Baseline Assessment of Existing or Potential MPA's in FISH Project Focal Areas:

Tawi-tawi

by

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Rationale

Fisheries are of major socio-economic importance in the Philippines. Aside from providing direct employment to some 2 million people, fisheries resources are also the most affordable source of protein for the country's rapidly expanding population. Yet there are signs indicating that the sustainability of these valuable resources are threatened by overharvest, destructive and illegal fishing. Fisheries production in the country attained its peak in the late 1980's and has remained around this level over the past 2 decades. Catch per unit effort has declined dramatically and the amount and sizes of fish caught in nearshore waters have decreased markedly.

The overexploitation of fisheries resources in the country is due to several factors including its open access nature, unregulated and destructive fishing leading to stock depletion and habitat degradation, the inability of responsible government agencies to effectively enforce fisheries-related laws, and the absence of rational national and local fisheries management policies and plans geared toward sustainable use.

The goal of the Fisheries Improved for Sustainable Harvest (FISH) Project is to conserve biological diversity in at least four biologically and economically important marine ecosystems in the Philippines as measured by a 10% increase in fish stocks by 2010. This is to be evaluated by the measurement of baseline estimates of quantitative indicators at the start of management interventions and through periodic monitoring for the duration of the project. This study was conducted to establish baseline indicator information in one of the FISH priority areas, Tawi-tawi, Surigao del Sur. A map of the focal area is shown in Fig. 1.

Objectives

The general objective was to provide baseline information for quantitative indicators that could be used in evaluating the impact of management interventions in the project sites. Specifically, this study aimed to:

1) determine the density, biomass and species composition of reef fish assemblages in selected existing and or potential marine protected areas within the project focal area, and

2) characterize reef habitat conditions by estimating the cover of various benthic life form categories inside and outside of these selected areas.

Methods

Manta Tow Survey

A manta tow survey covering reef areas was conducted to construct a broad picture of the distribution of live coral cover within the focal area. The survey extended from Pababag Island, just east of Bongao (Fig. 2), southwards to northeast Simunul Is., then further east and north covering the reef flat area surrounding the Bilatan group of islands/islets, up to the Balimbing reef flat, then westwards along the coast of Sugala. A series of 2-minute observations along a path that followed the reef slope as close as possible was made by a diver-observer handling a manta board towed by the pumpboat.

Geographical coordinates of each set of observations wer measured by a handheld GPS unit. The observer estimated the cover of live hard coral, live soft coral, dead coral, dead coral with algae, abiotics (sand, rocks or water) and others (algal beds, and other flora/fauna) on a 10 point scale. The scores were listed down on an underwater slate mounted on the manta board. After transcriptions of the observations, estimates of live hard coral cover were plotted on a map of the focal area to assist in site selection for the more detailed surveys (dive sites).

Selection of Dive Sites

Only one (1) existing MPA, Pababag Is., was surveyed during the study (Fig. 2). Since there were no buoy markers deployed, the exact location of the boundaries could not be determined. This site was also surveyed by the idependent assessor. Aside from Pababag Is., three (3) other sites were selected based on the broad area survey results. A total of thirty (30) dive stations were surveyed to gather baseline information covering a total of four (4) sites. Geographical coordinates of each transect (dive station) were recorded with the use of handheld GPS units. To ensure that future monitoring is done in the exact station, fabricated concrete markers (25cm x 25cm x 4cm) were laid and fixed (via steel rod thru a hole in the center of the concrete block) at approximately 5m intervals along at least one half of the transect line. On one occasion, rough seas forced us to dump the concrete blocks before they could be deployed. As a result, two (2) stations along the Sugala coastline are unmarked.

Fish Visual Census

Reef fish assemblages were surveyed using a modification of the standard visual census techniques described by English et al. (1994). A 50m transect line was set parallel to depth contours along the reef slope. All fish (including juveniles) encountered within 5m of the slope- side of the line were identified, counted, and their sizes (fork lengths) estimated to the nearest centimeter. The surface area covered in each fish census (dive) was thus 50m x 5m = 250m^2.

Macroinvertebrate Survey

Along the same transect, all mobile epibenthic macroinvertebrates (e.g., crustaceans, echinoderms, mollusks) within 1m of either side of the transect line were identified and counted. The surface area covered for macroinvertebrates was thus 50m x 1m x 2= 100m^2.

Reef Substrate Characterization

Benthic life form cover was determined using the point intercept technique (Uychiaoco et al., 2000), wherein lifeforms intercepted every 0.25m by the transect line were recorded. For the 50m transect, observations in a total of 50m/0.25m = 200 points were recorded. Substrate rugosity was measured by recording the length of the transect line underlying a ~3m segment of chain laid to follow the substrate's (surface) contour. Rugosity measurements were done every 5m, and the rugosity index is computed as the ratio of the length of the chain over the linear distance covered by laying the said chain. In addition, other characteristics such as depth of the transect and of the reef bottom (m), steepness of the reef slope (degrees, then scaled as follows: 0-10^o=0, 11-25^o=1, 26-30^o=1.5, 31-40^o =2, 41-45^o =2.5, 46-55^o =3.0, 56-60^o =3.5, 61-70^o =4, 71-75^o =4.5, 76-85^o =5, 86-90^o =5.5), water visibility (m), and general reef typology in each dive station were noted down. Steepness of the reef slope was estimated by using an underwater slate and the plastic pencil tied to it as a plumbline.

Density and Biomass

Fish density is reported as individuals per m^2 while fish abundance is reported in no./500m^2. Fish biomass (g/m^2 = mt/km^2) was derived using size estimates from the surveys and length-weight conversions of the form ($W = aL^b$). The species-specific parameters a & b of such conversions are available from various references. Fish biomass is reported in two forms to facilitate comparisons: fish biomass1 in mt/km^2 (~ g/m^2), and fish biomass2 in kg/500m^2.

Species richness

In this report, species richness is used to show diversity. For both macroepifauna and fish, species richness is indicated by the number of species (oftentimes, number of taxa or families are also used) recorded within the area surveyed. Hence fish species richness is presented as number of families or species per 250m^2, while for macroepifauna these are presented as number of taxa or species in 100m^2. Since the number of species encountered in any survey is a non-proportional function of the size of the area surveyed, species richness estimates for areas larger than what was actually surveyed cannot be directly raised using ratios of areas, as is routinely done for estimates of abundances or biomass. The proper way of extrapolating species richness estimates is with the use of species cumulative curves. Since the present survey design did not include the construction of such curves, species richness data cannot be expressed in any other units than those mentioned above.

Data Analysis

The Point Intercept Transect (PIT) data was analyzed using indices formulated by various authors. For the Mortality Index, two formulas were used and these were based on Gomez et al (1994) and by Ben-Tzvi (nd). The recruitment index and the deterioration index were based on Ben-Tzvi (nd). Three more indices (Development Index, Condition Index, and Succession Index (Manthachitra (1994)) were also computed. In order to avoid the problem of no recruitment/algae/ot/dc/sc in the transects (*recruits/algae/ot/dc/sc = 0*), a very small value (0.001) was used instead. This substituted value is actually 1/5 of the actual lowest we can get which is 0.005. By doing so, it was possible to calculate mean indices for sites where one or more of the transects posses *recruits/algae/ot/dc/sc = 0*.

The indices and their formulae are described as follows:

<u>Mortality Index 1</u> (Mort 1; Ben-Tzvi, nd)

Mortality 1 is estimated as the proportion of dead coral cover from the sum of dead and live coral cover, both hard and soft.

$$\text{Mort 1} = \frac{DC}{DC + LC}$$

where,
DC = dead coral (includes dead coral with algae)

LC = live coral (hard & soft)

Mortality Index 2 (Mort 2; Gomez et al)

Mortality 2 is estimated as the proportion of dead coral cover from the sum of dead and live hard coral cover.

$$\text{Mort 2} = \frac{DC}{DC + LHC}$$

where,

DC = dead coral (includes dead coral with algae)

LHC = live hard coral

Recruitment Index (RI)

Recruitment is represented by the proportion of small colonies, up to 3cm in diameter, from all living corals.

$$RI = \frac{\%\text{ cover of recruit}}{LC}$$

(using the same abbreviation as for MI)

Deterioration Index (Det. I)

DI value is indicative to the state of "health" of the examined coral reef. The idea is to examine the dynamics of the reef by comparing two of its major processes, the recruitment and the mortality of corals. It is simply the ratio between mortality index and recruitment index. The formula is as follows:

$$\text{Det. I} = \frac{MI}{RI}$$

where,

MI – Mortality Index

RI – Recruitment Index

Development Index (Dev. I)

The development index was computed following Manthachitra (1994). This index was used to indicate the degree of coral-reef assemblage development. For the PIT data, live coral, dead coral, algae and other fauna represent the Coral Related Component. The formula is as follows:

$$\text{Dev. I} = \log (CRC/ARC)$$

or

$$\text{Dev. I} = \log [(LC + DC + \text{Algae} + OT) / \text{Abiotics}]$$

where,

LC = percentage area cover of live coral category

DC = percentage area cover of dead coral category

Algae = percentage area cover of algae category

OT = percentage area cover of other fauna category
Abiotics = percentage area cover of abiotics category

However, this index requires that algae and other fauna be included in CRC only when they colonize on a coral component (live or dead). They are excluded from the CRC and are included in the abiotic related component (ARC) when they colonize on an abiotic component. For the PIT data, percentage area cover for Algae and OT was divided into Algae/OT CRC and Algae/OT ARC. The formulae are as follows:

Algae/OT ARC = Total Algae/OT x % Abiotics

and

Algae/OT CRC = Total Algae/OT – (Total Algae/OT x % Abiotics)

Condition Index (Cond. I)

The CI is used to indicate the condition of coral-reef assemblage. The formulation of CI was considered from the coral related component (CRC) by using the proportion between live coral and dead coral related component (DRC). The formula is as follows:

Cond. I = log (LC/DRC)

or

Cond. I = log [LC/(DC + Algae + OT)]

(using the same abbreviation as for Dev. I)

Succession Index (SI)

The SI is used to indicate the level of succession occurring on the reef. The term “succession” means the sequential changes of benthic community occurring on dead coral. This index is based on the DRC only. There are three major categories (dead coral, algae, and other fauna) used in the DRC of which algae and other fauna represent different stages of succession. Hence, Succession can be separated into two minor indices, Succ 1 as succession by algae and Succ 2 as succession by other fauna. The formulas of both indices are as follows:

Succ 1 = log [Algae/(DC + OT)]

and

Succ 2 = log [OT/(DC + Algae)]

(using the same abbreviation as for Dev. I)

Results and Discussion

Manta Tow Results & Dive Site Selection

The area covered by the manta tow survey extended from Pababag Island, just east of Bongao (Fig. 2), southwards to northeast Simunul Is., then further east and north covering the reef flat area surrounding the Bilatan group of islands/islets, up to the Balimbing reef flat, then westwards along the coast of Sugala. In the eastern portion of the study area, the extensive reef flat showed uniformly and consistently poor coral cover interspersed with extensive areas of sand and bare rock. For this reason, manta surveys were done for stretches of 10-15 min (in some cases even less), with 10-15 min runs in between. As a result, the estimated live coral cover markers are discontinuous, although the spaces in between are most likely of poor coral cover as well.

The overall results are shown in Fig. 2. There are only 3 sites where live hard coral cover exceeded 30%. These include the northeast portion of Simunul Is., the northern portion of the Balimbing reef flat and the coastline of Sugala. The thirty (30) dive stations were thus distributed among four (4) sites, including the MPA in Pababag Island (Fig. 3). Originally, the plan was to establish ten (10) dive stations in each of three sites. However, potentially dangerous conditions brought about by very strong currents in the Simunul site (Fig. 4b) limited our work there to six (6) stations. In addition, the lack of information on existing MPAs in the rest of the focal area made us decide to spread out the coverage of the remaining fourteen (14) stations along the Balimbing Reef Flat and the Sugala coastline (Fig. 2 & 4a). The thirty (30) stations were thus distributed as follows: Pababag MPA (10 stns), Simunul Is. (6 stns), Balimbing reef flat (5 stns), and the Sugala coastline (9 stns).

Reef Habitat Characteristics

Characterististics of each dive station are summarized in Table 1. These include the station coordinates, station depth (ft), visibility (m), slope (in degrees), depth of bottom of reef slope (ft), rugosity, and bottom lifeform categories (%). In this table, "Total Dead" excludes the category "Dead Coral with Algae (DCA)", while "Other Algae" includes only those growing on other substrate. The "Other Biota" category does not include any algae.

Benthic lifeforms are further summarized by site in Table 2 and presnted in Figs. 5 a-c. A comparison of coral indices is shown in Fig. 6. Based on underwater transect surveys, the overall live hard coral cover in the various dive sites was moderate (mean= 47.6%), but ranged from 5.5 to over 80% (Table 2). On average, the Balimbing reef flat site showed the lowest live hard coral cover, while there were at least three stations in each of the other three sites with good (> 50%) live cover (Fig. 5a). Highest live coral cover was shown for the west side of Pababag Is. and along the shallow central portion of Sugala. This might seem rather ironic, since blastfishing was observed to be most frequent in the vicinity of Pababag Is. (Table 3), although not necessarily within the reserve. In general, ther number of blasts per hour observed during the daytime was higher around the island sites (Pababag & Simunul Is.) and lower closer to the main island (Sugala and Balimbing) (Table 3). The percent cover of dead coral with algae (dca) was highest in the Simunul site (Fig. 5b), suggesting that considerable portions of the reef flat were included in the transects surveyed underwater. Strong currents made this inevitable over parts of the trasnsect. Similarly, the percent cover of sand, rock and rubble were also highest in sites where currents were also strongest, in Balimbing reef flat and in Simunul Is. (Table 2).

Coral parameters are summarized in Table 2 and shown in Fig. 6. Generally, mortality indices were highest for Simunul Is., reflecting physically exposed conditions (current gyres) along the channel. Showing the lowest index of succession by other sessile fauna is also consistent with such physical exposure. In contrast, the Balimbing site showed moderate mid-range values for all coral indices, although tidal currents are likewise strong in this site. It is possible that the proximity of Balimbing to the main island (Fig. 1) makes it less vulnerable to wave action than the more open Simunul Island.

In terms of coral development and condition, Pababag Island showed the highest mean values (Table 2). In both cases, the mean was greater than 1.0, showing that, on average, percent cover of coral assemblages is more than 10X that of the abiotic substrate in the site and that live hard coral cover alone is more than 10X higher than those of all other substrate types together. Succession by algae was generally low and highly variable in all sites (Fig. 6). Unfortunately, no coral recruits were recorded in any of the thirty stations.

Reef slope inclination (Fig. 7) was steepest in Simunul Is., where stations were located on the channel side of the island. Steep slopes were also observed in a few stations in the eastern portion of the Balimbing reef flat and along the coast of Sugala. This suggests spur and groove reef formations in these sites, since areas with steep slopes also showed deeper reef bottoms (Table 1). Visibility showed a similar distribution, although a few rather shallow stations in Pababag also showed high visibility (Table 1 and Fig. 8). Rugosity, on the other hand, was highest in Sugala and in a few stations in Pababag (Fig. 9), but lowest in sites with strong currents (Balimbing and Simunul). Another factor, physical relief, was derived as the product of slope (scaled from 1-5), rugosity and depth of the reef slope bottom. Overall physical relief is highest in Simunul (Fig. 10). High values of this derived parameter are indicative of deep reefs with steep slopes, which contribute more to large-scale habitat structure than rugosity.

Macroepifauna

A total of 82 species were recorded in the 30 dive transects surveyed in Tawi-tawi. The ascidians (tunicates) and bivalves were the most species-rich (Table 4), with 20 and 15 species respectively, while ascidians and echinoids were numerically dominant, comprising almost 72% of all macroepifauna recorded during the study. The overall mean abundance of macroepifauna was 2675 ind/500m^2, with ascidians and echinoids showing comparable abundances. The fifteen (15) most abundant species comprised about 92% of all macroepifauna recorded in the area surveyed (Table 5), with *Diadema setosum* being the most abundant species showing an overall mean abundance of 827 ind/500m^2. This sea urchin comprised almost a third of all macroepifauna recorded in the area.

