.495, df ~ 32, p = 0.00071), in spite of very high variability in biomass estimates. A comparison of reef fish parameter estimates between recent and previous surveys is shown in Figs. 5 a-d. This decline in reef fish populations is also shown by a 30% decrease (t' = 1.971; df = ~39; p = 0.028) in overall fish densities from a mean of 1.29 ind./m^2 (sd = 1.055) in 2001-02 to 0.86 ind./m^2 (sd = 0.440) in 2006-07.

A comparison of species composition of reef fish assemblages during the 2 periods shows no indication of a change in species make-up. With the exception of family Plotosidae (marine catfish), whose juveniles form schools with rather localized (patchy) distributions, the major fish groups comprising the assemblages observed in 2006-07 (Table 1) were the same groups that dominated assemblages observed in previous surveys. Moreover, the number of species observed per transect, which is an index of species richness, did not differ between the two periods (t = 0.271; df = 51, p = 0.394), with an average of 40.5 species/transect in 2001-02 against 41.4 species/transect in 2006-07. Hence, the rather large decline in overall biomass can be attributed to an overall decrease in abundance (Fig. 5b) as well as significantly smaller fish (40% reduction in ave. wt. of individual fish; t' = 3.753; df=~45; p = 0.00025) observed in recent surveys (Fig. 5d). A more detailed analysis is needed to determine which fish groups showed substantial reductions in size. Likewise, it is important to determine if what was observed is a true reduction in

