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Indo-Pacific Division
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Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

Kofiau and Boo Islands Marine Protected Area (MPA) is located in Raja Ampat Regency, West Papua, Indonesia in the heart of the Coral Triangle. The reefs of Raja Ampat have the world's highest diversity of fish and corals and also sustain the livelihoods of local communities through fisheries production, tourism and other marine industries. Management and zoning plans are currently being developed for all seven of the MPAs in Raja Ampat, including Kofiau and Boo Islands.

Reef health monitoring was conducted in Kofiau and Boo Islands MPA in 2009, 2010 and 2011 to: (a) obtain data on the state of the coral reefs to guide the design of the zoning plan for the MPA; and (b) establish a strong baseline to assess the effectiveness of the zoning and management plans by comparing changes in benthic and fish communities in different zones over time. Coral reef monitoring followed the protocol by Wilson and Green (2009). Reef health was assessed by documenting the composition of the benthic and fish communities at 10m depth using point intercept transects and underwater visual census along transects plus a long swim, respectively. A total of 25 permanent monitoring locations and 16 additional monitoring locations were selected. In addition, seawater temperatures were monitored using eight *in situ* temperature loggers positioned near reefs throughout the MPA.

Despite overfishing pressure the fish communities in Kofiau and Boo Islands MPA are still in relatively healthy condition, compared to other parts of Indonesia. Average total fish biomass in the MPA was 35.4 kg/ha, with an average of 49.1 kg/ha in Boo Island and of 27.7 ha/kg in Kofiau Island, with highest fish biomass recorded in 2010. The MPA still has large size fish predators such as sharks, groupers and Napoleon wrasse (*Cheilinus undulatus*). However, fish biomass decreased at most sites from 2009 to 2010, especially for herbivores, and this may have been due to intensive fishing by outside fishers from December 2009 to January 2010. There has been a decrease in the number of sharks and rays in the MPA over monitoring years. White tip reef (*Trianodon obesus*), black tip reef (*Carcharhinus melanopterus*) and nurse sharks (*Nebrius ferrugineus*) were recorded in Kofiau and Boo Islands MPA, although numbers of sightings of have decreased from 2009 to 2011, indicating fishers are targeting shark species.

The majority of reefs in Kofiau and Boo Islands MPA are gently sloping fringing reefs surrounding the islands. Coral cover ranged from 9.2 to 78.0 % with highest cover seen infront of Deer Village (Kampung Deer). Sites at Boo Island had higher coral cover than reefs surrounding Kofiau Island. The average live hard coral cover for the MPA was 29.9%. There was no significant change in any of the benthic categories in the MPA between the monitoring years 2009 and 2011. A decrease in coral cover was recorded in 2010, but this is likely a result of using a different observer that year. Coral cover in recently declared no take zones was higher than in zones where fishing and other uses is allowed, which suggests that the zoning plan for Kofiau and Boo Islands MPA has been well designed by local communities, government and partners.

Minor coral bleaching was recorded in 2009, 2010 and 2011 but there was no apparent mortality (recorded as increase in rock cover). Bleaching surveys in 2011 showed that $<2\%$ of coral colonies were pale, $<3\%$ were bleached, and $<1\%$ were dead. Surface water temperature in Kofiau and Boo Islands MPA varies between 24.4^{0}C and 34.7^{0}C, and averaged 27.9^{0}C. In December 2010–February 2011, surface water temperature was 1–1.5^{o}C higher than other years and stayed betweeen 29–30^{o}C in many locations. The coral bleaching documented in April 2011 is thought to be associated with this extended period of warmer than nomal temperatures.

The results of the coral reef health monitoring suggest that the Kofiau and Boo Islands MPA zoning plan protects a number of sites with good fish and benthic communities inno take zones (NTZs) and these will act as fish banks and reserves for the spill over of larvae and adults to other areas. The

Traditional Use Zones (TUZs) also have high biomass of fish families that are a target for Kofiau residents and so they should still be able to have enough fisheries resources for their local needs. However, to address the declining fish biomass in Kofiau and Boo Islands MPA, it is important for local communities and enforcement agencies to actively enforce the zoning system – to both protect NTZs from any fishing activity and also ensure that the number of outside fishers and gear types are adequately managed in TUZs.

Photographs (from left to right and top to bottom): Aerial view of Walo Island and lagoon (M.Ammer/Papua Diving), coral reefs adjacent to mangrove habitats (M.Lazuardi/CI), example of typical fringing reef found at Kofiau (J.Yonover), abundant fish life in Kofiau (J.Yonover), coral reef monitors (J.Yonover), coral and fish life in Kofiau MPA (J.Yonover).

1. INTRODUCTION

The Raja Ampat Islands encompasses 4 million hectares of sea and land located in West Papua, Indonesia, right in the heart of the Coral Triangle. The Raja Ampat Islands are a part of the Bird's Head Seascape, which has the greatest coral reef biodiversity on the planet (Veron et al. 2009, Allen and Erdman 2009, 2012, Mangubhai et al. 2012) and is a global priority for conservation. Surveys have shown that the Raja Ampat waters are home to 553 species of coral, or 75% of the world's known species of hard coral, 699 species of mollusc, and 1,437 species of fish (Donnelly et al. 2002, Veron et al. 2009, Allen and Erdman 2009, 2012).

Coral reefs are extremely important to local communities because they support key fish and invertebrate (e.g. seacucumber and *Trochus*) fisheries. Like many Indonesian coastal people, the communities of Raja Ampat depend on their coral reefs as a source of food and income through fishing and tourism (Larsen et al. 2011). However, the health of corals and associated fisheries in Indonesia, including in Raja Ampat, are threatened by the use of destructive fishing methods such as explosives and poison, and overfishing (Ainsworth et al. 2008, Varkey et al. 2010, Mangubhai et al. 2012). Elevations in water surface temperature associated with climate change also a threat to reef ecosystems (Hoegh-Guldberg et al. 2007).

In recognition of the conservation values of coral reefs and their importance to sustaining the livelihoods of local people, a network of seven marine protected areas (MPAs)[1] covering over 1 million ha was established in Raja Ampat. Five of the seven MPAs were declared in 2007 by a Head of Raja Ampat Regency decree (No. 66/2007), and formalized by a Regency Regulation (No. 27/2008), and are hereafter referred to as Regency MPAs. In 2009, the Head of the Raja Ampat Regency issued a second Regency Regulation (No. 5/2009) to form the basis for the management of the Raja Ampat MPA network. The main aim of establishing the MPA network was to conserve fish habitats, reproduction function and stocks, to ensure sustainable fisheries and wise use of other marine resources, through education, research and eco-tourism in the Raja Ampat Regency. Kofiau and Boo Islands MPA, hereinafter referred to as Kofiau MPA, is one of these MPAs.

Under Indonesian law, MPAs allow for multiple uses which are regulated through management and zoning plans. In 2008, management and zoning plans were initiated for the five Regency MPAs, including Kofiau MPA. In October 2011, there was a traditional 'adat' declaration of the zoning plan for Kofiau MPA which was supported by the Regency government. The Kofiau MPA zoning plan is now actively being enforced by local community patrols supported by local police.

Coral reef health monitoring data is used to support the development of management and zoning plans and, when repeated over time, can be used to assess the effectiveness of zoning and management plans and inform adaptive management. Therefore reef health monitoring was conducted annually from 2009 to 2011 in Kofiau MPA. The objectives of reef health monitoring surveys in Kofiau MPA were to:

a. Gather basic data on benthic and fish communities to inform Kofiau MPA management and zoning plans.
b. Provide baseline data to evaluate the effectiveness of Kofiau MPA zoning and management systems.

[1] In this report, the term Marine Protected Area or MPA is used as it is stipulated in Law 27/2009.

2. METHODS

2.1. KOFIAU MARINE PROTECTED AREA

Kofiau MPA is located in southern Raja Ampat and encompasses 170,000 hectares of islands, reefs and surrounding waters (Figure 1a-b). Kofiau MPA provides food and livelihoods to the 2000 people living in five villages on the larger island of Kofiau. Ethnically, the people of Kofiau are Betieu with strong connections and language links to Biak in the northern Bird's Head. There are few livelihood options in the MPA, and the majority of residents fish or farm copra.

2.2. ZONING PLAN

The Kofiau MPA zoning plan was gazetted in October 2012 and include two types of zones (Figure 1b). The Food Security and Tourism Zone which prohibits extractive activities is called a no take zone (NTZ) for the purposes of this report. The Traditional Use Zone (TUZ) allows for fishing activities by local Kofiau residents. In the 2011 zoning plan, four areas within Kofiau MPA were designated as NTZs and all other areas are classified in two large TUZs – TUZ 1 encompasses all the sites around Kofiau Islands and the other while TUZ 2 includes sites from Boo Island.

2.3. LOCATION AND SITE SELECTION

Within Kofiau MPA, sites for reef health surveys were selected that were representative of the main reef type found thoughout the MPA. Sites were chosen to encompass both NTZs and TUZs although in 2009 the exact configuration of the zoning plan had not been decided. In 2009, 25 locations were designated as permanent reef monitoring locations, which are expected to be included in long-term monitoring programs. In 2009, 2010 and 2011, monitoring was carried out in seven, five and one additional sites, respectively, (Figure 1a, Appnedix 1) to get more detailed information about reef resilience as input to Kofiau MPA zoning and management plans. The data about reef resilience will be analysed and presented in a separate report (Mangubhai et al. in prep.).

2.4. REEF HEALTH MONITORING – FISH AND BENTHIC COMMUNITIES

Reef health was assessed in Kofiau MPA annually from 2009-2011 by measuring benthic and fish communities following coral reef health monitoring protocols developed by Wilson and Green (2009). Surveys were timed to occur at the same time each year during calm weather periods (March-April) after the northwest monsoon season (December – February) and before the southeast trade winds (June – September) (Table 1).

Table 1. Sampling details of Kofiau MPA from 2009-2011.

Year	Dates of sampling	No. of sites
2009	15-26 April	30
2010	16-26 March	32
2011	22-31 March	26

2.4.1. Fish community surveys

Fish density and biomass were monitored by underwater visual census (UVC), using a combination of belt transect and long swim methods detailed in Wilson and Green (2009). The taxa recorded were commercial fish targeted by fishers and pelagic species that have an association with coral reefs (Table 2). The number of families recorded was increased from 12 in 2009 to 18 in 2010. In 2011, the family Kyphosidae was added in response to the publication of the herbivore monitoring protocol (Green et al. 2009).

Belt transects

Fish community composition was assessed by UVC along five transects, each 50 m in length, at 10 m depth with species, number and estimated length of each fish recorded. All fish of the families in Table 2 were recorded. Fish with a total length of 10-35 cm were recorded in 5 m wide transects, 2.5 m to the left and right of the transect tapes. Fish with a total length of >35 cm were recorded in 20 m wide transects, 10 m to the left and right. In 2009 and 2001, one experienced fish observer recorded both size classes on one pass of the transects. In 2010, two fish observers were available and one recorded fish in small size classes and the other recorded fish in large size classes.

Long swims

Long swim fish surveys were performed after the fifth fish survey transect, at the reef crest at a depth of 2-5 m. The number and size of large fish >35 cm (same fish families as for transect surveys) were recorded while swimming adjacent to the reef crest for approximately 20 minutes. All fish seen 10 m either side of the surveyor were recorded. The timing of the swim was adjusted to the conditions to ensure the distance covered was at least 400 m. The exact length of the long swims was calculated by recording the position of buoys at the beginning and end of the long swim with a global positioning system (GPS) device. If there were difficulties tracking the long swim directly (e.g. if buoys were lost), the length of the long swim was calculated by drawing the route on the mapping program application ArcGIS 10. Visibility was also recorded during each survey.

Observer training

Prior to the field surveys, the observers were given training in identifying fish species and estimating fish length to bring their capacity up to standard of 100% accuracy for identification of the fish families in Table 2, and >75% accuracy of fish length estimation within 5 cm intervals. If the observer was unsure of the fish species, the family would be recorded instead.

Table 2. Fish families recorded during coral reef health monitoring in Kofiau MPA 2009–2011. (Key: + = recorded, - = not recorded, C = commercial fish, P = pelagic fish).

Fish family	Species recorded	Category	Year		
			2009	2010	2011
Acanthuridae	-	C	+	+	+
Caesionidae	+	-	-	+	+
Carangidae	+	P	+	+	+
Carcharhinidae	+	C	+	+	+
Dasyatidae	+	-	+	+	+
Ephippidae	+	-	-	+	+
Haemulidae	+	C	+	+	+
Hemigaleidae	+	C	-	+	+
Kyphosidae	+	C	-	-	+
Labridae	-	C	+	+	+
Lethrinidae	+	C	+	+	+
Lutjanidae	+	C	+	+	+
Muraenidae	+	-	-	+	+
Myliobatidae	+	-	-	+	+
Scarini	-	C	+	+	+
Scombridae	+	P	+	+	+
Serranidae	+	C	+	+	+
Siganidae	+	C	+	+	+
Sphyraenidae	+	P	-	+	+

Length to biomass conversion

Estimated fish length values were converted into fish biomass based on the relationship between length and weight for each fish family or species, using the formula developed by Kulbicki et al. (2005) of $W = aL^b$, where W = fish weight in grams (g), L = fish length or fork length (FL) in centimetres (cm), and *a* and *b* = biomass constants for each fish species or genus. The values for fish biomass constants (*a* and *b*) were obtained from Kulibicki et al. (2005) or Froese and Pauly (2012), and are listed in Appendix 2. In this report, total length is used to calculate the relationship between fish weight and length because this was easier to estimate or collect data on in the field. Fish biomass is mass per unit of area, so fish biomass can be calculated by converting fish weight in kilograms (1 kg = 1,000 g) per unit of area in hectares (1 ha = 10,000 m^2). Thus, average biomass can be calculated using the following formula:

$$Fish\ biomass\ (kg\ per\ ha) = \frac{Weight\ per\ sampling\ unit\ (kg)}{Area\ of\ sampling\ unit\ (m^2)} x10.000$$

2.4.2. Benthic community surveys

Benthic community data was collected using the point intercept transect (PIT) method, recording 100 substrate points along each of 3 x 50 m transects on fringing reef slopes at a depth of 10 m (Wilson and Green 2009). A total of 28 types of benthic cover were recorded (Table 3) which were subsequently grouped into seven categories for data analysis: hard coral live (HCL), soft coral (SC), algae (AL), available substrate for coral settlement (AS), mobile substrate (MS), other (OTH), and bleached coral (BC). Hard coral was recorded to life form level as *Acropora* or non-*Acropora*. In each year, different observers recorded benthic categories. All were trained and experienced observers of benthic community structure.

Table 3. Benthic categories recorded during coral reef health monitoring in Kofiau Marine Protected Area from 2009–2011.

Type of benthos	Code	Category
Acropora branching	ACB	Hard coral live
Acropora encrusting	ACE	Hard coral live
Acropora submassive	ACS	Hard coral live
Acropora tabulate	ACT	Hard coral live
Hard coral branching	CB	Hard coral live
Hard coral encrusting	CE	Hard coral live
Hard coral foliose	CF	Hard coral live
Hard coral massive	CM	Hard coral live
Hard coral submassive	CS	Hard coral live
Mushroom coral	CMR	Hard coral live
Tubipora (hard coral)	CTU	Hard coral live
Millepora (fire coral)	CME	Hard coral live
Heliopora (blue coral)	CHL	Hard coral live
Soft coral	SC	Soft coral
Xenia	XN	Soft coral
Halimeda spp.	HA	Algae
Macroalgae	MA	Algae
Turf algae	TA	Algae
Coralline algae	CA	Stable substrate
Rock	RCK	Stable substrate
Dead coral	DC	Stable substrate
Sand	S	Mobile substrate
Rubble	R	Mobile substrate
Silt	SI	Mobile substrate
Sponge	SP	Other
Hydroid	HY	Other
Other	OT	Other
Bleached coral	BC	Bleached coral

2.4.3. Data analysis – comparing zones

Fish biomass and benthic community data were analysed statistically to determine if there were any significant differences between years and between zones. Only permanent monitoring sites were used in the analysis, where three years of data were available. For fish biomass analyses, we chose those families which were recorded in all years. Differences were detected using a one way analysis of variance (ANOVA) using Systat Software. As the zoning plan had not yet been implemented, the analysis was set up to compare each zone area to every other zone area (i.e. NTZ 1, NTZ 2 etc.). The analysis was unbalanced because there was a variable number of sites within each zone area. When the ANOVA showed significant differences, post-hoc tests were used to determine which zone areas were significantly different from each other. We did not include NTZ 4 in the analysis because this is the submerged pinnacle and the habitat is very different to the other reefs around Kofiau and Boo and it was only surveyed in 2010.

2.5. LOCATION AND SITE SELECTION

2.5.1. Field surveys

Dedicated coral bleaching surveys were done in 2011, at the 25 permanent reef health monitoring sites (Figure 1a). The genera, size and bleaching condition of all coral colonies were recorded along three 15 m x 1 m belt transects at 5 and 10 m depth. Each colony was assigned a single bleaching condition category by estimating the percentage of each colony surface as normal, pale, bleaching or dead (Table 4). Coral bleaching surveys were carried out in 2009 and 2010 as part of coral reef resilience surveys in Kofiau MPA (Mangubhai et al. in prep.).

Table 4. Coral condition categories.

Colony condition	Other condition measure
Normal	- 50 - 100% colony surface is healthy with normal color
Pale	- 50 - 100% colony surface is still alive but paler than normal due to loss of some zooxanthallae
Bleaching	- Any part of colony surface has bleached tissue – tissue is still alive but completely white
Dead	- ≧ 50% of the colony surface is recently dead likely due to bleaching

2.5.2. Data analyses

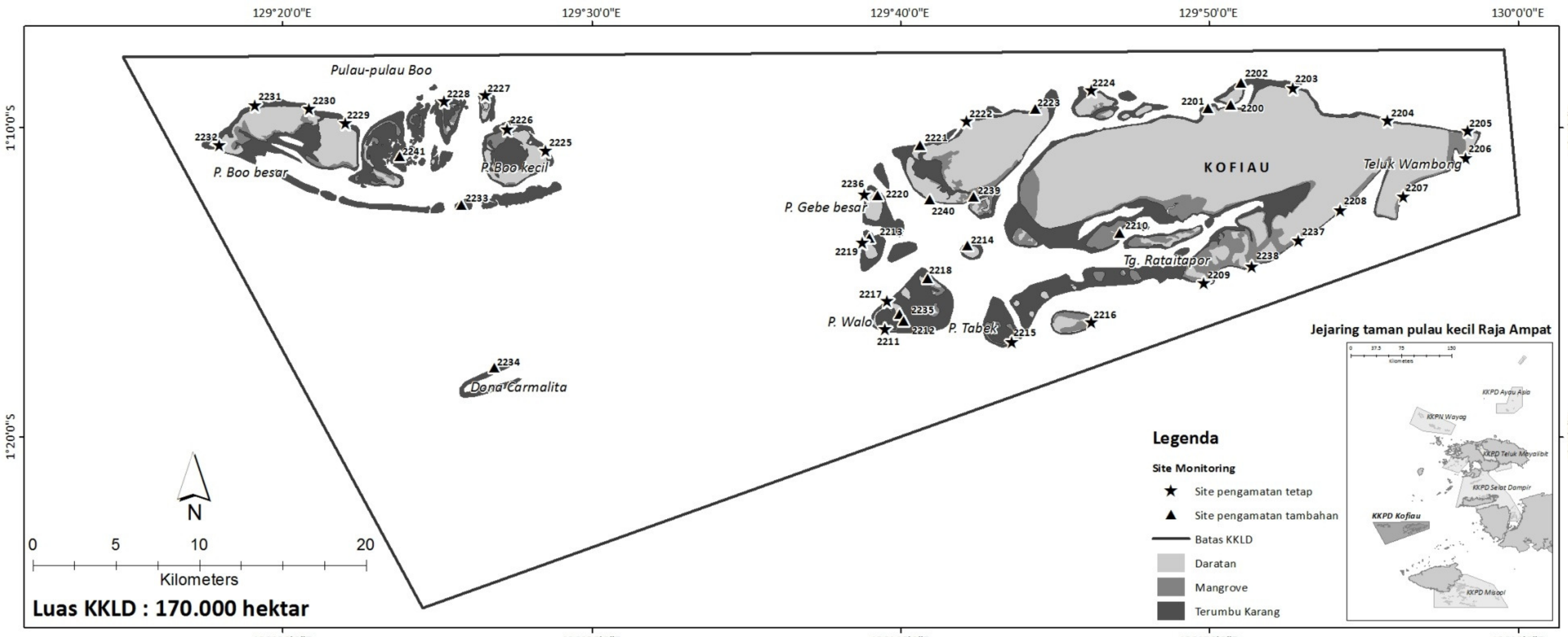
The incidence of bleaching was analysed by comparing differences among coral families and sampling sites. In addition, a regression of the percent of bleached colonies versus the proportion of the coral community made up of bleaching susceptible genera was done using Excel. Bleaching susceptible genera were defined as *Acropora, Montipora, Pocillopora, Seriatopora, Stylophora, Millepora* and *Astreopora* as per Marshall and Baird (2000).

2.6. SURFACE WATER TEMPERATURE

Surface water temperature was measured using HOBO Pro v2 (U22-001) water temperature data loggers. Eight temperature loggers were positioned at depths of between 2 m and 25 m in eight separate locations (Table 5) on reefs around Kofiau and Boo Islands. The temperature loggers were retreived and replaced at least once per year to download the data. The temperature loggers recorded surface water temperature at 15-minute intervals. This is the same recording interval as the other 78 temperature loggers installed throughout the Bird's Head Seascape, and managed by the State University of Papua and Conservation International. These data from Kofiau were used to identify periods when coral bleaching was likely to occur in the MPA.

Table 5. Locations of temperature loggers in Kofiau Marine Protected Area.

Name of location	Depth (m)	Coordinates	
		Latitude (South)	Longitude (East)
Boo Kecil Lagoon	2	01° 10.760'	129° 26.840'
Wamei	5	01° 10.106'	129° 58.375'
Wamei	25	01° 10.106'	129° 58.375'
Gebe Besar	5	01° 12.873'	129° 38.811'
Tanjung Lampu Boo Besar	22	01° 10.578'	129° 17.955'
Tanjung Lampu Boo Besar	5	01° 10.578'	129° 17.955'
Jailolo Besar	5	01° 08.809'	129° 46.354'
Rataitapor	5	01° 15.046'	129° 49.875'



SiteID	Site Name	Keterangan
2200	Kampung Deer	Site pengamatan tambahan
2201	Warmariar	Site pengamatan tambahan
2202	Tanjung Deer	Site pengamatan tambahan
2203	Twanyauhner	Site pengamatan tetap
2204	Yenmandur	Site pengamatan tetap
2205	Wamei	Site pengamatan tetap
2206	Wambong Kecil	Site pengamatan tetap
2207	Maet	Site pengamatan tetap
2208	Yenpapir	Site pengamatan tetap
2209	Rataitapor	Site pengamatan tetap
2210	Warturenmyotkuer	Site pengamatan tambahan
2211	Walo Bommoes	Site pengamatan tambahan
2212	Walo south	Site pengamatan tetap
2213	Gebe Kecil Wall	Site pengamatan tetap

SiteID	Site Name	Keterangan
2214	Karabas	Site pengamatan tambahan
2215	Tabek	Site pengamatan tetap
2216	Pamali	Site pengamatan tetap
2217	Walo	Site pengamatan tetap
2218	Cina	Site pengamatan tambahan
2219	Gebe Kecil	Site pengamatan tambahan
2220	Gebe Besar	Site pengamatan tambahan
2221	Tolobi 1	Site pengamatan tambahan
2222	Tolobi 2	Site pengamatan tetap
2223	Tolobi 3	Site pengamatan tambahan
2224	Jailolo Besar	Site pengamatan tetap
2225	Taupadwar	Site pengamatan tetap
2226	North Boo Kecil	Site pengamatan tetap
2227	Tomna	Site pengamatan tetap

SiteID	Site Name	Keterangan
2228	Taroiukoyer	Site pengamatan tetap
2229	Warmaret	Site pengamatan tetap
2230	Yenimfan	Site pengamatan tetap
2231	Tapordoker	Site pengamatan tetap
2232	Tanjung Lampu	Site pengamatan tetap
2233	Boo Barrier Reef	Site pengamatan tambahan
2234	Dona karmalita	Site pengamatan tetap
2235	Laguna Walo	Site pengamatan tambahan
2236	Wall Gebe Besar	Site pengamatan tetap
2237	Kor Mang Kwan	Site pengamatan tetap
2238	Yendot	Site pengamatan tetap
2239	Tampagula	Site pengamatan tambahan
2240	Huriba	Site pengamatan tambahan
2241	Baju Lagoon	Site pengamatan tambahan

Figure 1. Map of coral reef health monitoring locations and designated zones in Kofiau Marine Protected Area. Site pengamatan tambahan = Additional Site, Site pengamatan tetap = permanent site.