The number of invertebrate species (taxa) recorded was highest in Pababag (52 taxa), and lowest in Simunul (32 taxa), although overall abundance was much higher in the latter site (Fig. 11, Table 4). An ANOVA on ln-transformed overall abundances in the four sites showed that estimates in Simunul (mean = 4431 ind/500m^2) were significantly greater than those in the other three sites (SNK test; α=0.05). Of the various taxonomic groups, echinoids showed the largest difference in abundances with about 2798 ind/500m^2 in Simunul versus 256-750 ind/500m^2 in the three other sites (Fig. 12; Table 4). This is consistent with the distribution of total algal cover (=DCA + algae) which is also generally higher in Simunul (Fig. 5b). *Diadema setosum* was the most abundant echinoid in Simunul as well as in the other sites.

Reef Fish

A total of 350 species of reef fish, belonging to 43 families, were recorded in the 30 dive stations surveyed in Tawi-tawi (Table 6). Of these, the Labridae (73) and

Pomacentridae (63) were the most species-rich families, together making up about 39% of all species recorded in the 4 sites. The 15 most abundant species recorded comprised about 51% of the total (Table 7). Of these, eight (8) are pomacentrids. The overall mean fish abundance was 903.9 ind/500m^2, which is in the higher range of estimates for reefs along the South China Sea Coast of Luzon and those in western Visayas (Campos et al., 2004), but are still considered moderate in level with respect to the entire country (Hilomen et al., 2001).

The number of taxa (species or families) observed per transect provides an idea of potential species richness, although true species richness refers to the total number of species observed in all transects surveyed in a given site. Potential species richness, expressed as mean number of species per transect, was highest in Simunul (mean =62.2 spp/250m^2), followed by the Balimbing reef flat and Sugala coast (mean = 56.4 & 56.8 respectively) (Fig. 13; Table 8), and lowest in Pababag Island. Species richness (no. of fish families or spp), on the other hand, cannot be directly compared between the four sites, because of differences in the number of stations surveyed. Theoretically, the number of taxa observed increases as the number of samples increases. Hence, when sites with many stations show less taxa than sites with less stations, species richness is likely to be higher in the latter. In the four sites surveyed, the total number of families recorded was highest (33) in those sites with the most stations (Pababag & Sugala), although Simunul, with only six (6) stations surveyed, was not far behind with 30 families recorded (Table 9). This suggests a higher species richness in the latter, and is consistent with Fig. 13.

Reef fish parameters are summarized in Table 8. Fish abundance was highest along the Sugala coast, with a mean of 1126.4 ind/500m^2 (Table 8), although there were one or two stations with high abundance estimates in the other sites as well (Fig. 14a). Fish biomass, however, was high in both Sugala and Simunul (means: 9.9-13 kg/500m^2; range: 4.6 - 21.5) but similarly low in Pababag and Balimbing (means: 4.9 - 5.6 kg/500m^2; range: 2.8 – 8.6) (Table 8 & Fig. 14b). Overall fish biomass for the area was 8.1 kg/500m^2, with a range of 2.8 – 21.5. While this is still low compared to the rest of the country (Hilomen et. al, 2000), estimates for Sugala and Simunul are moderate in level, with a couple of stations in these sites showing high biomass.

Overall, pomacentrids and labrids dominated the fish assemblages in all sites, making up the two most abundant species in three of the four sites. Only in Simunul were anthiases (Serranidae-Anthiinae) among the top two families (Table 9), while this group was not even in the top ten families in the other three sites. The four sites showed differences in the composition of their respective top ten families. Plotosids and caesionids were most abundant along the Sugala Coast, pinguipedids and nemipterids in Balimbing, scombrids and balistids tohether with anthiases in Simunul, and clupeids in Pababag (Table 9). Similarly for the most abundant species in each station (Table 10), Sugala and Balimbing, which are geographically adjacent to each other, showed rather similar compositions, although *Chrysiptera parasema*, *Plotosus lineatus* and *Pterocaesio tesellata* were more abundant in Sugala. Pababag, on the other hand, were dominated by three species of apogonids, while Simunul was dominated by two species of anthiases. In all sites, however, the planktovorous *Cirrilabrus cyanopleura* dominated most stations, comprising about 1/6 of all fish recorded in the survey.

Average fish size was largest in Simunul (Fig. 15). This explains the high mean biomass with only moderate fish abundances in the site as mentioned earlier. Juvenile fish abundances, on the other hand, were highest along the Sugala coast and near the

Balimbing reef flat (Fig. 16), where habitats seem to be more protected by the main island.

Target & other species

The target species include haemulids, lethrinids, lutjanids, serranids, acanthurids and siganids. Together, these groups showed highest abundances in Simunul (Fig. 17), showing an average biomass of 2.6 kg/500m2, representing about 21% of total fish biomass in the site (Table 11). Overall, target species showed a mean biomass of 1.2 kg/500m2, representing only about 13% of mean total fish biomass in the four sites. Target fish abundances ranged from 0-42 ind/500m2 in all sites except Simunul. These are comparable to values reported for Cabacongan, Bohol and Port Barton, Palawan (Uychiaoco et al., 2002a and b respectively). In Simunul however, target fish abundance was much higher, ranging from 64-716 ind/500m2. These estimates are much higher than what has been reported in other reef areas in the country (Philreefs 2002). The highly productive reefs in Bohol Sea, including Pamilacan, Sumilon and Balicasag (White and Meneses, 2002) would fall into the same category as Simunul. Together with other locally valuable fish groups, i.e. scaridae and caesionidae, target/valuable species represented at least 30% of mean total fish biomass in Sugala and Simunul (Table 11).

Chaetodontids are considered indicator species of good reef health since they are corallivores. Since live hard coral cover declines as stress on reefs increases, chaetodontid abundances should be low in impacted reefs. Chaetodontids were most abundant in Simunul, but showed rather scattered abundances in Pababag and Sugala (Fig. 18). They were least abundant along the Balimbing reef flat, where % cover of llive hard coral is also lowest (Fig. 5a). Mean chaetodontid abundance in the four sites surveyed ranged from 0-82 ind/500m^2 (mean = 17.9), which is higher than the range of predicted values based on an empirical relationship between overall live coral cover (~50%, Table 2) and chaetodontid abundances presented by Nanola & Alino (1999).

As mentioned already, the schooling caesionids were most abundant along the Sugala coast (Fig. 19), while the distribution of high scarid biomass was scattered throughout the area surveyed (Fig. 20).

Regression analysis

Regression analysis explained from 47 to 73.5% of total variation in reef fish parameters, with the matrix of coefficients showing higher dependence on physical habitat parameters, such as physical relief, reef depth, slope, rugosity and even visibility (Table 12). Benthic life form catgories were only secondary. Similarly, regressions explained from 26-88% of total variation in (Ln-transformed) densities of the various species, including juveniles. Overall, except for a few species, physical habitat factors seemed to be more influential than benthic lifeforms. This is consistent with biological factors having a fine-tuning effect on the distribution of various species, while physical habitat factors have broader effects on the overall distribution of fish assemblages as a whole.

Management Implications

The focal area is characterized by extensive reef flats, especially along the eastern portion around Bilatan Island (Fig. 2). Our surveys, however, did not include shallow water habitats such as seagrass beds and mangroves. Hence, there is little we can say about such extensive reef flat formations and their apparent significance as nursing grounds. From our manta tow observations, the seaward portion of the eastern reef flat consistently showed poor live coral cover, with intermittent extensive tracts of sand. Considering the geographical location of Tawi-tawi, even this inner portion of the bay could experience rough seas with westerly winds, limiting the development of shallow water nursing grounds. In contrast, the leeward (southern) coast of the main island (i.e., Sugala coast) and the Balimbing reef flat are likely much less exposed to wind-induced rough conditions. Hence mangroves line most of the coast, while seagrass beds are likely well-developed inside the reef flat in Balimbing. During the survey, seaweed culture lines were observed in Balimbing. These are the likely reasons why juvenile fish densities are higher in these areas.

The Pababag Island MPA is likewise located in the leeward side of the main island. Unfortunately, no one was able to show us where the boundaries were. Nevertheless, on the whole, Pababag Is. showed more similarities with the mainland coast than with Simunul.

A reason for high live coral cover in Simunul is the rather deep channel and steep reef slope. The area also has a reef flat, although far less extensive as in the other sites. Because the specific site is just off one of the more heavily populated areas in the island, it is likely that conditions here are calmer than elsewhere around Simunul, allowing the development of nursing grounds, the mangrove shoreline and the grassbeds on the reef flat. At least in Simunul, this vicinity appears to be a recommendable location for establishing a protected area.

The overall mean frequency of blastfishing is at least 1.1 blasts per hour during the daytime (Table 3). This was most frequent in Pababag and least in Sugala, where enforcement is likely higher because of its proximity to the municipal center. This overall mean is much less that what has been recorded in the Bolinao reef flat in the mid-80's, where there were, on average, at least 6 blasts per hour during the daytime (del Norte et al., 1989). At the time, Bolinao was already heavily-fished and producing from 5 – 7 kg/500m^2 (~ 10-14 mt/km^2) of fish, and perhaps as high as 8 kg/500m^2 (~ 16 mt/km^2) (Campos et al., 1994). These estimates are for fisheries on the reef flat. Mean reef slope fish densities in Bolinao ranged from 300-400 ind/500m^2 in 1988 to less than 200 ind/500m^2 in 2000 (Uychiauco et al., 2002). This decrease is attributed to several factors, including continued overfishing and previous extensive blastfishing, and provides an idea of what might happen as a result of continued destructive fishing. In the focal area, reef slope fish densities are 2-3X higher than the estimates in Bolinao, inspite of the current blastfishing and habitat destruction resulting from it (form personal field observations, blastfishing of comparable frequency was already observed in Simunul and other outlying islands of the Tawi-tawi island group in 1990). Hence, it is likely that natural reef fish productivity could be higher if such destructive fishing can be completely stopped.

Fish egg and larval samples were collected during the survey, but rough sea conditions and time constraints allowed sample collection only in the western and central portions of Tawi-Tawi Bay. Nevertheless, it would be interesting to see how fish eggs, larvae and juveniles are distributed in the area.

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Table 1. Habitat characteristics of each dive station surveyed in the Tawi-Tawi focal area in July-August 2004. Note: All lifeform categories are in percent cover.

Station	North	East	Live Hard Coral	Live Soft Coral	Dead Coral	DCA	Other Algae	Other Biota	Abiotic	Rugosity	Slope (°)	Transect Depth (m)	Slope Bottom Z (m)	Phys. Relief	Visibility (m)
Pababag Island															
Pbg 01	5.032	119.802	77.5	9.0	0.0	4.5	0.0	6.0	3.0	1.36	0	3.0	3.0	0.0	7.5
Pbg 02	5.029	119.803	9.5	63.5	0.0	0.0	0.0	1.0	26.0	1.40	20	6.1	9.1	83.9	10
Pbg 03	5.025	119.799	14.5	58.5	0.0	0.0	0.0	16.0	11.0	1.36	0	5.3	5.3	0.0	7.5
Pbg 04	5.024	119.797	21.5	67.0	0.0	0.0	0.0	5.0	6.5	1.27	10	4.6	5.3	22.3	12.5
Pbg 04	5.025	119.794	55.5	21.5	0.0	13.0	0.0	5.5	4.5	1.78	0	5.3	6.1	0.0	7.5
Pbg 06	5.028	119.792	80.5	16.0	0.0	2.5	0.0	0.0	1.0	1.61	22.5	4.6	7.6	80.6	12.5
Pbg 07	5.030	119.789	60.0	17.0	0.0	7.5	0.0	5.5	10.0	1.78	0	3.8	3.8	0.0	10
Pbg 08	5.031	119.786	83.0	2.5	0.0	3.0	0.0	1.0	10.5	1.38	0	4.6	4.6	0.0	11
Pbg 09	5.032	119.783	68.5	3.0	0.0	23.5	0.0	2.5	2.5	1.67	0	3.8	3.8	0.0	8
Pbg 10	5.032	119.784	70.0	6.5	0.0	9.5	0.0	0.0	14.0	1.33	10	4.6	5.3	23.3	10
n			10	10	10	10	10	10	10	10	10	10	10	10	10
mean			54.1	26.5	0.0	6.4	0.0	4.3	8.9	1.5	6.3	4.6	5.4	21.0	9.7
sd			28.3	26.0	0.0	7.5	0.0	4.8	7.4	0.2	8.9	0.9	1.8	33.6	2.0
Simunul Island															
Sml 01	4.920	119.834	13.0	6.0	0.0	25.0	0.0	10.5	45.5	1.38	65	4.6	30.5	692.4	10
Sml 02	4.914	119.841	81.0	0.0	0.0	7.0	0.0	1.0	11.0	1.44	70	4.6	30.5	722.3	15
Sml 03	4.913	119.843	20.0	6.5	1.5	38.5	1.5	9.5	22.5	1.26	65	4.6	30.5	628.7	10
Sml 04	4.910	119.845	60.5	0.0	0.0	4.0	0.0	3.0	32.5	1.41	65	4.6	30.5	707.0	12.5
Sml 05	4.908	119.847	27.0	8.5	0.0	35.5	0.0	7.5	21.5	1.57	65	4.6	30.5	787.1	10
Sml 06	4.905	119.849	59.5	1.5	0.0	17.5	0.0	1.0	20.5	1.73	65	4.6	30.5	865.0	17.5
n			6	6	6	6	6	6	6	6	6	6	6	6	6
mean			43.5	3.8	0.3	21.3	0.3	5.4	25.6	1.5	65.8	4.6	30.5	733.8	12.5
sd			27.2	3.7	0.6	14.3	0.6	4.3	11.9	0.2	2.0	0.0	0.0	82.1	3.2

Table 1. Cont'd

Stn	North	East	Live Hard Coral	Live Soft Coral	Dead Coral	DCA	Other Algae	Other Biota	Abiotic	Rugosity	Slope (°)	Transect Depth (m)	Slope Bottom Z (m)	Phys. relief	Visibility (m)
Balimbing Reef Flat															
Blb01	5.068	120.003	28.5	36.0	0.0	0.5	0.0	8.5	26.5	1.66	27.5	4.6	13.7	149.3	10
Blb02	5.067	119.995	39.5	31.0	0.0	1.5	0.0	3.0	25.0	1.66	45	6.1	15.2	290.5	11
Blb03	5.072	119.987	37.0	17.0	0.0	2.0	0.0	6.0	38.0	1.43	30	4.6	7.6	89.5	10
Blb04	5.075	119.980	5.5	2.5	0.0	0.0	42.5	9.5	40.0	1.19	0	3.0	3.0	0.0	12.5
Blb05	5.072	119.970	31.5	32.5	0.5	2.5	0.5	15.0	17.5	1.38	0	3.8	3.8	0.0	10
n			5	5	5	5	5	5	5	5	5	5	5	5	5
mean			28.4	23.8	0.1	1.3b	8.6	8.4	29.4	1.5	20.5	4.4	8.7	105.9	10.7
sd			13.5	13.9	0.2	1.0	19.0	4.5	9.4	0.2	19.9	1.1	5.6	121.1	1.1
Sugala															
Sgl06	5.070	119.925	32.5	39.0	1.5	9.5	1.5	1.5	14.5	1.52	45	4.6	12.2	212.7	5
Sgl07	5.069	119.902	70.5	5.0	1.5	9.0	1.5	9.0	3.5	2.05	22.5	4.6	9.1	123.0	7
Sgl08	5.066	119.897	56.5	14.5	0.0	19.5	0.0	8.0	1.5	1.59	45	3.8	7.6	139.4	6
Sgl09	5.067	119.892	75.5	0.0	0.0	19.0	0.0	3.0	2.5	1.92	22.5	4.6	6.9	86.6	7
Sgl10	5.064	119.886	35.0	0.0	0.0	10.0	0.0	8.5	46.5	1.56	45	4.6	12.2	218.9	5
Sgl11	5.060	119.883	70.0	0.0	0.0	24.5	0.5	2.5	2.5	2.43	17.5	3.0	6.1	48.6	8
Sgl12	5.061	119.876	81.5	0.0	0.0	13.0	0.0	1.0	4.5	1.86	5	3.0	4.6	28.0	10
Sgl13	5.040	119.833	48.0	20.5	0.0	0.0	0.0	4.0	27.5	1.52	10	5.3	7.6	38.0	7
Sgl14	5.041	119.836	15.5	42.0	0.0	0.0	0.0	9.5	33.0	1.46	0	4.6	4.6	0.0	8.5
n			9	9	9	9	9	9	9	9	9	9	9	9	9
mean			53.9	13.4	0.3	11.6	0.4	5.2	15.1	1.8	23.6	4.2	7.9	99.5	7.1
sd			22.6	17.0	0.7	8.4	0.7	3.5	16.6	0.3	17.7	0.8	2.9	79.7	1.6
ALL FOUR (4) SITES															
n			30	30	30	30	30	30	30	30	30	30	30	30	30
mean			47.6	17.6	0.2	10.1	1.6	5.5	17.5	1.6	25.8	4.4	11.7	201.2	9.6
sd			25.2	19.9	0.5	10.8	7.7	4.3	14.0	0.3	25.2	0.8	10.0	282.7	2.8

Table 2. Summary of benthic lifeform categories, along with mean values of reef indices in each of the four dive sites in the Tawi-Tawi focal area in July-August 2004.

