Box 23.2. The coral reefs of West Sumatra.

Andreas Kunzmann, *Coral Reef Assessment and Monitoring Project (CRAMP), Bung Hatta University, Jl. Sumatera Ulak Karang, Padang 25114, Indonesia.*

Introduction

Padang, the capital of West Sumatra Province, is located at 01° S and 100° E. The coastline of West Sumatra extends from Air Bangis (north) to Mukomuko (south) for a length of about 450 km (fig. 23.27). The provincial waters include the Mentawai Islands (Pulau Siberut, Sipura and Pagai), located about 167 km to the west. The surface area of the sea comprises about 20,000 km^2, or about 50% of the total provincial area. The Exclusive Economic Zone (EEC) amounts to more than 140,000 km^2 (data from Dirjen 1993; BAPPEDA 1993; and Kunzmann and Efendi 1994). Altogether about 297 islands and reefs (shallower than 20 m depth) are mentioned on the hydrographic charts of West Sumatra. However, West Sumatra only represents about 0.6% of Indonesian territorial waters. With less than 100 islands, West Sumatra also represents only about 0.6% of the 17,508 islands in Indonesia. Only seven islands in the province are larger than 343 km^2. From north to south these islands are Pini, Tanahmasa, Tanahbala, Siberut, Sipura, Pagai Utara and Pagai Selatan.

Fish Landings and Economy

The total fish landings of West Sumatra in 1993 amounted to 66,000 tonnes with a value of about Rp 8.8×10^{10}. The fishing industry supports about 6000 fishermen. In the vicinity of the provincial capital, Padang, catches and fishermen total 50,000 tonnes and 2500 people, respectively (Dinas Perikanan 1994). The share of catch from coral reefs is underrepresented and amounts to only 5000 tonnes. The fishes and fishing methods, which are by far dominant in terms of volume, value and labour involved, are anchovies (*teri*), which are caught in liftnets with lights (*bagans*), and small tuna (*tongkol*), which are caught by gillnets and hook and line. Subsistence fishing, which could increase total landings by at least 50%, is not included in official figures. It is estimated that the number of people relying directly on marine fisheries is 30,000 to 36,000.

Meteorological and Oceanographical Data

West Sumatra, due to its position on the equator, is free from hurricanes and cyclones. Also, the monsoon influence is less dramatic as compared to Java or Kalimantan. Wind and waves from the northwest and west prevail from November through May, and from July through October winds are mainly from the southeast. On the Beaufort wind scale, winds are usually 4-5 Bft, occasionally 6-7 Bft, and even more rarely may reach 8 or 9 Bft (DHI 1990). In the last 20 years there is no record of storms exceeding 9 Bft and only one record, from April 1985, reports two days wind with 9 Bft (BMG 1994). The average surface water temperatures range from 28°C in December to 30°C in May. The salinity and density values are very stable throughout the year, with 33-34 psu and 1020-1021 $kg.m^{-3}$ (DHI 1990) for most of the area. According to Umbgrove (1931), the sea level around Padang has sunk, or the land has risen, 3 to 5 metres, judging from sea level marks in the rocks. It appears that the entire Sunda volcanic arc, including Padang, has been subsiding since the last interglacial high sea level period. This subsiding is masked by a slight mid-Holocene emergence (Hantoro and Naryanto 1992), which is in line with Umbrove's findings.

Islands and Reefs of Padang

There are about 86 islands and reefs within 56 km of Padang (fig. 23.28). In general, we find very few fringing reefs along the main shoreline. Most reefs, 1 to 26 km offshore, are breaking or submerged patch reefs, or fringing reefs surrounding high islands.

Box 23.2. (Continued.)

To the north of the Arau River, we find a flat coast with sandy beaches and alluvial soil, mostly flanked by wetlands/swamps. In this area the distance between the shore and the trans-Sumatra mountain chain, Bukit Barisan, is one or more kilometres. Consequently, all reefs and islands along the north coast are coral cays. There is no documentation whether cores of the islands are volcanic or entirely made by corals. Umbgrove (1931) mentions cores from two coral islands close to Padang, where one is definitely built on a foundation of volcanic rock, whereas the second rests entirely on the muddy bottom of the bay, as is the case with the Kepulauan Seribu in Jakarta Bay and the Spermonde Archipelago.