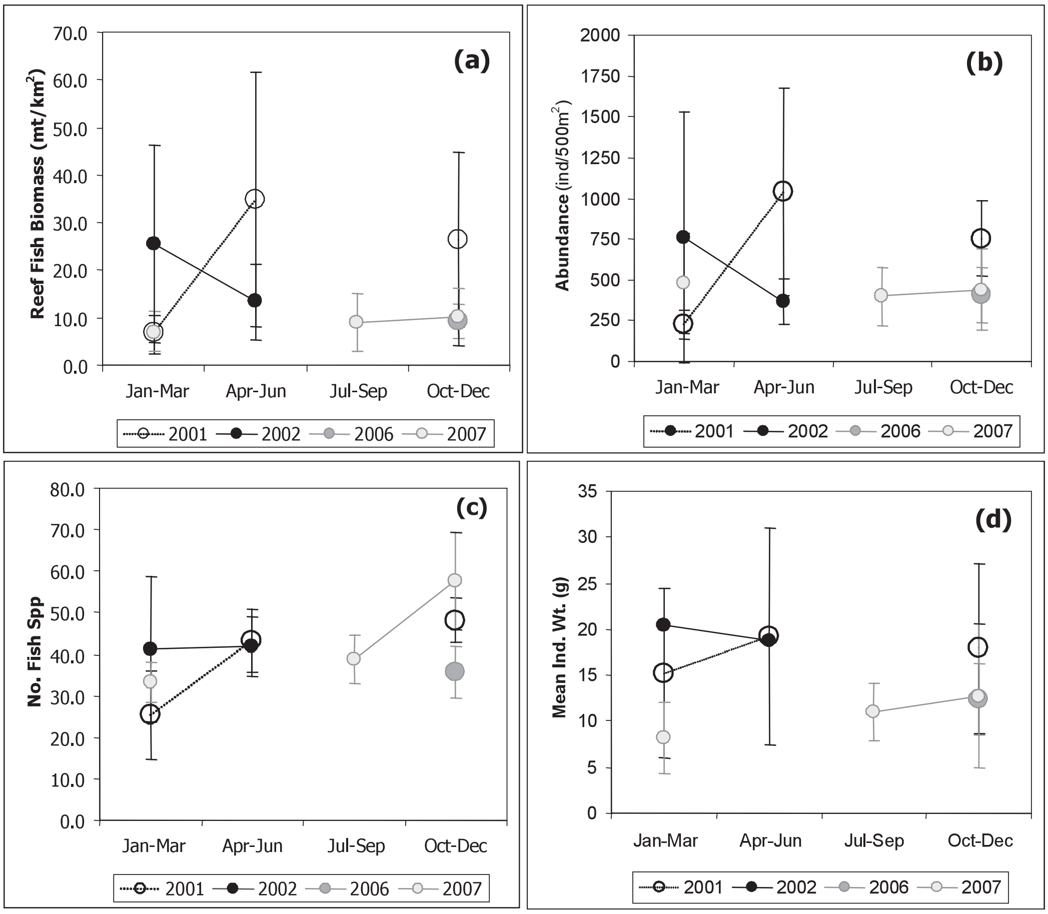

Fig. 5. Comparison of reef fish parameter estimates from previous (2000 -01) and recent (2006-07) surveys covering the same stations in the study area; (a) fish biomass (mt/km^2), (b) fish abundance (ind/500m^2), (c) number of fish species, and (d) mean individual weight (g/ind).

fish size or a reflection of increased proportional abundance of typically small fish such as pomacentrids (damselfish), apogonids (cardinalfish), and some labrids (wrasses) which occur in a wide range of body forms and sizes.

It is unlikely that the observed differences in reef fish assemblages between pre-spill and post-spill years are a direct result of the oil spill, since overall abundance remained low even twenty (20) months after the accident (based on qualitative field observations from the most recent surveys conducted in 2008, although actual survey data are still being processed). A drop in reef habitat conditions, possibly triggered by the spill, could have such an effect on the reef fish, but there were no observed reductions in live hard coral cover in the area surveyed during the same period (see section below). Hence, the decrease in overall reef fish abundance is more probably the result of and/or in addition to other factors.

On the whole, a reduction in the size of fish is a typical indicator of intense fishing in local reefs. Reef fisheries in the area were monitored in 2000-02[4], while similar surveys are currently being conducted by another study group in the general vicinity of southern Guimaras. A comparison of fisheries information during these two periods will allow verifying if there have been any changes in local fishing activities and overall intensity. Around the time of the previous surveys in the area (2000-02), destructive fishing activities like blastfishing were rare (at worst)[3]. However, resident fishers make mention of a return of compressor diving and even blastfishing even within the reserve in recent years. Attempts to verify this have been limited to informal conversations with fishers from a few barangays (Lusaran & Alman) within the reserve. Fish landing sites need to be monitored closely to verify if any catches from compressor diving or other restricted fishing activities are presently being landed, how regular these landings are, how long such activities have been taking place and from where landings were actually caught.

Clearly, there should be closer coordination with the project investigating capture fisheries in southern Guimaras. Table 2 presents estimates of catch rates from southern Guimaras cov-

Table 1. Summary of reef fish composition across all six (6) stations for each survey in 2006 & 2007.

Family	Mean Abundance (ind./500m^2) Sep/Oct 06	Feb 07	Aug 07	Dec 07	mean	sd	%
Pomacentridae	196.8	187.3	199.5	190.3	193.5	5.6	44.8
Labridae	55.0	50.2	63.3	63.3	58.0	6.5	13.4
Plotosidae	0	126.3	0	0	31.6	63.2	7.3
Serranidae/Anthiinae	38.3	22.8	30.8	26.8	29.7	6.6	6.9
Chaetodontidae	20.0	20.2	22.8	36.5	24.9	7.9	5.8
Caesionidae	22.3	19.3	9.0	38.5	22.3	12.2	5.2
Acanthuridae	21.3	17.8	14.8	29.7	20.9	6.4	4.8
Scaridae	6.5	8.3	9.7	17.3	10.5	4.8	2.4
Apogonidae	0.8	5.7	16.2	7.3	7.5	6.4	1.7
Pomacanthidae	9.3	5.7	4.7	5.2	6.2	2.1	1.4
Mullidae	4.3	1.8	4.3	6.3	4.2	1.9	1.0
Clupeidae	16.7	0	0	0.0	4.2	8.4	1.0
Zanclidae	2.3	1.2	2.7	5.2	2.8	1.7	0.7
Nemipteridae	3.8	1	2.8	1.3	2.2	1.3	0.5
Balistidae	0.3	0.8	2.7	3.0	1.7	1.3	0.4
Siganidae	1.3	0.3	3.3	0.5	1.4	1.4	0.3
Pempheridae	0.2	4.5	0.2	0.0	1.2	2.2	0.3
Serranidae/Epinephelinae	1.2	1.3	0.8	1.5	1.2	0.3	0.3
Synodontidae	0.5	1.3	0.7	0.3	0.7	0.4	0.2
Grammistidae	1.3	0.7	0.7	0.0	0.7	0.5	0.2
Lutjanidae	1.2	0	1.0	0.2	0.6	0.6	0.14
Carangidae	0	0	2.3	0.0	0.6	1.2	0.13
Gobiidae	0	1.2	0.2	0.3	0.4	0.5	0.10
Others	3.5	3.4	6.0	5.7	4.6	1.4	1.2