	Pababag Is.		**Simunul Is.**		**Balimbing Reef Flat**		**Sugala**		**All 4 Sites**	
	Mean	s	mean	s	mean	s	mean	s	mean	s
Live Hard Coral	54.1	28.3	43.5	27.2	28.4	13.5	53.9	22.6	47.6	25.2
Live Soft Coral	26.5	26.0	3.8	3.7	23.8	13.9	13.4	17.0	17.6	19.9
Dead Coral	0.0	0.0	0.3	0.6	0.1	0.2	0.3	0.7	0.2	0.5
DCA	6.4	7.5	21.3	14.3	1.3	1.0	11.6	8.4	10.1	10.8
Other Algae	0.0	0.0	0.3	0.6	8.6	19.0	0.4	0.7	1.6	7.7
Other Biota	4.3	4.8	5.4	4.3	8.4	4.5	5.2	3.5	5.5	4.3
Abiotics	8.9	7.4	25.6	11.9	29.4	9.4	15.1	16.6	17.5	14.0
Mort. 1	0.070	0.079	0.339	0.247	0.024	0.016	0.144	0.093	0.138	0.165
Mort. 2	0.082	0.086	0.377	0.286	0.042	0.029	0.163	0.102	0.159	0.183
Dev. Index	1.120	0.447	0.412	0.298	0.275	0.309	0.963	0.656	0.790	0.576
Cond. Index	1.118	0.434	0.415	0.583	0.746	0.742	0.742	0.368	0.803	0.546
Succ. 1	-0.296	1.103	0.007	0.872	-0.334	0.763	-0.247	0.990	-0.227	0.935
Succ. 2	-0.345	1.222	-1.099	0.532	0.203	0.729	-0.224	0.905	-0.368	0.992

Table 3. Summary of observations on the number of blasts per hour during the daytime in the four sites surveyed in the Tawi-Tawi focal area in July-August 2004.

Observation sets	Pababag	Simunul	Balimbing	Sugala	ALL 4 sites
1	3.52	1.56	0	0	
2	3.25	1.41	2.00	0	
3	1.69	0.77	0.92	0	
4	0	-	-	0	
5	0	-	-	2.49	
6	-	-	-	0	
n	5	3	3	6	17
mean	1.69	1.25	0.97	0.41	1.10
sd	1.69	0.42	1.00	1.01	1.21

Table 4. Summary of macroepifaunal groups, their number of species (in $100m^2$ area surveyed), mean abundance (ind/$500m^2$) and relative abundance (%) in the 4 sites, and in all sites combined in the Tawi-Tawi focal area in July-August 2004.

	Balimbing			Sugala			Pababag			Simunul			All 4 sites		
Group	**No. spp.**	**Mean**	**%**	**No. spp.**	**Mean**	**%**	**No. spp.**	**Mean**	**%**	**No. spp.**	**Mean**	**%**	**No. spp**	**Mean**	**%**
Ascidian	14	710	43.9	13	1491.5	72.0	10	906	33.6	4	559	12.6	20	979.5	36.6
Echinoid	4	424	26.2	4	256.5	12.4	6	750	27.8	3	2797.5	63.1	6	957	35.8
Holothuroid	4	72	4.4	4	4	0.2	4	747.5	27.7	1	1	0.0	8	262.5	9.8
Ophiuroid	1	90	5.6	2	153	7.4	1	53	2.0	1	602.5	13.6	2	199	7.4
Bivalve	12	169	10.4	8	113	5.5	14	154.5	5.7	6	115	2.6	15	136.5	5.1
Asteroid	6	112	6.9	5	21	1.0	8	44	1.6	6	198.5	4.5	10	79.5	3.0
Polychaete	1	34	2.1	1	22	1.1	1	21	0.8	1	101.5	2.3	1	39.5	1.5
Gastropod	3	4	0.2	5	4.5	0.2	5	4	0.1	9	40	0.9	12	11.5	0.4
Crustacean	1	2	0.1	2	1.5	0.1	3	15	0.6	1	16	0.4	5	9	0.3
Nudibranch	1	1	0.1	2	3.5	0.2	-	-	-	-	-	-	3	1	0.0
Total	47	1618	100	46	2070.5	100	52	2695	100	32	4431	100	82	2675	100.0

Table 5. List of the fifteen most abundant macroepifaunal taxa, their mean abundance (ind/500m^2) and relative abundance (%) in the Tawi-tawi focal area in July-August 2004.

Taxa	Group	Mean Abund	%
Diadema setosum	Echinoid	827.0	30.9
Atriolum robustom	Ascidian	330.7	12.4
Synaptula sp.	Holothuroid	259.5	9.7
Ophiomastix sp.	Ophiuroid	198.5	7.4
Clavelina sp. (yellow)	Ascidian	166.9	6.2
Oxycorynia sp. (blue)	Ascidian	139.4	5.2
Clavelina robusta	Ascidian	129.0	4.8
Diadedma savignyi	Echinoid	88.5	3.3
Didemnum molle	Ascidian	70.4	2.6
Pedum spondyloideum	Bivalve	59.7	2.2
Linckia laevigata	Asteroid	56.4	2.1
Oxycorynia fascicularis	Ascidian	52.7	2.0
Echinothrix calamaris	Echinoid	40.5	1.5
Sabellidae	Polychaete	39.7	1.5
Unidentified bivalve	Bivalve	27.0	1.0
			92.9

Table 6. Summary of all fish families recorded in all sites combined, their respective number of species, mean abundance and relative abundance in the Tawi-Tawi focal area in July-August 2004.

Family	**No. spp**	**Mean Abund.** (ind/500m^2)	**Rel. Abund.** (%)	**Family**	**No. spp**	**Mean Abund.** (ind/500m^2)	**Rel. Abund.** (%)
Pomacentridae	63	327.1	36.2	Aulostomidae	1	1.3	0.15
Labridae	73	232.1	25.7	Synodontidae	2	1.3	0.14
Apogonidae	16	107.6	11.9	Cirrhitidae	5	1.3	0.14
Serranidae-Anthiinae	5	45.5	5.0	Monacanthidae	6	1.2	0.13
Plotosidae	1	33.9	3.8	Pseudochromidae	3	0.9	0.10
Caesionidae	5	24.3	2.7	Ostraciidae	3	0.9	0.10
Scaridae	18	18.9	2.1	Lutjanidae	4	0.7	0.07
Chaetodontidae	21	17.9	2.0	Holocentridae	4	0.5	0.05
Clupeidae	1	16.7	1.8	Lethrinidae	3	0.5	0.05
Acanthuridae	13	11.5	1.27	Muraenidae	2	0.4	0.04
Pomacanthidae	10	8.3	0.92	Ephippidae	2	0.3	0.04
Gobiidae	7	6.7	0.74	Microdesmidae	2	0.3	0.04
Nemipteridae	11	6.3	0.70	Gobiesocidae	1	0.3	0.030
Pinguipedidae	7	5.6	0.62	Fistulariidae	1	0.1	0.015
Blennidae	10	5.3	0.58	Callionymidae	1	0.1	0.007
Tetraodontidae	5	4.5	0.49	Carangidae	1	0.1	0.007
Serranidae-Epinephelinae	9	3.6	0.40	Malacanthidae	1	0.1	0.007
Zanclidae	1	3.4	0.38	Pempheridae	1	0.1	0.007
Mullidae	6	2.5	0.27	Priacanthidae	1	0.1	0.007
Balistidae	9	2.4	0.27	Scorpaenidae	1	0.1	0.007
Centriscidae	1	2.1	0.23				
Haemulidae	7	2.1	0.23				
Siganidae	4	2.0	0.22	All Families	350	903.9	100.0
Scombridae	1	1.8	0.20				
Serranidae-Diploprioninae	1	1.6	0.18	Total no. families*	43		

* Serranidae with three (3) subgroups

Table 7. List of the fifteen most abundant fish species recorded in all 30 stations surveyed in the Tawi-Tawi focal area in July-August 2004.

Species	Family	Mean Density (ind/m^2)	Mean Abund. (ind/500m^2)	Rel. Abund. (%)
Cirrhilabrus cyanopleura	Labridae	0.277	138.4	15.3
*Plotosus lineatus**	Plotosidae	0.068	33.9	3.8
Pomacentrus moluccensis	Pomacentridae	0.068	33.9	3.8
Pseudanthias squamipinnis	Serranidae	0.063	31.3	3.5
Archamia zosterophora	Apogonidae	0.061	30.5	3.4
Pomacentrus lepidogenys	Pomacentridae	0.056	27.9	3.1
Chrysiptera parasema	Pomacentridae	0.049	24.4	2.7
Cheilodipterus quinquelineatus	Apogonidae	0.046	23.0	2.5
Thalassoma lunare	Labridae	0.044	21.9	2.4
Chrysiptera rollandi	Pomacentridae	0.041	20.6	2.3
Pomacentrus amboinensis	Pomacentridae	0.034	16.9	1.9
*Spratelloides gracilis (?)**	Clupeidae	0.033	16.7	1.8
Pomachromis richardsonii	Pomacentridae	0.029	14.7	1.6
Pomacentrus auriventris	Pomacentridae	0.029	14.4	1.6
Pomacentrus brachialis	Pomacentridae	0.029	14.3	1.6
				51.0
Overall density all spp		1.808		
Overall ind/500m^2 all spp			903.9	
Total number spp			350	

* school forming early juveniles

Table 8. Reef fish parameters in each site and for all four sites combined in the Tawi-Tawi focal area in July-August 2004.

Stn	Fish Biom 1 (mt/km^2)	Fish Biom 2 (kg/500m^2)	Fish Abund (ind/500m^2)	Juv Abund (ind/500m^2)	No. of Fam	No. of spp	Ave. wt. (g/ind)
Site: Pababag Is., Bongao (MPA Site)							
Pbg 01	14.6	7.3	1038	164	19	56	7.0
Pbg 02	9.2	4.6	606	48	22	49	7.6
Pbg 03	7.5	3.7	530	114	20	49	7.0
Pbg 04	7.1	3.6	584	58	14	39	6.1
Pbg 05	5.6	2.8	606	118	18	50	4.7
Pbg 06	8.5	4.2	1920	46	17	46	2.2
Pbg 07	9.0	4.5	652	122	16	51	6.9
Pbg 08	12.7	6.4	886	26	15	53	7.2
Pbg 09	10.5	5.3	612	74	17	53	8.6
Pbg 10	12.8	6.4	544	20	18	54	11.8
n	10	10	10	10	10	10	10
mean	9.7	4.9	797.8	79	17.6	50	6.9
sd	2.9	1.4	426.4	47.9	2.4	4.8	2.5
min	5.6	2.8	530	20	14	39	2.2
max	14.6	7.3	1920	164	22	56	11.8
Site: Balimbing Reef Flat							
Blb01	9.1	4.6	840	164	17	61	5.4
Blb02	9.5	4.8	940	182	17	69	5.1
Blb03	17.3	8.6	782	100	18	62	11.0
Blb04	11.8	5.9	684	108	10	42	8.6
Blb05	8.8	4.4	692	138	11	48	6.3
n	5	5	5	5	5	5	5
mean	11.3	5.6	787.6	138.4	14.6	56.4	7.3
sd	3.5	1.8	107.1	35.2	3.8	11.1	2.5
min	8.8	4.4	684	100	10	42	5.1
max	17.3	8.6	940	182	18	69	11.0

Table 8. Cont'd

Stn	Fish Biom 1 (mt/km^2)	Fish Biom 2 (kg/500m^2)	Fish Abund (ind/500m^2)	Juv Abund (ind/500m^2)	No. of Fam	No. of spp	Ave. wt. (g/ind)
Site: Sugala Coast (Batu-Batu)							
Sgl 06	16.0	8.0	1324	152	11	45	6.0
Sgl 07	20.4	10.2	1104	274	18	64	9.3
Sgl 08	26.4	13.2	1112	132	19	55	11.9
Sgl 09	16.5	8.3	880	246	17	55	9.4
Sgl 10	26.6	13.3	932	44	18	59	14.3
Sgl 11	22.2	11.1	1962	574	19	53	5.7
Sgl 12	9.2	4.6	916	172	17	59	5.0
Sgl 13	11.8	5.9	916	32	18	57	6.5
Sgl 14	29.8	14.9	992	48	18	64	15.0
n	9	9	9	9	9	9	9
mean	19.9	9.9	1126.4	186	17.2	56.8	9.2
sd	7.1	3.5	343.3	169.2	2.4	5.8	3.8
min	9.2	4.6	880	32	11	45	5.0
max	29.8	14.9	1962	574	19	64	15.0
Site: Simunul Is.							
Sml 01	22.2	11.1	804	114	19	67	13.8
Sml 02	43.0	21.5	1388	50	23	52	15.5
Sml 03	15.1	7.6	552	50	23	63	13.7
Sml 04	24.9	12.5	1104	82	16	65	11.3
Sml 05	11.3	5.7	558	58	17	68	10.1
Sml 06	39.3	19.6	656	20	20	58	29.9
n	6	6	6	6	6	6	6
mean	26.0	13.0	843.7	62.3	19.7	62.2	15.7
sd	12.8	6.4	336.9	32.2	2.9	6.1	7.2
min	11.3	5.7	552	20	16	52	10.1
max	43.0	21.5	1388	114	23	68	29.9
All 4 Sites							
n	30	30	30	30	30	30	30
mean	16.3	8.1	903.9	117.7	17.4	55.5	9.4
sd	9.4	4.7	363.9	107.9	3.05	7.76	5.2
min	5.6	2.8	530	20	10	39	2.2
max	43.0	21.5	1962	574	23	69	29.9

Table 9. Comparison of the top ten fish families in each of the four sites surveyed in the Tawi-Tawi focal area in July-August 2004. Note: Values presented are the ranks of the various families in the respective sites.