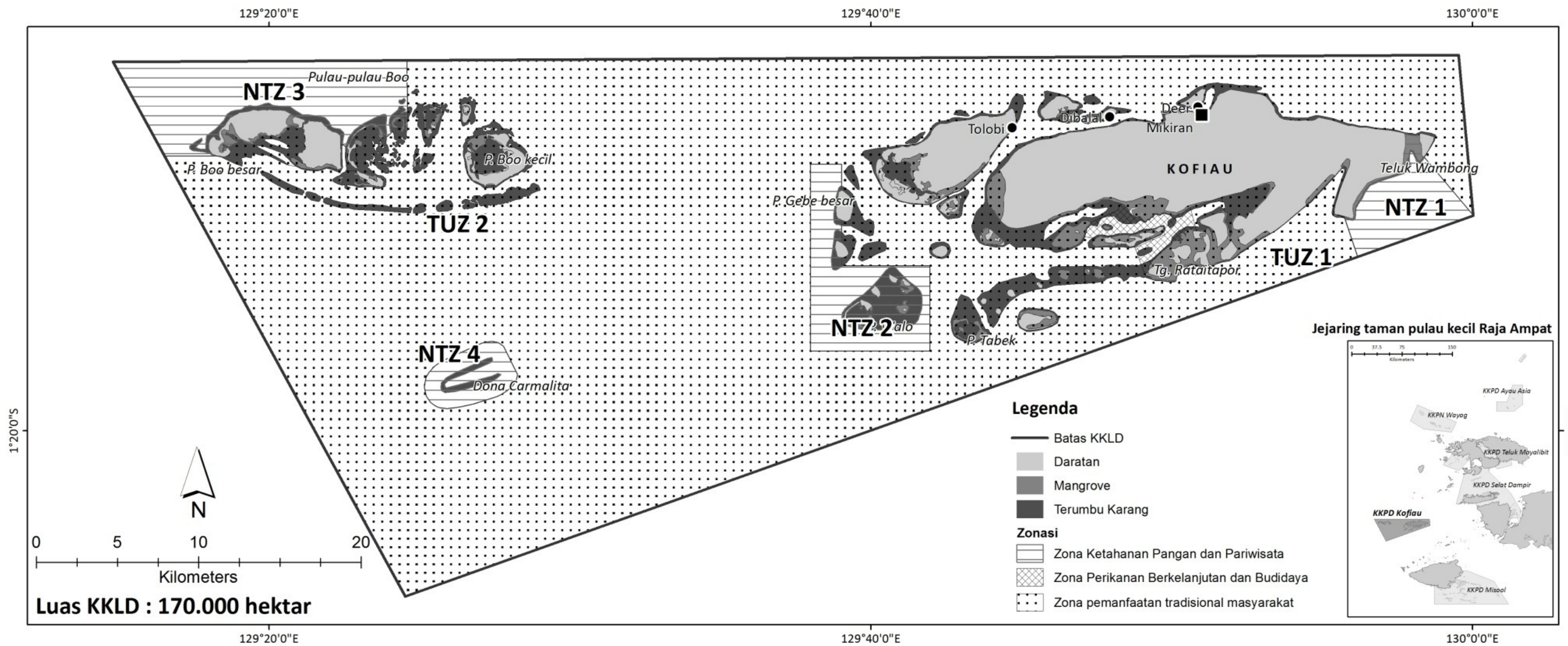


Figure 1b. Zoning plan for Kofiau Marine Protected Area declared by local communities in October 2011. Zona Ketahanan Pangan dan Pariwisata = Food Security and Tourism Zone (referred to as No Take Zone in this report), Zona Perikanan berkelanjutan dan Budidaya = Sustainable Fisheries and Mariculture Zone, Zona Permanfaatan Tradisional Masyarakat = Community Traditional Use Zone (referred to as Traditional Use Zone in this report).

3. RESULTS AND DISCUSSION

3.1. FISH COMMUNITIES

Fish communities in Kofiau MPA are considered to be relatively healthy due to good diversity and abundance of fish and the occurrence of large individuals of some predators such as sharks, grouper and Napoleon wrasse (*Cheilinus undulatus*). However there is evidence of overfishing at Kofiau indicated by the fact that it is relatively rare to encounter these very large predators and declining biomass of many families including herbivores and sharks over past three years. In 2011, the fish community of Kofiau MPA was dominated (in terms of biomass) by herbivores of the families Scaridae and Acanthuridae (parrot and rabbitfish), Casesoinidae (fusiliers), and predators from Lutjanidae (snappers), Serranidae (grouper), Haemulidae (sweetlip), and Lethrinidae (emperors). The most abundant fish communities were found on the eastern tip of Kofiau Island (Wamei and Wambong Kecil) and this area may be an important spawning aggregation site. At Boo Island, the highest fish counts were recorded on the western tip at Tangjung Lampu.

3.1.1. Fish biomass by location and monitoring year

Overall, there was a significant decline in biomass and density in the MPA between years ($p<0.05$). Fish biomass was significantly lower in 2011 compared to 2009 ($p<0.05$), while fish density was significantly lower in 2011 compared to 2010 ($p<0.05$).

Fish biomass and density was higher in Boo Island than in Kofiau Island in 2009 but by 2011, fish biomass had declined in both regions and was relatively equal although fish density was higher in Boo (Figure 2). In Boo island the fish biomass values decreased from 2009-2011, while in Kofiau, the fish biomass declined from 2009-2010, but increased slightly in 2011 (Figure 2).

Statistical analyses showed that the overall decline in Kofiau MPA was a result of the significant decline in biomass on reefs at Boo Island ($p<0.05$). This data is consistent with resource use patterns in the MPA. Muhajir et al. (2012) showed Boo Island was targeted by outside fishers who removed large volumes of fish from the area, compared to locals who target Kofiau Island and have smaller catches.

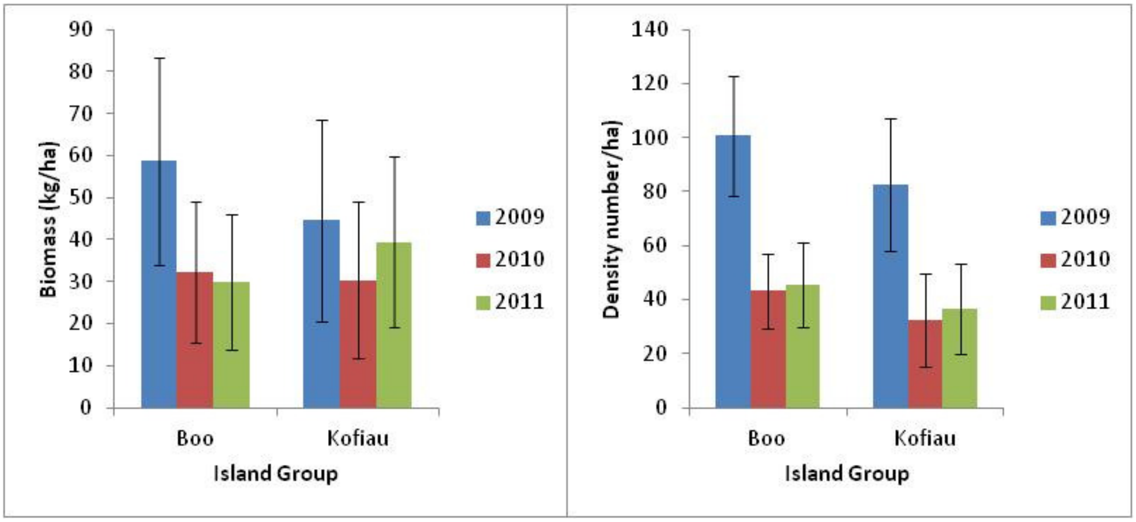


Figure 2. The average biomass (kg/ha) and density (number/ha) of fish from all sites around Kofiau and Boo Islands from 2009-2011. Error bars = standard error.

In Boo, the greatest fish biomass was recorded in Tanjung Lampu and Tapordoker, and in Kofiau, in Wambong Kecil and Wamei (Figure 3). The lowest fish biomass in Boo was recorded in Warmaret, and the lowest in Kofiau was in Yenmandur (Figure 3). Fish biomass decreased from 2009–2011 at 18 of the 25 monitoring sites. The most striking decrease in fish biomass between 2009 and 2011 was in Jailolo Besar on the north side of Kofiau close to Tolobi and Dibalal villages and therefore may be due to intensive use of resources in this location. Fish biomass increased at 4 sites (Wambong Kecil, Wamei, Yendot and Maet) (Figure 3).

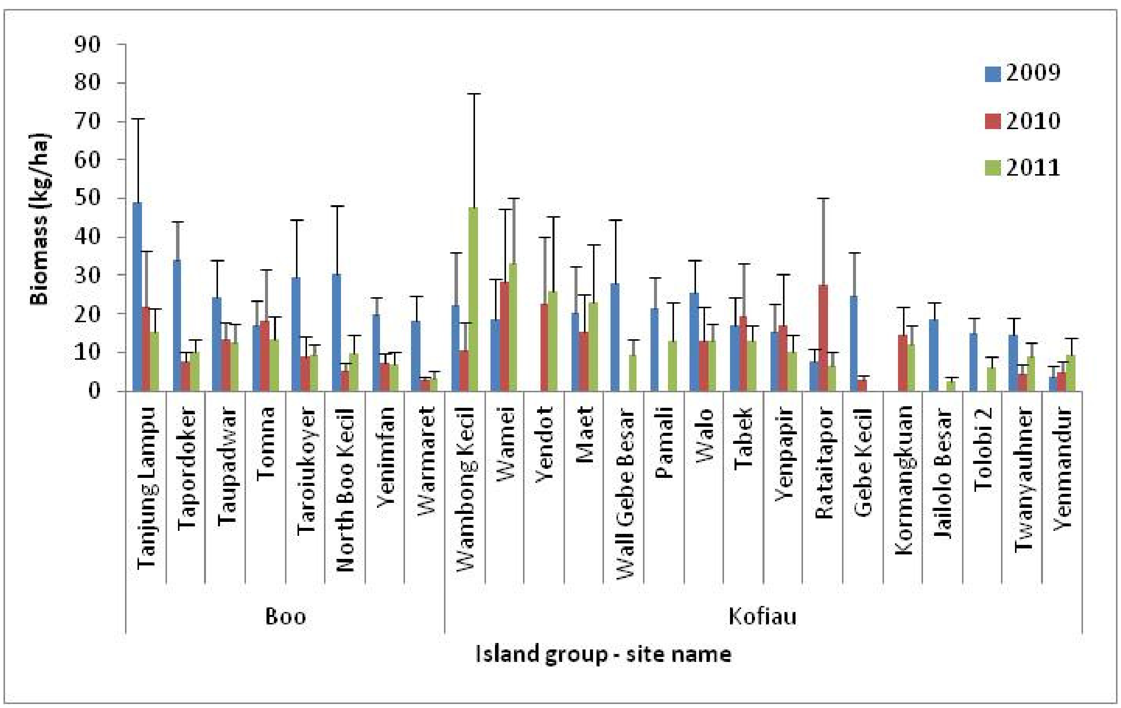


Figure 3. Average fish biomass (kg/ha +SE) by location in Kofiau and Boo Islands in all monitoring years. Large schools of fish of the family Caesionidae in Lampu Bay and Tomna in 2010 are not included.

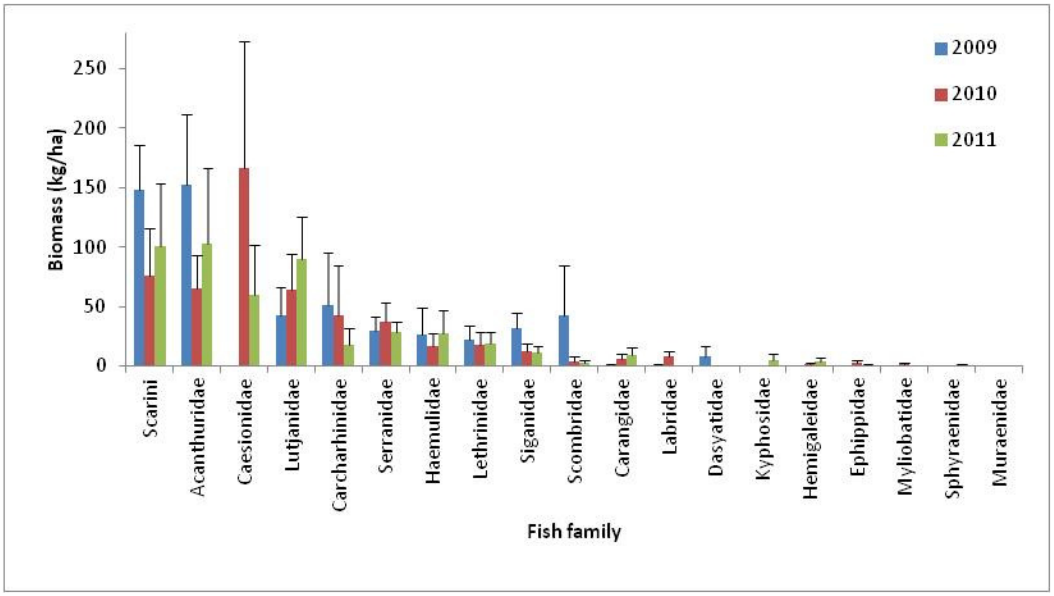


Figure 4. Biomass (kg/ha) of all families of fish in each survey year 2009-2011 at Kofiau Marine Protected Area. Error bars = standard error.

Tanjung Lampu in Boo and Wamei in Kofiau had the highest fish biomass and these sites have been identified as potential fish spawning and feeding locations (Muljadi 2009). These two sites are bays or island points, which are characterised oceanographically by strong currents, and have waters with a specific base topography well-suited to fish spawning sites (Sadovy and Domeier 2005). The fish community at Tanjung Lampu and Tomna in Boo were dominated by fusiliers (Caesionidae), at 126 kg/ha and 487 kg/ha, respectively. This is thought to be due to several factors, including the biological characteristics of this family, oceanographic characteritics, and the very healthy coral condition at these two sites (Appendix 1).

The three families with the highest biomass are fusiliers (Caesionidae), parrotfish (Scarini), and surgeonfish (Acanthuridae) (Figure 5). Fusiliers live in large groups in shallow waters on reefs (Froese and Pauly 2012). Although their average size is small (<30 cm), because they are found in large numbers, they have a high fish biomass. Parrotfish and surgeonfish had the second and third largest biomass (Figure 5, Appendix 5). Most species of parrotfish and surgeonfish live permanently in groups, in shallow water at a depth of 0-15 m (Froese and Pauly 2012), so were commonly observed in the monitoring transects at 10 m depth. Most species of parrotfish and surgeonfish are herbivorous, eating algae that cling to coral, marine vegetation, and shallow water substrate (Green et al. 2009, Froese and Pauly 2012). A small proportion of species of surgeonfish are planktivorous, but these are nevertheless associated with coral reef, and are therefore observed most frequently in open sea or in shallow waters.

Snappers from the family Lutjanidae also have a fairly high biomass, because most live in groups. While some species of this family, such as *Lutjanus rivulatus* and *Aprion virescen,* tend to live in waters deeper than 50 m, they are nevertheless associated with shallow reefs when it comes to hunting prey (Froese and Pauly 2012). This factor also means that the biomass of this family is higher than that of other fish families.

The eight families that have a low biomass are generally fish that live solitary lives, hiding in holes in the coral, such as *Dasyatidae, Myliobatide* and *Hemigaleidae*, or groups of semi-pelagic fish, such as barracuda or *Sphyraenideae,* which have wide feeding grounds. Pelagic fish tend to live in deep waters, venturing into coral reef areas only occasionally to feed. Interestingly, tuna, skipjack and Spanish mackerel (Scomberomorus commerson) or the Scombridae family are found only in Kofiau and not in Boo.

3.1.2. Fish communities in each zone

Figure 5 shows a comparison of the average biomass and density of fish families for sites included in areas designated as no take and use zones in the Kofiau MPA zoning plan traditionally declared in October 2011. Fish biomass and density declined in all zones of Kofiau MPA from 2009 to 2011 with the exception of NTZ 1 where fish biomass increased from 2010 to 2011. In 2011, fish biomass was higher at sites in use zones and generally lower in areas chosen as no take zones – again with the exception of NTZ 1. It is important to note that declines in fish biomass were not statistically significant for any of the zones, which suggests that either (a) there are no declines occurring in the MPA, or (b) there are some declines that are happening, but these are still very small and if properly addressed through management can be reversed. If management fails to address fishing pressure or to adequately implement the zoning plan, we would expect that the next monitoring may start to record significant declines.

There are variations in average fish biomass across the zones, both TUZ and NTZ. This is thought to be due to the biological characteristics of the fish and also the pressure of fishing, which varies across all the zones in Kofiau and Boo. The high fish biomass in TUZ 2 or Boo Island and NTZ 1 or the eastern part of Kofiau Island is thought to be due to the distance of these locations from human settlement, and although there is use of resources in these locations it is not as intensive as in the other zones. The selection of areas with high fish biomass on the eastern tip of Kofiau and the western tip of Boo, where fish communities are abundant and may also be the site of spawning aggregations, should support sustainable fisheries as these areas are expected to be the source of fish and larvae for the surrounding areas.

Photographs showing fishing activities in Kofiau and Boo Islands Marine Protected Area (D.A Handono./TNC).

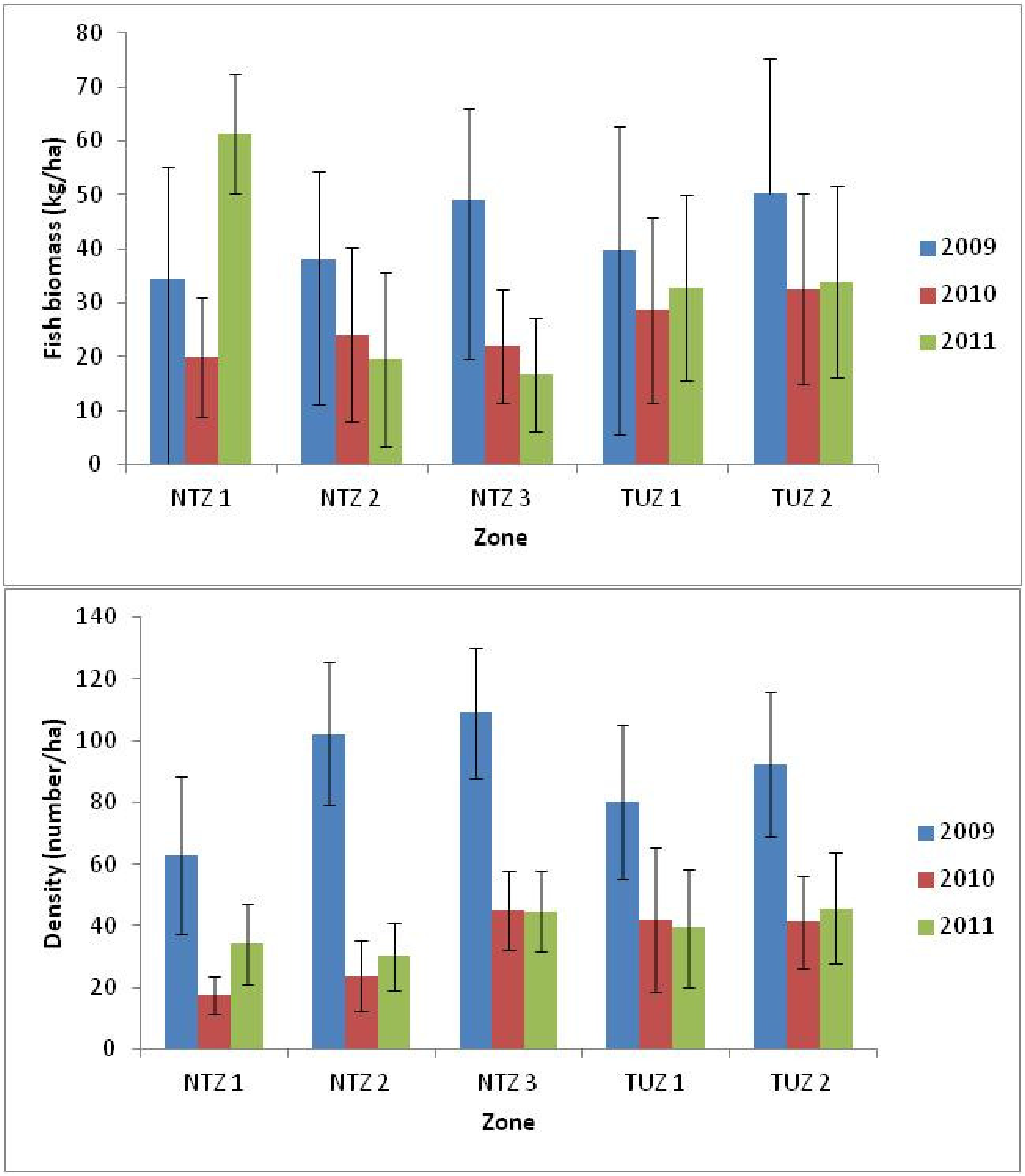


Figure 5. Average fish biomass (kg/ha) and density (number/ha) for sites in each zone of Kofiau Marine Protected Area from 2009-2011. Error bars = standard error.

3.1.3. Differences among zones for select families of fish

There are some differences in the biomass of different fish families in the different zones of Kofiau MPA. Average grouper biomass was similar in no take and use zones with the exception of NTZ 3 where grouper biomass is slightly lower, but this is not significant ($p>0.05$, Figure 6). Some sites within NTZ 1 and NTZ 2 have been identified as potential grouper spawning sites (Muljadi 2009), and with effective compliance and enforcement of NTZs, the number and biomass of grouper should increase at these sites. However, many grouper have life-history patterns that make them vulnerable to exploitation and slow to recover, as seen in other parts of Indonesia (Mangubhai et al. 2011). The low numbers of grouper in NTZ 3 (Figure 6) may be due to unsuitable habitat because here the reef ends at approximately 10-12 m deep and the benthos becomes sandy.

For emperors and sweetlips, the biomass in 2011 was generally lower in NTZs than in TUZs (Figure 6). However, with the exception of emperors in NTZ 3 ($p<0.001$), changes in biomass were not significant for all other zones ($p>0.05$). This means there are still abundant fish resources in areas where local communities are still allowed to fish and it is expected that the biomass will increase in NTZs after protection for 5 years.

The biomass of snapper increased or was stable in all zones from 2009-2011 and the average biomass is similar in all zones (Figure 6). The greatest increases in snappers were recorded in TUZ 1 ($p<0.01$).

The biomass of pelagic fish families - mackerel, trevally and barracuda - is slightly higher in sites around Kofiau than Boo and this may be due to Kofiau having more suitable habitat. Kofiau has higher freshwater runoff and mangrove habitat which mackerel prefer (McPherson 1985, Froese and Pauly 2012). On one occasion a school of Spanish mackerel was observed at Yemandur at Kofiau (Figure 6).

