A Post-Tsunami Assessment of Coastal Living Resources of Langkawi Archipelago, Peninsular Malaysia

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Abstract

Rapid and detailed post-tsunami surveys carried out in the Langkawi archipelago in January 2005 showed that the coral reefs did not suffer any significant structural damage. Nevertheless, there were signs of recent sediment resuspension at the sites studied. The diversity and abundance of coral reef fishes and invertebrates were low. However, this was not attributed to the tsunami effect but rather to the present environmental conditions. The extent of damage at the villages of Kubang Badak and Kuala Teriang may indicate that intact coastal ecosystems such as mangroves have the potential to protect lives and property during natural disasters

Introduction

The Langkawi archipelago (06° 18' N, 099° 47' E) is in the northwestern part of Peninsular Malaysia that was hit by a tsunami at 12.20 pm on 26 December 2004. Albeit, it was a weak wave (a shadow wave) of the main tsunami that devastated southern Thailand and various coastal nations in the Indian Ocean. It was generated by an underwater earthquake (9.3 on the Richter scale) off the west coast of Aceh province in Indonesia (Stein and Okal 2005). A group of researchers from WWF-Malaysia, Universiti Malaya Maritime Research Centre (UMMReC), Malaysian Society of Marine Sciences (MSMS), Universiti Kebangsaan Malaysia (UKM) and the WorldFish Center rapidly conducted a post-tsunami impact assessment reef survey (POSTIARS) with the aim to ascertain areas where the tsunami had hit, assess the changes in the underwater environment caused by the tsunami and assess the damage done to the biological resources of the coral reefs. Selected islands around the Langkawi archipelago were surveyed from 28 to 30 January 2005. This assessment was of particular interest to WWF-Malaysia as it is currently carrying out a collaborative fisheries management (CFM) project on the northern coast of Langkawi and wanted to gather data on the possible adverse effects of the tsunami on the fishing community. This paper discusses the findings of the survey and compares conditions of coral reefs before and after the shadow wave as well as emphasizing the importance of intact coastal ecosystems such as mangrove forests against natural disasters such as a tsunami.

Materials and Methods

Two strategies were used to assess the impact of the tsunami on the coastal living resources - coral reefs, coral reef fishes and invertebrates. The first was a rapid assessment and monitoring technique for tsunami damage that was in development at that time by GCRMN/CORDIO/ReefBase/Reef Check for ICRI/ISRS (ICRI/ISRS 2005). The second strategy was to obtain a more detailed assessment by using a modified Reef Check method (Hodgson et al. 2004) combined with a modified Line Intercept Transect (LIT) method (English et al. 1997).

The first strategy utilized a rapid survey with a timed swim by a pair of snorkellers at sites suspected to have received the impact of the shadow wave. Snorkellers recorded the presence of debris, broken and overturned corals as well as estimated the percentage of live coral cover per area observed. Rapid surveys were conducted at four sites, which were Pulau Beras Basah (two sites), Pulau Intan Kecil and Pulau Anak Burau (Figure 1).

The second strategy allowed for the collection of three different sets of data: the status of coral reefs, reef fishes and invertebrates. Three teams of two divers each used a 100 m transect line deployed between 3-6 m in depth. The first team laid down the transect line and carried out the coral reef fish visual census. The identification of coral reef fish was based on Lieske and Myers (1994) and Allen et al. (2003). The second team surveyed the invertebrates using a Belt Transect of 400 m^2. The third team recorded the coral cover and signs of tsunami damage. The detailed surveys were carried out at three sites, Pulau Tepor, Tanjung Hulur and Pulau Anak Datai (Figure 1). These three sites were chosen based on the direction of the shadow wave, which suggests that these sites would have received the most impact.

Physical parameters measured at each survey site were vertical visibility, temperature, pH, conductivity, salinity, total dissolved solids and dissolved oxygen in seawater. Visibility was measured using a Secchi disc, whereas the other parameters were recorded using YSI multi-probes model pH100, EC300 and 550A.

Secondary information on the effects of the shadow wave was also collected through interviews with fishermen at the affected sites (Kubang Badak and Kuala Teriang) and newspaper articles.