Family	Pababag	Simunul	Balimbing	Sugala
Labridae	1	3	2	2
Pomacentridae	2	1	1	1
Apogonidae	3	6	3	4
Clupeidae	4			
Scaridae	5	7	4	7
Chaetodontidae	6	4		6
Pomacanthidae	7	8		
Acanthuridae	8	5		8
Gobiidae	9		5	
Tetraodontidae	10		10	
Serranidae-Anthiinae		2	7	
Scombridae		9		
Balistidae		10		
Pinguipedidae			6	
Blennidae			8	
Nemipteridae			9	9
Plotosidae				3
Caesionidae				5
Centriscidae				10
Rel. Abund. of top 10 families	95.0	92.9	96.2	95.7
Total no. families*	33	30	24	33

Table 10. Comparison of the top 10 species in each of the four sites surveyed in the Tawi-Tawi focal area in July-August 2004. Note: Values presented are the ranks of the various species in the respective sites.

Species	Pababag	Simunul	Balimbing	Sugala
Cirrhilabrus cyanopleura	1	2	1	1
Archamia zosterophora	2			
Spratelloides gracilis ?	3			
Pomacentrus moluccensis	4		3	5
Cheilodipterus quinquelineatus	5		10	
Pomacentrus lepidogenys	6			4
Pomacentrus amboinensis	7		8	
Apogon parvulus	8			
Chrysiptera rollandi	9		5	9
Thalassoma lunare	10	10	6	7
Pomacentrus brachialis			7	
Chromis viridis			4	
Pseudanthias squamipinnis		1		
Pseudanthias huchtii		3		
Pomacentrus auriventris		4	2	
Pomachromis richardsonii		5		
Chaetodon kleinii		6		
Pomacentrus coelestis		7		
Ctenochaetus binotatus		8		
Dascyllus trimaculatus		9		
Chrysiptera parasema				3
Pomacentrus nagasakensis			9	
Amblyglyphidodon aureus				6
Pterocaesio tessellata				8
Plotosus lineatus				2
Amblyglyphidodon curacao				10
Rel Abund. Top 10 spp	59.8	58.0	50.2	52.0
Overall mean density	1.60	1.69	1.58	2.25
Overall mean Abundance	797.8	843.7	787.6	1126.4
Total no. spp	199	165	144	192

Table 11. Summary of biomass (kg/500m^2) estimates for target and other fish species groups recorded in the four sites surveyed in the Tawi-Tawi focal area in July-August 2004.

Stn	Target	Indicator	Caesio	Labrid	Pomacen	Scarid	Others	Total	Target % tot	Value % tot
Site: Pababag Is.										
Pbg01	0.86	0.03	0.00	1.15	0.34	0.15	4.75	7.28	11.9	14.0
Pbg02	0.67	0.12	0.00	0.71	0.23	0.33	2.55	4.60	14.6	21.8
Pbg03	0.38	0.25	0.00	1.16	0.00	0.09	1.83	3.72	10.3	12.7
Pbg04	0.43	0.04	0.00	1.17	0.75	0.13	1.04	3.56	11.9	15.5
Pbg05	0.32	0.04	0.00	1.16	0.09	0.53	0.68	2.82	11.3	30.1
Pbg06	0.38	0.01	0.00	0.61	0.64	0.10	2.49	4.23	9.1	11.4
Pbg07	0.48	0.26	0.00	1.08	0.65	1.10	0.92	4.49	10.7	35.2
Pbg08	1.31	1.75	0.00	1.54	0.58	0.04	1.15	6.37	20.5	21.1
Pbg09	0.35	0.47	0.00	1.13	0.78	0.80	1.74	5.26	6.6	21.8
Pbg10	0.41	0.34	0.00	1.44	0.41	2.79	1.02	6.41	6.4	49.9
n	10	10	10	10	10	10	10	10	10	10
mean	0.56	0.33	0.00	1.11	0.45	0.61	1.82	4.87	11.3	23.4
sd	0.31	0.52	0.00	0.28	0.28	0.84	1.22	1.43	4.1	12.0
%tot Ab	*2.5*	*1.4*	*0.0*	*28.8*	*20.5*	*2.1*	*44.6*			
Site: Simunul Is.										
Sml01	2.57	0.75	0.00	1.59	0.84	0.34	5.15	11.24	22.9	25.8
Sml02	3.46	0.59	0.09	1.67	0.82	1.42	13.45	21.51	16.1	23.1
Sml03	0.83	0.34	0.00	0.90	0.41	0.02	5.26	7.77	10.7	10.9
Sml04	3.41	0.70	0.00	2.20	0.23	1.19	4.72	12.45	27.4	36.9
Sml05	1.83	0.48	0.00	1.44	0.27	0.41	1.40	5.83	31.4	38.5
Sml06	3.58	0.73	0.42	1.47	1.36	4.25	7.82	19.63	18.3	42.0
n	6	6	6	6	6	6	6	6	6	6
mean	2.61	0.60	0.09	1.55	0.65	1.27	6.30	13.07	21.1	29.6
sd	1.10	0.16	0.17	0.42	0.43	1.55	4.06	6.30	7.6	11.8
%tot Ab	*29.4*	*4.6*	*0.4*	*23.5*	*28.1*	*2.2*	*11.9*			

Table 11. Cont'd.

Stn	Target	Indicator	Caesio	Labrid	Pomacen	Scarid	Others	Total	Target % tot	Value % tot
Site: Balimbing Reef Flat										
Blb01	0.24	0.11	0.00	1.95	0.52	0.77	0.98	4.57	5.3	22.2
Blb02	0.32	0.00	0.00	2.01	0.21	0.61	1.60	4.75	6.6	19.4
Blb03	2.43	0.19	0.00	2.44	0.71	1.37	1.48	8.63	28.2	44.1
Blb04	0.54	0.07	0.00	3.91	0.54	0.34	0.47	5.89	9.2	15.1
Blb05	0.00	0.00	0.00	1.99	0.71	0.78	0.91	4.38	0.0	17.8
n	5	5	5	5	5	5	5	5	5	5
mean	0.71	0.08	0.00	2.46	0.54	0.78	1.09	5.64	9.9	23.7
sd	0.98	0.08	0.00	0.84	0.20	0.38	0.46	1.77	10.8	11.7
%tot Ab	*2.5*	*0.6*	*0.0*	*34.1*	*43.5*	*3.0*	*16.3*			
Site: Sugala Coast										
Sgl06	0.12	0.02	4.20	1.32	1.36	0.43	0.54	7.99	1.5	59.4
Sgl07	0.59	0.63	3.05	1.95	0.76	2.06	1.19	10.22	5.8	55.8
Sgl08	2.85	0.10	1.49	2.64	0.29	0.15	5.68	13.21	21.5	34.0
Sgl09	0.46	0.36	2.43	1.63	0.80	0.50	2.08	8.26	5.6	41.0
Sgl10	1.92	0.37	2.57	2.47	1.22	3.18	1.57	13.30	14.4	57.7
Sgl11	2.26	0.44	0.00	1.04	3.21	1.16	2.99	11.11	20.4	30.8
Sgl12	1.01	0.24	0.00	1.31	0.77	0.60	0.66	4.59	21.9	35.1
Sgl13	0.37	0.47	0.05	1.25	1.25	0.02	2.50	5.91	6.3	7.5
Sgl14	0.68	0.20	0.22	2.39	2.57	1.50	7.33	14.89	4.6	16.1
n	9	9	9	9	9	9	9	9	9	9
mean	1.14	0.31	1.55	1.78	1.36	1.07	2.73	9.94	11.3	37.5
sd	0.96	0.19	1.58	0.60	0.94	1.03	2.32	3.53	8.2	18.2
%tot Ab	*2.1*	*1.7*	*7.0*	*21.0*	*43.6*	*1.6*	*23.0*			
All 4 sites										
n	30	30	30	30	30	30	30	30	30	30
mean	1.17	0.34	0.48	1.62	0.78	0.91	2.87	8.16	13.1	28.9
sd	1.11	0.36	1.10	0.69	0.68	1.01	2.86	4.70	8.2	14.7
median	0.63	0.25	0.00	1.46	0.68	0.57	1.67	6.39	11.0	24.5
min	0.00	0.00	0.00	0.61	0.00	0.02	0.47	2.82	0.0	7.5
max	3.58	1.75	4.20	3.91	3.21	4.25	13.45	21.51	31.4	59.4
%tot Ab	*7.4*	*2.0*	*2.7*	*25.7*	*33.9*	*2.1*	*26.3*			

Table 12. Results of the forward stepwise multiple regression of the various reef fish parameters and abundances (ln-transformed) on physical habitat and lifeform variables characterizing reefs in the Tawi-Tawi focal area in July-August 2004. Note: Values shown are the standardized beta coefficients of factors showing significant (a = 0.10) contributions to overall regression. Multiplier r^2 indicates the proportion of total variation explained by the regression.

	Fish Biom	**Fish Den**	**Fish Abund**	**Juv Den**	**Juv Abund**	**No. of Fam**	**No. of spp**	**Ave. wt.**	**Target Spp Abund**	**Juv Pomacen**	**Juv Gobiid**
Multiplier r^2	0.500	0.617	0.638	0.735	0.684	0.467	0.662	0.539	0.456	0.734	0.257
Physical Relief								2.294			
Bottom Z						1.619		-1.970			
Slope	0.674	0.711	0.695		0.400				0.457	0.979	-0.330
Rugosity		0.401	0.412	0.825	0.653					0.519	0.296
Transect Z		-0.409	-0.407	-0.315	-0.316						
Visibility		-0.291	-0.290		-0.296						
Live Hard		0.283	0.291							0.537	
Live Soft	-0.313			0.294	0.644		-0.395			0.790	
Dead Coral						-0.296			-0.337		0.293
DCA		-0.706	-0.743								
Other Algae					0.426	-0.425	-0.494			0.591	
Abiotic							0.487	0.413			
Other Biota					0.397					0.500	

Table 12. Cont'd.

	Caesio	Serra	Pomacen	Plotos	Mullid	Scarid	Chaeto	Siganid	Labrid	Zanclid	Apogon	Acanth
Multiplier r^2	0.675	0.878	0.524	0.573	0.418	0.342	0.504	0.307	0.408	0.281	0.477	0.562
Physical Relief	2.911	-1.355										0.745
Bottom Z		2.653					1.065		2.054			
Slope	0.711			0.707					-1.000			
Rugosity			0.281	0.478	-0.455	0.442		0.554				
Transect Z			-0.540	-0.336	0.239							
Visibility	-0.616	-0.274										
Live Hard			0.550								1.216	
Live Soft			0.155			0.046	-0.274			-0.362	0.661	-0.441
Dead Coral	0.290	-0.280		-0.284	-0.284	0.329	-0.335					
DCA	-0.419	-0.361			0.563							
Other Algae	-3.061	0.355										
Abiotic		-0.481										

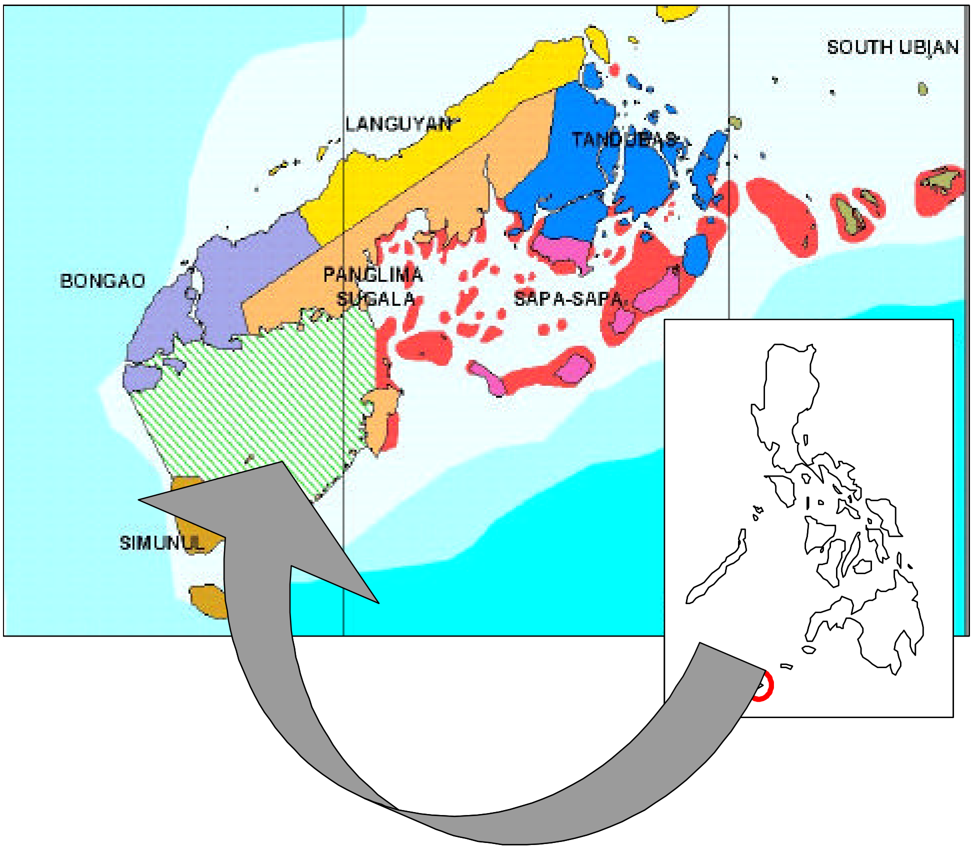

Fig. 1. Map showing the Bongao-Simunul-Sugala focal area in Tawi-Tawi (hatched green area).

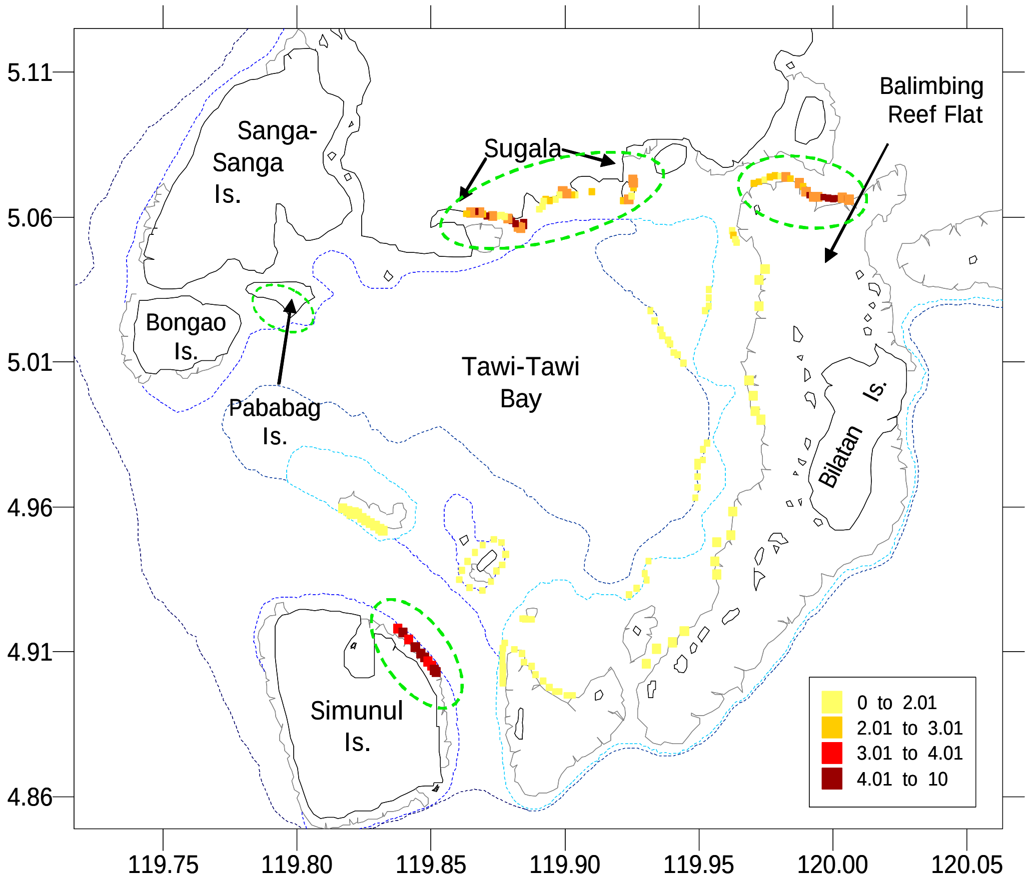

Fig. 2. Map showing the results of the manta tow survey and the dive site locations (green dashed ellipses) in Tawi-Tawi in July-August 2004.