The average biomass of herbivore fish families (surgeonfish, rabbitfish and parrotfish) is relatively similar among zones (Figure 6). These families all suffered significant declines from 2009-2010 throughout the MPA ($p<0.01$, Figure 6) and this may be due to a large group of fishermen from Halmahera and Sulawesi operating in Kofiau and Boo in December 2009–January 2010. These fishers used gill and bottom set nets and bubu traps which are known to target herbivores. Although invited by some Kofiau residents, not everyone was happy about this and their presence caused conflict in the community. It is possible that this single intensive fishing event caused the decline in herbivores and other fish families from 2009-2010 throughout Kofiau MPA.

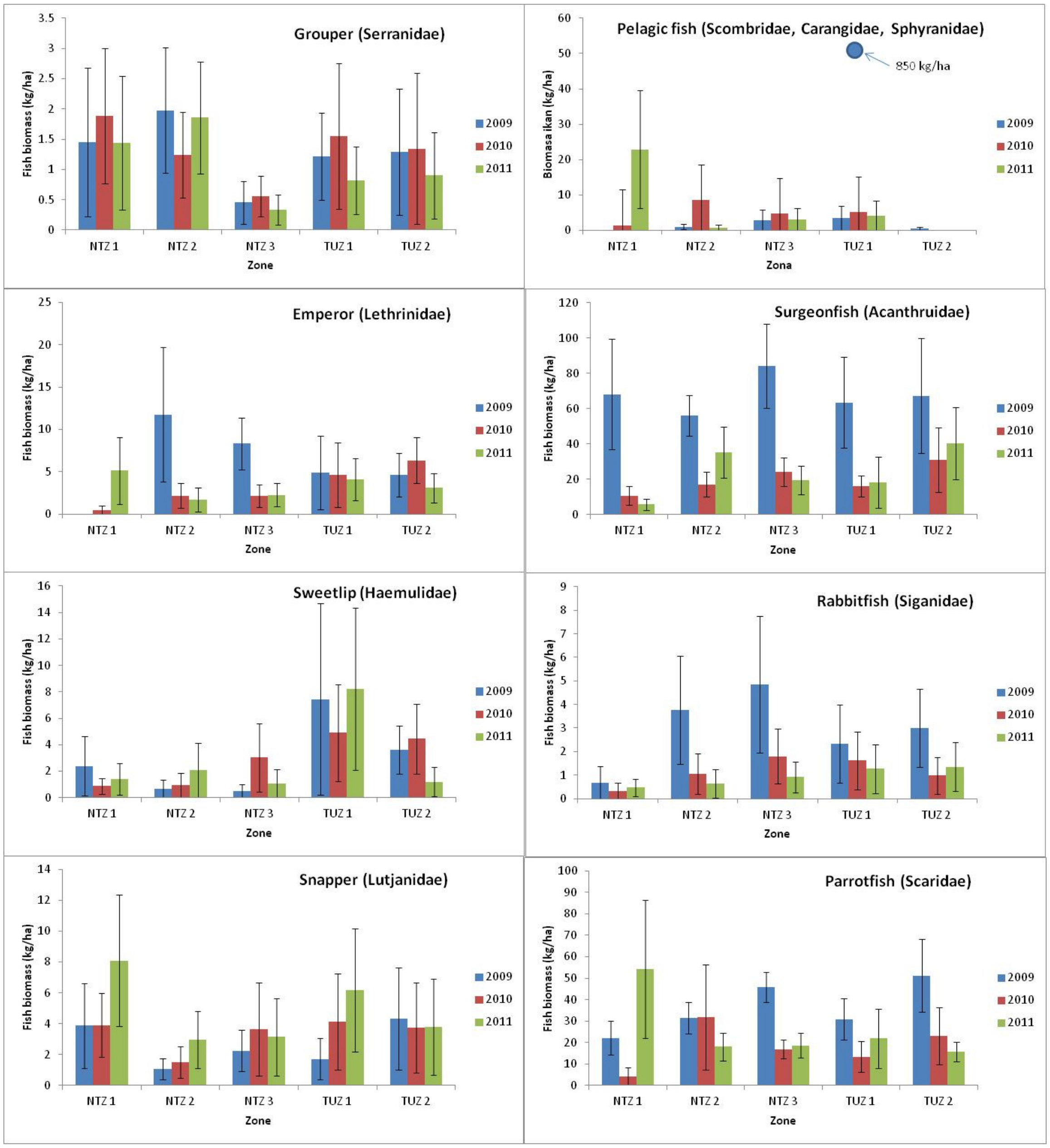


Figure 6. Annual average biomass of most important fish families in Kofiau MPA between no take and use zones, from 2009-2011. These fish are important to local communities as a source of food or income – grouper, emperor, sweetlip, snapper, pelagic and/or important to the ecology of the reef (i.e. herbivore families surgeonfish, rabbitfish and parrotfish). The zones were designated and became locally enforced in October 2011, after the March 2011 monitoring. Error bars = standard error.

3.1.4. Fish biomass, density and families recorded during long swims

During the long swims, stingray or Dasyatidae and sharks of the families Charcharinidae and Gynglymostomatidae had the greatest biomass (Figure 7a). Fish of the Khyposidae, Sphyraenidae (barracuda) and Lutjanidae (snapper) families had the highest density (Figure 7b). Napoleon wrasse (*Cheilinus undulatus,* family Labridae) had the lowest biomass. Fish biomass is determined by the number and size of the fish. Ray and shark, which have large bodies, have a high biomass but a low density, because they are found in small numbers. Additional analyses of fish data collected are available in Appendix 3.

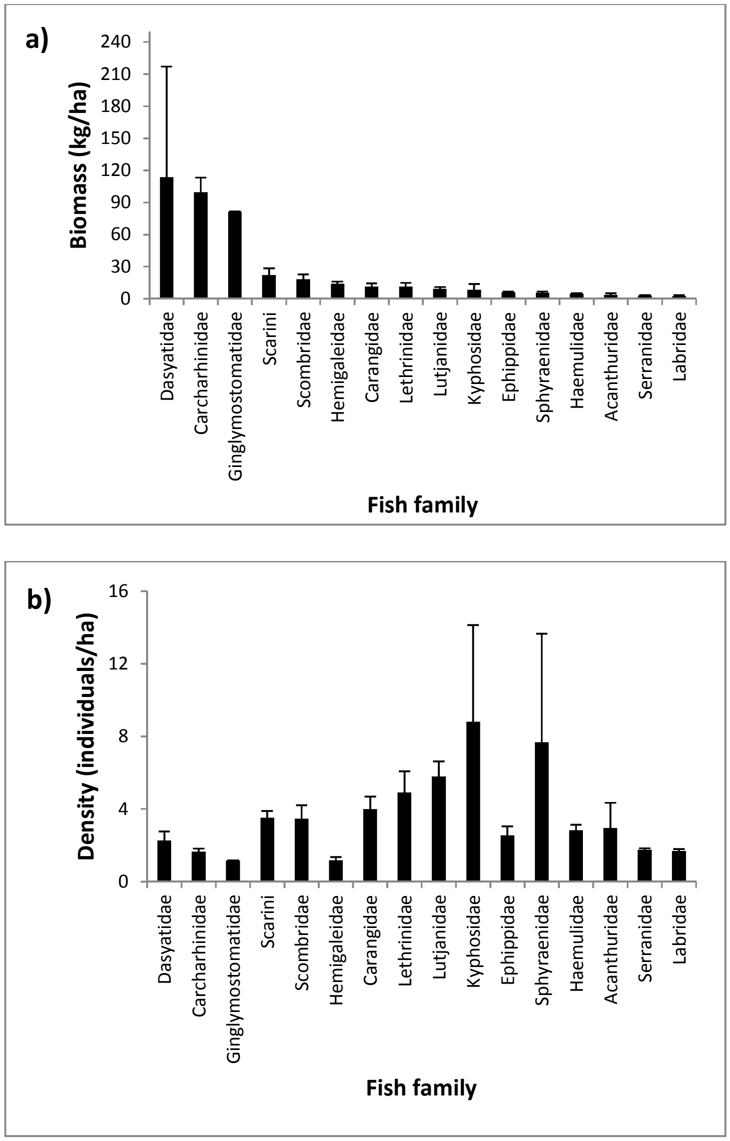


Figure 7. Average fish biomass (kg/ha +SE) and density (individuals/ha +SE) in all locations and all monitoring years.

3.1.5. Sharks and rays

A total of 51 individuals of three species of shark were recorded for all monitoring years. Black tip reef shark (*Carcharinus melanopterus)* was the species most frequently recorded in Kofiau. Only one individual of nurse shark (*Nebrius ferrugineus*) was recorded, in 2010 (Table 6). Two species of ray or *Dasyatidae* were recorded: bluespotted ribbon tail stingray (*Taeniura lymma)* and whitetail stingray *(Himantura granulata*). A total of 42 individuals of the species *Taeniura lymma* were recorded in 2009, none in 2010, and one in 2011. Only one individual of the species *Himantura granulata* was recorded, in 2010.

Table 6. Species of shark recorded in transects and during the long swims in Kofiau MPA from 2009–2011.

Species	Common name	2009		2010		2011		Total
		Transects	Long swim	Transects	Long swim	Transects	Long swim	
Carcharhinus melanopterus	Black tip	13	6	11	10	5	1	46
Nebrius ferrugineus	Nurse	0	0	0	1	0	0	1
Trianodon obesus	White tip	0	1	1	1	1	0	4
Total		13	7	12	12	6	1	51

Sharks are a target for fishers, especially outside fishers from Buton, Seram, Suluwesi and Halmahera (Muhajir et al. 2012). They have a high economic value and are taken for their fins, which fetch IDR 800,000 – 1,000,000 per kg, depending on species and quality (Mangubhai et al. 2012). The high price they fetch is likely encouraged more intensive fishing of sharks, which has in turn, led to a decrease in the number of sharks in Kofiau MPA. Most fishers who fish for shark are not locals from Kofiau, and they use long lines and nets. Shark are not a primary target for local Kofiau fishers, and only occasionally do they catch shark unintentionally, trapped in nets or taking bait meant for other species of fish (Muhajir et al. 2012).

3.2. BENTHIC COVER

3.2.1. Benthic composition of reef communities in Kofiau MPA

The reefs of Kofiau MPA are healthy as indicated by abundant live coral (30%) and soft corals (13%) growing on the reef slopes and low algal cover (<5%) (Figure 8). While there was a significant decline in coral cover in 2010 ($p<0.001$), coral cover increased in 2011 and was similar again to the cover recorded in 2009 (Figure 8). There is substrate available for new coral settlement (15%) although rubble is still a prominent feature of the reefs (30%) indicating past damage likely from destructive fishing or storms. Mild coral bleaching was recorded in bet transects in 2011 (see section 3.2.3), and in resilience assessments conducted in 2009 and 2010 (Mangubhai et al. in prep.).

Spatial differences

Hard coral cover was around 10-20% higher in Boo Island than on reefs around Kofiau Island (Figure 9). This may be due to reef habitat and environmental conditions being more suitable for coral growth at Boo, or higher intensity of fishing around Kofiau Island. The close proximity of human settlements to the Kofiau Island means that there is more fishing activity in Kofiau than in Boo (Muhajir et al. 2012). Soft coral cover was similar (15%) with slighly higher values recorded around Kofiau compared to Boo Island in 2010 and 2011. Soft coral was not recorded on Dona Carmalita – the submerged pinnacle – probably due to the high wave exposure and depth. It is noted that surveys on the pinnacle were only done on the top of the pinnacle, and not along the sides, which may be more suitable habitat for soft corals.

The site with the highest recorded coral cover was in the channel infront of Deer Village which was dominated by branching non-*Acropora* species. Other sites with hard coral cover between 50-80% cover were both exposed sites on the north side of Boo Island (Tomna and Yenimfan) and sheltered sites around Kofiau Islands (Tampagula and Walo Bommies). There were five sites where coral cover less than 15% was recorded – all of these sites were around Kofiau Islands. Four of these sites were on the exposed south east coast of Kofiau (Maet, Yendot, Rataitapor and Tabek) and one site on the north side of Dibalal.

Temporal differences

On average, the composition of the benthic community in Kofiau MPA was relatively stable from 2009-2011 (Figure 8). Hard coral cover was lower at Kofiau in 2010 (18%) compared with 2009 and 2011 (around 27%). In Boo, hard coral cover declined slightly from 43% in 2009 to around 37% in 2010 and 2011 (Figure 9). Average soft coral coverage at Boo decreased from 15% in 2009 to 10% in 2010-2011. Stable substrate which provides surfaces for coral settlement increased slightly, from 11% in 2009 to 15% in 2010 and 2011 (Figure 9). The percent cover of mobile substrate such as rubble was relatively stable over the monitoring years (around 28%), which indicates that there is relatively little use of explosives for fishing or of other activities damaging to the reefs in Kofiau MPA. This is confirmed by the absence of any sightings of the use of explosives during resource use monitoring (Muhajir et al. 2012), or during routine enforcement patrols. It is noted though that a small group of bomb fishers from Sulawesi were caught in February 2012 in Kofiau MPA, and successfully prosecuted which will send a strong message to other potential offenders.

While small (5-10%) variation is expected between surveys due to natural variability in habitat and the location of transects, large interannual variations are not expected unless there are events such as crown of thorns, severe bleaching or storms which may have damaged reefs. These were not recorded in Kofiau during the study period. In 2010, a different observer conducted PIT in Kofiau MPA. Given the coral cover in 2011 was similar and not significantly different with cover recorded in 2009 ($p>0.05$), and given that corals have slow growth rates, it is likely that the decline recorded in 2010 relates to observer bias (Figure 8 and 9). Therefore in general, some of the differences seen in 2010, may relate to observer differences in recording benthic categories. This may also explain approximately 5% of the variability between years.

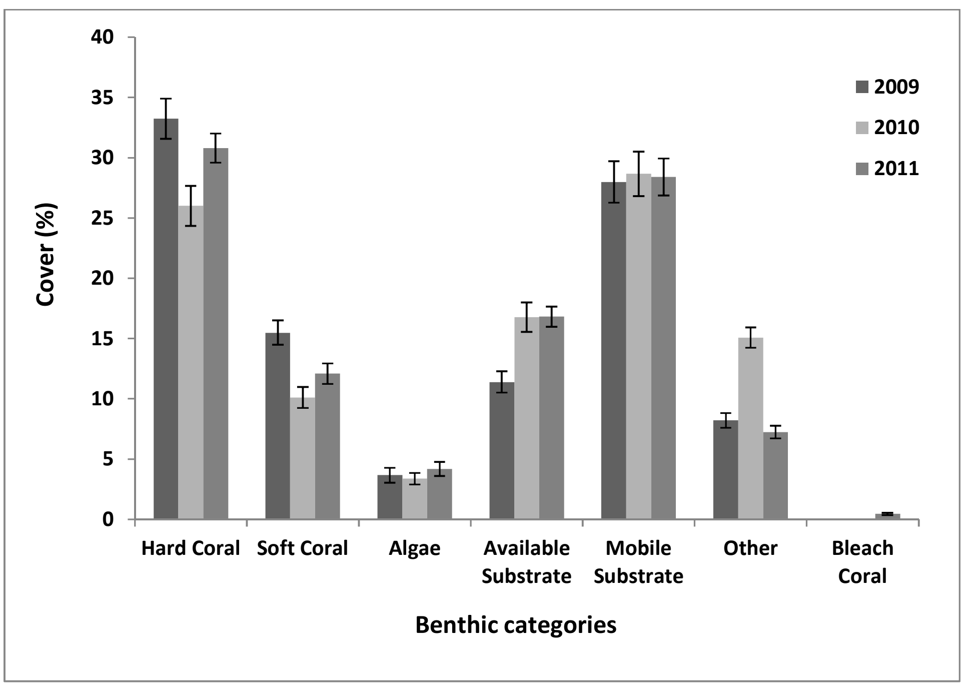


Figure 8. Annual changes in percent benthic cover (average +SE) from 2009-2011 in Kofiau Marine Protected Area.

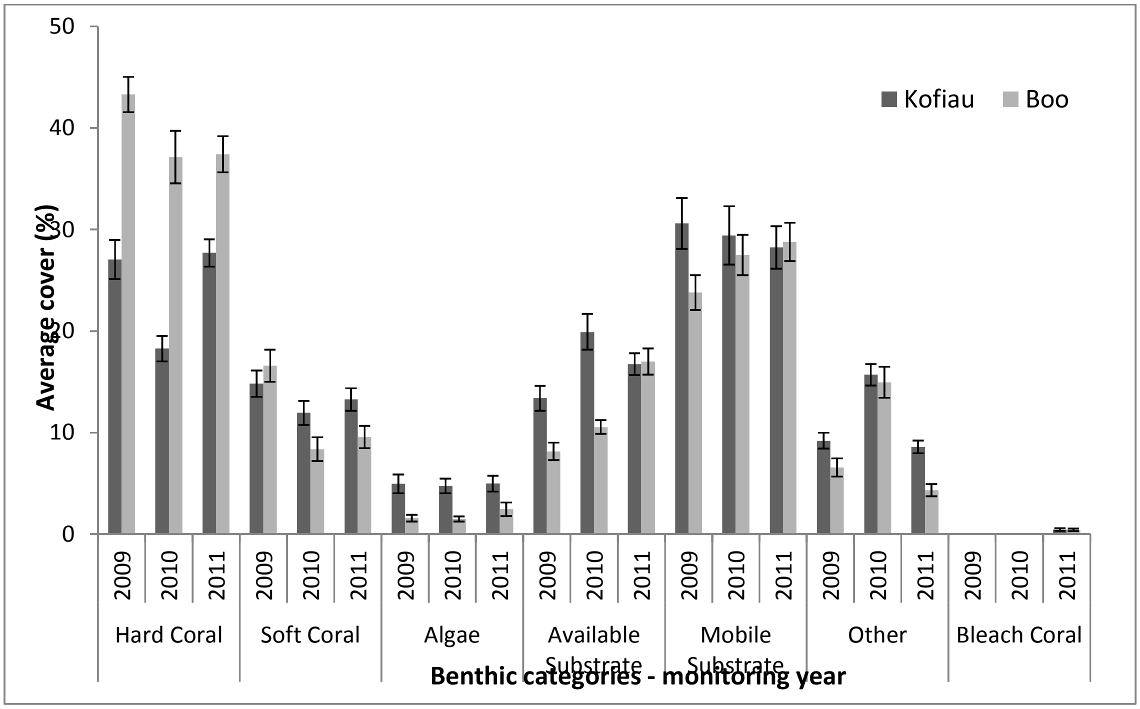


Figure 9. Comparison of changes in annual benthic cover (average percent cover + SE) beteen Boo and Kofiau Islands from 2009–2011.

3.2.2. Benthic community composition by zone type

The composition of the benthic community in each zone and each year of sampling is shown in Figure 10. This provides information on the baseline conditions in each zone type and area just prior to implementation of the zoning plan. These data also show the level of variability among sampling years due to natural and observer variability (a different observer was used in 2010). The results of comparisions of benthic communities in different zone types show there were few differences among zones and most differences reflect spatial or habitat differences between sites around the Boo Island compared to Kofiau Island. This is to be expected because the zoning plan was not implemented and enforced until October 2011, after the last sampling in March 2011, and reefs are very similar throughout Kofiau MPA. Additional analyses of benthic data (e.g. individual sites) are available in Appendix 4. Using the 2011 data, statistical tests were run to look at differences between different zones for the three benthic categories below. The few differences in benthic communities among zones include:

a. Hard coral cover: significantly higher coral cover in both NTZ 3 and TUZ 2 around Boo Island than in the TUZ 1 around Kofiau (TUZ 1) ($p<0.001$, Figure 10a). However hard coral cover was not significantly different between NTZ 1 and 2 and TUZ 1 around Kofiau Islands.
b. Macroalgae: Macroalgal cover was not significantly difference between any of the zones (Figure 10c).
c. Substrate: There was significantly higher available substrate in NTZ 2 compared to TUZ 1 around Kofiau Island ($p<0.05$). There was significantly less mobile substrate (rubble) in NTZ2 compared to TUZ 1 ($p<0.05$, Figure 10 e,f). This may be due to these reefs being steeper (there are wall reefs at this site) and higher energy reefs where rubble and sand would be swept to deeper areas.

With implementation of the zoning plan, we may expect that benthic communities in NTZs will increase in cover of hard coral and available substrate. It is also hoped that previously bombed reefs may recover over the next 20-30 years depending on how well the MPA is managed, and reproduction and recruitment processes within the MPA.

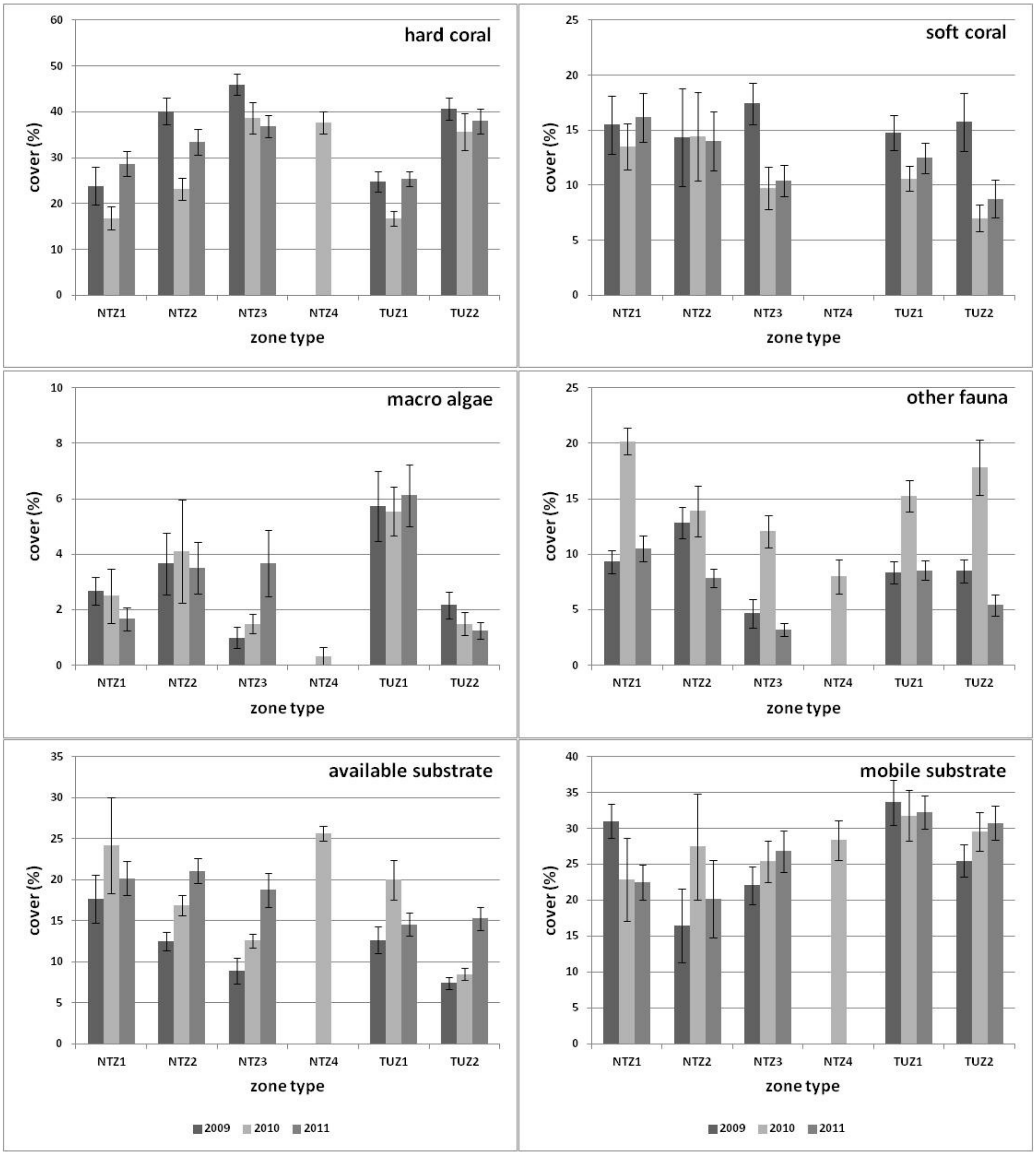


Figure 10. Average percentage (%) benthic coverage in each zone for all monitoring years in Kofiau MPA (NTZ = No Take Zone, TUZ = Traditional Use Zone).