To the south of the Arau River, the mountains line the coast and volcanic rock prevails both on the coastal shore as well as on many island shores. Frequently the volcanic rock on these islands protrudes through the thin soil cover. Only a few corals grow on this volcanic rock, but we do find barnacles, snails and soft corals.

Apart from this separation into a northern and southern island/reef community, we find two chains of islands/reefs paralleling the coast of West Sumatra at distances of about 13 km and 22 km, respectively. The inshore chain is situated on the continental shelf with depths of no more than 50-70 m around the reefs. The outer chain is west of the 200 m isobath, right on the continental slope, where the islands/reefs are surrounded by deep water with a maximum depth of 2000 m (e.g., Mentawai Basin). Therefore, depths on western and southern reef slopes can easily reach 50 m and more.

The outer chain of islands and reefs parallels the coast from roughly west of Air Haji (2° S) up to Tiku (0°20' S; fig. 23.27), where the shelf broadens and extends out west towards the Batu Islands. Here the chain follows the 200 m isobath, heading away from the coast with a submerged patch reef located every 6-9 km. The entire length of the 'barrier reef system' is close to 278 km.

Most of the islands have a kidney shape or are slightly elongated (i.e., north to south) in response to the prevailing west and northwest wind and wave action. The average island size is about 20 ha, with a circumference of 1500-2000 m. Most islands are encircled by rather steep, coral-covered slopes, thus at a distance of 50 m from the shoreline, we find depths of 30 m and more. The majority of islands are vegetated, mainly by coconuts and *alang* grass, with some hosting trees and bushes. The northern islands are flat and sandy, while the southern islands are frequently high, with more vegetation and some lined by a few mangrove bushes (Parsumpahan, Cubadak). There are no atolls or lagoons.

The reefs on the west (i.e., weather) side of these islands, and partly along the north and south sides, are roughly 50 m wide. The reefs extend from the lower tide level to depths of 6-9 m. At a few islands the reef flat is up to 100 m wide. Spurs-and-grooves are well developed, and although waves enter with full force, rather fragile branching corals such as *Acropora formosa* and *A. nobilis*, or foliose species of *Montipora,* are present (fig. 23.29). From a depth of 6-10 m, a steep reef slope descends down to depths of 30-40 m. Octocorals and gorgonians are fairly common, with some as large as 3 m. From a depth of about 40 m, a more gentle slope, usually covered with rubble, sand, larger fragments and the occasional coral colony, continues down to 60-80 m.

The southern reefs can be exposed to strong winds for three months or more, each year. No generalization on the reef type is possible, but here are found the only real drop-offs from about 10 m depth down to 40 m with giant gorgonians (4 m and more in diameter; Pieh, G. Pieh - East, G. Air [G. = Gosong, submerged reef; islands are named here without the preceeding P. = Pulau]). Especially in the south of the outer islands can be found a second steep slope starting at about 45-50 m, leading down to several hundred metres (e.g., Pieh, Pandan).

Box 23.2. (Continued.)