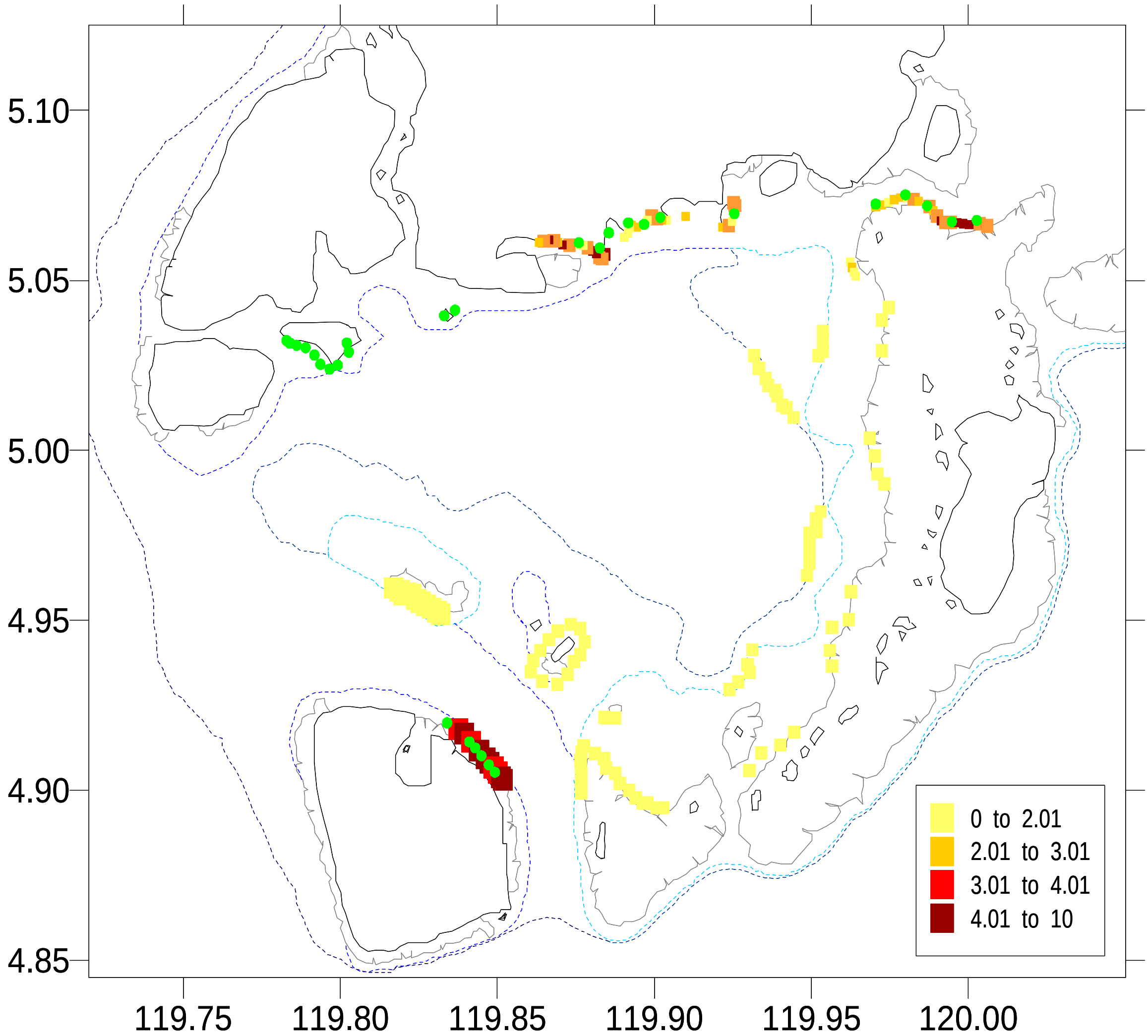

Fig. 3. Map showing the location of the thirty (30) dive stations (green dots) in the Tawi-Tawi focal area in July-August 2004. Note: Manta tow results are superimposed.

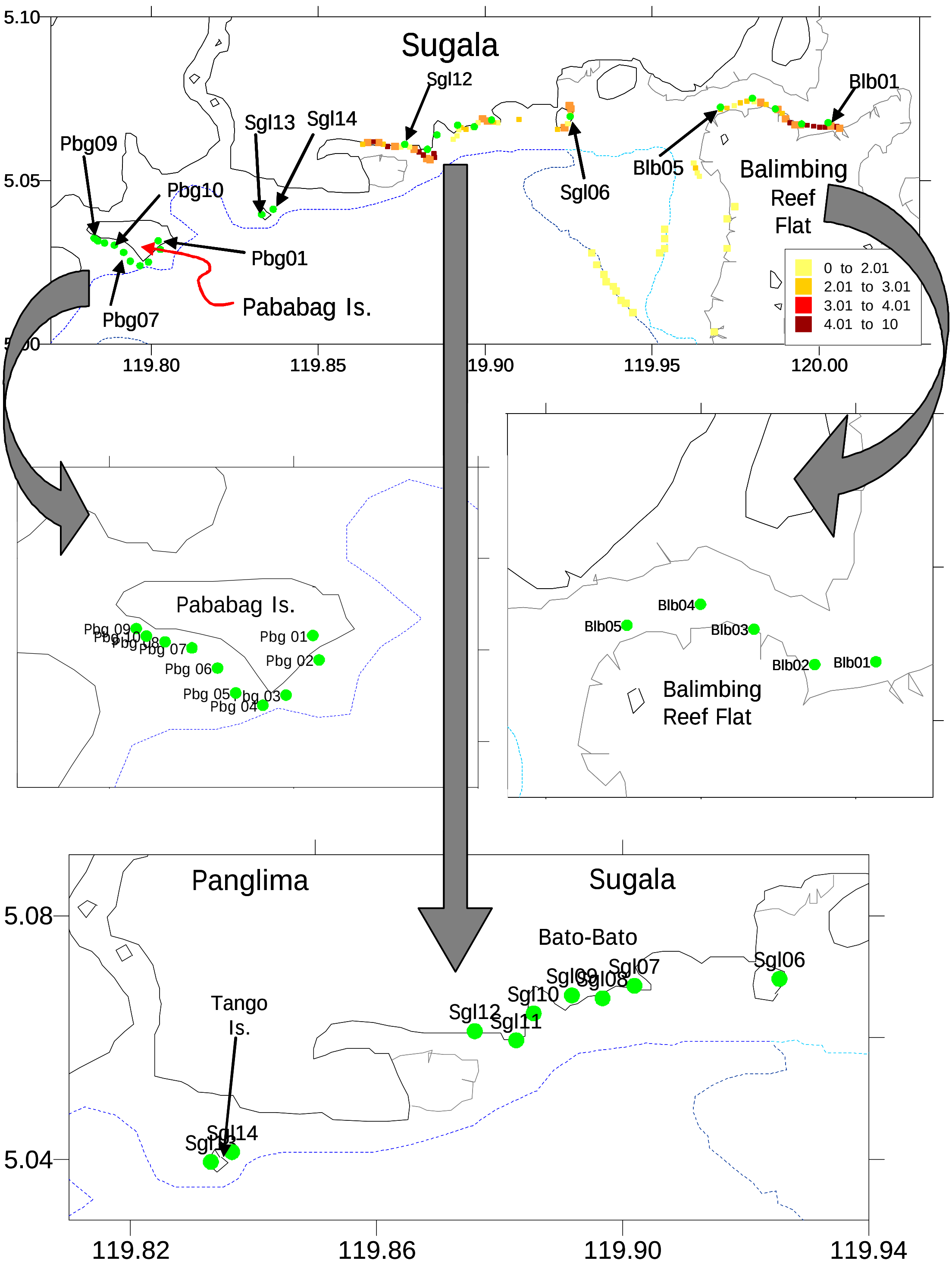

Fig. 4a. Specific dive station locations in the northern portion of Tawi-Tawi in July-August 2004. Note: Green dots indicate stations. Initial manta tow results are superimposed.

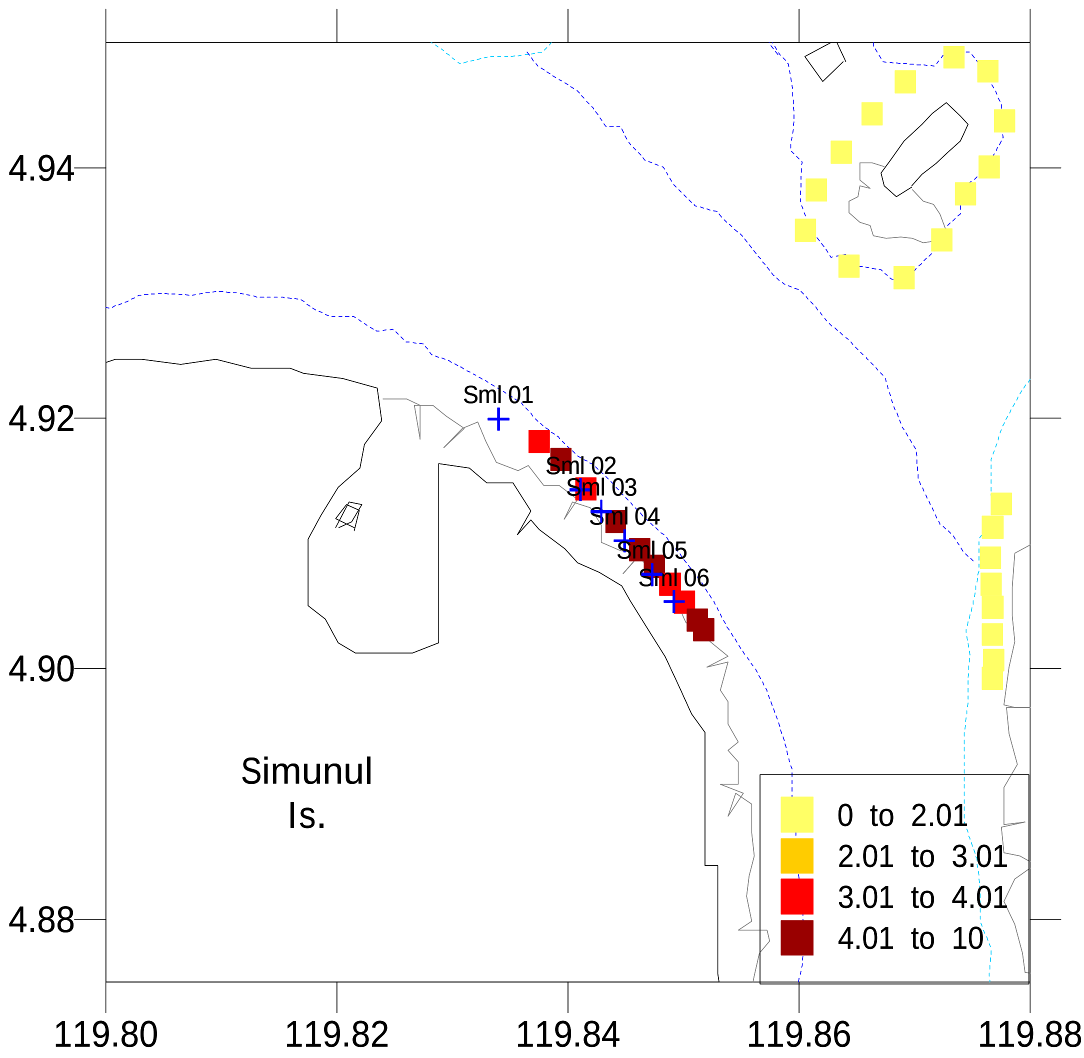

Fig. 4b. Specific dive station locations in the southern portion of Tawi-Tawi off Simunul Is. in July-August 2004. Note: Initial manta tow results are superimposed. Blue crosses indicate stations.

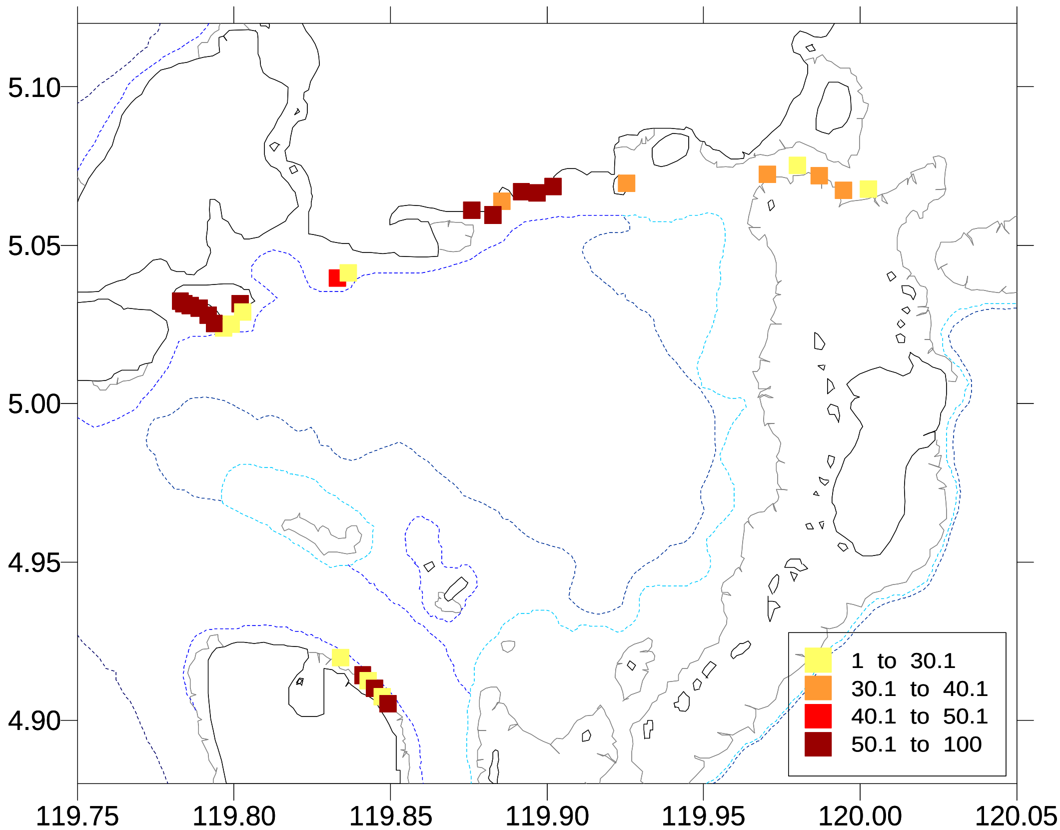

Fig. 5a. The distribution of live hard coral cover (%) (from PIT) in the 30 stations surveyed in Tawi-Tawi in July-August 2004.