3.2.3. Coral bleaching

Bleached corals were observed in 2009 and 2010 although in low numbers and only in colonies outside the transects (Mangubhai et al. in prep.). In 2011, bleached corals were observed on transects for the first time and the results of dedicated surveys in 2011 are reported here. The presence of bleached coral in Kofiau in 2011 is thought to be due to warmer than normal surface water temperatures from November 2010 – February 2011 in many parts of Kofiau MPA which was documented by *in situ* temperature loggers (Section 3.3).

Overall, the number of colonies affected by bleaching in 2011 was low. From the 17,402 colonies that were surveyed from 25 sites, on average more than 95% were in normal condition, less than 2% pale, less than 3% bleached, and less than 1% dead. However there were some spatial differences with more corals affected in shallow transects (5%) compared to deeper transects (3.5%). There were also differences among sites with 25% of colonies recorded as bleached or pale at Twanyauhner, 9% at Yenmandur and 6% at Wamei (Figure 11). At Yenimafan almost 10% of the colonies were pale.

Some coral genera are more susceptible to bleaching than others. In 2011, *Acropora* (Acroporidae) and *Porites* (Pocilloporidae) were the dominant genera in terms of coral cover at Kofiau MPA. Acroporidae and Pocilloporidae are two coral families known to be susceptible to bleaching (Marshall and Baird 2000). In Kofiau, *Porites* was the genus with the highest percentage of pale colonies recorded. *Porites* is a genus that is moderately susceptible to bleaching (Marshall and Baird 2000). *Stylophora* (also from the family Pocilliporidae) which forms small colonies common on the reefs of Kofiau MPA, was the most affected by bleaching with more than 60% of all colonies recorded as bleached. Bleaching was also recorded in several other genera, including *Montipora* (foliose & encrusting), *Acropora*, *Hydnophora* (encrusting), and *Physogrya* (massive) (Figure 12).

The composition of the coral community explains part of the variation in bleaching impact among sites. A regression of percent composition of genera against the percent of corals bleached or pale shows that 36% of the variation in among sites can be explained by differences in the percentage of susceptible genera (Figure 13). At Twanyauhner, Yenmandur and Yenimfan, more than 50% of colonies were bleaching susceptible genera from family Acroporidae . Wamei had fewer colonies of susceptible genera e.g. *Acropora*, but a sligthly higher incidence of bleaching compared to other sites. It is not known why this site experienced more bleaching than other sites because it has good water movement and sometimes experiences strong currents.

In 2011, there was a difference in the values for bleached coral betwen the reef health surveys using PIT and belt transects. This is because a larger number of coral colonies was surveyed (average of 120 colonies per belt transect) compared with an average of 20-30 colonies per transect using PIT.

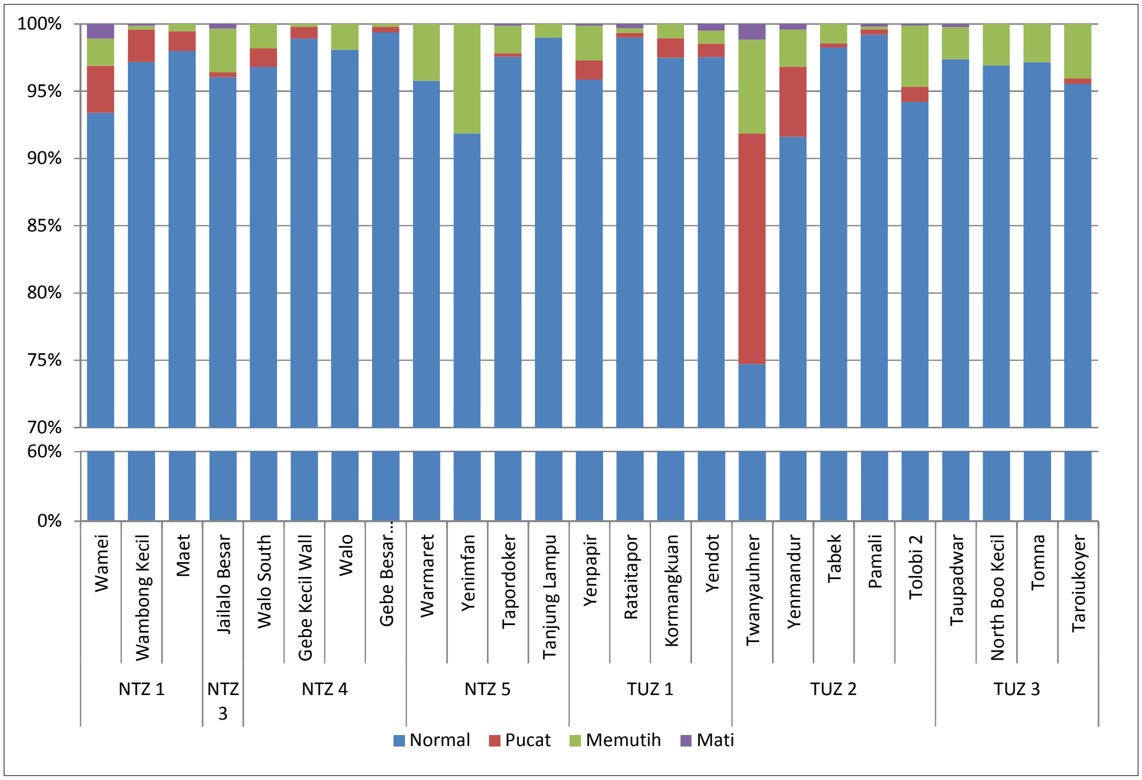


Figure 11. Composition (%) of coral colonies by monitoring location and proposed zone in Kofiau Marine Protected Area. NTZ = No Take Zone, TUZ = Traditional Use Zone.

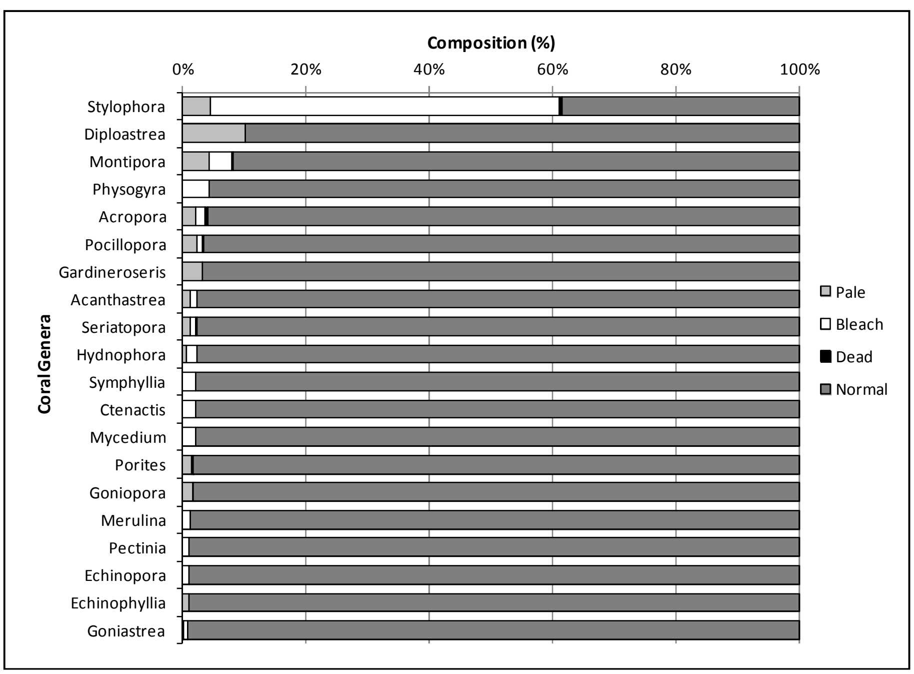


Figure 12. Composition (%) of coral genera conditions. Only 20 coral genera shown in the figure.

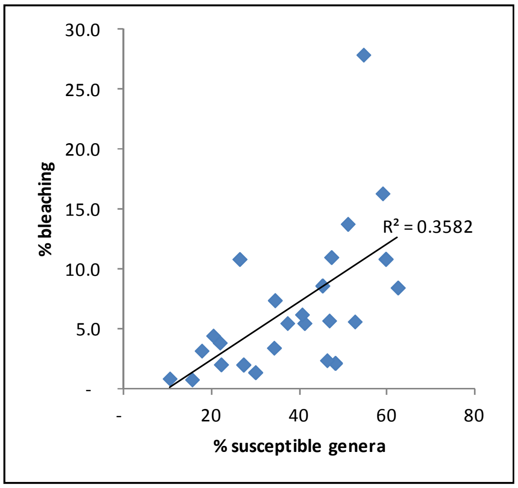


Figure 13. Scatter plot of percentage of bleaching corals compare to percentage of susceptible genera.

3.3. SURFACE WATER TEMPERATURE

From February 2009 to March 2011, surface water temperature in Kofiau MPA varied between 24.4^{0}C and 34.7^0 C, with an average of 27.9^{0}C. The highest temperature at a depth of 2 m was recorded in Boo Kecil in May 2009, and the highest temperature at a depth of 5 m was recorded in Gebe Besar in September 2009 (Table 7).

The seasonal temperature pattern recorded by the eight temperature loggers showed temperatures increased from February to their peak in April followed by a decline over winter with minimum temperatures in July-August and gradually increasing to December (Figure 14). January was usually cooler due to westerly winds and cloud which cool the area. Temperatures in 2010 were generally hotter than in 2009 and notably there was very little difference between summer and winter temperatures. In December 2010–February 2011, surface water temperature was 1–1.5°C higher than other years and stayed betweeen 29–30°C in many locations. The coral bleaching documented in April 2011 is thought to be associated with this extended period of warmer than nomal temperatures in 2010 and early 2011.

A comparison of temperature records from loggers at 25 m and 5 m depth at Wamei and Boo Besar indicated there was no difference in the temperature patterns between depths (Figure 14) indicating good mixing at these sites. Temperature fluctuations in Boo Kecil are a little different from those in other locations, because here there are large fluctuations in a short period of time. This is because the temperature loggers are positioned at a depth of 2 m in a shallow lagoon, which means that sunlight is absorbed more quickly into the water column and disperses more quickly from the sea. This means that fluctuations in surface water temperature occur more quickly than in other locations that are more open and have deeper waters. Corals living in these environments which experience large temperature fluctuations and elevated temperatures may have increased tolerance to bleaching.

Although personal observation indicates that several locations where the temperature loggers are positioned, such as in Wamei and Tanjung Lampu, have strong currents, there are no rapid decreases in temperature in any of the monitoring sites, including these two locations. This suggests that there is no upwelling in the locations where the temperature loggers are positioned in Kofiau.

Table 7. Surface water temperatures (°C) in Kofiau Marine Protected Area, 2009 – 2011 (Max = maximum, Avg = average, Min = minimum, "-" = no data. Highest and lowest temperatures (across all years) are highlighted in grey.

Year	Month	Site - Temperature (^{0}C)																							
		Boo Kecil 2 m			Jailolo 5 m			GebeBesar 5 m			Rataitapor 5 m			BooBesar 5 m			BooBesar 25 m			Wamei 5 m			Wamei 25 m		
		Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min
2009	2	32.9	29.2	27.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	33.3	29.5	27.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	33.1	30	26.3	31.8	29.3	29	30.3	29.5	29.2	-	-	-	29.9	29.5	28.8	29.9	29.4	28.3	30.3	29.3	28.3	29.8	29.1	27.5
	5	**34.7**	30.4	27.6	30.7	29.6	28.3	30.5	29.7	28.8	-	-	-	31.1	29.7	28.1	30.3	29.6	27.3	30.9	29.5	28.3	30	29.1	26.5
	6	33.1	29.2	26.6	29.4	28.8	28.3	29.5	28.8	27	-	-	-	29.6	29	28.2	29.5	28.9	27.9	29.3	28.7	27.9	29.3	28.5	26.5
	7	31.6	28.7	26	29	28.2	27.2	28.9	28.1	26.4	-	-	-	29.1	28.4	27.2	29	28.3	26.8	28.7	28	26.9	28.7	27.9	26
	8	32.5	28.4	26.3	28.4	27.8	26.9	28.4	27.4	24.8	-	-	-	28.9	27.9	26.7	28.6	27.8	26.3	28.4	27.6	26.6	28.4	27.5	24.7
	9	32.8	29	27.5	29.5	28.3	26.9	29.2	28.1	**24.4**	-	-	-	29.2	28.3	26.6	29.1	28.2	25.7	29	28.2	27.5	29	28.1	26.4
	10	33.1	29.5	27.4	29.4	28.8	26.5	30.2	28.7	26.9	30.3	29.2	27.9	29.8	28.9	27.4	29.7	28.8	26.6	29.5	28.7	28	29.2	28.4	26.7
	11	33.3	29.6	27.9	30.1	28.9	27.1	30.1	29	26.2	30.5	29	25.9	30.2	29.2	26	29.9	28.9	25.5	29.8	28.8	27.2	29.5	28.2	24.8
	12	33.2	29.4	27.5	30.1	28.7	27.3	29.9	28.7	26.5	29.8	28.9	26.6	29.7	28.8	27.5	29.6	28.7	27.3	30	28.7	27.9	29.5	28.4	25.8
2010	1	32	29.2	27.6	29.5	28.7	27.8	30.5	29	26.4	30.3	28.7	26.1	30	29	27.5	29.8	28.8	26.8	29.7	28.8	28	29.3	28.4	25.6
	2	31.7	29.3	27.5	29.7	29.1	28.4	29.5	29	26.3	29.4	28.8	27.8	29.5	29	27.9	29.4	28.9	27.4	30.1	29.1	28.4	29.6	28.7	25.8
	3	33.3	29.6	26.2	29.9	29.2	26.7	30.4	29.2	27.5	30.2	29	26.6	30.2	29.3	27.8	30.1	29.1	26.7	30.6	29.3	28.4	29.8	28.8	25.4
	4	32.9	30.2	28	30.4	29.4	27.7	30.4	29.6	27.8	30.8	29.4	26.1	30.7	29.7	28	30.7	29.4	25.6	30.5	29.5	28.3	30.1	28.8	26.1
	5	33.7	30.3	28.4	31.3	29.7	27.9	31.1	29.7	28	30.4	29.5	27.3	30.5	29.6	27.9	30.4	29.2	27	30.9	29.5	27.7	30.3	28.6	26
	6	32.9	29.7	27.7	30.4	29.2	28.3	29.9	29	27.7	29.9	29	26.6	30	29.3	27.8	29.9	29.1	26.9	30	29.1	28.2	29.6	28.7	26.8
	7	33.3	29.7	28	30	29.3	28.5	30.1	29.1	27.8	30.2	29.1	27.4	30.3	29.3	28	30.2	29.1	26.1	30.2	29.1	28.2	30	28.9	27.4
	8	33	29.5	27.7	30.2	29.1	28.6	29.9	28.9	27.8	30.1	29	28.1	29.9	29.1	28	29.6	29	27.7	29.9	29.1	28.3	29.5	29	27.7
	9	33	29.6	28	30	29.2	28.5	29.8	29	25.6	30.4	29.1	28	29.7	29.1	27.7	29.5	29	27.3	30.6	29.1	28.3	29.5	28.9	27.1
	10	33.5	29.9	27.8	30.4	29.4	28.5	31	29.3	27.9	30.7	29.4	28	30.2	29.3	27.8	30	29.1	26.8	30.9	29.3	28.3	29.8	29.1	27.6
	11	33.4	30	28.4	30.6	29.7	29.1	30.5	29.6	28.7	30.7	29.6	28	30.3	29.7	28.8	30.1	29.5	28.2	31.2	29.8	28.6	30.6	29.3	28
	12	32.4	29.9	27.3	30.7	29.9	29.1	30.8	29.9	29.2	30.9	29.8	27.4	30.7	29.9	28.6	30.5	29.8	27.9	31	29.9	29.2	30.6	29.6	28.4
2011	1	32.9	29.7	27.2	30.4	29.6	29.2	30.8	29.7	29.3	30.3	29.6	28.7	30.4	29.7	29.2	30.4	29.6	29.1	-	-	-	30.4	29.6	28.1
	2	32.1	29.6	27.2	30.5	29.5	29	30.3	29.5	29.1	30.3	29.4	28.8	29.9	29.5	28.9	29.8	29.4	28.9	-	-	-	30.1	29.5	28.2
	3	32.7	29.7	27.4	30.6	29.5	27.7	30.7	29.5	28.7	30.3	29.4	28.3	30	29.5	27.7	30	29.4	27.5	-	-	-	30.2	29.4	28.3
Standard Deviation		0.6	0.5	0.7	0.7	0.5	0.8	0.7	0.6	1.4	0.4	0.3	0.9	0.5	0.5	0.7	0.5	0.5	0.9	0.8	0.6	0.6	0.6	0.5	1.1

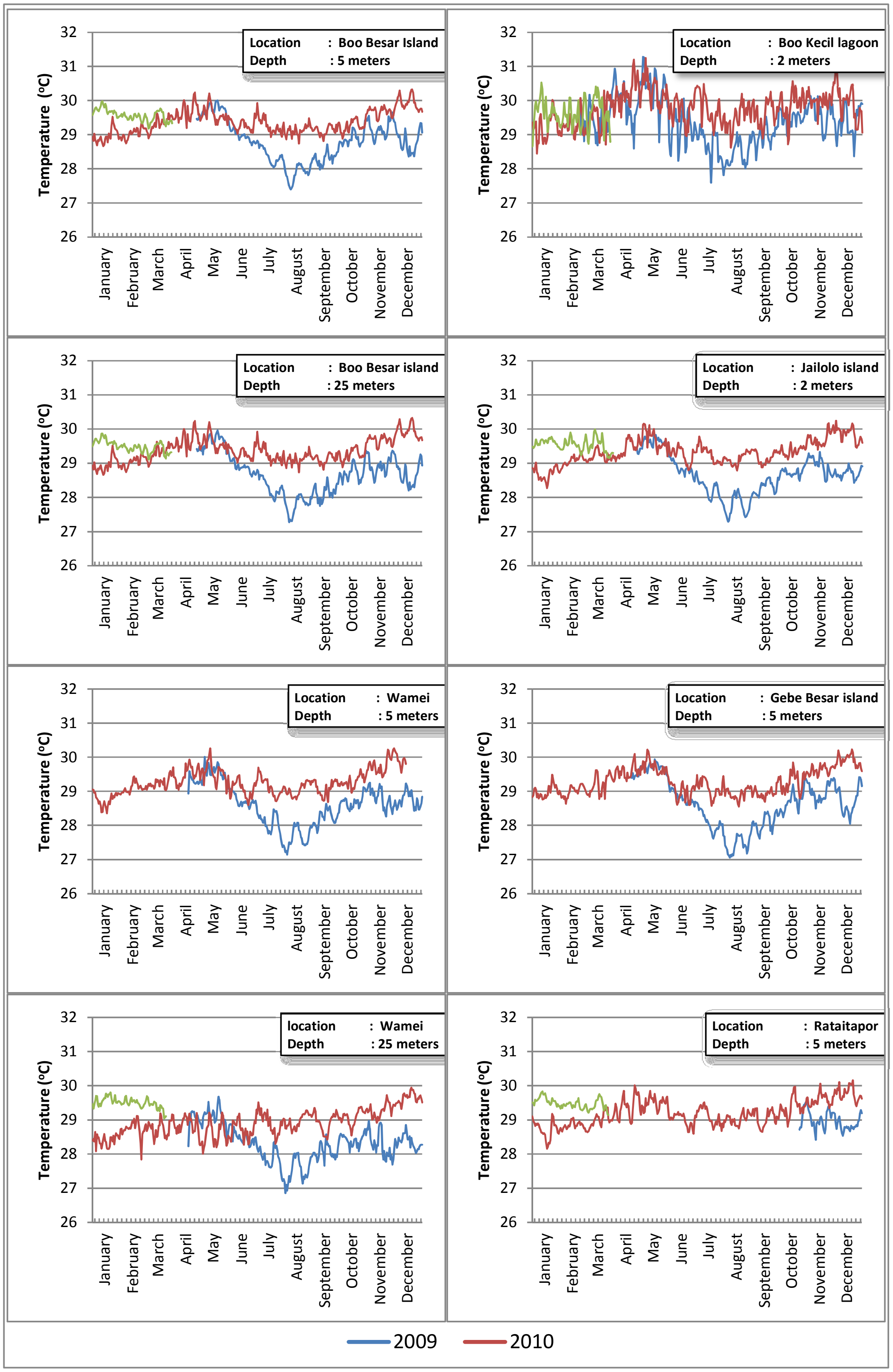


Figure 14. Fluctuations in average surface water temperature (°C) by month and year for all monitoring sites in Kofiau Marine Protected Area.

4. CONCLUSIONS

From the findings and discussion of the coral reef health monitoring in Kofiau MPA, the following conclusions can be made:

- The fish community in Kofiau MPA still in health condition due to good diversity and abundance of fish and the occurrence of large individuals of some predators such as sharks, grouper and napoleon wrasse.
- However, fish biomass has decreased at most sites from 2009 to 2010 especially for herbivores and this may have been due to intensive fishing by outside fishers in December 2009- January 2010.
- The number of shark sightings was very low in 2011 compared to 2009 and 2010 and this may be due to the continued high fishing pressure on sharks in Kofiau and the wider the Raja Ampat regency.
- Three species of shark have been recorded from Kofiau MPA – black tip reef *(Carcharinus melanopterus)*, white tip reef (*Trianodon obesus)* and nurse (*Nebrius ferrugineus)* sharks were recorded. From the ray or *Dasyatidae* family, two species were recorded – bluespotted ribbon tail stingray (*Taeniura lymma)* and whitetail stingray (*Himantura granulate).*
- There has been no significant change in benthic coverage in Kofiau MPA between the years 2009 and 2011.
- Total average percentage coverage of live hard coral was 30%, of soft coral was 13%, and of other benthos was 10%, with a little variation but no significant difference between monitoring years and proposed zones.
- Mild coral bleaching was recorded in 2009 and 2010 during reef resilience surveys (Mangubhai et al. in prep.), and was also documented in belt transects at two depths in 2011. However, less than 5% of corals were affected in 2011.
- *Stylophora* was the genus of coral most commonly affected by bleaching (57% of 559 colonies). Other genera, such as *Montipora* (foliose and encrusting), *Acropora* (sub-massive), *Hydnophora* (encrusting) and *Physogrya* (massive) were bleached between 3% and 7%.
- Surface water temperature in Kofiau MPA varies between 24.4^{0}C and 34.7^{0}C, with an average of 27.9^{0}C. An extended period of warmer than normal water temperatures throughout Kofiau MPA in 2010 and early 2011 probably caused the mild coral bleaching seen in April 2011.

5. RECOMMENDATIONS

From findings and discussion of the reef health monitoring, the following recommendations can be made:

- The Kofiau MPA zoning plan protects a number of sites with good fish and benthic communities in NTZs and these will act as fish banks and reserves for the spill over of larvae and adults to other areas.
- The TUZs also have high biomass of fish families that are a target for Kofiau residents and so they should still be able to have enough fisheries resources for their local needs.
- To address the declining fish biomass in Kofiau MPA, it is important to enforce the zoning system – to both protect NTZs from any fishing activity and also ensure that outside fishers are prohibited from fishing in TUZs
- It is especially important to protect the sites which are likely fish spawning and feeding grounds such as NTZ 1 and NTZ 3.
- It is essential to maintain and strengthen the local patrols and outreach activities to ensure compliance with the zoning system.
- The best site for tourism activities is is NTZ 3 because of the dramatic underwater landscape features.
- Future monitoring at sites in NTZ and TUZs in Kofiau MPA will provide information on the effectiveness of the zoning plan ie. If fish biomass and coral health are stable or increasing. It is recommended this be undertaken every 2-3 years.
- Information about fish density and biomass can be further combined with information about catches from resource use monitoring to obtain clarification about the status of fish resources in Kofiau MPA.