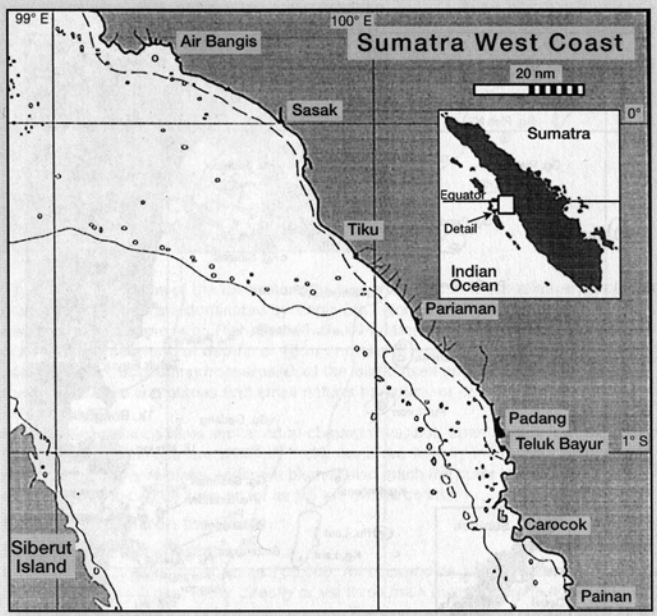

Figure 23.27. Map of the northern coastal area of West Sumatra with depth contours for 20 m and 200 m, respectively (grey = islands and land; white circles = reefs).

Box 23.2. (Continued.)

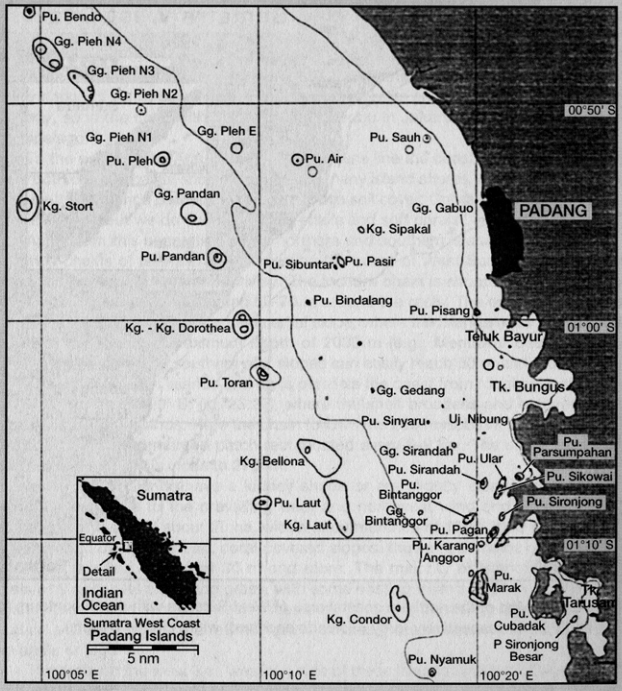

Figure 23.28. Islands and reefs in the vicinity of Padang (Pu. = Pulau = island; Gg. = Gosong = reef). Named reefs indicate research locations up to September 1995.

Box 23.2. (Continued.)

Figure 23.29. Reef section of Pieh Island, western reef crest, 8 m depth.
Photo by A. Kunzmann.

The eastern sides of the islands are the leeward sides. In these relatively protected environments, reefs are dominated by single big colonies of *Porites* and/or *Diploastrea*, down to 10 m or more (e.g., Pieh, Saoh, Karsik-Pariaman and Ujung-Tiku). More diverse communities are found at depths of 10 m or more. These reefs are subjected to heavy sedimentation, originating from erosion of the island itself as well as from the rivers. On the east side we sometimes find small natural harbours, or channel-like entrances, for safe anchorage.

The inner islands have similar coral communities, but, apart from a few exceptions (e.g., Ular), gorgonians are absent. These reefs are heavily influenced by river sediments. After heavy rainfalls, sediment plumes also reach the outer islands. The brownish sediment plume can be seen as far as 5.5 km off the coast.

Human Pressure on the Reefs

Pollution and Sedimentation

Padang has a population of about 700,000. All households and settlements discharge their waste into the sea, either directly or via three main rivers. There is no waste treatment plant for household or industrial wastes. The rivers and the sea are still used for the disposal of domestic and industrial wastes. Hundreds of neatly packed plastic bags, full of waste, can be seen floating down the river into the sea, eventually littering the beaches. Recently we discovered a fully packed waste bag in the middle of a reef, 15 km from the beach!

Commercial ports and fishing harbours are additional sources of pollution (e.g., Teluk Bayur and Bungus Bay, respectively). Located in Bungus Bay are a plywood factory and an oil pier whose negative impact on corals was demonstrated by Nusyirwan (1994).