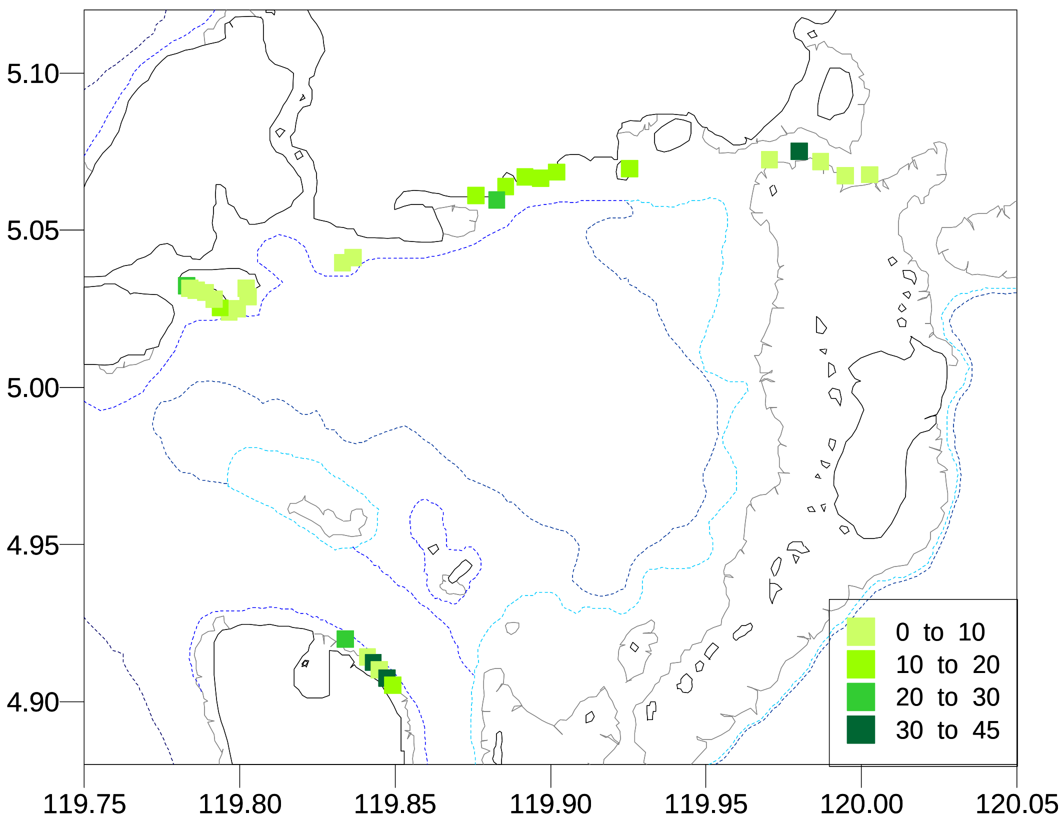

Fig. 5b. The distribution of all algae (dead coral w/ algae + other algae) in the 30 stations surveyed in Tawi-Tawi in July-August 2004.

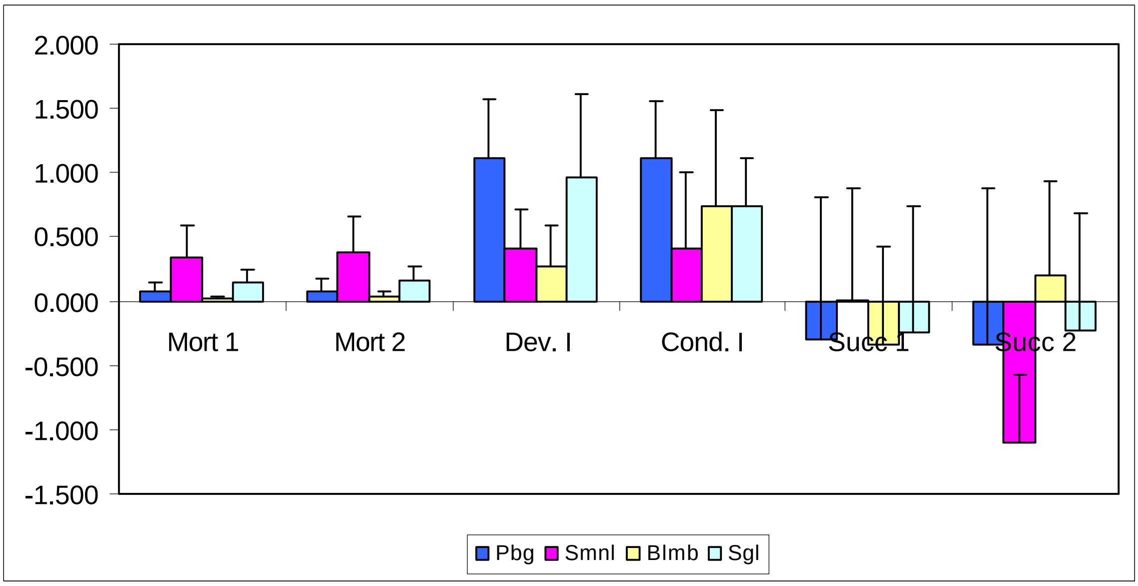

Fig. 6. Comparison of Coral Population Indices among the four sites surveyed in Tawi-Tawi in July-August 2004.

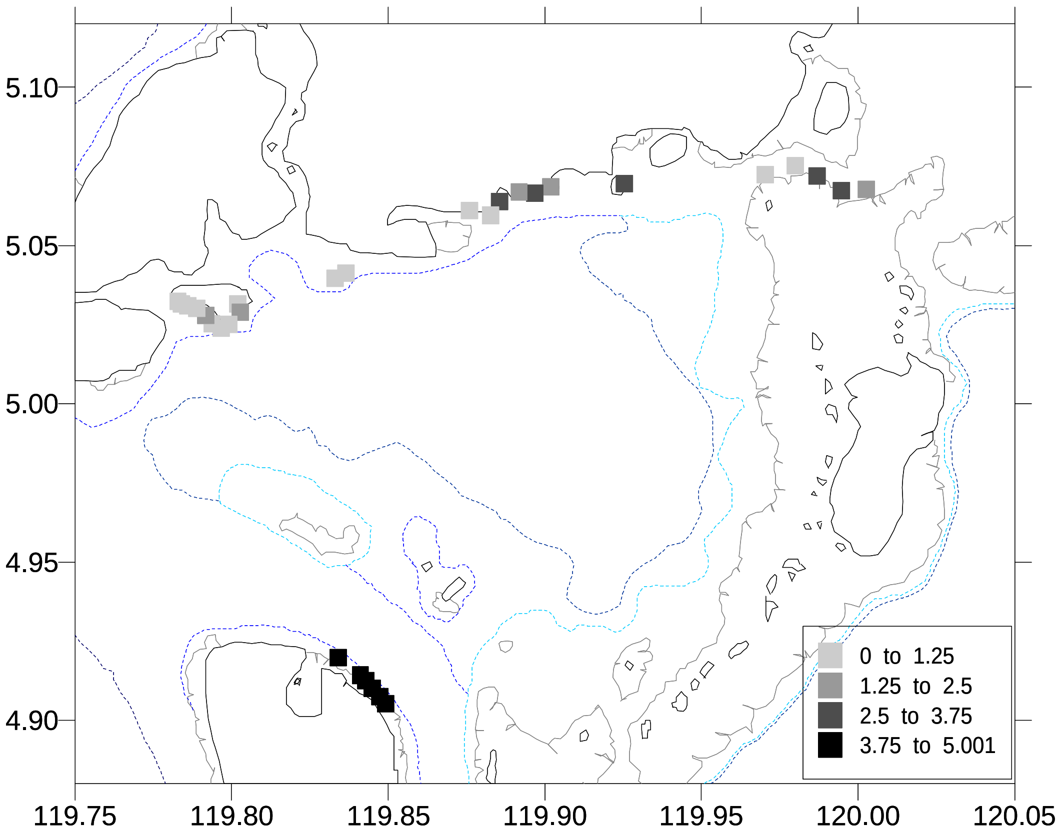

Fig. 7. Map showing the spatial distribution of estimated reef slope inclination (scaled, see text for explanation) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

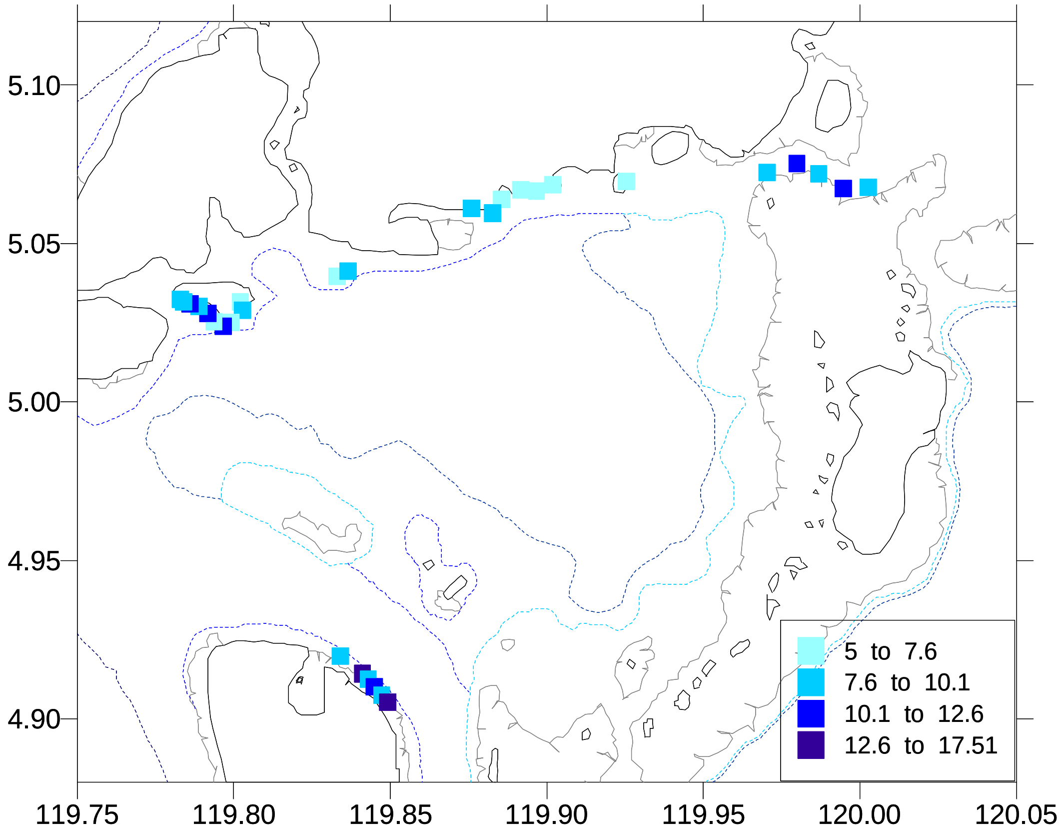

Fig. 8. Map showing the distribution of visibility (m) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

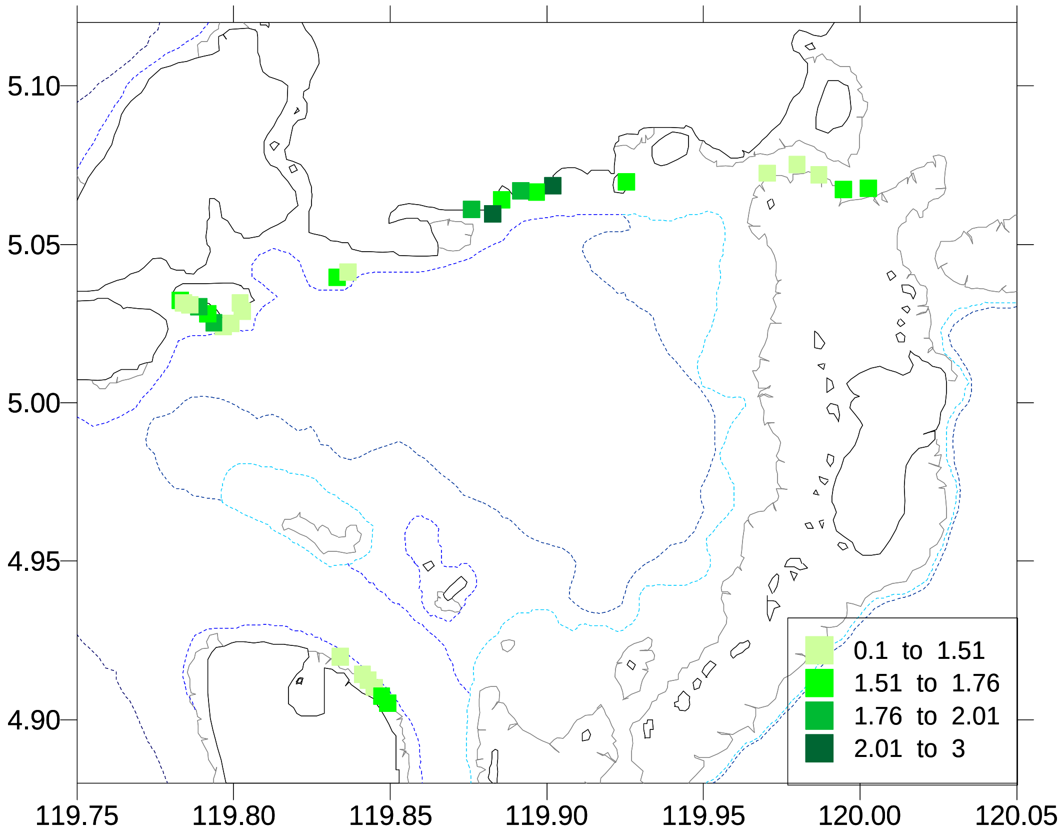

Fig. 9. Map showing the distribution of rugosity in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

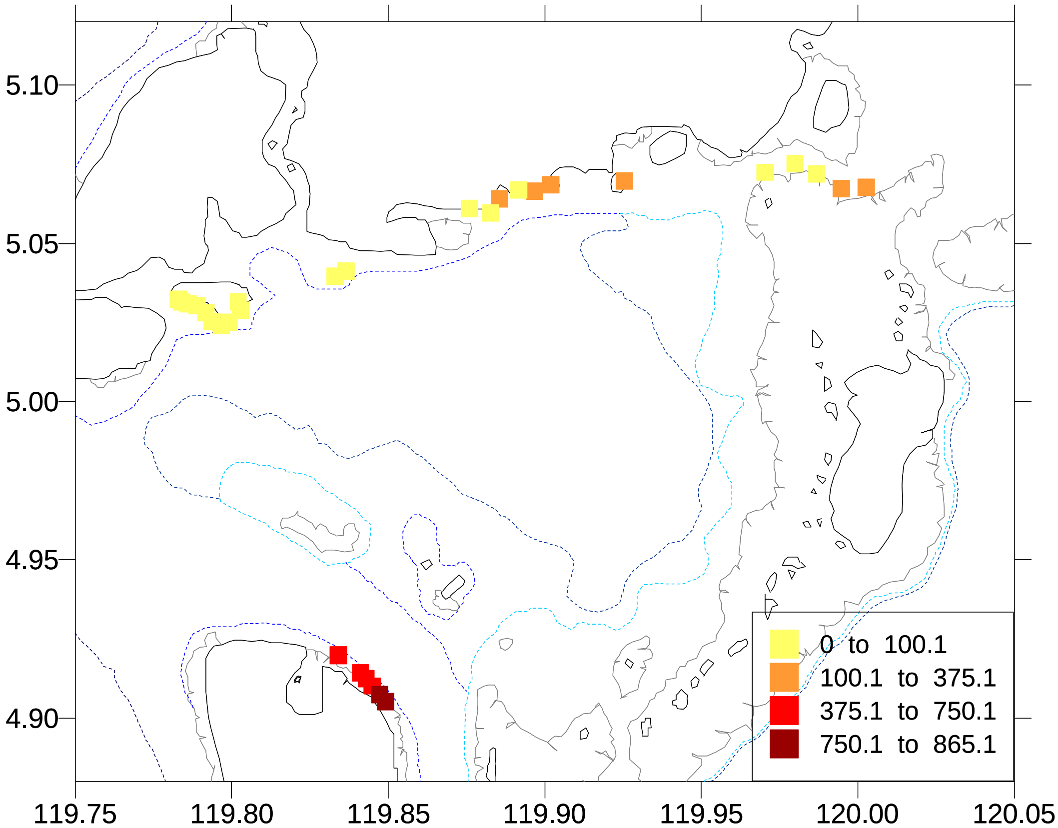

Fig. 10. Map showing the distribution of physical relief factor in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