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APPENDICES

Appendix 1. The names and GPS locations of sites sampled in Kofiau Marine Protected Area.

SiteID	Site Name	Island	Zone	Reef Type	Exposure	Latitude (S)	Longitude (E
2200	Kampung Deer	Kofiau	TUZ1	slope	sheltered	1° 09.267’	129° 50.703’
2201	Warmariar	Kofiau	TUZ1	slope	exposed	1° 09.361’	129° 49.960’
2202	Tanjung Deer	Kofiau	TUZ1	slope	exposed	1° 08.553’	129° 51.033’
2203	Twanyauhner	Kofiau	TUZ1	slope	exposed	1° 08.723’	129° 52.725’
2204	Yenmandur	Kofiau	TUZ1	slope	exposed	1° 09.770’	129° 55.785’
2205	Wamei	Kofiau	TUZ1	slope	exposed	1° 10.106’	129° 58.375’
2206	Wambong Kecil	Kofiau	NTZ1	slope	exposed	1° 10.997’	129° 58.323’
2207	Maet	Kofiau	NTZ1	slope	exposed	1° 12.233’	129° 56.302’
2208	Yenpapir	Kofiau	TUZ1	slope	exposed	1° 12.672’	129° 54.260’
2209	Rataitapor	Kofiau	TUZ1	slope	exposed	1° 15.040’	129° 49.825’
2210	Warturenmyotkuer	Kofiau	TUZ1	slope	semi-exposed	1° 13.413’	129° 47.103’
2211	Walo Bommoes	Kofiau	NTZ2	patch	semi-exposed	1° 16.255’	129° 40.097’
2212	Walo south	Kofiau	NTZ2	slope	exposed	1° 16.514’	129° 39.502’
2213	Gebe Kecil Wall	Kofiau	NTZ2	wall	exposed	1° 13.721’	129° 38.772’
2214	Karabas	Kofiau	TUZ1	slope	exposed	1° 13.818’	129° 42.176’
2215	Tabek	Kofiau	TUZ1	slope	exposed	1° 16.937’	129° 43.626’
2216	Pamali	Kofiau	TUZ1	slope	exposed	1° 16.306’	129° 46.183’
2217	Walo	Kofiau	NTZ2	slope	exposed	1° 15.601’	129° 39.578’
2218	Cina	Kofiau	NTZ2	slope	exposed	1° 14.878’	129° 40.880’
2219	Gebe Kecil	Kofiau	NTZ2	slope	exposed	1° 13.568’	129° 38.999’
2220	Gebe Besar	Kofiau	TUZ1	slope	exposed	1° 12.189’	129° 39.272’
2221	Tolobi 1	Kofiau	TUZ1	slope	exposed	1° 10.558’	129° 40.648’
2222	Tolobi 2	Kofiau	TUZ1	slope	exposed	1° 09.786’	129° 42.153’
2223	Tolobi 3	Kofiau	TUZ1	slope	exposed	1° 09.395’	129° 44.375’
2224	Jailolo Besar	Kofiau	TUZ1	slope	exposed	1° 08.792’	129° 46.202’
2225	Taupadwar	Boo	TUZ2	slope	exposed	1° 10.748’	129° 28.524’
2226	North Boo Kecil	Boo	TUZ2	slope	exposed	1° 10.051’	129° 27.269’
2227	Tomna	Boo	TUZ2	slope	exposed	1° 08.958’	129° 26.552’
2228	Taroiukoyer	Boo	TUZ2	slope	exposed	1° 09.156’	129° 25.238’
2229	Warmaret	Boo	NTZ3	slope	exposed	1° 09.866’	129° 22.027’
2230	Yenimfan	Boo	NTZ3	slope	exposed	1° 09.388’	129° 20.843’
2231	Tapordoker	Boo	NTZ3	slope	exposed	1° 09.279’	129° 19.090’
2232	Tanjung Lampu	Boo	NTZ3	slope	exposed	1° 10.578’	129° 17.955’
2233	Boo Barrier Reef	Boo	TUZ2	barrier	exposed	1° 12.502’	129° 25.789’
2234	Dona karmalita	Dona Karmalita	NTZ4	patch	exposed	1° 17.753’	129° 26.855’
2235	Laguna Walo	Kofiau	NTZ2	lagoon	sheltered	1° 16.024’	129° 39.975’
2236	Wall Gebe Besar	Kofiau	NTZ2	wall	exposed	1° 12.175’	129° 38.839’
2237	Kor Mang Kwan	Kofiau	TUZ1	slope	exposed	1° 13.655’	129° 52.897’
2238	Yendot	Kofiau	TUZ1	slope	exposed	1° 14.508’	129° 51.398’
2239	Tampagula	Kofiau	TUZ1	slope	semi-exposed	1° 12.239’	129° 42.372’
2240	Huriba	Kofiau	TUZ1	slope	exposed	1° 12.320’	129° 40.948’
2241	Baju Lagoon	Boo	TUZ2	slope	semi-exposed	1° 10.930’	129° 23.780’

Appendix 2. List of fish biomass constants used to calculate biomass

FishID	Species_name	Family	Biomass constant a	Biomass constant b	Reference	Notes
1	Acanthurus bariene	Acanthuridae	0.028	2.983	Kulbicki etal 2005	Used Acanthurus spp.
2	Acanthurus blochii	Acanthuridae	0.0251	3.032	Kulbicki etal 2005	Used A. blochii
3	Acanthurus dussumieri	Acanthuridae	0.0426	2.868	Kulbicki etal 2005	
4	Acanthurus fowleri	Acanthuridae	0.028	2.983	Kulbicki etal 2005	Used Acanthurus spp.
5	Acanthurus leucocheilus	Acanthuridae	0.028	2.983	Kulbicki etal 2005	Used Acanthurus spp.
6	Acanthurus lineatus	Acanthuridae	0.0126	3.064	Fishbase (www.fishbase.com)	
7	Acanthurus mata	Acanthuridae	0.0222	3.008	Kulbicki etal 2005	
8	Acanthurus nigricans	Acanthuridae	0.067	2.669	Fishbase (www.fishbase.com)	
9	Acanthurus nigricauda	Acanthuridae	0.0168	3.168	Kulbicki etal 2005	
10	Acanthurus nigrofuscus	Acanthuridae	0.0264	3.028	Kulbicki etal 2005	
11	Acanthurus olivaceus	Acanthuridae	0.007	3.398	Fishbase (www.fishbase.com)	
12	Acanthurus pyroferus	Acanthuridae	0.0051	3	Fishbase (www.fishbase.com)	
13	Acanthurus spp.	Acanthuridae	0.028	2.983	Kulbicki etal 2005	
14	Acanthurus spp. (ringtail)	Acanthuridae	0.028	2.983	Kulbicki etal 2005	
15	Acanthurus triostegus	Acanthuridae	0.0831	2.57	Kulbicki etal 2005	
16	Acanthurus xanthopterus	Acanthuridae	0.0267	2.984	Kulbicki etal 2005	
17	Ctenochaetus binotatus	Acanthuridae	0.0392	2.875	Kulbicki etal 2005	
18	Ctenochaetus cyanocheilus	Acanthuridae	0.0237	3.056	Kulbicki et al 2005	Used Ctenochaetus spp.
19	Ctenochaetus spp.	Acanthuridae	0.0237	3.056	Kulbicki etal 2005	
20	Ctenochaetus striatus	Acanthuridae	0.0231	3.063	Kulbicki etal 2005	
21	Ctenochaetus tominensis	Acanthuridae	0.0237	3.056	Kulbicki et al 2005	Used Ctenochaetus spp.
22	Naso annulatus	Acanthuridae	0.051	2.715	Kulbicki etal 2005	
23	Naso brevirostris	Acanthuridae	0.0107	3.243	Kulbicki etal 2005	
24	Naso hexacanthus	Acanthuridae	0.0202	2.956	Kulbicki etal 2005	
25	Naso lituratus	Acanthuridae	0.0497	2.839	Fishbase (www.fishbase.com)	
26	Naso lopezi	Acanthuridae	0.0594	2.854	Fishbase (www.fishbase.com)	
27	Naso minor	Acanthuridae	0.0085	3.25	Kulbicki etal 2005	Used Naso spp.
28	Naso spp.	Acanthuridae	0.0085	3.25	Kulbicki etal 2005	
29	Naso unicornis	Acanthuridae	0.0179	3.035	Kulbicki etal 2005	
30	Naso vlamingii	Acanthuridae	0.0753	2.843	Fishbase (www.fishbase.com)	
31	Zebrasoma scopas	Acanthuridae	0.0291	2.993	Kulbicki etal 2005	
32	Zebrasoma spp.	Acanthuridae	0.0378	2.857	Kulbicki etal 2005	
33	Zebrasoma veliferum	Acanthuridae	0.0343	2.866	Kulbicki etal 2005	
34	Albula spp.	Albulidae	0.0205	2.869	Kulbicki etal 2005	
35	Antennarius spp.	Antennariidae	0.0236	3.293	Kulbicki etal 2005	
36	Apogon angustatus	Apogonidae	0.0049	3.78	Kulbicki etal 2005	
37	Apogon aureus	Apogonidae	0.0064	3.509	Kulbicki etal 2005	
38	Apogon bandanensis	Apogonidae	0.014	3.25	Kulbicki etal 2005	
39	Apogon catalai	Apogonidae	0.0052	3.935	Kulbicki etal 2005	
40	Apogon compressus	Apogonidae	0.0186	2.984	Kulbicki etal 2005	
41	Apogon cookii	Apogonidae	0.0058	3.689	Kulbicki etal 2005	
42	Apogon cyanosoma	Apogonidae	0.0074	3.563	Kulbicki etal 2005	
43	Apogon doderleini	Apogonidae	0.009	3.46	Kulbicki etal 2005	
44	Apogon ellioti	Apogonidae	0.0172	2.991	Kulbicki etal 2005	
45	Apogon exostigma	Apogonidae	0.0164	3.069	Kulbicki etal 2005	
46	Apogon fraenatus	Apogonidae	0.013	3.165	Kulbicki etal 2005	
47	Apogon fuscus	Apogonidae	0.0407	2.699	Kulbicki etal 2005	
48	Apogon hyalosoma	Apogonidae	0.0071	3.449	Kulbicki etal 2005	
49	Apogon kallopterus	Apogonidae	0.0101	3.314	Kulbicki etal 2005	
50	Apogon lateralis	Apogonidae	0.0184	3.051	Kulbicki etal 2005	
51	Apogon lineolatus	Apogonidae	0.0045	3.683	Kulbicki etal 2005	
52	Apogon nigrofasciatus	Apogonidae	0.0086	3.51	Kulbicki etal 2005	
53	Apogon norfolcensis	Apogonidae	0.0102	3.277	Kulbicki etal 2005	
54	Apogon novemfasciatus	Apogonidae	0.0086	3.414	Kulbicki etal 2005	
55	Apogon spp.	Apogonidae	0.0155	3.121	Kulbicki etal 2005	
56	Apogon trimaculatus	Apogonidae	0.0217	2.971	Kulbicki etal 2005	
57	Archamia fucata	Apogonidae	0.0089	3.323	Kulbicki etal 2005	
58	Archamia leai	Apogonidae	0.0072	3.48	Kulbicki etal 2005	
59	Archamia lineolata	Apogonidae	0.0485	2.586	Kulbicki etal 2005	
60	Archamia spp.	Apogonidae	0.0084	3.395	Kulbicki etal 2005	
61	Cheilodipterus artus	Apogonidae	0.0038	3.59	Kulbicki etal 2005	
62	Cheilodipterus lachneri	Apogonidae	0.0022	3.858	Kulbicki etal 2005	
63	Cheilodipterus macrodon	Apogonidae	0.0054	3.433	Kulbicki etal 2005	
64	Cheilodipterus quinquelineatus	Apogonidae	0.0161	2.999	Kulbicki etal 2005	
65	Cheilodipterus spp.	Apogonidae	0.0132	3.085	Kulbicki etal 2005	
66	Fowleria aurita	Apogonidae	0.0376	2.776	Kulbicki etal 2005	
67	Fowleria marmorata	Apogonidae	0.0024	4.136	Kulbicki etal 2005	
68	Fowleria spp.	Apogonidae	0.0082	3.567	Kulbicki etal 2005	
69	Fowleria variegata	Apogonidae	0.0134	3.35	Kulbicki etal 2005	
70	Atherinomorus lacunosus	Atherinidae	0.0064	3.298	Kulbicki etal 2005	
71	Aulostomus chinensis	Aulostomidae	0.0002	3.514	Kulbicki etal 2005	
72	Abalistes stellaris	Balistidae	0.0472	2.76	Kulbicki etal 2005	
73	Balistapus undulatus	Balistidae	0.0058	3.5540	Fishbase (www.fishbase.com)	Used Balistoides spp.
74	Balistoides conspicillum	Balistidae	0.019	3.078	Kulbicki et al 2005	Used Balistoides spp.
75	Balistoides spp.	Balistidae	0.019	3.0780	Kulbicki etal 2005	
76	Balistoides viridescens	Balistidae	0.0244	3.018	Kulbicki etal 2005	
77	Belonidae semi-elongated	Balistidae	0.0008	3.203	Kulbicki etal 2005	
78	Melichthys vidua	Balistidae	0.0058	3.554	Fishbase (www.fishbase.com)	
79	Odonus niger	Balistidae	0.0366	3	Fishbase (www.fishbase.com)	
80	Pseudobalistes fuscus	Balistidae	0.0726	2.76	Kulbicki etal 2005	

81	Sufflamen bursa	Balistidae	0.0326	3	Fishbase (www.fishbase.com)	
82	Sufflamen fraenatus	Balistidae	0.0287	2.966	Kulbicki etal 2005	
83	Sufflamen spp.	Balistidae	0.0324	2.929	Kulbicki etal 2005	
84	Strongylura incisa	Belonidae	0.0016	2.996	Kulbicki etal 2005	
85	Strongylura spp.	Belonidae	0.0011	3.101	Kulbicki etal 2005	
86	Strongylura urvilli	Belonidae	0.0005	3.361	Kulbicki etal 2005	
87	Tylosurus crocodilus	Belonidae	0.0006	3.285	Kulbicki etal 2005	
88	Atrosalarias fuscus	Blenniidae	0.0149	3.018	Kulbicki etal 2005	
89	Cirripectes chelomatus	Blenniidae	0.0147	3.099	Kulbicki etal 2005	
90	Cirripectes spp.	Blenniidae	0.013	3.15	Kulbicki etal 2005	
91	Cirripectes stigmaticus	Blenniidae	0.0183	2.969	Kulbicki etal 2005	
92	Ecsenius bicolor	Blenniidae	0.0239	2.5830	Kulbicki etal 2005	
93	Ecsenius spp.	Blenniidae	0.0239	2.584	Kulbicki etal 2005	
94	Meiacanthus spp.	Blenniidae	0.0009	4.47	Kulbicki etal 2005	
95	Petroscirtes spp.	Blenniidae	0.0097	3.016	Kulbicki etal 2005	
96	Plagiotremus rhinorhynchos	Blenniidae	0.0012	3.792	Kulbicki etal 2005	
97	Plagiotremus spp.	Blenniidae	0.0018	3.581	Kulbicki etal 2005	
98	Plagiotremus tapeinosoma	Blenniidae	0.0057	2.908	Kulbicki etal 2005	
99	Salarias fasciatus	Blenniidae	0.0138	2.98	Kulbicki etal 2005	
100	Arnoglossus spp.	Bothidae	0.0002	4.811	Kulbicki etal 2005	
101	Asterorhombus intermedius	Bothidae	0.001	4.075	Kulbicki etal 2005	
102	Bothus pantherinus	Bothidae	0.002	3.751	Kulbicki etal 2005	
103	Engyprosopon grandisquama	Bothidae	0.0168	2.894	Kulbicki etal 2005	
104	Grammatobothus polyophthalmus	Bothidae	0.0148	2.895	Kulbicki etal 2005	
105	Dinematichthys spp.	Bythitidae	0.0072	3.155	Kulbicki etal 2005	
106	Caesio caerulaurea	Caesionidae	0.02	2.991	Kulbicki etal 2005	
107	Caesio cuning	Caesionidae	0.0149	3.121	Kulbicki etal 2005	
108	Caesio lunaris	Caesionidae	0.0149	3.121	Kulbicki etal 2005	
109	Caesio spp.	Caesionidae	0.0093	3.253	Kulbicki etal 2005	
110	Caesio teres	Caesionidae	0.0149	3.121	Kulbicki etal 2005	
111	Pterocaesio diagramma	Caesionidae	0.0069	3.341	Kulbicki etal 2005	
112	Pterocaesio marri	Caesionidae	0.0092	3.234	Kulbicki etal 2005	Used Pterocaesio spp.
113	Pterocaesio pisang	Caesionidae	0.0092	3.234	Kulbicki etal 2005	
114	Pterocaesio spp.	Caesionidae	0.0092	3.234	Kulbicki etal 2005	
115	Pterocaesio tile	Caesionidae	0.01120606	3	Fishbase (www.fishbase.com)	
116	Pterocaesio trilineata	Caesionidae	0.0107	3.178	Kulbicki etal 2005	
117	Synchiropus rameus	Callionymidae	0.0687	2.184	Kulbicki etal 2005	
118	Synchiropus splendidus	Callionymidae	0.0109	3.341	Kulbicki etal 2005	
119	Synchiropus spp.	Callionymidae	0.0491	2.317	Kulbicki etal 2005	
120	Atule mate	Carangidae	0.0166	2.949	Kulbicki etal 2005	
121	Auxis thazard	Carangidae	0.0018	3.334	Fishbase (www.fishbase.com)	
122	Carangoides armatus	Carangidae	0.0115	3.126	Kulbicki etal 2005	
123	Carangoides bajad	Carangidae	0.0463	2.746	Kulbicki etal 2005	Used C. gymnostethus
124	Carangoides chrysophrys	Carangidae	0.0267	2.902	Kulbicki etal 2005	
125	Carangoides ferdau	Carangidae	0.0368	2.851	Kulbicki etal 2005	
126	Carangoides fulvoguttatus	Carangidae	0.0329	2.808	Kulbicki etal 2005	
127	Carangoides gymnostethus	Carangidae	0.0463	2.746	Kulbicki etal 2005	
128	Carangoides hedlandensis	Carangidae	0.0381	2.864	Kulbicki etal 2005	
129	Carangoides orthogrammus	Carangidae	0.0156	3.026	Kulbicki etal 2005	
130	Carangoides spp.	Carangidae	0.0361	2.812	Kulbicki etal 2005	
131	Carangoides uii	Carangidae	0.0321	2.902	Kulbicki etal 2005	
132	Caranx ignobilis	Carangidae	0.0164	3.059	Kulbicki etal 2005	
133	Caranx melampygus	Carangidae	0.0234	2.918	Kulbicki etal 2005	
134	Caranx papuensis	Carangidae	0.0235	2.923	Kulbicki etal 2005	
135	Caranx sexfasciatus	Carangidae	0.0318	2.93	Fishbase (www.fishbase.com)	
136	Caranx spp.	Carangidae	0.0198	2.986	Kulbicki etal 2005	
137	Decapterus russellii	Carangidae	0.0139	2.963	Kulbicki etal 2005	
138	Elagatis bipinnulatus	Carangidae	0.0135	2.92	Fishbase (www.fishbase.com)	
139	Gnathanodon speciosus	Carangidae	0.0199	2.995	Kulbicki etal 2005	
140	Other trevally spp	Carangidae	0.0083	3.197	Kulbicki etal 2005	
141	Pseudocaranx dentex	Carangidae	0.0271	2.886	Kulbicki etal 2005	
142	Scomberoides lysan	Carangidae	0.0109	2.923	Kulbicki etal 2005	
143	Scomberoides tol	Carangidae	0.0154	2.787	Kulbicki etal 2005	
144	Selar crumenophthalmus	Carangidae	0.0097	3.194	Kulbicki etal 2005	
145	Carcharhinus albimarginatus	Carcharhinidae	0.0001	4.268	Kulbicki etal 2005	
146	Carcharhinus amblyrhynchos	Carcharhinidae	0.0023	3.373	Kulbicki etal 2005	
147	Carcharhinus limbatus	Carcharhinidae	0.0033	3.283	Kulbicki etal 2005	
148	Carcharhinus melanopterus	Carcharhinidae	0.0013	3.508	Kulbicki etal 2005	
149	Carcharhinus sorrah	Carcharhinidae	0.0007	3.656	Kulbicki etal 2005	
150	Carcharhinus spp.	Carcharhinidae	0.0013	3.508	Kulbicki etal 2005	
151	Ambassis interruptus	Centropomidae	0.0079	3.543	Kulbicki etal 2005	
152	Chaetodon adiergastos	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
153	Chaetodon auriga	Chaetodontidae	0.0404	2.829	Kulbicki etal 2005	
154	Chaetodon baronessa	Chaetodontidae	0.0448	2.828	Fishbase (www.fishbase.com)	
155	Chaetodon bennetti	Chaetodontidae	0.0384	2.885	Kulbicki etal 2005	
156	Chaetodon citrinellus	Chaetodontidae	0.0353	2.834	Kulbicki etal 2005	
157	Chaetodon ephippium	Chaetodontidae	0.0225	3.061	Kulbicki etal 2005	
158	Chaetodon flavirostris	Chaetodontidae	0.0251	3.113	Kulbicki etal 2005	
159	Chaetodon kleini	Chaetodontidae	0.0448	2.828	Fishbase (www.fishbase.com)	
160	Chaetodon lineolatus	Chaetodontidae	0.0693	2.622	Kulbicki etal 2005	