Logging and mining activities in the mountains, and intensive agriculture, fill the rivers with eroded soil, fertilizer and heavy metals. The sediment and pollution loads of most West Sumatra rivers are discharged into the Indian Ocean. Depending on the prevailing wind and wave directions, the brownish river runoff concentrates in a 6-km-wide stretch along the coast, usually in a southerly direction, but in rare cases, in a northerly direction as well. The islands/reefs most influenced by river sediments are from north to south: Air Bangis, Tiku and Pariaman Islands, Saoh, G. Saoh, G. Gabuo, Pisang, G. Marlbro, Ular, Sikowai, Sironjong, Pagang, Painan Islands, Batang Kapas Islands and the Kambang reefs. At G. Gabuo, Pisang and Ular, the sediment layer can reach more than one metre. At these reefs, corals with long polyps, like *Euphyllia* spp. and *Goniopora* spp., can be seen trying to reach the surface of the mud by sticking the polyps through, whereas other species have died off and are completely covered by mud.

Box 23.2. (Continued.)

Coral and Shell Mining

Due to the highly productive cement factory of Padang and the availability of boulders and gravel from several rivers, there is no large-scale coral mining for construction purposes. However, over time, coral- and shell-collecting, even though on a relatively small scale, have accumulated impressive figures. According to Syarif (1994), residents of five islands are involved in shell-collecting activities. These islands, within 6 km of the coast, are Pisang, Parsumpahan, Sirandah, Sinyaru and Sikowai. Shells and corals are sold to tourists and locals for ornamental purposes in house walls and aquaria or simply as souvenirs. Branching or brain-shaped corals sold most frequently are *Acropora* spp., *Pocillopora* spp. and small *Porites* and Fungiidae. This activity extracts roughly 10-24 tonnes of shells and coral from the reefs per year, and involves about 10 people collecting once or twice a week (Syarif 1994). Apart from corals, fishermen also collect sea cucumbers and giant clams.

The erosion of heavily mined coral reefs can be witnessed at Pulau Laut, which has been locally renamed 'Gosong (submerged reef) Laut', because it only surfaces during low tide. In sea charts based on Dutch nautical measurements, it is clearly marked as an island. Large-scale movement of sand along the coastline can be seen every rainy season from the campus of Bung Hatta University.

Destructive Fishing

Around 6000 fishermen, with about 2500 fishermen from Padang alone, are operating in the coastal waters with mainly small-scale and medium-scale gear (Dinas Perikanan 1994). Moreover, foreign fishing fleets and countless fishermen from North Sumatra, some still illegally using trawls, poison and explosives, place a heavy pressure on marine life.

West Sumatra fishermen also use explosives and poison (Kunzmann et al. 1993), and when local and national newspapers published several articles, based on research and observations by our research team, the provincial government was moved to reissue a decree, which states that fishing with explosives and poison is illegal (Governor Decree 1993), citing the relevant presidential decrees from 1980, 1982 and 1985.

However, there still are illegal fishing activities on three levels:

i) Small-scale fishermen operate with outrigger canoes and use self-constructed bombs made from old batteries and fertilizer in order to catch fish by blowing up small reef areas. Also, outriggers use small compressors to supply air to divers who catch groupers, snappers and rock-lobsters by use of poisons, which also kill corals.

ii) Medium-scale illegal blasting with big bombs, destroying vast areas of reefs. Two large, two-storey ships, equipped with radio, rubber dinghies, and sizable crews, have been spotted several times.

iii) Large-scale operators with official licenses.

Large ASEAN and Southeast Asian fishing vessels have licenses to catch tuna and sharks offshore in the EEC – however, they also come to the Mentawai Islands, enter territorial waters and each year systematically bomb large areas during the 'ekor kuning' season (*Caesionidae*).

On Siberut in Teluk Sarabua, live groupers and wrasses are sold to foreign vessels, arriving once a month. Many of these groupers are caught with potassium-cyanide, killing corals in the process.