Results and Discussion

Rapid and detailed assessment of coral reefs

No significant physical damage from the impact of the shadow wave was observed at any of the sites surveyed. There were overturned and broken corals in a few locations, which may have been due to fishers or anchors and not necessarily the tsunami. In addition, the detailed surveys confirmed that there was no significant damage from the shadow wave as the proportion of recently killed, broken and overturned corals was very low (Figures 2 and 3).

Pulau Tepor, Tanjung Hulur and Pulau Anak Datai recorded good levels of live coral cover (50–53%) based on the health scale of the ASEAN-Australian Living Coastal Resources project (Chou 1994) and very low percentage of recently killed corals of 1-3% (Figure 3). However, there was a conspicuous layer of silt overlying surfaces of corals at all sites surveyed. This layer of silt may have settled out of the water column quite recently as it was noted to be quite thin and the coral polyps underneath showed recent death or severe signs of stress such as copious mucus secretion and tentacular extension (Stafford-Smith and Ormond 1992).

It is well known that a tsunami is a fast flowing wave that moves straight across the ocean and onto the land, unlike the circular motions of normal wind- or current-generated waves. Therefore, the

Figure 1. Satellite image of the Langkawi archipelago showing the locations of the survey sites. (Image courtesy of Dr Azhar Husin/ UMMReC).

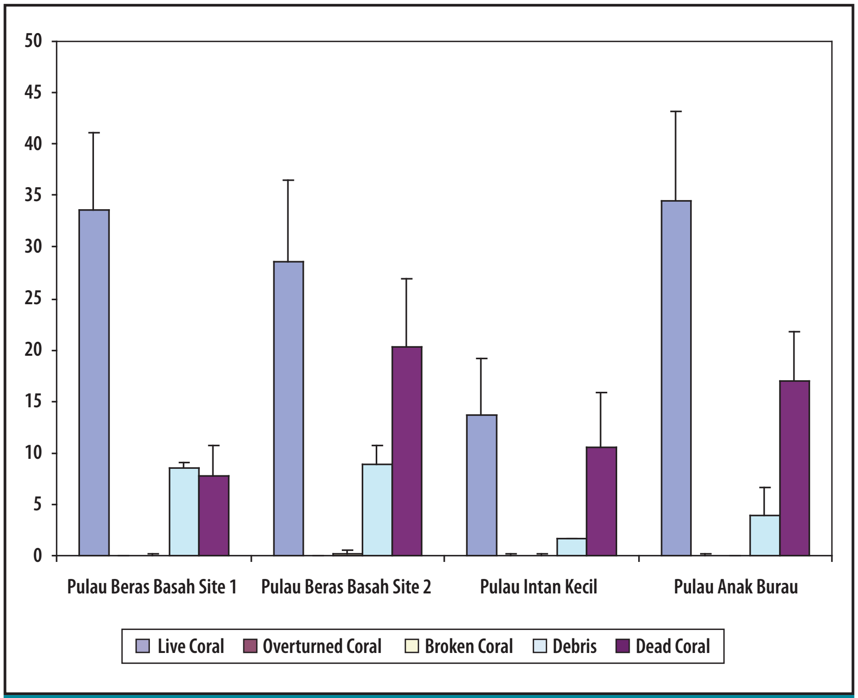

Figure 2. The percentage of live, damaged and dead coral at each survey site from the rapid assessment snorkel surveys. Debris also included old broken corals. Error bars are for standard deviation (SD).

tsunami may have brought fine sediment into the coastal area and onto corals after it receded from the land. The shadow wave may not only have brought in more fine sediment but also re-suspended existing fine sediment in the shallow water environment. The waters of Langkawi were already turbid from sediment runoff brought on by intense coastal development (Abdullah and Yasin 2002). Prior to the tsunami, sedimentation was an issue for coral reefs around Langkawi. Jonsson (2002), when studying corals in Langkawi, found that 100% of the dead corals were covered by sediment, suggesting that the death of corals in the area is mainly due to heavy sedimentation. She also found that for Pulau Rebak Besar, Pulau Singa Besar and Teluk Datai, 70%, 50% and 60%, respectively, of the corals were covered in sediment. Therefore, sedimentation was already an issue for coral reefs around Langkawi and the relative impact of the tsunami is unclear. The effects of sedimentation on corals are well documented. It can: increase the energy demands of the corals because more energy is needed for sediment rejection activities (Dodge et al. 1974); cause abrasion on corals (Loya 1976) and coral tissue death (Rogers 1983); influence the species composition due to differences in sediment tolerance among species (Cortes and Risk 1985); disrupt the coral's energy budget through reduced light availability (Abdel-Salam and Porter 1989); negatively affect rates of survival and settlement of coral larvae (Babcock and Davies 1991); reduce the coral's capacity to capture food (Stafford-Smith and Ormond 1992); and depress rates of zooxanthellate photosynthesis (Riegl and Branch 1995; Yentsch et al. 2002). Another survey of the same sites to document any changes with respect to the sedimentation and impact on the corals is planned for July 2005.