161	Chaetodon lunula	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
162	Chaetodon lunulatus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
163	Chaetodon melannotus	Chaetodontidae	0.0267	3.049	Kulbicki etal 2005	
164	Chaetodon mertensii	Chaetodontidae	0.0043	3.793	Kulbicki etal 2005	
165	Chaetodon meyeri	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
166	Chaetodon ocellicaudus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
167	Chaetodon octofasciatus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
168	Chaetodon ornatissimus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
169	Chaetodon oxycephalus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
170	Chaetodon pelewensis	Chaetodontidae	0.0153	3.297	Kulbicki etal 2005	
171	Chaetodon plebeius	Chaetodontidae	0.0606	2.628	Kulbicki etal 2005	
172	Chaetodon punctatofasciatus	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
173	Chaetodon rafflesi	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
174	Chaetodon semeion	Chaetodontidae	0.045	2.814	Kulbicki et al 2005	Used Chaetodon spp.
175	Chaetodon speculum	Chaetodontidae	0.0664	2.693	Kulbicki etal 2005	
176	Chaetodon spp.	Chaetodontidae	0.045	2.814	Kulbicki etal 2005	
177	Chaetodon trifascialis	Chaetodontidae	0.0258	2.969	Kulbicki etal 2005	
178	Chaetodon trifasciatus	Chaetodontidae	0.0311	2.976	Kulbicki etal 2005	
179	Chaetodon ulietensis	Chaetodontidae	0.0311	2.874	Kulbicki etal 2005	
180	Chaetodon unimaculatus	Chaetodontidae	0.0533	2.833	Kulbicki etal 2005	
181	Chaetodon vagabundus	Chaetodontidae	0.0278	2.973	Kulbicki etal 2005	
182	Chelmon rostratus	Chaetodontidae	0.0091	3.208	Fishbase (www.fishbase.com)	
183	Coradion chrysozonus	Chaetodontidae	0.0468	2.758	Fishbase (www.fishbase.com)	
184	Heniochus acuminatus	Chaetodontidae	0.0247	3.106	Kulbicki etal 2005	
185	Heniochus chrysostomus	Chaetodontidae	0.0161	3.262	Kulbicki etal 2005	
186	Heniochus monoceros	Chaetodontidae	0.017	3.211	Kulbicki etal 2005	
187	Heniochus singularis	Chaetodontidae	0.0487	3	Fishbase (www.fishbase.com)	
188	Heniochus spp.	Chaetodontidae	0.0252	3.082	Kulbicki etal 2005	
189	Heniochus varius	Chaetodontidae	0.025	3	Fishbase (www.fishbase.com)	
190	Chanos chanos	Chanidae	0.0047	3.389	Kulbicki etal 2005	
191	Chirocentrus dorab	Chirocentridae	0.0051	2.987	Kulbicki etal 2005	
192	Cirrhitichtys falco	Cirrhitidae	0.0033	3.849	Kulbicki etal 2005	
193	Paracirrhites forsteri	Cirrhitidae	0.0033	3.849	Kulbicki et al 2005	Used Cirrhitichtys falco
194	Heteroclinus roseus	Clinidae	0.0168	2.775	Kulbicki etal 2005	
195	Anodontostoma chacunda	Clupeidae	0.0202	3.049	Kulbicki etal 2005	
196	Herklotsichthys quadrimaculatus	Clupeidae	0.0065	3.317	Kulbicki etal 2005	
197	Sardinella fijiensis	Clupeidae	0.0163	2.971	Kulbicki etal 2005	
198	Conger cinereus	Congridae	0.0008	3.127	Kulbicki etal 2005	
199	Muraenesox bagio	Congridae	0.0026	2.824	Kulbicki etal 2005	
200	Dasyatis kuhlii	Dasyatidae	0.0092	3.357	Kulbicki etal 2005	
201	Dasyatis spp.	Dasyatidae	0.0094	3.352	Kulbicki etal 2005	
202	Himantura granulata	Dasyatidae	0.0094	3.352	Kulbicki etal 2005	Used Dasyatis spp.
203	Taeniura lymma	Dasyatidae	0.0094	3.352	Kulbicki etal 2005	
204	Diodon hystrix	Diodontidae	0.1934	2.472	Kulbicki etal 2005	
205	Diodon spp.	Diodontidae	0.0678	2.784	Kulbicki etal 2005	
206	Echeneis naucrates	Echeneididae	0.0008	3.358	Kulbicki etal 2005	
207	Butis amboinensis	Eleotrididae	0.0075	3.029	Kulbicki etal 2005	
208	Elops machnata	Elopidae	0.0125	2.927	Kulbicki etal 2005	
209	Stolephorus spp.	Engraulidae	0.0252	2.6	Kulbicki etal 2005	
210	Thryssina baelama	Engraulidae	0.0028	3.586	Kulbicki etal 2005	
211	Platax batavianus	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
212	Platax boersi	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
213	Platax orbicularis	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
214	Platax pinnatus	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
215	Platax spp.	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
216	Platax teira	Ephippidae	0.0443	2.951	Kulbicki etal 2005	
217	Fistularia commersonii	Fistulariidae	0.0009	3	Fishbase (www.fishbase.com)	
218	Fistularia petimba	Fistulariidae	0.0003	3.205	Kulbicki etal 2005	
219	Fistularia spp.	Fistulariidae	0.0005	3.048	Kulbicki etal 2005	
220	Gerres filamentosus	Gerreidae	0.024	3.011	Kulbicki etal 2005	
221	Gerres ovatus	Gerreidae	0.0229	3.005	Kulbicki etal 2005	
222	Gerres oyena	Gerreidae	0.0095	3.337	Kulbicki etal 2005	
223	Gerres spp.	Gerreidae	0.0194	3.07	Kulbicki etal 2005	
224	Nebrius ferrugineus	Ginglymostomatidae	0.0013	3.508	Kulbicki etal 2005	Used Carcharhinus spp.
225	Amblygobius phalaena	Gobiidae	0.0184	2.834	Kulbicki etal 2005	
226	Exyrias bellissimus	Gobiidae	0.013	2.882	Kulbicki etal 2005	
227	Exyrias spp.	Gobiidae	0.012	2.921	Kulbicki etal 2005	
228	Gnatholepis spp.	Gobiidae	0.0175	2.827	Kulbicki etal 2005	
229	Gobiodon citrinus	Gobiidae	0.0577	2.439	Kulbicki etal 2005	
230	Istigobius decoratus	Gobiidae	0.018	2.777	Kulbicki etal 2005	
231	Istigobius ornatus	Gobiidae	0.0098	3.108	Kulbicki etal 2005	
232	Istigobius spp.	Gobiidae	0.0183	2.782	Kulbicki etal 2005	
233	Oxyurichthys papuensis	Gobiidae	0.0126	2.91	Kulbicki etal 2005	
234	Oxyurichthys spp.	Gobiidae	0.0134	2.903	Kulbicki etal 2005	
235	Priolepis cinctus	Gobiidae	0.0153	3.008	Kulbicki etal 2005	
236	Valenciennea longipinnis	Gobiidae	0.0054	3.136	Kulbicki etal 2005	
237	Valenciennea spp.	Gobiidae	0.0104	2.859	Kulbicki etal 2005	
238	Diploprion bifasciatum	Grammistidae	0.0089	3.278	Kulbicki etal 2005	
239	Diagramma melanacrum	Haemulidae	0.0144	2.988	Kulbicki etal 2005	
240	Diagramma pictus	Haemulidae	0.0144	2.988	Kulbicki etal 2005	

241	Hemiramphus affinis	Haemulidae	0.0007	3.575	Kulbicki etal 2005	
242	Hemirhamphus far	Haemulidae	0.3298	1.831	Kulbicki etal 2005	
243	Other sweetlips	Haemulidae	0.0217	2.898	Kulbicki etal 2005	
244	Plectorhinchus albovittatus	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
245	Plectorhinchus chaetodonoides	Haemulidae	0.0173	3.04	Kulbicki etal 2005	
246	Plectorhinchus chrysotaenia	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
247	Plectorhinchus gibbosus	Haemulidae	0.0226	2.962	Kulbicki etal 2005	
248	Plectorhinchus lessonii	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
249	Plectorhinchus lineatus	Haemulidae	0.0126	3.079	Kulbicki etal 2005	
250	Plectorhinchus obscurus	Haemulidae	0.027	2.885	Kulbicki etal 2005	
251	Plectorhinchus picus	Haemulidae	0.0115	3.089	Kulbicki etal 2005	
252	Plectorhinchus polytaenia	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
253	Plectorhinchus spp.	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
254	Plectorhinchus vittatus	Haemulidae	0.0197	2.969	Kulbicki etal 2005	
255	Pomadasys argenteus	Haemulidae	0.0188	2.954	Kulbicki etal 2005	
256	Triaenodon obesus	Hemigaleidae	0.0018	3.344	Kulbicki etal 2005	
257	Kuhlia marginata	Holocentridae	0.0146	3.083	Kulbicki etal 2005	
258	Kuhliidae Kuhlia	Holocentridae	0.016	3.034	Kulbicki etal 2005	
259	Myripristis amaena	Holocentridae	0.0158	3.261	Kulbicki etal 2005	
260	Myripristis berndti	Holocentridae	0.0277	3.003	Kulbicki etal 2005	
261	Myripristis hexagona	Holocentridae	0.025	3.089	Kulbicki etal 2005	
262	Myripristis kuntee	Holocentridae	0.0099	3.468	Kulbicki etal 2005	
263	Myripristis melanosticta	Holocentridae	0.0292	3.024	Kulbicki etal 2005	
264	Myripristis pralinia	Holocentridae	0.0227	3.095	Kulbicki etal 2005	
265	Myripristis spp.	Holocentridae	0.0276	3.03	Kulbicki etal 2005	
266	Myripristis violacea	Holocentridae	0.0364	2.94	Kulbicki etal 2005	
267	Neoniphon argenteus	Holocentridae	0.0317	2.823	Kulbicki etal 2005	
268	Neoniphon sammara	Holocentridae	0.0276	2.888	Kulbicki etal 2005	
269	Neoniphon spp.	Holocentridae	0.0288	2.867	Kulbicki etal 2005	
270	Plectrypops lima	Holocentridae	0.0177	3.139	Kulbicki etal 2005	
271	Sargocentron diadema	Holocentridae	0.0251	2.955	Kulbicki etal 2005	
272	Sargocentron rubrum	Holocentridae	0.0275	2.998	Kulbicki etal 2005	
273	Sargocentron spiniferum	Holocentridae	0.0154	3.119	Kulbicki etal 2005	
274	Sargocentron spp.	Holocentridae	0.0219	3.047	Kulbicki etal 2005	
275	Kyphosus spp.	Kyphosidae	0.0129	3.151	Kulbicki etal 2005	
276	Kyphosus vaigiensis	Kyphosidae	0.02	3.037	Kulbicki etal 2005	
277	Amblyglyphidodon ternatensis	Labridae	0.0144	3.33	Kulbicki etal 2005	Used Amblyglyphidodon spp.
278	Anampses caeruleopunctatus	Labridae	0.0226	2.793	Kulbicki etal 2005	Used Anampses spp.
279	Anampses meleagrides	Labridae	0.0226	2.793	Kulbicki etal 2005	Used Anampses spp.
280	Anampses spp.	Labridae	0.0226	2.793	Kulbicki etal 2005	
281	Bodianus diana	Labridae	0.0108	3.173	Kulbicki etal 2005	Used Bodianus spp.
282	Bodianus mesothorax	Labridae	0.0108	3.173	Kulbicki etal 2005	Used Bodianus spp.
283	Bodianus perditio	Labridae	0.0119	3.149	Kulbicki etal 2005	
284	Bodianus spp.	Labridae	0.0108	3.173	Kulbicki etal 2005	
285	Cheilinus bimaculatus	Labridae	0.0679	2.317	Kulbicki etal 2005	
286	Cheilinus chlorourus	Labridae	0.0197	2.993	Kulbicki etal 2005	
287	Cheilinus fasciatus	Labridae	0.0318	3	Fishbase (www.fishbase.com)	
288	Cheilinus spp.	Labridae	0.0155	3.058	Kulbicki etal 2005	
289	Cheilinus trilobatus	Labridae	0.0162	3.059	Kulbicki etal 2005	
290	Cheilinus undulatus	Labridae	0.0113	3.136	Kulbicki etal 2005	
291	Cheilio inermis	Labridae	0.0035	3.082	Kulbicki etal 2005	
292	Choerodon anchorago	Labridae	0.0151	3.122	Kulbicki etal 2005	Used Choerodon graphicus
293	Choerodon graphicus	Labridae	0.0151	3.122	Kulbicki etal 2005	
294	Choerodon monostigma	Labridae	0.0151	3.122	Kulbicki etal 2005	Used Choerodon graphicus
295	Choerodon schoenleini	Labridae	0.0208	3	Fishbase (www.fishbase.com)	
296	Cirrhilabrus cyanopleura	Labridae	0.0065	3.254	Kulbicki etal 2005	Used Coris spp.
297	Cirrhilabrus spp.	Labridae	0.0065	3.254	Kulbicki etal 2005	Used Coris spp.
298	Coris aygula	Labridae	0.0027	3.489	Kulbicki etal 2005	
299	Coris batuensis	Labridae	0.0065	3.254	Kulbicki etal 2005	Used Coris spp.
300	Coris gaimard	Labridae	0.0172	3	Fishbase (www.fishbase.com)	
301	Coris spp.	Labridae	0.0065	3.254	Kulbicki etal 2005	
302	Diproctacanthus xanthurus	Labridae	0.0076	3.105	Fishbase (www.fishbase.com)	
303	Epibulus insidiator	Labridae	0.0161	3.081	Kulbicki etal 2005	
304	Gomphosus varius	Labridae	0.0244	2.703	Kulbicki etal 2005	
305	Halichoeres argus	Labridae	0.0175	2.957	Kulbicki etal 2005	
306	Halichoeres chloropterus	Labridae	0.016	2.87	Fishbase (www.fishbase.com)	
307	Halichoeres chrysus	Labridae	0.016	2.987	Kulbicki etal 2005	Used Halichoeres spp.
308	Halichoeres hortulanus	Labridae	0.0222	3	Fishbase (www.fishbase.com)	
309	Halichoeres margaritaceus	Labridae	0.0182	3.0000	Fishbase (www.fishbase.com)	
310	Halichoeres marginatus	Labridae	0.0215	3	Fishbase (www.fishbase.com)	
311	Halichoeres melanurus	Labridae	0.0093	3.262	Kulbicki etal 2005	
312	Halichoeres prosopeion	Labridae	0.016	2.987	Kulbicki etal 2005	Used Halichoeres spp.
313	Halichoeres richmondi	Labridae	0.016	2.987	Kulbicki etal 2005	Used Halichoeres spp.
314	Halichoeres solorensis	Labridae	0.016	2.987	Kulbicki etal 2005	Used Halichoeres spp.
315	Halichoeres spp.	Labridae	0.016	2.987	Kulbicki etal 2005	
316	Halichoeres trimaculatus	Labridae	0.0275	2.736	Kulbicki etal 2005	
317	Hemigymnus fasciatus	Labridae	0.0289	3	Fishbase (www.fishbase.com)	
318	Hemigymnus melapterus	Labridae	0.0242	2.923	Kulbicki etal 2005	
319	Hologymnosus annulatus	Labridae	0.0035	3.082	Fishbase (www.fishbase.com)	Used Cheilio inermis
320	Labrichthys unilineatus	Labridae	0.0257	3	Fishbase (www.fishbase.com)	

321	Labroides bicolor	Labridae	0.0059	3.231	Kulbicki etal 2005	Used Labroides bicolor
322	Labroides dimidiatus	Labridae	0.0059	3.231	Kulbicki etal 2005	
323	Labroides pectoralis	Labridae	0.0059	3.231	Kulbicki etal 2005	Used Labroides bicolor
324	Labropsis alleni	Labridae	0.0076	3.105	Fishbase (www.fishbase.com)	Used Labropsis xanthonota
325	Labropsis spp.	Labridae	0.0076	3.105	Fishbase (www.fishbase.com)	Used Labropsis xanthonota
326	Macropharyngodon meleagris	Labridae	0.0228	3	Kulbicki etal 2005	Used Macropharyngodon geoffroy
327	Macropharyngodon negrosensis	Labridae	0.0228	3	Kulbicki etal 2005	Used Macropharyngodon geoffroy
328	Novaculichthys taeniourus	Labridae	0.0065	3.254	Kulbicki etal 2005	Used Coris spp.
329	Oxycheilinus celebicus	Labridae	0.0201	3	Fishbase (www.fishbase.com)	
330	Oxycheilinus digramma	Labridae	0.0225	3	Fishbase (www.fishbase.com)	
331	Oxycheilinus rhodochorus	Labridae	0.0201	3	Fishbase (www.fishbase.com)	Used Oxycheilinus celebicus
332	Paracheilinus sp.	Labridae	0.0065	3.254	Kulbicki etal 2005	Used Coris spp.
333	Pomacanthus semicirculatus	Labridae	0.0286	3	Fishbase (www.fishbase.com)	
334	Pseudocheilinus evanidus	Labridae	0.0049	3.51	Fishbase (www.fishbase.com)	
335	Pseudocheilinus hexataenia	Labridae	0.0366	3	Fishbase (www.fishbase.com)	
336	Pseudocheilinus tetrataenia	Labridae	0.0366	3	Fishbase (www.fishbase.com)	Used Pseudocheilnus hexataenia
337	Pseudodax mollucanus	Labridae	0.0226	2.793	Kulbicki etal 2005	Used Anampses spp.
338	Stethojulis bandanensis	Labridae	0.0304	2.581	Kulbicki etal 2005	
339	Stethojulis spp.	Labridae	0.0185	2.892	Kulbicki etal 2005	
340	Stethojulis strigiventer	Labridae	0.0191	2.876	Kulbicki etal 2005	
341	Stetholulis interrupta	Labridae	0.0292	2.608	Kulbicki etal 2005	
342	Thalassoma amblycephalum	Labridae	0.0172	3	Fishbase (www.fishbase.com)	
343	Thalassoma hardwicke	Labridae	0.0178	2.978	Kulbicki etal 2005	
344	Thalassoma lunare	Labridae	0.0211	2.832	Kulbicki etal 2005	
345	Thalassoma lutescens	Labridae	0.013	3.042	Kulbicki etal 2005	
346	Thalassoma spp.	Labridae	0.0123	3.097	Kulbicki etal 2005	
347	Unid wrasse species 1	Labridae	0.0185	2.892	Kulbicki etal 2005	Used Stethojullis sp.
348	Unid wrasse species 2	Labridae	0.0185	2.892	Kulbicki etal 2005	Used Stethojullis sp.
349	Gazza minuta	Leiognathidae	0.0327	2.876	Kulbicki etal 2005	
350	Leiognathus bindus	Leiognathidae	0.0263	2.897	Kulbicki etal 2005	
351	Leiognathus equulus	Leiognathidae	0.027	2.98	Kulbicki etal 2005	
352	Leiognathus fasciatus	Leiognathidae	0.02	3.102	Kulbicki etal 2005	
353	Leiognathus leuciscus	Leiognathidae	0.007	3.488	Kulbicki etal 2005	
354	Leiognathus rivulatus	Leiognathidae	0.0192	3.008	Kulbicki etal 2005	
355	Leiognathus splendens	Leiognathidae	0.0288	2.949	Kulbicki etal 2005	
356	Leiognathus spp.	Leiognathidae	0.0157	3.187	Kulbicki etal 2005	
357	Secutor ruconius	Leiognathidae	0.0268	2.969	Kulbicki etal 2005	
358	Gnathodentex aurolineatus	Lethrinidae	0.018	3.063	Kulbicki etal 2005	
359	Gymnocranius euanus	Lethrinidae	0.0225	3.001	Kulbicki etal 2005	
360	Gymnocranius grandocculis	Lethrinidae	0.032	2.885	Kulbicki etal 2005	
361	Gymnocranius sp.	Lethrinidae	0.0276	2.933	Kulbicki etal 2005	
362	Gymnocranius spp.	Lethrinidae	0.0302	2.909	Kulbicki etal 2005	
363	Lethrinus atkinsoni	Lethrinidae	0.0178	3.057	Kulbicki etal 2005	
364	Lethrinus genivittatus	Lethrinidae	0.0179	2.995	Kulbicki etal 2005	
365	Lethrinus harak	Lethrinidae	0.017	3.042	Kulbicki etal 2005	
366	Lethrinus lentjan	Lethrinidae	0.0197	2.986	Kulbicki etal 2005	
367	Lethrinus miniatus	Lethrinidae	0.0066	3.277	Kulbicki etal 2005	
368	Lethrinus nebulosus	Lethrinidae	0.0187	2.996	Kulbicki etal 2005	
369	Lethrinus obsoletus	Lethrinidae	0.0173	3.026	Kulbicki etal 2005	
370	Lethrinus olivaceus	Lethrinidae	0.0294	2.851	Kulbicki etal 2005	
371	Lethrinus ravus	Lethrinidae	0.0141	3.065	Kulbicki etal 2005	
372	Lethrinus rubrioperculatus	Lethrinidae	0.0128	3.108	Kulbicki etal 2005	
373	Lethrinus semicinctus	Lethrinidae	0.0118	3.117	Kulbicki etal 2005	
374	Lethrinus spp.	Lethrinidae	0.0165	3.043	Kulbicki etal 2005	
375	Lethrinus xanthochilus	Lethrinidae	0.0201	2.964	Kulbicki etal 2005	
376	Monotaxis grandoculis	Lethrinidae	0.023	3.022	Kulbicki etal 2005	
377	Monotaxis heterodon	Lethrinidae	0.023	3.022	Kulbicki etal 2005	Used M. grandoculis
378	Aprion virescens	Lutjanidae	0.023	2.886	Kulbicki etal 2005	
379	Lutjanus adetii	Lutjanidae	0.0071	3.261	Kulbicki etal 2005	
380	Lutjanus argentimaculatus	Lutjanidae	0.028	2.844	Kulbicki etal 2005	
381	Lutjanus biguttatus	Lutjanidae	0.0151	3.057	Kulbicki etal 2005	
382	Lutjanus bohar	Lutjanidae	0.0156	3.059	Kulbicki etal 2005	
383	Lutjanus carponotatus	Lutjanidae	0.0151	3.057	Kulbicki etal 2005	Used Lutjanus spp.
384	Lutjanus decussatus	Lutjanidae	0.0151	3.057	Kulbicki etal 2005	
385	Lutjanus fulviflamma	Lutjanidae	0.0205	2.96	Kulbicki etal 2005	
386	Lutjanus fulvus	Lutjanidae	0.0211	2.974	Kulbicki etal 2005	
387	Lutjanus gibbus	Lutjanidae	0.0131	3.138	Kulbicki etal 2005	
388	Lutjanus kasmira	Lutjanidae	0.0084	3.247	Kulbicki etal 2005	
389	Lutjanus lutjanus	Lutjanidae	0.0182	2.969	Kulbicki etal 2005	
390	Lutjanus monostigma	Lutjanidae	0.0222	2.913	Kulbicki etal 2005	
391	Lutjanus quinquelineatus	Lutjanidae	0.0146	3.1	Kulbicki etal 2005	
392	Lutjanus rivulatus	Lutjanidae	0.0084	3.26	Kulbicki etal 2005	
393	Lutjanus russelli	Lutjanidae	0.0166	2.978	Kulbicki etal 2005	
394	Lutjanus sebae	Lutjanidae	0.0116	3.152	Kulbicki etal 2005	
395	Lutjanus semicinctus	Lutjanidae	0.004	3.428	Kulbicki etal 2005	
396	Lutjanus spp.	Lutjanidae	0.0151	3.057	Kulbicki etal 2005	
397	Lutjanus vitta	Lutjanidae	0.00999	3.086	Fishbase (www.fishbase.com)	
398	Lutjanus vittus	Lutjanidae	0.0125	3.075	Kulbicki etal 2005	
399	Macolor macularis	Lutjanidae	0.0211	3	Fishbase (www.fishbase.com)	
400	Macolor niger	Lutjanidae	0.0145	3	Fishbase (www.fishbase.com)	