In Bungus Bay aquarium, fishes were exported on a large scale. These fish were gathered by using large amounts of potassium cyanide. Fortunately, this business was stopped in early 1995 and about 75 kg of potassium cyanide were seized.

Box 23.2. (Continued.)

All three examples are operators with valid licenses issued by the government. However, monitoring of fishing practices, and enforcement of existing regulations, is hampered by the large areas involved, the lack of personnel, budgetary constraints and the difficulties in coordinating all the departments, police and military units which share the responsibilities.

Current Condition of the Coral Reefs

As a result of the above-mentioned natural and human activities, the coral reefs of Padang are in poor condition. The Research Center for Fisheries Development at Bung Hatta University has been carrying out research on coral reefs and mangroves since early 1993 (Zimmermann and Kunzmann 1994), and in early 1995 the Coral Reef Assessment and Monitoring Project (CRAMP) was launched.

The results indicate that about 74% of all investigated locations are seriously damaged (percentage cover with live coral; PC = 0% - 24%), about 22% of the locations are moderately damaged (PC = 25% - 49%) and only 3.7% of the locations are in good or very good condition (classification according to Sukarno 1993). Only very few islands or reefs have larger reef areas with a PC of more than 70% (Kunzmann and Efendie 1994; table 23.4).

Some locations, although close to a river mouth or a harbour, show a comparatively high percentage cover. Also, the coral species diversity is high and the individual colony size is above average. The investigated locations can be grouped into three categories, such as:

i) islands/reefs with less than 13 km distance to the coast, where visibility is low, the percentage cover, coral species diversity and individual colony size are comparatively high.

ii) islands/reefs at a distance of 13 to 27 km from the coast, where visibility is already good, the percentage cover, however, is low, the species diversity low to moderate and the individual colonies have moderate sizes.

iii) islands/reefs at more than 27 km distance to the coast, where visibility is excellent, but most locations have only very few hard corals with some places being totally destroyed (with very few exceptions).

These transect data are all biased in a way, that only the 'best spots' identified by manta-tows were chosen for transects. Therefore, indicated percentage covers are an overestimation of the general situation – and very difficult to reproduce due to a) the patchiness of 'best spots' in a bad environment, and b) the low number of transects performed on such a large area. Especially in the case of a heavily disturbed reef, no transects were performed at all, and PC's of around 10% can be anything between 0% and 25% PC. However, in the case of a good reef, the indicated percentage covers are quite close to reality. The percentage cover of live coral also depends strongly on the angle of the substrate and the exposure to wind. This is why percentage values cannot always be directly compared.

The dead cover consists in most cases of coral rubble, dead corals overgrown with algae, and reef substrate overgrown with algae. On eastern reefs we also find sandy areas, on reefs south of Padang, also volcanic rock.

In May 1995 we discovered a recently blasted area at Pandan, an area where data had been collected prior to the blasting. Here, a reef flat at about 1 m to 6 m depth, roughly 50 m wide and 400 m long, was totally destroyed. Individual craters were about 1 m, inner diameter, 10 - 15 cm deep. The outer diameter of the crater is about 10 m with lots of rubble, especially fragments of *Acropora* spp., covering the area. Cut-off pieces

Box 23.2. (Continued.)

of foliose corals like *Montipora* spp. and *Echinopora* spp. were spread over the area, some still alive, and nothing overgrown yet. At the outer margins of such craters we found heavily damaged colonies, with sharp borders, as if they had been cut with a knife. Six weeks later, most of the area, especially where live coral rubble had accumulated, was covered by green and brown algae. We also found that the potential for fast growth of turf algae is very high, as a tape measure, running from 8 m depth down to 32 m depth, left underwater for only one week, was completely covered with brownish algae between 8 m and 15 m and started to be overgrown down to 22 m. This area is now regularly visited, in order to document the growth of fragments and the resettlement of new corals.

Table 23.4. Percent coral cover of coral reef communities along the coast of West Sumatra. Pulau = island. Gosong = submerged reef. X = not investigated. N = north, E = east, S = south and W = west.