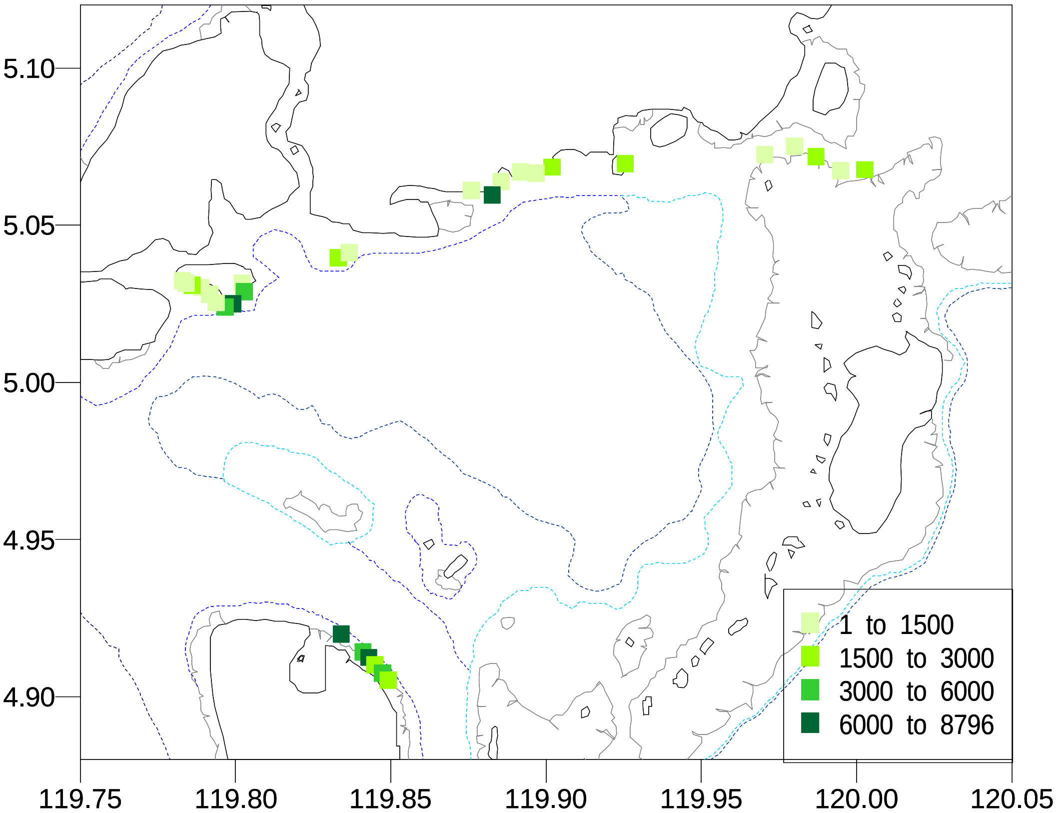

Fig. 11. Map showing the distribution of macroepifaunal abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

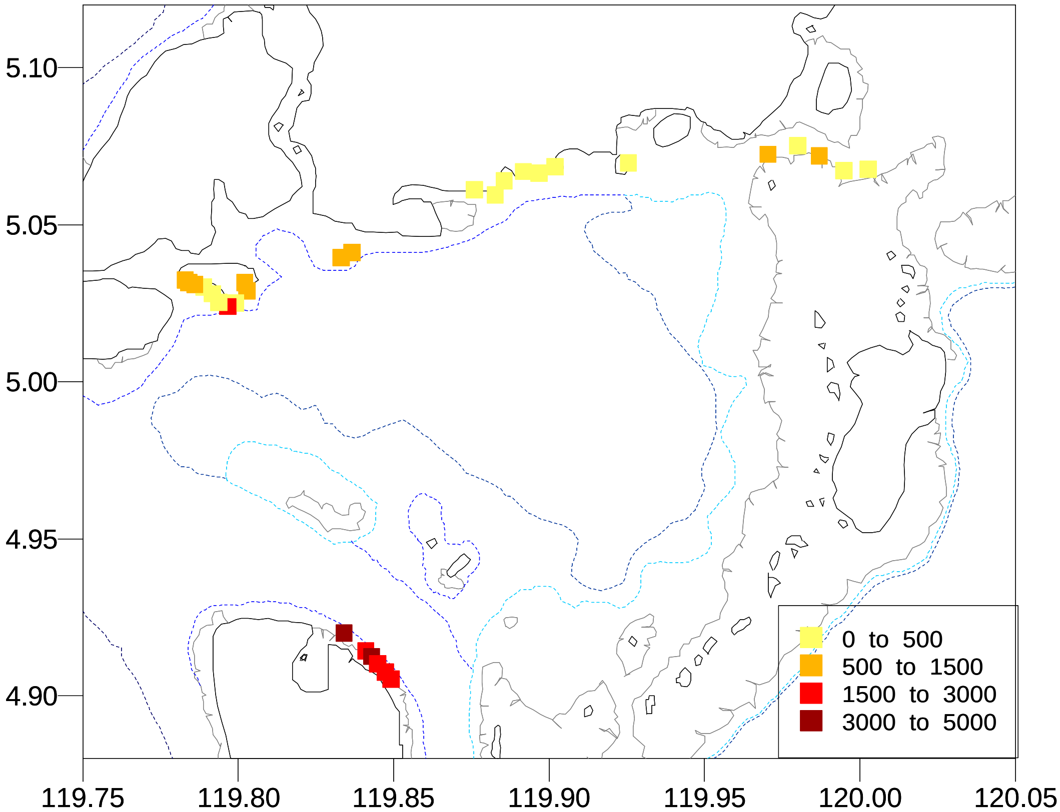

Fig. 12. Map showing the distribution of echinoid abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

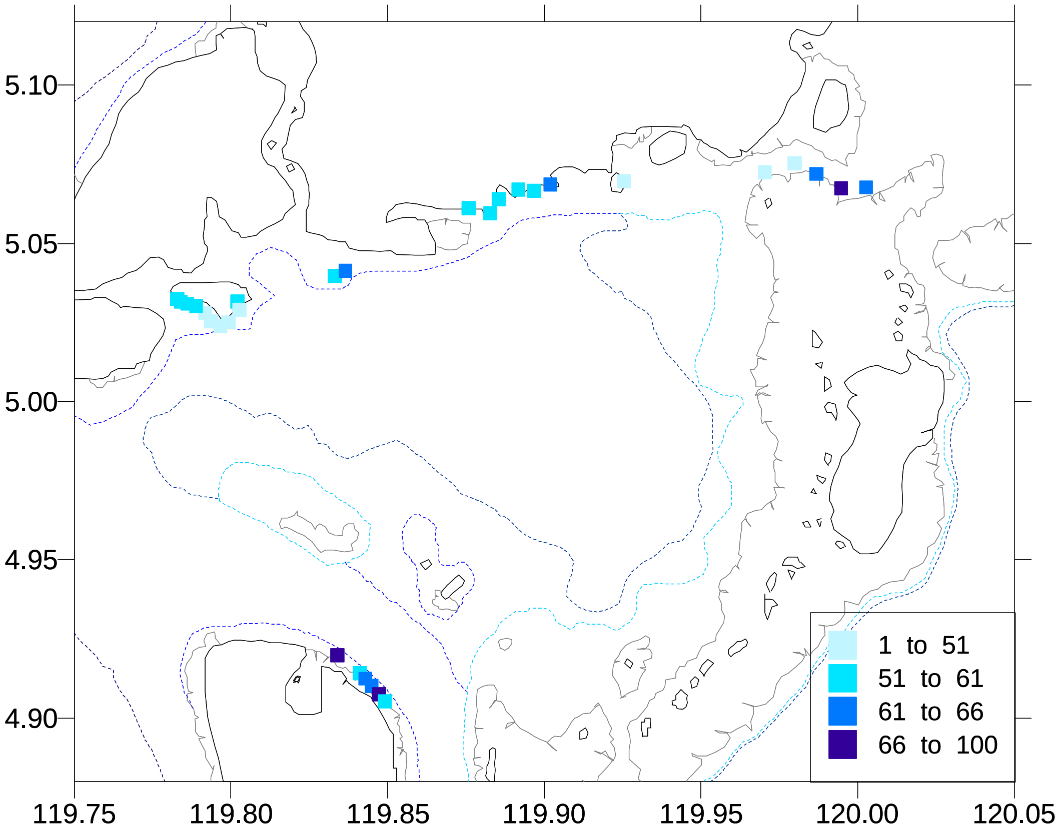

Fig. 13. Map showing the distribution of potential fish species richness (no. spp in 250m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

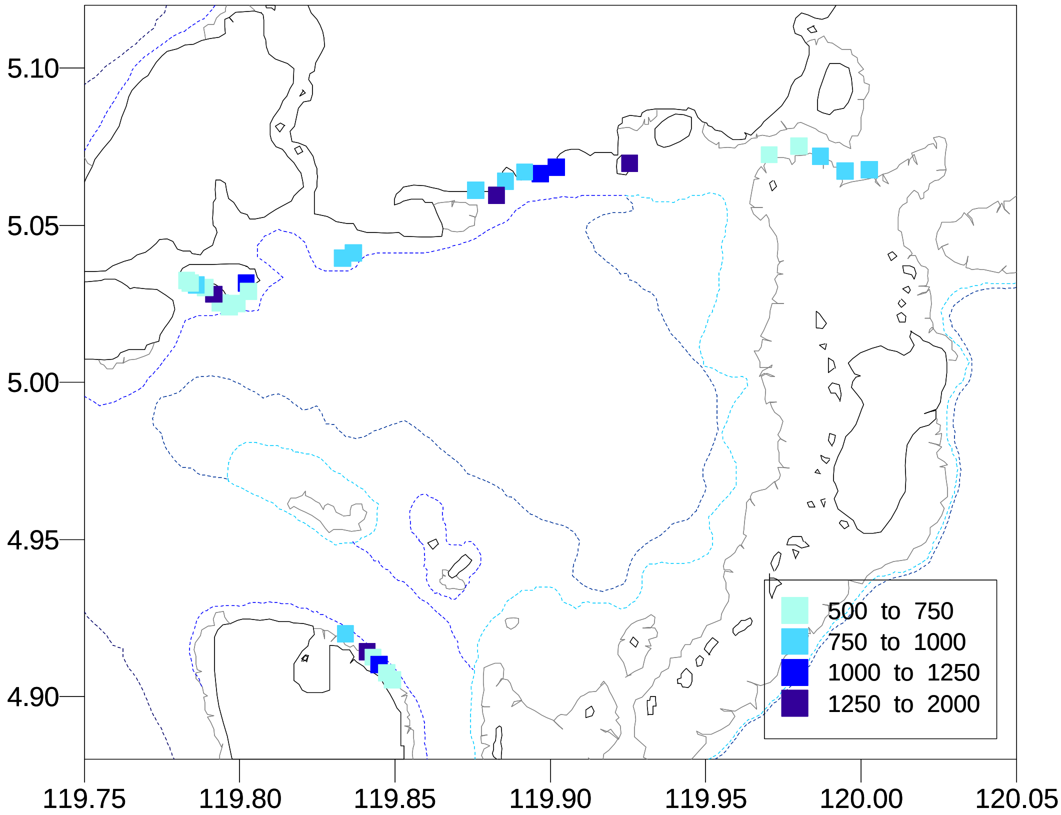

Fig. 14a. Map showing the distribution of overall fish abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

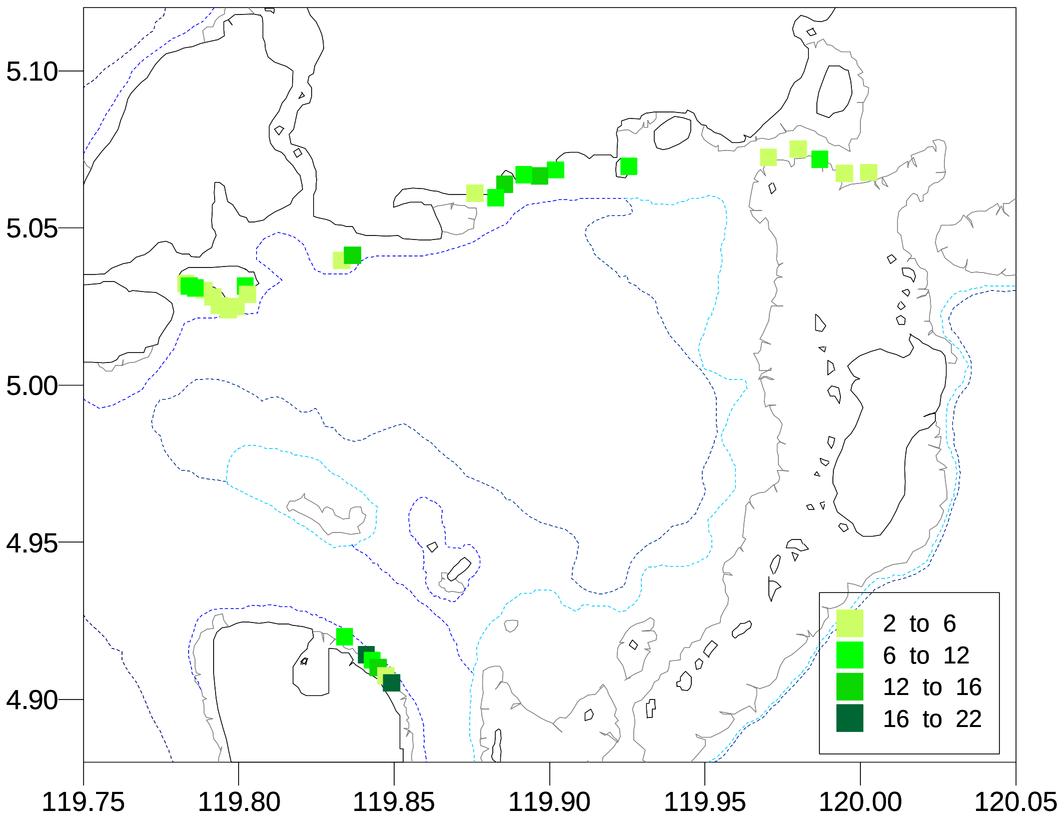

Fig. 14b. Map showing the distribution of fish biomass (kgs/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

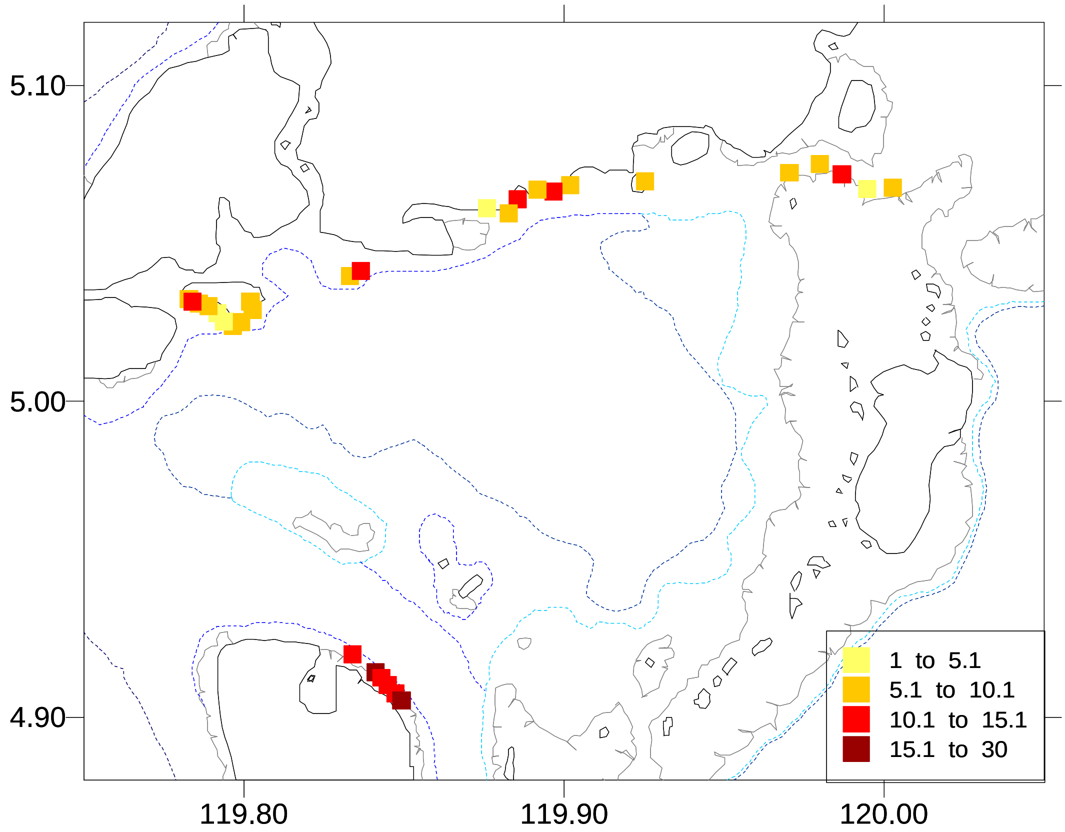

Fig. 15. Map showing the distribution of ave fish size (g/ind) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