401	Symphorus nematophorus	Lutjanidae	0.0147	3.046	Kulbicki etal 2005	
402	Symphorichthys spilurus	Lutjanidae	0.0145	3.0000	Fishbase (www.fishbase.com)	
403	Megalops cyprinoides	Megalopidae	0.0122	3.033	Kulbicki etal 2005	
404	Microcanthus strigatus	Microcanthidae	0.0526	2.818	Kulbicki etal 2005	
405	Paramonacanthus japonicus	Microcanthidae	0.0219	2.889	Kulbicki etal 2005	
406	Manta sp	Mobulidae	0.0164	3	Fishbase (www.fishbase.com)	
407	Amanses scopas	Monacanthidae	0.017	3.07	Fishbase (www.fishbase.com)	Used Canthigaster pardalis
408	Pseudalutarius nasicornis	Monacanthidae	0.007	3.262	Kulbicki etal 2005	
409	Monodactylus argenteus	Monodactylidae	0.0303	2.964	Kulbicki etal 2005	
410	Liza macrolepis	Mugilidae	0.0144	3.014	Kulbicki etal 2005	
411	Liza melinoptera	Mugilidae	0.0133	3.045	Kulbicki etal 2005	
412	Liza spp.	Mugilidae	0.0141	3.023	Kulbicki etal 2005	
413	Mugil cephalus	Mugilidae	0.0109	3.089	Kulbicki etal 2005	
414	Valamugil buchanani	Mugilidae	0.0101	3.104	Kulbicki etal 2005	
415	Valamugil engeli	Mugilidae	0.0058	3.287	Kulbicki etal 2005	
416	Valamugil seheli	Mugilidae	0.0061	3.275	Kulbicki etal 2005	
417	Valamugil spp.	Mugilidae	0.0088	3.148	Kulbicki etal 2005	
418	Mulloides flavolineatus	Mullidae	0.012	3.101	Kulbicki etal 2005	
419	Mulloides spp.	Mullidae	0.0074	3.293	Kulbicki etal 2005	
420	Mulloidichthys vanicolensis	Mullidae	0.0099	3.0150	Fishbase (www.fishbase.com)	
421	Parupeneus barberinus	Mullidae	0.0131	3.122	Kulbicki etal 2005	
422	Parupeneus bifasciatus	Mullidae	0.0036	3.4510	Fishbase (www.fishbase.com)	
423	Parupeneus ciliatus	Mullidae	0.0116	3.22	Kulbicki etal 2005	
424	Parupeneus cyclostomus	Mullidae	0.0243	3.0000	Fishbase (www.fishbase.com)	
425	Parupeneus heptacanthus	Mullidae	0.0169	3.078	Kulbicki etal 2005	
426	Parupeneus indicus	Mullidae	0.0142	3.114	Kulbicki etal 2005	
427	Parupeneus multifasciatus	Mullidae	0.0114	3.211	Kulbicki etal 2005	
428	Parupeneus spilurus	Mullidae	0.0192	3.022	Kulbicki etal 2005	
429	Parupeneus spp.	Mullidae	0.0145	3.13	Kulbicki etal 2005	
430	Upeneus australiae	Mullidae	0.013	3.112	Kulbicki etal 2005	
431	Upeneus guttatus	Mullidae	0.0218	2.883	Kulbicki etal 2005	
432	Upeneus moluccensis	Mullidae	0.017	3.022	Kulbicki etal 2005	
433	Upeneus spp.	Mullidae	0.0103	3.215	Kulbicki etal 2005	
434	Upeneus sulphureus	Mullidae	0.0081	3.322	Kulbicki etal 2005	
435	Upeneus tragula	Mullidae	0.0137	3.068	Kulbicki etal 2005	
436	Upeneus vittatus	Mullidae	0.0072	3.354	Kulbicki etal 2005	
437	Echidna spp.	Muraenidae	0.0003	3.352	Kulbicki etal 2005	
438	Gymnothorax fimbriatus	Muraenidae	0.0004	3.324	Kulbicki etal 2005	
439	Gymnothorax javanicus	Muraenidae	0.0005	3.303	Kulbicki etal 2005	used Gymnothorax spp.
440	Gymnothorax spp.	Muraenidae	0.0005	3.303	Kulbicki etal 2005	
441	Thyrsoidea macrura	Muraenidae	0.0113	2.311	Kulbicki etal 2005	
442	Thyrsoidea spp.	Muraenidae	0.0115	2.305	Kulbicki etal 2005	
443	Aetobatus narinari	Myliobatidae	0.0059	3.13	Fishbase (www.fishbase.com)	
444	Nemipterus furcosus	Nemipteridae	0.006	3.357	Kulbicki etal 2005	
445	Nemipterus peroni	Nemipteridae	0.0079	3.251	Kulbicki etal 2005	
446	Nemipterus spp.	Nemipteridae	0.0068	3.307	Kulbicki etal 2005	
447	Pentapodus aureofasciatus	Nemipteridae	0.0283	3	Fishbase (www.fishbase.com)	Used Penatpodus caninus
448	Pentapodus spp.	Nemipteridae	0.0283	3	Fishbase (www.fishbase.com)	Used Penatpodus caninus
449	Pentapodus trivittatus	Nemipteridae	0.0283	3	Fishbase (www.fishbase.com)	Used Penatpodus caninus
450	Scolopsis bilineatus	Nemipteridae	0.0138	3.174	Kulbicki etal 2005	
451	Scolopsis ciliatus	Nemipteridae	0.0641	2.48	Fishbase (www.fishbase.com)	
452	Scolopsis margaritifer	Nemipteridae	0.0157	3.054	Kulbicki etal 2005	Used Scolopsis spp.
453	Scolopsis spp.	Nemipteridae	0.0157	3.054	Kulbicki etal 2005	
454	Scolopsis taeniopterus	Nemipteridae	0.0185	2.981	Kulbicki etal 2005	
455	Scolopsis temporalis	Nemipteridae	0.0113	3.09	Fishbase (www.fishbase.com)	
456	Opisthognathus spp.	Opistognathidae	0.0231	2.452	Kulbicki etal 2005	
457	Eucrossorhinus dasypogon	Orectolobidae	0.0038	3.06	Fishbase (www.fishbase.com)	used Rhynchobatus djiddensis
458	Lactoria cornuta	Ostraciidae	0.0065	3.168	Kulbicki etal 2005	
459	Lactoria spp.	Ostraciidae	0.4029	1.928	Kulbicki etal 2005	
460	Ostracion cubicus	Ostraciidae	0.1288	2.519	Kulbicki etal 2005	
461	Ostracion meleagris	Ostraciidae	0.1288	2.519	Kulbicki etal 2005	Used Ostracion cubicus
462	Tetrosomus gibbosus	Ostraciidae	0.182	2.369	Kulbicki etal 2005	
463	Parapercis cylindrica	Pinguipedidae	0.0124	3	Kulbicki etal 2005	
464	Parapercis hexophtalma	Pinguipedidae	0.0068	3.157	Kulbicki etal 2005	
465	Parapercis millipunctata	Pinguipedidae	0.0133	2.943	Kulbicki etal 2005	Used Parapercis spp.
466	Parapercis spp.	Pinguipedidae	0.0133	2.943	Kulbicki etal 2005	
467	Parapercis xanthozona	Pinguipedidae	0.0133	2.89	Kulbicki etal 2005	
468	Cymbacephalus beauforti	Platycephalidae	0.004	3.211	Kulbicki etal 2005	
469	Onigocia macrolepis	Platycephalidae	0.0239	2.646	Kulbicki etal 2005	
470	Onigocia spinosa	Platycephalidae	0.0352	2.465	Kulbicki etal 2005	
471	Thysanophrys chiltonae	Platycephalidae	0.0027	3.347	Kulbicki etal 2005	
472	Assessor macneili	Plesiopidae	0.0181	2.791	Kulbicki etal 2005	
473	Plesiops coeruleolineatus	Plesiopidae	0.0067	3.496	Kulbicki etal 2005	
474	Polydactylus microstoma	Polynemidae	0.0135	3.117	Kulbicki etal 2005	
475	Apolomichthys trimaculatus	Pomacanthidae	0.0309	3	Fishbase (www.fishbase.com)	Used Apolimichthyes arcuatus
476	Centropyge bicolor	Pomacanthidae	0.0415	3	Fishbase (www.fishbase.com)	
477	Centropyge bispinosus	Pomacanthidae	0.092	2.458	Kulbicki etal 2005	
478	Centropyge nox	Pomacanthidae	0.0745	2.577	Kulbicki etal 2005	Used Centropyge spp.
479	Centropyge spp.	Pomacanthidae	0.0745	2.577	Kulbicki etal 2005	
480	Centropyge tibicen	Pomacanthidae	0.0492	2.795	Kulbicki etal 2005	

481	Centropyge vroliki	Pomacanthidae	0.0745	2.577	Kulbicki etal 2005	Used Centropyge spp.
482	Chaetodontoplus mesoleucus	Pomacanthidae	0.0669	2.724	Kulbicki etal 2005	Used Pomacentrus sextriatus
483	Pomacanthus imperator	Pomacanthidae	0.0276	3	Fishbase (www.fishbase.com)	
484	Pomacanthus navarchus	Pomacanthidae	0.0669	2.724	Kulbicki etal 2005	Used Pomacentrus sextriatus
485	Pomacanthus sextriatus	Pomacanthidae	0.0669	2.724	Kulbicki etal 2005	
486	Pomacanthus xanthometopon	Pomacanthidae	0.0669	2.724	Kulbicki etal 2005	Used Pomacentrus sextriatus
487	Pygoplites diacanthus	Pomacanthidae	0.0276	3	Fishbase (www.fishbase.com)	
488	Abudefduf bengalensis	Pomacentridae	0.0226	3.132	Kulbicki etal 2005	Used Abudefduf spp.
489	Abudefduf sexfasciatus	Pomacentridae	0.0213	3.152	Kulbicki etal 2005	
490	Abudefduf spp.	Pomacentridae	0.0226	3.132	Kulbicki etal 2005	
491	Abudefduf whitleyi	Pomacentridae	0.0254	3.093	Kulbicki etal 2005	
492	Amblyglyphidodon aureus	Pomacentridae	0.0144	3.33	Kulbicki etal 2005	Used Amblyglyphidodon spp.
493	Amblyglyphidodon curacao	Pomacentridae	0.0126	3.435	Kulbicki etal 2005	
494	Amblyglyphidodon leucogaster	Pomacentridae	0.0297	2.936	Kulbicki etal 2005	
495	Amblyglyphidodon spp.	Pomacentridae	0.0144	3.33	Kulbicki etal 2005	
496	Amphiprion akindynos	Pomacentridae	0.0316	2.93	Kulbicki etal 2005	
497	Amphiprion clarkii	Pomacentridae	0.0189	3.19	Kulbicki etal 2005	Used Amphiprion spp.
498	Amphiprion melanopus	Pomacentridae	0.0155	3.298	Kulbicki etal 2005	
499	Amphiprion perideraion	Pomacentridae	0.0189	3.19	Kulbicki etal 2005	Used Amphiprion spp.
500	Amphiprion spp.	Pomacentridae	0.0189	3.19	Kulbicki etal 2005	
501	Amphiprion tricinctus	Pomacentridae	0.0385	2.904	Kulbicki etal 2005	
502	Chromis alpha	Pomacentridae	0.0229	3.175	Kulbicki etal 2005	Used Chromis spp.
503	Chromis amboinensis	Pomacentridae	0.0258	3	Fishbase (www.fishbase.com)	
504	Chromis atripectoralis	Pomacentridae	0.0179	3.291	Kulbicki etal 2005	
505	Chromis atripes	Pomacentridae	0.0237	3	Fishbase (www.fishbase.com)	
506	Chromis chrysura	Pomacentridae	0.0228	3.222	Kulbicki etal 2005	
507	Chromis delta	Pomacentridae	0.0229	3.175	Kulbicki etal 2005	Used Chromis spp.
508	Chromis elerae	Pomacentridae	0.0229	3.175	Kulbicki etal 2005	Used Chromis spp.
509	Chromis fumea	Pomacentridae	0.0144	3.351	Kulbicki etal 2005	
510	Chromis iomelas	Pomacentridae	0.0151	3.383	Kulbicki etal 2005	
511	Chromis lepidolepis	Pomacentridae	0.195	1.939	Kulbicki etal 2005	
512	Chromis margaritifer	Pomacentridae	0.0229	3.175	Kulbicki etal 2005	Used Chromis spp.
513	Chromis retrofasciatus	Pomacentridae	0.009	2.773	Fishbase (www.fishbase.com)	
514	Chromis spp.	Pomacentridae	0.0229	3.175	Kulbicki etal 2005	
515	Chromis ternatensis	Pomacentridae	0.016	3.408	Kulbicki etal 2005	
516	Chromis viridis	Pomacentridae	0.0351	2.9	Kulbicki etal 2005	
517	Chromis weberi	Pomacentridae	0.0391	3	Fishbase (www.fishbase.com)	
518	Chromis xanthura	Pomacentridae	0.009	2.773	Fishbase (www.fishbase.com)	
519	Chrysiptera hemicyanea	Pomacentridae	0.026	2.926	Kulbicki etal 2005	Used Chrysiptera spp.
520	Chrysiptera oxycephala	Pomacentridae	0.026	2.926	Kulbicki etal 2005	Used Chrysiptera spp.
521	Chrysiptera rollandi	Pomacentridae	0.026	2.926	Kulbicki etal 2005	Used Chrysiptera spp.
522	Chrysiptera spp.	Pomacentridae	0.026	2.926	Kulbicki etal 2005	
523	Chrysiptera springeri	Pomacentridae	0.026	2.926	Kulbicki etal 2005	Used Chrysiptera spp.
524	Chrysiptera talboti	Pomacentridae	0.026	2.926	Kulbicki etal 2005	Used Chrysiptera spp.
525	Chrysiptera taupou	Pomacentridae	0.022	3.001	Kulbicki etal 2005	
526	Dascyllus aruanus	Pomacentridae	0.0415	2.989	Kulbicki etal 2005	
527	Dascyllus reticulatus	Pomacentridae	0.0311	3.133	Kulbicki etal 2005	
528	Dascyllus spp.	Pomacentridae	0.0462	2.911	Kulbicki etal 2005	
529	Dascyllus trimaculatus	Pomacentridae	0.0313	3.043	Kulbicki etal 2005	
530	Dischistodus perspicillatus	Pomacentridae	0.0395	2.989	Kulbicki etal 2005	Used Stegastes spp.
531	Dischistodus prosopotaenia	Pomacentridae	0.0395	2.989	Kulbicki etal 2005	Used Stegastes spp.
532	Hemiglyphidodon plagiometopon	Pomacentridae	0.0652	2.741	Kulbicki etal 2005	Used Stegastes lividus
533	Neoglyphidodon melas	Pomacentridae	0.0175	3.212	Kulbicki etal 2005	Used Neoglyphidodon spp.
534	Neoglyphidodon nigroris	Pomacentridae	0.0178	3.182	Kulbicki etal 2005	
535	Neoglyphidodon polyacanthus	Pomacentridae	0.0206	3.146	Kulbicki etal 2005	
536	Neoglyphidodon spp.	Pomacentridae	0.0175	3.212	Kulbicki etal 2005	
537	Neoglyphidodon thoracotaeniatus	Pomacentridae	0.0175	3.212	Kulbicki etal 2005	Used Neoglyphidodon spp.
538	Neopomacentrus azysron	Pomacentridae	0.0258	2.943	Kulbicki etal 2005	
539	Neopomacentrus bankieri	Pomacentridae	0.0258	2.933	Kulbicki etal 2005	Used Neopomacentrus spp.
540	Neopomacentrus filamentosus	Pomacentridae	0.0258	2.933	Kulbicki etal 2005	Used Neopomacentrus spp.
541	Neopomacentrus nemurus	Pomacentridae	0.0259	2.913	Kulbicki etal 2005	
542	Neopomacentrus spp.	Pomacentridae	0.0258	2.933	Kulbicki etal 2005	
543	Plectroglyphidodon imparipennis	Pomacentridae	0.0612	2.747	Fishbase (www.fishbase.com)	Used Plectroglyphidodon dickii
544	Plectroglyphidodon lacrymatus	Pomacentridae	0.0612	2.747	Fishbase (www.fishbase.com)	Used Plectroglyphidodon dickii
545	Pomacentrus adelus	Pomacentridae	0.0176	3.292	Kulbicki etal 2005	
546	Pomacentrus amboinensis	Pomacentridae	0.0439	2.824	Kulbicki etal 2005	
547	Pomacentrus auriventris	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
548	Pomacentrus bankanensis	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
549	Pomacentrus brachialis	Pomacentridae	0.0066	3.312	Kulbicki etal 2005	Used Pomacentrus spp.
550	Pomacentrus chrysurus	Pomacentridae	0.0264	3.083	Kulbicki etal 2005	
551	Pomacentrus cuneatus	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
552	Pomacentrus grammorhynchus	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
553	Pomacentrus imitator	Pomacentridae	0.0102	3.469	Kulbicki etal 2005	
554	Pomacentrus lepidogenys	Pomacentridae	0.0215	3.21	Kulbicki etal 2005	
555	Pomacentrus melanopterus	Pomacentridae	0.0116	3.387	Kulbicki etal 2005	
556	Pomacentrus moluccensis	Pomacentridae	0.0305	3.012	Kulbicki etal 2005	
557	Pomacentrus nagasakiensis	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
558	Pomacentrus nigromanus	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
559	Pomacentrus opisthostigma	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
560	Pomacentrus pavo	Pomacentridae	0.0252	2.972	Kulbicki etal 2005	

561	Pomacentrus philippinus	Pomacentridae	0.0231	3.058	Kulbicki etal 2005	
562	Pomacentrus reidi	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
563	Pomacentrus smithi	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
564	Pomacentrus sp. 2	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
565	Pomacentrus sp. 3	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
566	Pomacentrus sp. 5	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
567	Pomacentrus sp. 6	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
568	Pomacentrus sp. 7	Pomacentridae	0.028	3.024	Kulbicki etal 2005	Used Pomacentrus spp.
569	Pomacentrus spp.	Pomacentridae	0.028	3.024	Kulbicki etal 2005	
570	Pomacentrus vaiuli	Pomacentridae	0.0472	2.775	Kulbicki etal 2005	
571	Premnas biaculeatus	Pomacentridae	0.0537	2.8860	Fishbase (www.fishbase.com)	
572	Stegastes fasciatus	Pomacentridae	0.0028	4.063	Kulbicki etal 2005	
573	Stegastes lividus	Pomacentridae	0.0652	2.741	Kulbicki etal 2005	
574	Stegastes nigricans	Pomacentridae	0.0384	3.01	Kulbicki etal 2005	
575	Stegastes spp.	Pomacentridae	0.0395	2.989	Kulbicki etal 2005	
576	Teixeirichthys jordani	Pomacentridae	0.0197	3.072	Kulbicki etal 2005	
577	Heteropriacanthus cruentatus	Priacanthidae	0.0279	2.823	Kulbicki etal 2005	
578	Priacanthus hamrur	Priacanthidae	0.03	2.801	Kulbicki etal 2005	
579	Pseudochromis purpurascens	Pseudochromidae	0.0099	3.145	Kulbicki etal 2005	
580	Pseudochromis salvati	Pseudochromidae	0.0218	2.752	Kulbicki etal 2005	
581	Pseudochromis spp.	Pseudochromidae	0.0096	3.167	Kulbicki etal 2005	
582	Nemateleotris magnifica	Ptereleotridae	0.0104	2.859	Kulbicki etal 2005	Used Valenciennea spp.
583	Ptereleotris evides	Ptereleotridae	0.0104	2.859	Kulbicki etal 2005	Used Valenciennea spp.
584	Bolbometopon muricatum	Scarini	0.0098	3.1329	Hamilton 2004	
585	Calatomus carolinus	Scarini	0.0243	2.969	Kulbicki etal 2005	Used Chlorurus sordidus
586	Cetoscarus bicolor	Scarini	0.01567017	3	Fishbase (www.fishbase.com)	
587	Chlorurus bleekeri	Scarini	0.0243	2.969	Kulbicki etal 2005	
588	Chlorurus bleekeri	Scarini	0.0243	2.969	Kulbicki etal 2005	Used Chlorurus sordidus
589	Chlorurus bowersi	Scarini	0.0243	2.969	Kulbicki etal 2005	Used Chlorurus sordidus
590	Chlorurus frontalis	Scarini	0.0136	3.11	Fishbase (www.fishbase.com)	
591	Chlorurus japanensis	Scarini	0.0243	2.969	Kulbicki etal 2005	Used Chlorurus sordidus
592	Chlorurus microrhinus	Scarini	0.0273	2.93	Fishbase (www.fishbase.com)	
593	Chlorurus sordidus	Scarini	0.0243	2.969	Kulbicki etal 2005	
594	Hipposcarus longiceps	Scarini	0.0633	2.6184	Kulbicki etal 2005	Used Hipposcarus spp.
595	Leptoscarus vaigiensis	Scarini	0.0163	2.991	Kulbicki etal 2005	
596	Scarus altipinnis	Scarini	0.0184	3.029	Kulbicki etal 2005	
597	Scarus chameleon	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
598	Scarus dimidiatus	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
599	Scarus flavipectoralis	Scarini	0.0202	2.9811	Hoey and Bellwood unpubl. data	
600	Scarus forsteni	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
601	Scarus frenatus	Scarini	0.0279	3.06	Choat et al 1996	
602	Scarus ghobban	Scarini	0.0165	3.041	Kulbicki etal 2005	
603	Scarus globiceps	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
604	Scarus niger	Scarini	0.0134	3.16	Kulbicki etal 2005	
605	Scarus prasiognathus	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
606	Scarus psittacus	Scarini	0.0105	3.319	Kulbicki etal 2005	
607	Scarus quoyi	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
608	Scarus rivulatus	Scarini	0.0175	3.074	Kulbicki etal 2005	
609	Scarus rubroviolaceus	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
610	Scarus schlegeli	Scarini	0.0231	2.969	Kulbicki etal 2005	
611	Scarus spp.	Scarini	0.0234	2.956	Kulbicki etal 2005	
612	Scarus tricolor	Scarini	0.0234	2.956	Kulbicki etal 2005	Used Scarus spp.
613	Scatophagus argus	Scatophagidae	0.0345	2.948	Kulbicki etal 2005	
614	Grammatorycnus bilineatus	Scombridae	0.0099	3	Fishbase (www.fishbase.com)	
615	Gymnosarda unicolor	Scombridae	0.0105	3.065	Fishbase (www.fishbase.com)	
616	Rastrelliger kanagurta	Scombridae	0.0014	3.377	Fishbase (www.fishbase.com)	
617	Scomberoides lysan	Scombridae	0.0117	2.896	Fishbase (www.fishbase.com)	
618	Scomberomorus commersoni	Scombridae	0.0162	2.856	Kulbicki etal 2005	
619	Selaroides leptolepis	Scombridae	0.017	3	Fishbase (www.fishbase.com)	
620	Dendrochirus brachypterus	Scorpaenidae	0.0097	3.337	Kulbicki etal 2005	
621	Pterois spp.	Scorpaenidae	0.0358	2.697	Kulbicki etal 2005	
622	Scorpaenodes guamensis	Scorpaenidae	0.0196	3.038	Kulbicki etal 2005	
623	Scorpaenodes parvipinnis	Scorpaenidae	0.0254	2.999	Kulbicki etal 2005	
624	Scorpaenodes scabra	Scorpaenidae	0.0245	2.96	Kulbicki etal 2005	
625	Scorpaenodes spp.	Scorpaenidae	0.0169	3.138	Kulbicki etal 2005	
626	Scorpaenopsis spp.	Scorpaenidae	0.0131	3.261	Kulbicki etal 2005	
627	Aethaloperca rogaa	Serranidae	0.0299	3	Fishbase (www.fishbase.com)	
628	Anyperodon leucogrammicus	Serranidae	0.0014	3.548	Kulbicki etal 2005	
629	Cephalopholis argus	Serranidae	0.0093	3.181	Kulbicki etal 2005	
630	Cephalopholis boenack	Serranidae	0.0146	3.019	Kulbicki etal 2005	
631	Cephalopholis cyanostigma	Serranidae	0.0115	3.109	Kulbicki etal 2005	
632	Cephalopholis leopardus	Serranidae	0.0115	3.109	Kulbicki etal 2005	Used Cephalopholis spp.
633	Cephalopholis microprion	Serranidae	0.0115	3.109	Kulbicki etal 2005	
634	Cephalopholis miniata	Serranidae	0.0107	3.114	Kulbicki etal 2005	
635	Cephalopholis sexmaculata	Serranidae	0.0115	3.109	Kulbicki etal 2005	
636	Cephalopholis sonnerati	Serranidae	0.0066	3.277	Kulbicki etal 2005	
637	Cephalopholis spp.	Serranidae	0.0115	3.109	Kulbicki etal 2005	
638	Cephalopholis urodeta	Serranidae	0.0282	2.818	Kulbicki etal 2005	
639	Cromileptes altivelis	Serranidae	0.0962	2.489	Kulbicki etal 2005	
640	Diploprion sp.	Serranidae	0.0089	3.278	Kulbicki etal 2005	Used Diplorion bifasciatum