The available LIT data on coral cover at two sites (Pulau Tepor and Datai) before the incident of the shadow wave was used for comparison. The present survey recorded higher live coral cover at Pulau Tepor and little difference at Datai (Table 1). The difference in the LIT data for Pulau Tepor is likely to be indicative of the patchy nature of the reefs around the islands where some parts along the same beach have good coral cover and other parts have low live coral cover. This feature was also observed during the rapid assessment at Pulau Beras Basah.

Table 1. Comparison of live coral cover data collected by LIT before and after the shadow wave.

	Percentage of live coral cover	
Area	2001 (Hendry and McWilliams 2002)	2005 (Present study)
Pulau Tepor	20.0	53.0
Datai	49.5	50.5

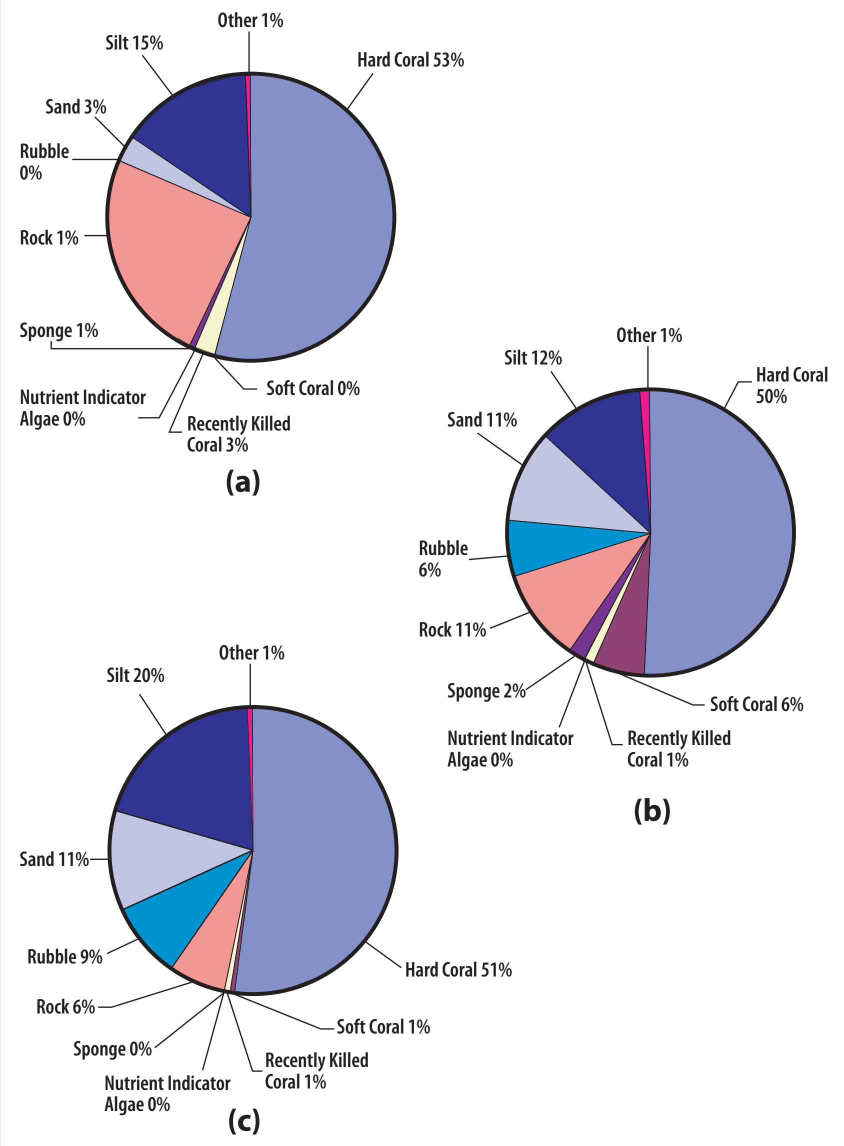

Figure 3. The percentage cover of coral and other benthic species and substrate types from the detailed assessment for corals of (a) Pulau Tepor; (b) Tanjung Hulur; and (c) Pulau Anak Datai using the modified Reef Check method.