No.	Name of location	Percent live coral cover (%)			
		N	E	S	W
1	Pulau Marak	X	18	12	27
2	Pulau Sinyaru	17	34	X	21
3	Pulau Pasumpahan	X	25	56	<10
4	Pulau Air	X	37	X	X
5	Pilau Pisang	X	X	59	X
6	Pulau Kasik	X	X	X	10
7	Pulau Sirandah	37	29	X	X
8	Pulau Sauh	X	11	X	66
9	Ujung Nibung	43			
10	Teluk Buo	38			
11	Pulau Ujung Pariaman	X	50	65	X
12	Pulau Karsik Periamn	X	X	X	71
13	Gosong Gabuo	58	X	X	77
14	Gosong Gedang	X	29	X	X
15	Gosong Sipakal	X	X	86	X
16	Gosong Sibarat	X	X	41	X
17	Pulau Pini (Labuhan Bajo)	39			
18	Pulau Ular	31	X	X	X
19	Pulau Anso	10	X	X	X
20	Pulau Nyamuk	<10			
21	Pulau Pandan	50	45	X	40
22	Pulau Bitangor	X	X	X	30
23	Pulau Sironjong	X	X	X	30
24	Pulau Pagang	<10			
25	Pulau Karang Anggo	X	X	45	40
26	Pulau Pieh	83	76	76	71

Box 23.2. (Continued.)

Up to now 101 species of hard corals from 59 genera and 19 families were positively identified (Wallace et al. in prep; Hoeksema this volume) and are available in a collection in Padang, with more species awaiting identification. For a rough overall generalization, the reefs or certain reef areas (e.g., one side or reef-crest, etc.) can be classified into:

- *Acropora*-dominated reefs, where about 24 species of *Acropora* have been identified so far (G. Gedang SE, G. Air, Parsumpahan E, G. Sipakal E).
- Foliose coral (*Montipora, Echinopora*) dominated reefs (Pandan W, Pieh W).
- Reefs with high sediment load or low light conditions, where *Goniopora, Euphyllia, Galaxea* are frequent (G. Gabuo, Pisang SE).
- Reefs with low light conditions, where, in about 15 m depth, a 'second' reef community starts down to 30 m and deeper, where *Lobophyllia* and *Symphyllia* are frequent (Sinyaru NE, Sirandah NE).
- Reefs where *Porites* or other brain-shaped corals (several members of the Family Faviidae) are frequent (Saoh E, Karsik, Ujung).
- Reefs where *Heliopora* is dominating (Saoh, Laut) or where soft corals are dominating or frequent (Marak E, Bintanggor E).
- Reefs where resettlement communities dominated by macroalgae occur (Sinyaru N, Marak E).
- Islands surrounded by dead reefs (i.e., predominantly coral rubble) (Nyamuk, Bando).

Furthermore, the following generalizations and observations have been made:

- There is a heavy pressure on the reefs, all reefs are disturbed more or less and some are very seriously disturbed, mainly mechanically. Many reef areas in fact only consist of loose fragments, or fragments which have been 'glued-together' by fast-growing calcareous algae. Fortunately, the number of recruits is impressive, especially in shallow waters (mainly *Acropora, Pocillopora* and encrusting species).
- Reef fishes are still present in almost all locations which were investigated. However, the fish diversity is clearly higher at reefs which are still in good or excellent condition. Particularly, the high number of butterflyfishes and angelfishes indicates almost intact reef systems.
- Reefs close to the shore show high sedimentation loads. At some locations corals are buried at depths of 6 m. In general, the southern side is the best (lee to prevailing currents) (G. Gabuo, G. Saoh, Pisang).
- Offshore reefs can be the best and the worst, due to bombing and fishing with poison or other mechanical destruction (anchoring, dredging, harvesting giant clams). One of the reefs with high coral diversity and high percentage cover of live coral is about 27 km away (Pieh), but also the worst spots, where virtually the entire island consists of rubble only (Nyamuk, Bando), can be found at this distance to the coast. At intermediate distances to the coast, we find heavily disturbed and hardly disturbed reefs. Therefore, conclusions such as: 'close to human populations the reef conditions are declining most', are not necessarily true.