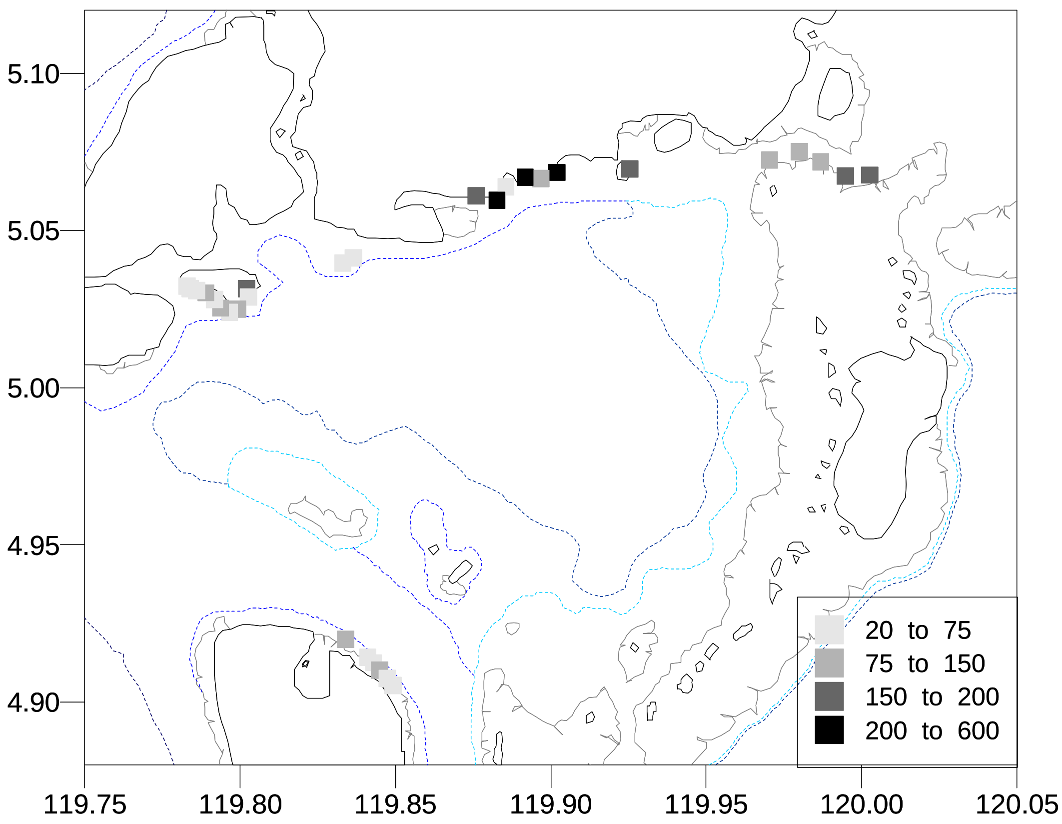

Fig. 16. Map showing the distribution of juvenile fish abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

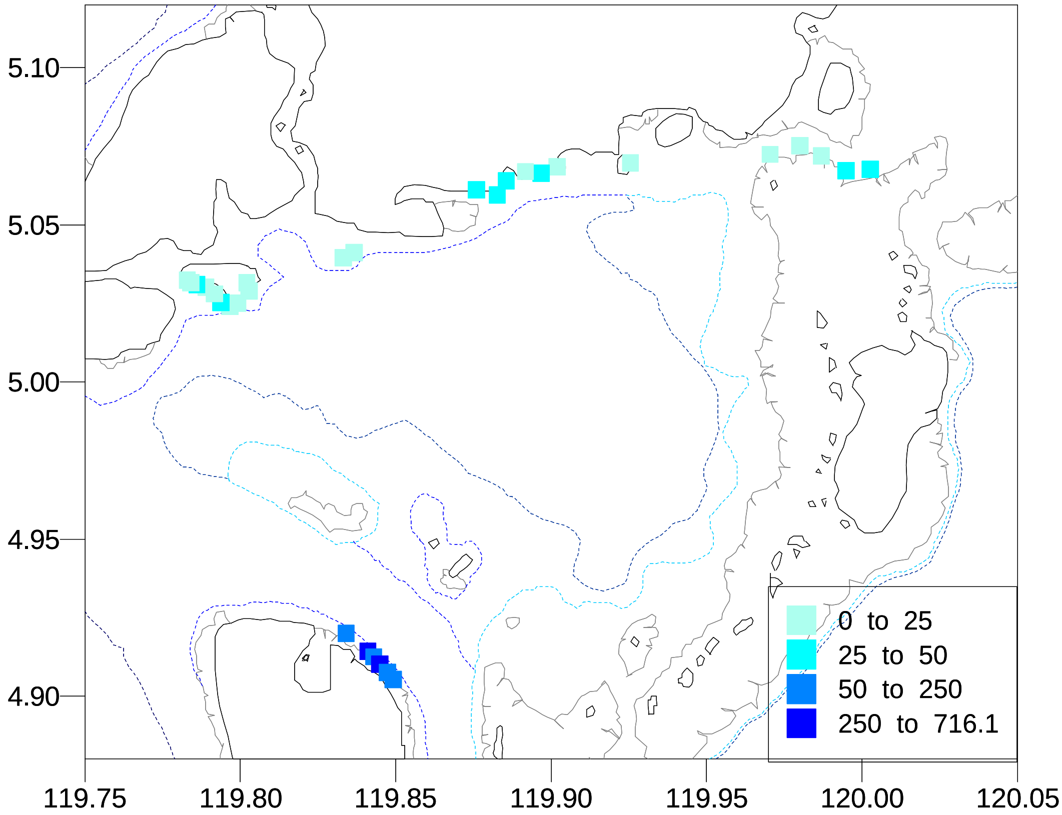

Fig. 17. Map showing the distribution of target fish abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

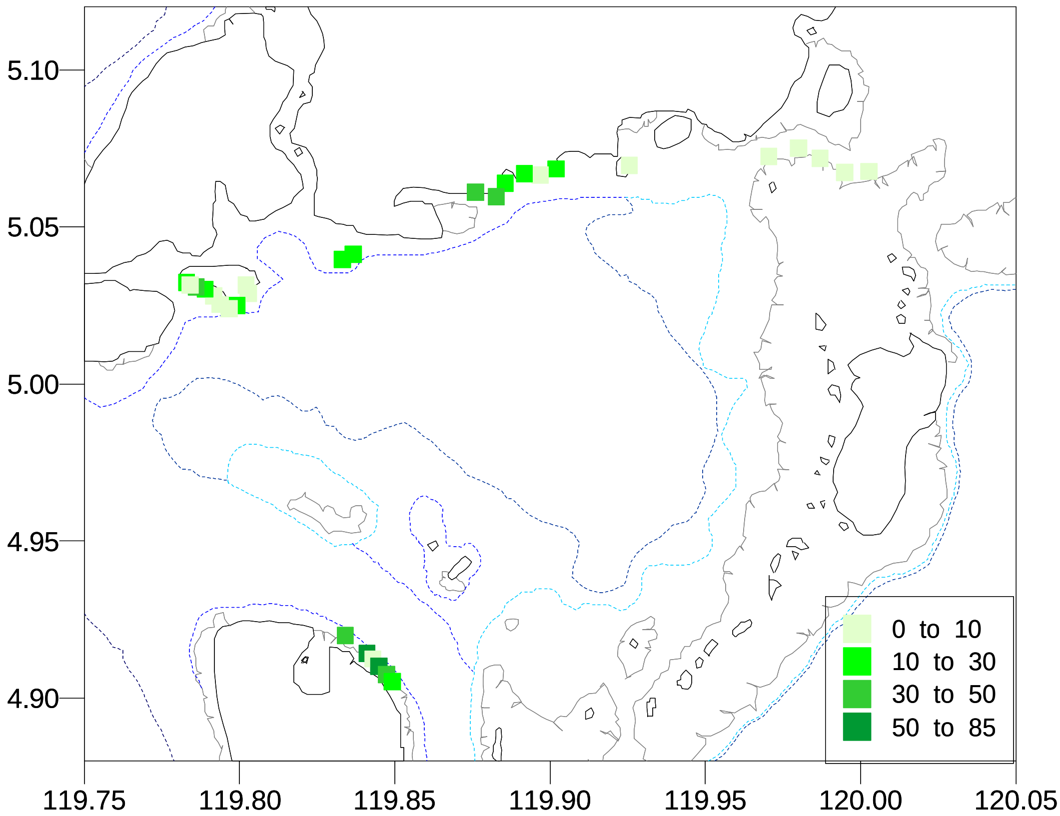

Fig. 18. Map showing the distribution of reef fish indicator (Chaetodontidae) species abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

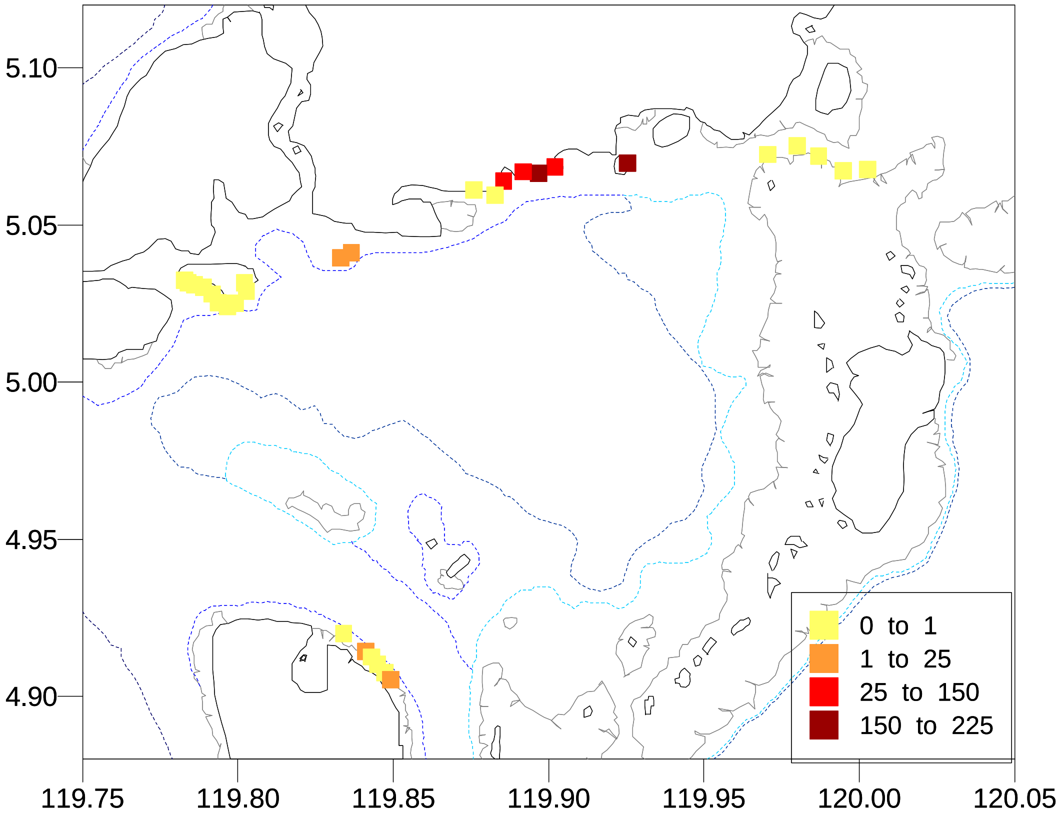

Fig. 19. Map showing the distribution of caesionid abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.

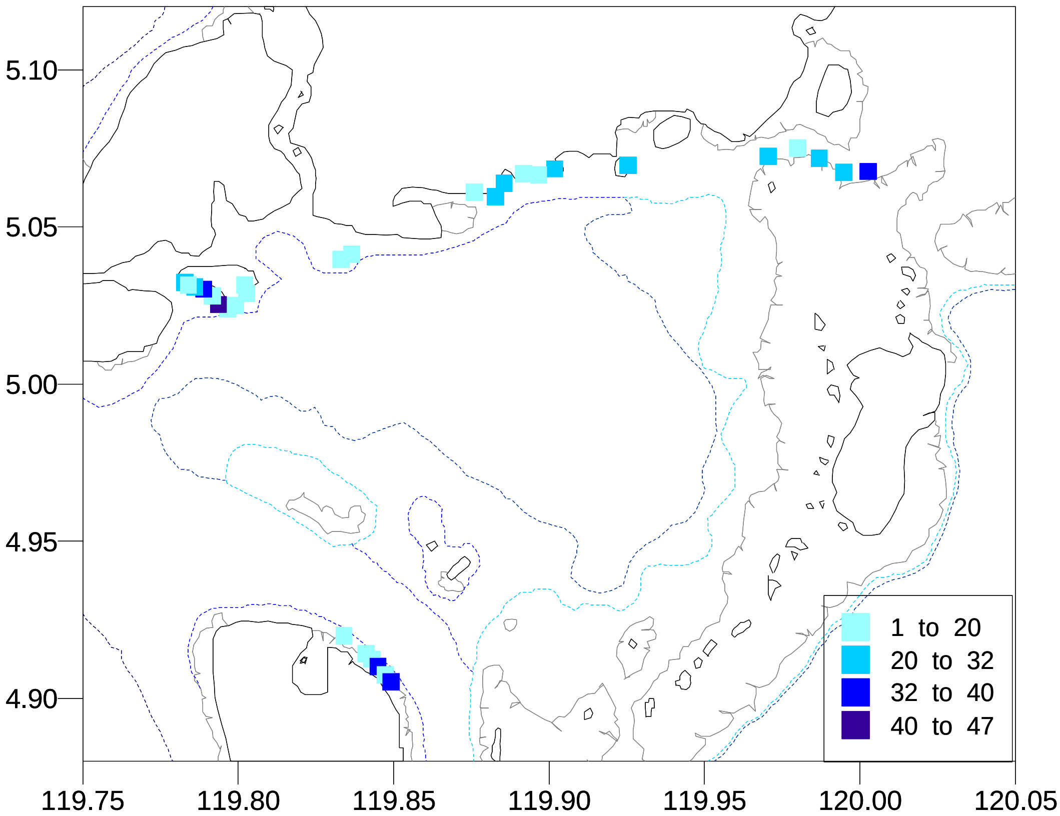

Fig. 20. Map showing the distribution of scarid abundance (ind/500m^2) in the 30 dive stations surveyed in Tawi-Tawi in July-August 2004.