Physical parameters

All physical parameters were within normal ranges (Table 2). For example, the study by Jonsson (2002) reported the Teluk Datai area as having seawater temperatures in the range of 27.3°C-28.5°C, salinity ranging between 32.4-33.0 ppt and D.O. ranging between 5.8-7.4 mg/l. Nevertheless, visibility was poor for all sites as shown by the Secchi disk reading ranging between 1.25-3.75 m for this study.

Coral reef fish

The number of coral reef fish species and individuals observed at three selected sites at Pulau Langkawi was relatively low as compared to the other sites in Peninsular Malaysia, using the same sampling protocol (Table 3). However, there is insufficient data to conclude that the coral reef fish population was affected by the recent tsunami. There is no data to enable comparisons with numbers prior to the tsunami. The low numbers may also be due to issues such as the health of the coral reefs or levels of fishing. In the study areas, most of the major families of coral reef fish such as Pomacentridae (damselfish), Labridae (wrasse), Chaetodontidae (butterflyfish) and Scaridae (parrotfish) were poorly represented and there was a notable absence of species from the families Pomacanthidae (angelfish) and Acanthuridae (surgeonfish). These six families are important components of reef communities, have widespread distributions and are closely associated with coral reefs ecosystem (Allen and Werner 2002).

The number of Reef Check target species observed at three sites was also generally low, especially for families of snapper (Lutjanidae), commercial sized grouper (Serranidae - more than 30 cm) and parrotfish (Scaridae). Barramundi cod (*Cromileptes altivelis*), humphead wrasse (*Cheilinus undulatus*), bumphead parrotfish (*Bolbometopon muricatum*), grunts/sweetlips (Haemulidae) and moray eel (Muraenidae) were totally absent from the sites surveyed (Table 4). This may indicate that the areas are under pressure from fishing by local fishers. This situation is particularly visible at Teluk Datai, where fish holding pens (*kelong/belat*) were present in the coral reef areas.

The main Reef Check target species observed at Pulau Langkawi were butterflyfish (Chaetodontidae). However, the number of species was also low as compared to other sites globally. The number of butterflyfish observed at three sites (Pulau Tepor, Tanjung Hulor and Pulau Anak Datai) were 8, 17 and 3 individuals, respectively. The numbers observed were low when compared to the average density of butterflyfish in the Indo-Pacific coral reefs (10.0 ± 10.0 fish per 100 m^2 reef) (Hodgson and Liebeler 2002). The main butterflyfish observed was *Chaetodon octofasciatus* (8-banded butterflyfish), which is generally found in shallow and turbid coral reef areas (Hutomo et al. 1991; Manthachitra et al. 1991).

Reef invertebrates

Aside from corals, the diversity and density of the reef invertebrates at the study sites was generally low compared to other marine parks and islands on the east coast of Peninsular Malaysia (Kee Alfian et al. 2005). The highest density was recorded for the pen shell (*Atrina pectinata)* in Pulau Langkawi (Table 5). The low abundance of the reef invertebrates in Pulau Langkawi may be due to the high sedimentation around the island.

The number of Diadema (sea urchin) per square meter is generally high as

Table 2. Physical parameters for all surveyed sites.