Table 2. Summary of catch rates (catch per unit effort) for various gear types used within the inner reserve area (TINMAR) and non-protected adjacent areas (Outside) from 1997-98 and 2000-02. The effort units for the different gear are shown in parentheses.

	1997-98	2001		2002	
Area fished	TINMAR	TINMAR	Outside	TINMAR	Outside
Reference	Subade & Campos (1999)	Campos et al. (2002)		Campos et al. (2004)	
Drive-in GN (seg-man-hr)	0.30	0.15	0.13	0.24	0.25
Set GN(seg-hr)	0.08	0.39	0.11	0.32	0.12
Seine (man-hour)	1.37	-	-	-	-
Hook & Line (man-hour)	0.41	0.74	0.40	0.51	0.35
Spear (man-hour)	0.46	0.46	0.30	0.36	0.47
Longline (per 100 hks) large	-	0.56	0.53	0.50	0.66

ering several years before the 2006 oil spill. There appears to be considerable differences between observed catch rates in 1997-98 and those in 2000-02 for both set and drive-in gillnets. Catch rate variability in such gear types could be extensive, depending on factors including area fished (shallow grassbed/reef areas within the reserve versus deep water within the reserve), season and lunar phase. An intensification of fishing pressure over a period of five (5) years, either through an increase in fisher density or use of abusive/destructive gear types (e.g., blastfishing, fishing with compressors, use of fine-mesh nets) or both, may lead to an overall decrease in reef fish abundance, biomass and size, as observed in this study. These would eventually be reflected in lower catch rates. Recent estimates of catch rates and related information from fish landing sites (e.g., effort by gear type), if available, may be compared with those shown in Table 2 and those from even earlier surveys[5] to verify if there has truly been any significant change before and after the oil spill.

Coral Cover

The extent of live hard coral cover is oftentimes used as an indicator of reef health. Substantial differences (increases) are shown for stations 1, 4 and 5 (Fig. 6), and it may appear that there is an increase in live hard coral cover in these stations, and over all stations on the average (Table 3). Because of the slow growth of corals (mm-cm per year), it is unlikely that the apparent increase is due to a real increase in survival and subsequent growth of the corals. This is consistent with the rather low % cover of coral recruits, which were observed only in late 2006 (Table 3). High variability may of course mask any true increase in coral cover. However, it is likely that slight differences in the locations of stations censused during each of the surveys may have caused the increasing trend. The level of precision of the GPS units in use is about 10-20m. If we add in the effect of wind and current on anchor position of the dive boats, it's not difficult to get a difference in distance just about as long as the transect line (50m). Differences in hard coral cover of this level are within range of natural variability levels at spatial scales of 10 to a few hundreds of meters of reefs in areas such as the Calamianes (Palawan), Danajon Bank (Bohol), Surigao del Sur and Tawi-tawi[6,7]. To minimize this source of variability concrete blocks were deployed and pegged to the substrate at 5m intervals at each station in February 2008. Compared to previous surveys, recent estimates of live hard coral cover are in the upper range of previously reported values (Fig. 7).