641	Epinephelus areolatus	Serranidae	0.0114	3.048	Kulbicki etal 2005	
642	Epinephelus caeruleopunctatus	Serranidae	0.018	2.938	Kulbicki etal 2005	
643	Epinephelus coioides	Serranidae	0.0099	3.102	Kulbicki etal 2005	
644	Epinephelus cyanopodus	Serranidae	0.0111	3.114	Kulbicki etal 2005	
645	Epinephelus fasciatus	Serranidae	0.0138	3.041	Kulbicki etal 2005	
646	Epinephelus fuscoguttatus	Serranidae	0.0134	3.057	Kulbicki etal 2005	
647	Epinephelus hexagonatus	Serranidae	0.0122	3.053	Kulbicki etal 2005	Used Epinephalus spp.
648	Epinephelus howlandi	Serranidae	0.0153	2.999	Kulbicki etal 2005	
649	Epinephelus lanceolatus	Serranidae	0.0173	3	Fishbase (www.fishbase.com)	
650	Epinephelus macrospilos	Serranidae	0.0132	3.031	Kulbicki etal 2005	
651	Epinephelus maculatus	Serranidae	0.011	3.062	Kulbicki etal 2005	
652	Epinephelus malabaricus	Serranidae	0.0121	3.052	Kulbicki etal 2005	
653	Epinephelus melanostigma	Serranidae	0.0122	3.053	Kulbicki etal 2005	
654	Epinephelus merra	Serranidae	0.0158	2.966	Kulbicki etal 2005	
655	Epinephelus ongus	Serranidae	0.019	2.928	Kulbicki etal 2005	
656	Epinephelus polyphekadion	Serranidae	0.0083	3.166	Kulbicki etal 2005	
657	Epinephelus rivulatus	Serranidae	0.0114	3.086	Kulbicki etal 2005	
658	Epinephelus spp.	Serranidae	0.0122	3.053	Kulbicki etal 2005	
659	Gracila albomarginata	Serranidae	0.0122	3.053	Kulbicki etal 2005	Used Epinephalus spp.
660	Other grouper spp	Serranidae	0.0134	3.031	Kulbicki etal 2005	
661	Plectropomus areolatus	Serranidae	0.0115	3.0889	Fishbase (www.fishbase.com)	
662	Plectropomus laevis	Serranidae	0.0059	3.238	Kulbicki etal 2005	
663	Plectropomus leopardus	Serranidae	0.0118	3.06	Kulbicki etal 2005	
664	Plectropomus maculatus	Serranidae	0.0156	3	Fishbase (www.fishbase.com)	
665	Plectropomus oligocanthus	Serranidae	0.0132	3	Fishbase (www.fishbase.com)	
666	Plectropomus spp.	Serranidae	0.0107	3.086	Kulbicki etal 2005	
667	Pseudanthias hypselosoma	Serranidae	0.0137	3.149	Kulbicki etal 2005	
668	Variola albimarginata	Serranidae	0.0139	3.0427	Fishbase (www.fishbase.com)	
669	Variola louti	Serranidae	0.0122	3.079	Kulbicki etal 2005	
670	Pseudanthias huchti	Serranidae/Anthiinae	0.0127	3.085	Fishbase (www.fishbase.com)	
671	Pseudanthias tuka	Serranidae/Anthiinae	0.0137	3.149	Kulbicki etal 2005	Used Pseudanthias hypselosoma
672	Siganus argenteus	Siganidae	0.0109	3.154	Kulbicki etal 2005	
673	Siganus canaliculatus	Siganidae	0.0120	3.0110	Fishbase (www.fishbase.com)	
674	Siganus corallinus	Siganidae	0.0023	3.821	Kulbicki etal 2005	
675	Siganus doliatus	Siganidae	0.0104	3.272	Kulbicki etal 2005	
676	Siganus fuscescens	Siganidae	0.0137	3.068	Kulbicki etal 2005	
677	Siganus guttatus	Siganidae	0.0219	2.998	Kulbicki etal 2005	
678	Siganus javus	Siganidae	0.0219	2.998	Kulbicki etal 2005	
679	Siganus lineatus	Siganidae	0.0219	2.998	Kulbicki etal 2005	
680	Siganus puellus	Siganidae	0.0176	3.028	Kulbicki etal 2005	
681	Siganus punctatus	Siganidae	0.0095	3.276	Kulbicki etal 2005	
682	Siganus punctatussimus	Siganidae	0.0095	3.276	Kulbicki etal 2005	
683	Siganus spinus	Siganidae	0.015	3.093	Kulbicki etal 2005	
684	Siganus spp.	Siganidae	0.0145	3.122	Kulbicki etal 2005	
685	Siganus vulpinus	Siganidae	0.0287	3	Fishbase (www.fishbase.com)	
686	Sillago ciliata	Sillaginidae	0.0028	3.396	Kulbicki etal 2005	
687	Sillago sihama	Sillaginidae	0.0051	3.18	Kulbicki etal 2005	
688	Sillago spp.	Sillaginidae	0.004	3.264	Kulbicki etal 2005	
689	Pardachirus pavoninus	Soleidae	0.0078	3.218	Kulbicki etal 2005	
690	Acanthopagrus berda	Sparidae	0.0224	3.044	Kulbicki etal 2005	
691	Sphyraena barracuda	Sphyraenidae	0.0062	3.011	Kulbicki etal 2005	
692	Sphyraena flavicauda	Sphyraenidae	0.0044	3.083	Kulbicki etal 2005	
693	Sphyraena forsteri	Sphyraenidae	0.0053	3.034	Kulbicki etal 2005	
694	Sphyraena novaehollandiae	Sphyraenidae	0.024	2.53	Kulbicki etal 2005	
695	Sphyraena obtusata	Sphyraenidae	0.0257	2.588	Kulbicki etal 2005	
696	Sphyraena putnamiae	Sphyraenidae	0.0075	2.931	Kulbicki etal 2005	
697	Sphyraena spp.	Sphyraenidae	0.0058	3.013	Kulbicki etal 2005	
698	Sphyraena waitei	Sphyraenidae	0.0089	2.855	Kulbicki etal 2005	
699	Sphyrnidae Sphyrna	Sphyraenidae	0.0042	3.239	Kulbicki etal 2005	
700	Inimicus didactylus	Synanceiidae	0.0232	2.865	Kulbicki etal 2005	
701	Hippocampus spp.	Syngnathidae	0.0004	4.12	Kulbicki etal 2005	
702	Saurida gracilis	Synodontidae	0.0066	3.165	Kulbicki etal 2005	
703	Saurida nebulosa	Synodontidae	0.0058	3.214	Kulbicki etal 2005	
704	Saurida spp.	Synodontidae	0.008	3.059	Kulbicki etal 2005	
705	Saurida undosquamis	Synodontidae	0.0063	3.134	Kulbicki etal 2005	
706	Synodus dermatogenys	Synodontidae	0.0047	3.346	Kulbicki etal 2005	
707	Synodus hoshinonis	Synodontidae	0.0018	3.662	Kulbicki etal 2005	
708	Synodus spp.	Synodontidae	0.0085	3.078	Kulbicki etal 2005	
709	Synodus variegatus	Synodontidae	0.0031	3.484	Kulbicki etal 2005	
710	Terapon jarbua	Teraponidae	0.0132	3.131	Kulbicki etal 2005	
711	Arothron hispidus	Tetraodontidae	0.0634	2.756	Kulbicki etal 2005	
712	Arothron immaculatus	Tetraodontidae	0.0351	2.845	Kulbicki etal 2005	
713	Arothron manillensis	Tetraodontidae	0.0299	2.907	Kulbicki etal 2005	
714	Arothron nigropunctatus	Tetraodontidae	0.0266	3	Fishbase (www.fishbase.com)	
715	Arothron spp.	Tetraodontidae	0.0352	2.901	Kulbicki etal 2005	
716	Arothron stellatus	Tetraodontidae	0.0915	2.672	Kulbicki etal 2005	
717	Canthigaster papua	Tetraodontidae	0.0424	2.822	Kulbicki etal 2005	Used Canthigaster spp.
718	Canthigaster solandri	Tetraodontidae	0.0299	2.979	Kulbicki etal 2005	
719	Canthigaster spp.	Tetraodontidae	0.0424	2.822	Kulbicki etal 2005	
720	Canthigaster valentini	Tetraodontidae	0.0367	2.943	Kulbicki etal 2005	
721	Lagocephalus sceleratus	Tetraodontidae	0.0182	2.924	Kulbicki etal 2005	
722	Trichiurus lepturus	Trichiuruidae	0.0002	3.324	Kulbicki etal 2005	
723	Ctenotrypauchen microcephalus	Trypauchenidae	0.0144	2.568	Kulbicki etal 2005	
724	Zanclus cornutus	Zanclidae	0.0147	3.37	Kulbicki etal 2005	

Appendix 3. Additional fish data analyses for Kofiau Marine Protected Area.

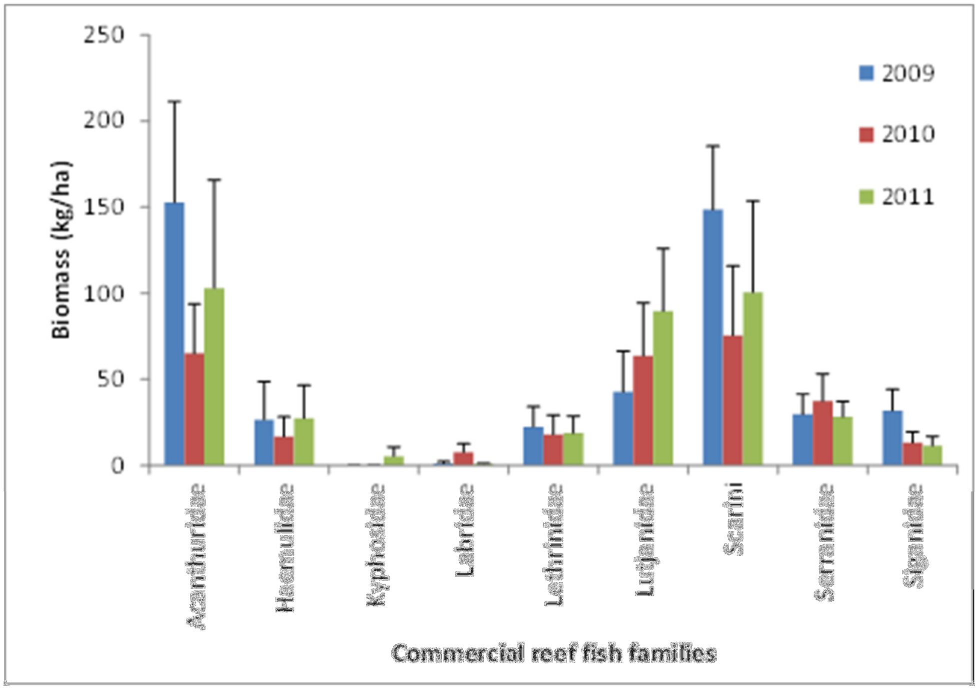

Figure a. Average total biomass (kg/ha) of commercial fish by monitoring year for the entire MPA.

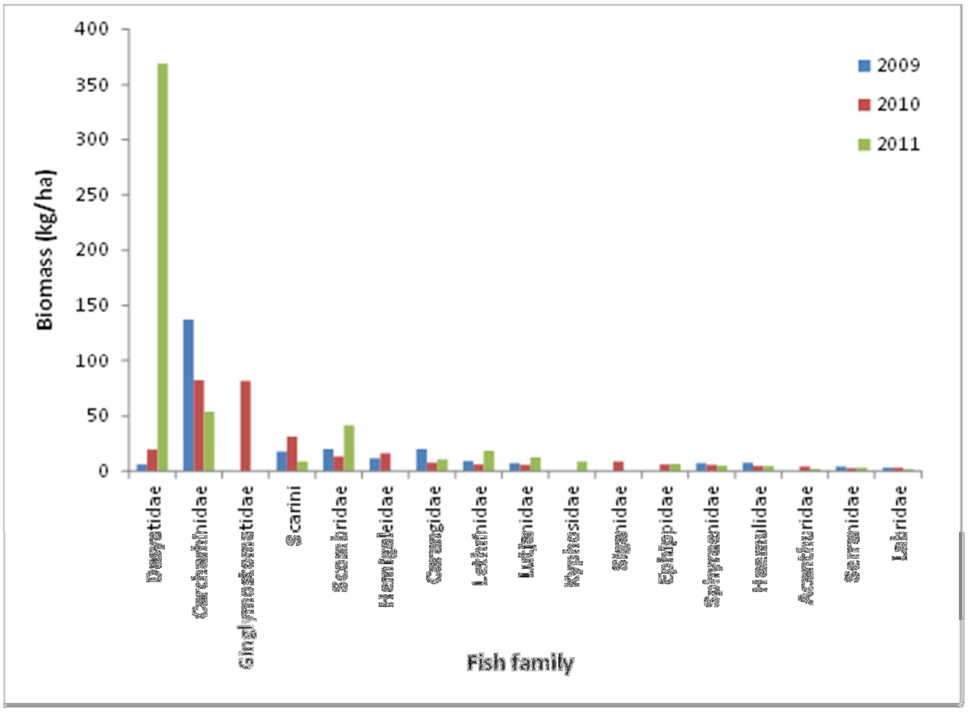

Figure b. Biomass of fish (kg/ha) recorded in long swim in Kofiau Marine Protected Area.

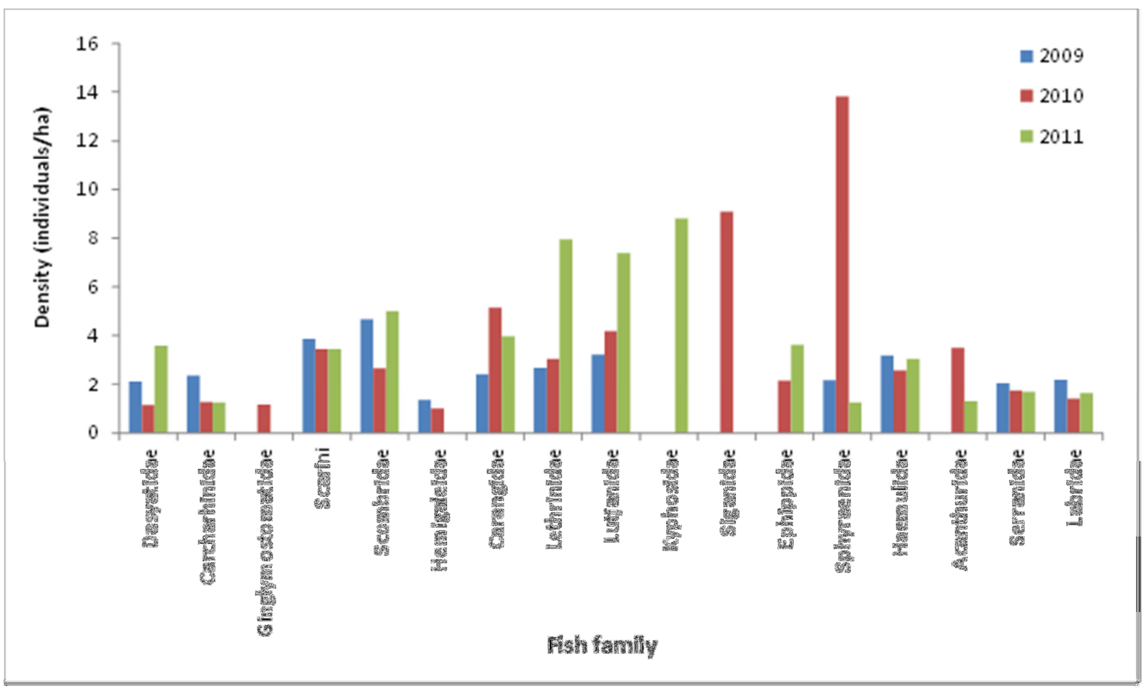

Figure c. Density of fish (individuals/ha) recorded in long swim in Kofiau Marine Protected Area.

Appendix 4. Additional benthic data analyses for Kofiau Marine Protected Area.

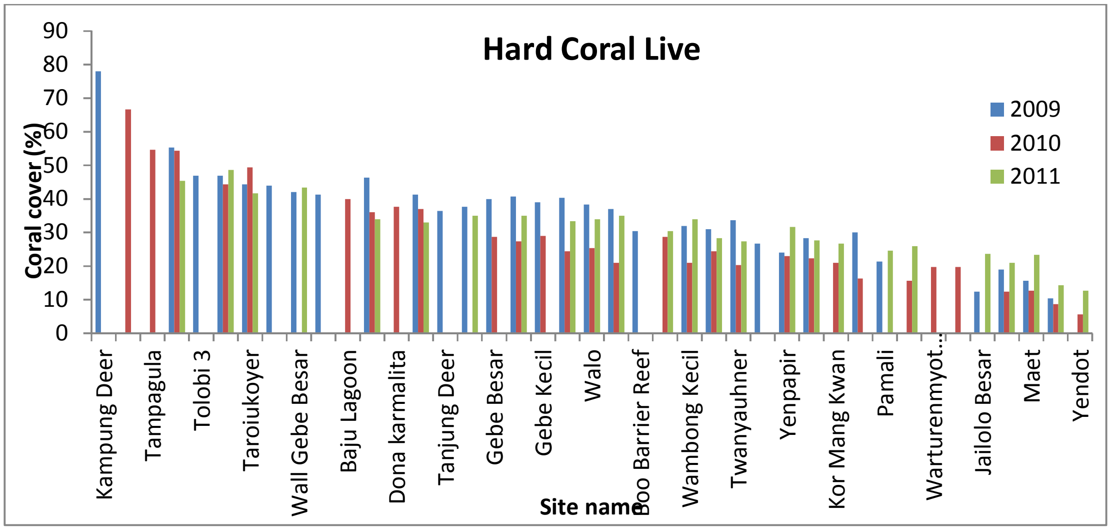

Figure d. Average percentage coverage of hard coral live in all locations by monitoring year.

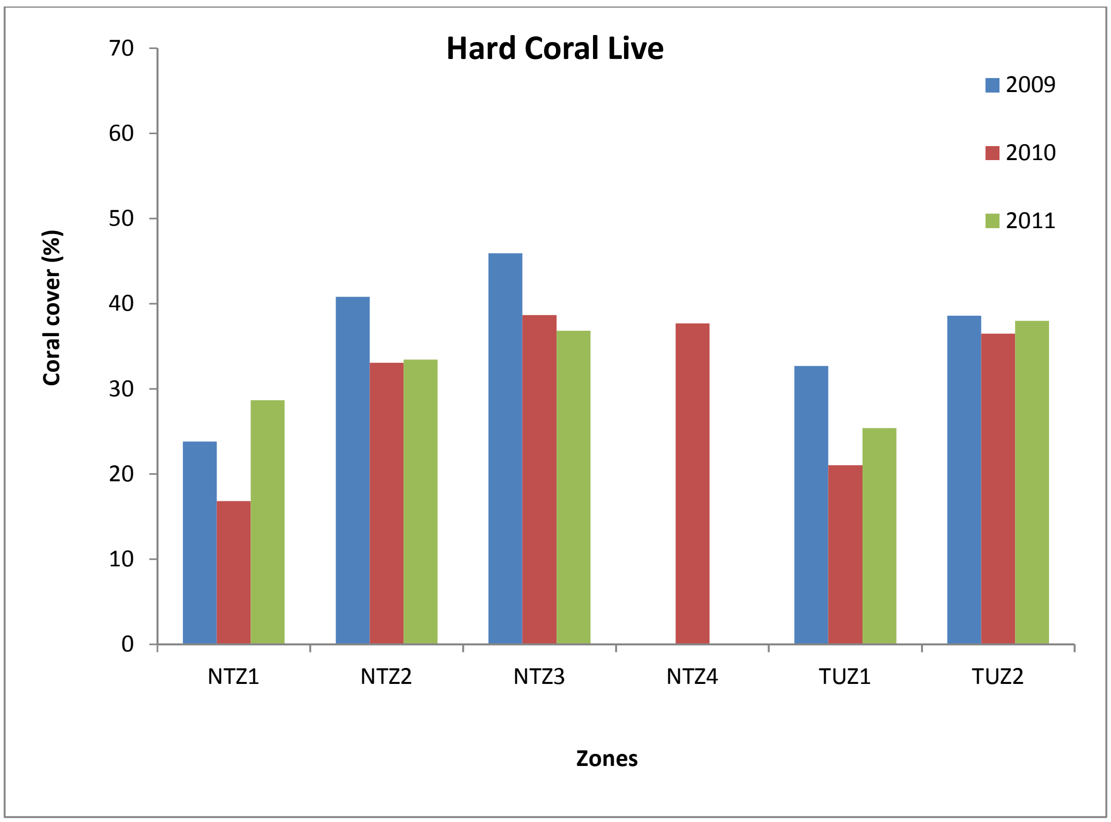

Figure e. Average percentage coverage of hard coral live in all zones by monitoring year.

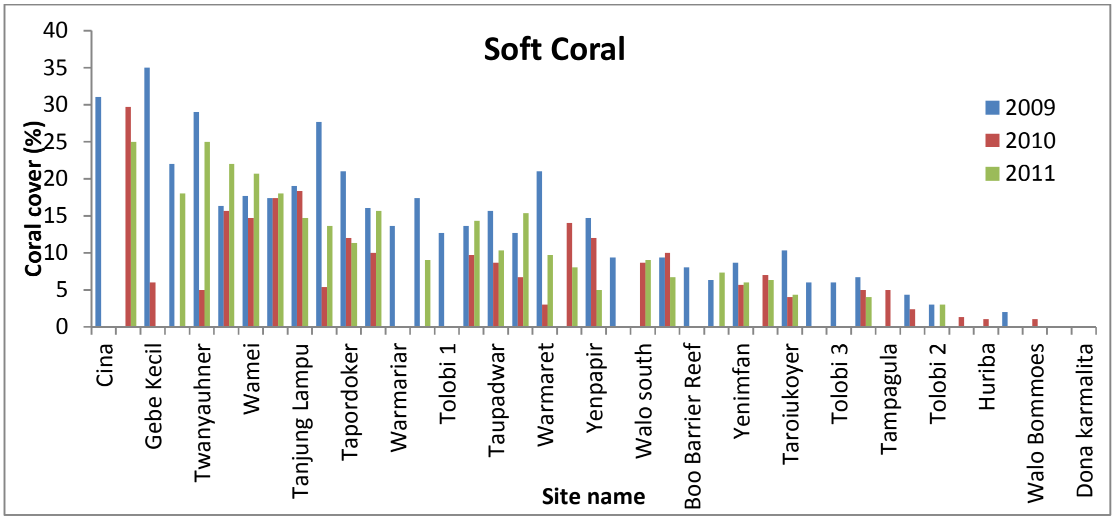

Figure f. Average percentage coverage of soft coral in all locations by monitoring year.

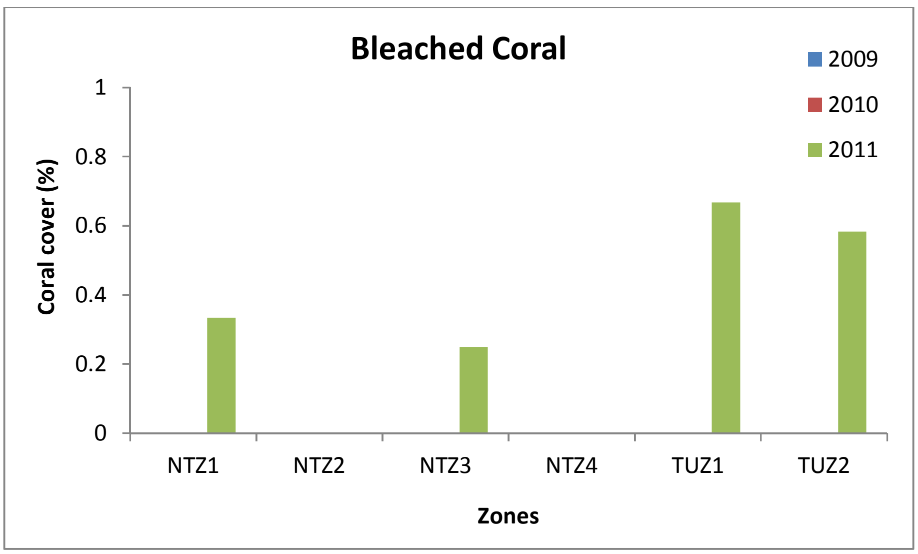

Figure g. Average percentage coverage of bleached coral in each zone in Kofiau Marine Protected Area.

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