Site		Secchi (m)	Conductivity (ms)	Salinity (ppt)	pH	Temp (°C)	TDS (g/l)	DO (mg/l)
Pulau Beras Basah Site 1		2.00	44.32	28.5	8.08	28.5	28.84	5.64
Pulau Beras Basah Site 2		2.25	46.14	29.8	8.12	28.8	29.97	5.71
Pulau Intan Kecil		1.25	46.90	30.3	8.09	29.2	30.50	6.45
Pulau Tepor	Surface	1.75	46.50	30.0	8.11	29.6	30.20	6.05
	Bottom (3 m)	n/a	46.60	30.1	8.12	n/a	30.30	6.08
Pulau Anak Burau		1.75	46.14	30.0	8.10	28.9	30.14	5.41
Tanjung Hulur	Surface	3.75	46.53	30.0	8.13	28.6	30.22	5.93
	Bottom (3 m)	n/a	46.60	30.4	8.11	n/a	30.51	4.58
Pulau Anak Datai	Surface	2.50	50.90	30.2	8.16	29.9	30.30	6.64
	Bottom (3 m)	n/a	47.03	30.5	8.15	n/a	30.55	4.71

Note: n/a = not available

Table 3. Number of species and individuals of coral reef fish at three sites at Pulau Langkawi and comparisons with other sites in peninsular Malaysia.

Site	No. of individuals	Species
Pulau Tepor, Langkawi	232	20
Tanjung Hulor, Datai, Langkawi	365	31
Pulau Anak Datai, Langkawi	85	21
Pulau Payar	1 568 ± 934.7	55.2 ± 4.4
Pulau Perhentian Kecil	974.2 ± 332.4	60 ± 10.4
Pulau Perhentian Besar	1 929.6 ± 2228.8	61.8 ± 12.8
Pulau Pangkor	1 136.0 ± 630	29.7 ± 3.2

Data of other sites are from Yusuf et al. 2002. Mean and standard deviation indicate that sampling was done at a few sites in the islands.

Table 4. The number of individuals observed of the Reef Check coral reef targeted fish groups.

Targeted species	Sites		
	Pulau Tepor	Tanjung Hulur, Datai	Pulau Anak Datai
Snapper	3	2	0
Grouper >30 cm	0	1	0
Parrotfish >20 cm	0	1	0
Butterflyfish	8	17	3
Barramundi cod	0	0	0
Humphead wrasse	0	0	0
Bumphead parrotfsh	0	0	0
Grunts/Sweetlips	0	0	0
Moray eel	0	0	0

Table 5. Density of reef invertebrates in the surveyed areas.

	Site (individual/m^{-2})		
	PulauTepor	Tanjung Hulur, Datai	Pulau Anak Datai
Brachyuran	0.01	0	0.01
Atrina pectinata	0.19	0.16	1.52
Diadema setosum	0.03	0.07	0.07
Heteractis magnifica	0	0.01	0.04

compared to the mean abundance of Diadema in the Indo-Pacific based on Reef Check data (10.9 ± 42.1 per 100 m^2 in 2000) (Hodgson and Liebeler 2002). Even though moderate Diadema populations are critical to maintaining the natural balance between algae and coral in a healthy reef system, high population density is considered a negative indicator as it can cause a high level of coral bioerosion and make it difficult for new coral recruitment in the area (Vo and Hodgson 1997).

Effects of the shadow wave on fishing communities

Interviews with fishermen at Kampung Kubang Badak revealed that they were able to take shelter in the mangroves as the shadow wave came surging up the Kubang Badak estuary (Figure 1). The fish landing facility was only slightly damaged. They were quick to point out that the Kubang Badak mangrove forest had buffered them against strong waves and quick-rising waters. The fishing village in Kuala Teriang, northeastern Langkawi, was not as fortunate. The village was flooded, property damaged and one life lost. This may be due to the clearing of mangroves in the area and exacerbated by the construction of a manmade wave barrier near the Langkawi airport. The wave barrier and the existing land mass created a narrow channel that could have increased the velocity of the wave and caused significant damage to the area (Azhar Husin pers. comm.).

Conclusions

The shadow wave that hit Langkawi did not cause any structural damage to coral reefs, nor did it drastically alter the physical parameters. However, sedimentation and re-suspension of fine silt onto the reefs was observed at all sites. Sedimentation has been recorded around Langkawi before the tsunami, so the impact of the tsunami on sedimentation is uncertain. Sedimentation will have long lasting negative effects on the coral communities. Data collected on the coral reef fishes and invertebrates showed that their diversity and abundance was very low, but this could be attributed to pre-tsunami conditions of less-than-optimal water quality, fishing and high sedimentation. The natural disaster also reiterated the importance of conserving intact and healthy coastal ecosystems, not only to sustain the livelihood of people depending on them but also to protect their lives and property.

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