In terms of the macro-epifauna, ascidians dominated in 2006-07, comprising from 60-80% of all epifauna recorded (Table 4). These were followed by bivalves and the gastropods. A comparison of the abundances of 5 major groups included in both previous and recent surveys shows large overall increases in bivalves and gastropods in 2006-07 (Fig. 8). Bivalves are generally filter-feeders, while gastropods are typically grazers on algae in reefs. While an increase in grazing may lead to an overall decrease in reef algal cover, as shown in Fig. 9, this is not a simple relationship. Unfortunately, it is not possible to discern any long term trends from the available data, as what had been shown for sea urchins in grassbeds in the area. Perhaps continued monitoring will provide more insights on possible causes for the observed increase in bivalves

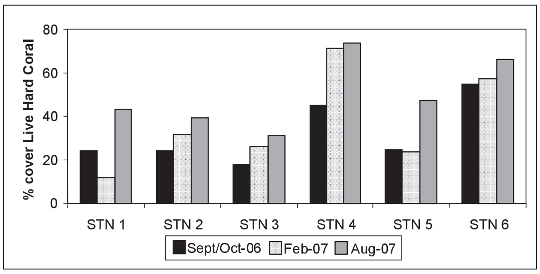

Fig. 6. Monthly estimates of live hard coral cover (%) in the six stations surveyed in the vicinity of the reserve from late 2006 to mid 2007.

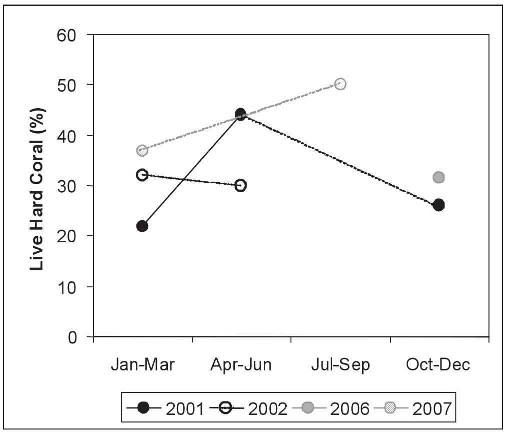

Fig. 7. Estimates of mean live hard coral cover (%) from the six stations surveyed in the vicinity of the reserve in 2001-02, and 2006-07.

Table 3. Summary of bottom lifeform cover for each month and for all months combined in Southern Guimaras. Note: DCA refers to algae growing on dead coral or rubble; Other Algae includes only those not growing on dead coral or rubble; Other biota does not include any algae.

	Sept/Oct-06		Feb-07		Aug-07		All months combined	
	Mean	sd	Mean	sd	Mean	sd	Overall Mean	sd
Live Hard Coral	31.7	14.7	37.0	22.6	50.2	16.4	39.6	9.5
Live Soft Coral	12.9	15.7	15.5	15.6	9.8	11.5	12.7	2.8
Dead Coral	3.5	6.3	0.5	0.7	2.6	2.8	2.2	1.5
DCA	35.8	20.3	23.8	11.8	24.6	4.9	28.1	6.7
Other Algae	0.02	0.04	0.11	0.18	0.14	0.34	0.09	0.1
Other Biota	1.7	1.6	2.3	1.9	4.7	5.5	2.9	1.6
Abiotic	14.4	14.2	20.8	27.8	8.0	8.3	14.4	6.4
% cover of recruits	0.04	0.06	-	-	-	-	-	-

Table 4. Summary of abundance and species richnes of reef macroinvertebrates across all six stations for each survey conducted in 2006 an in 2007.

	Abundance (ind/100m2)						No. Species in transect		
	Sept/Oct-06		Feb07		Aug07		Sept/Oct06	Feb07	Aug07
	Mean	%	Mean	%	Mean	%	Mean	Mean	Mean
Taxa									
Ascidian	281.5	88.7	108.2	70.1	168.0	69.4	9	3	3
Asteroid	2.3	0.7	2.2	1.4	3.2	1.3	2	2	3
Bivalve	6.5	2.0	1.8	1.2	12.0	5.0	10	5	7
Crustacean	1.8	0.6	3.2	2.1	1.5	0.6	3	4	4
Echinoid	0.8	0.3	0.5	0.3	0.0	0.0	1	2	0
Gastropod	10.2	3.2	22.8	14.8	15.5	6.4	10	9	9
Holothuroid	0.5	0.2	0.0	0.0	0.2	0.1	1	0	1
Nudibranch	0.3	0.1	0.3	0.2	0.0	0.0	2	1	0
Ophiuroid	2.8	0.9	2.2	1.4	1.5	0.6	2	4	2
Platyhelminthes	0.2	0.1	0	0.0	0	0.0	1	0	0
Polychaete	10.5	3.3	13.2	8.5	40.2	16.6	2	2	2
All groups	317.5	100.0	154.3	100.0	242.0	100.0	43	32	31

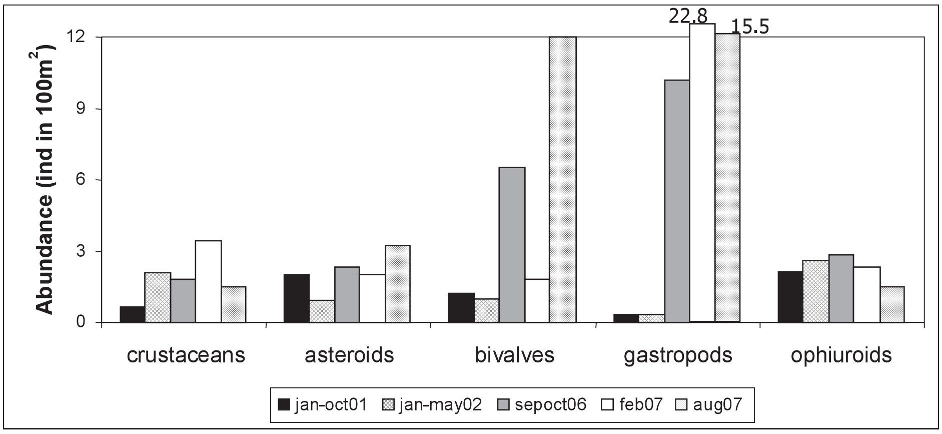

Fig. 8. Abundance (ind in $100m^2$) estimates of major macro-epifaunal groups in the six stations surveyed in the vicinity of the reserve in 2001-02, 2006 and 2007.

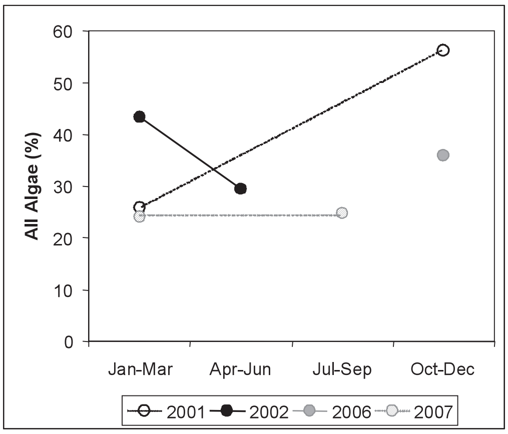

Fig. 9 Estimates of mean algal (on all substrate types) cover (%) from the six stations surveyed in the vicinity of the reserve in 2001-02, and 2006-07.

and gastropods in reefs bordering the reserve.

Quarterly reef surveys will be continued until the end of Year 2 of the study, while monthly surveys of grassbeds will continue until size data covering at least 1 year become available. This will allow examining the population dynamics of the sea urchin, *T. gratila,* and the sea star, *P. nodosus,* in seagrass beds in the reserve.

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