The Mentawai and Batu Islands Area

The islands north and south of Padang (more than 55 km away) and the Mentawai and Batu Complex account for about 210 of the total of 297 islands/reefs in West Sumatra. The coastline of the Mentawai Islands alone is some 600 km, more than the coastline of the mainland.

The 200 m isobath marks the northern end of the Mentawai Basin, and here the continental shelf includes the big Batu Islands Complex, consisting of three main islands (Tanahbala, Tanahmasa and Pini) and numerous smaller islands and large submerged

Box 23.2. (Continued.)

reefs. In this northernmost area of West Sumatra, we actually find the largest reef complexes of the entire west coast of Sumatra. South and southwest of Pini, for example, a complex system of submerged patch reefs covers an area of about 51.4 km^2. Because sea charts of this area are not updated regularly, navigation is very dangerous here, especially at night or during bad weather. Unfortunately, this area is so remote that access (and escape) can almost always be done without being seen. Thus, it is not surprising that most reefs are heavily exploited, mainly by teams who harvest giant clams by hammering the shells out of the reef with long and sharp iron bars. It is also this area, especially more to the south, where most illegally operating trawlers have been observed.

Between Tanahmasa and Tanahbala Island is a 27-km-long channel, only 1 km wide and with an average depth of 10 to 20 m. The coral species in this channel are, apart from sandy and muddy areas, a lagoonal type of community. Another lagoonal type of reef community, flanked by mangrove trees and bushes, is found in Teluk Sarabua, north of Muara Siberut at 01°30' S and 99°10' E. With a length of almost 13 km and several islands and submerged reefs, the bay is a huge aquarium, which was earmarked in 1980 to become a marine park (McNeely 1980). A diver can virtually dive down into the reef by jumping from mangrove roots, which stand on top of huge massive *Porites* corals.

Unfortunately, due to a severe lack of control, about half of the area of the anticipated marine park (which also includes the Muara Saibi area in the north and the northernmost part of Teluk Siberut in the south, fig. 23.30) has been totally destroyed, with only endless areas of coral rubble remaining. It is also this bay where one of the largest live reef fish trades of West Sumatra is based, as mentioned earlier. Several net cages in Teluk Sarabua host live groupers and wrasses waiting to be exported. Fishermen use cyanide in order to deliver enough fish to the middleman, who pays good prices to local fishermen.

As a matter of fact, the above-described rubble areas seem to be characteristic of most reefs of the Mentawai and Batu Island area. What we are witnessing here is an ongoing ecological disaster. Hundreds of km^2 of reef are destroyed in an apparently systematic way. The fact that virtually no reef is spared, suggests that modern navigation equipment and echosounders are skillfully employed by the operators. The seasonally occurring large-scale bombing, which targets mainly the 'ekor kuning' fish (yellowtail fusiliers, *Caesionidae*), is common knowledge and continues each year.

Based on earlier investigations in 1986, reports from student excursions, from fishermen and an extensive survey in July 1995, this situation can be generalized for the entire Mentawai Islands (Tanahmasa/Tanahbala, Siberut, Sipura, Pagai), including the distant reefs at the northern edge of the Mentawai Basin (0°30' S/ 99°20' E; fig. 23.27) and the area at East Siberut, which is still under consideration for a marine park (McNeely 1980; Salm 1984; Mastaller 1991; Mitchell, pers. comm.).

Concluding Remarks

The islands close to the coast are under pressure by pollution and sediment loads from rivers and harbours. This does not, however, necessarily seriously affect hard corals. In contrast, some of the biggest specimens of *Porites* species were found here. Also, the highest number of coral genera was found here (with the exception of Pieh Island). The islands further offshore are obviously less influenced by river discharge, as is also indicated by the data on visibility and physical water parameters. However, most of the heavily damaged reefs are located here. This is clearly a result of the fishing activities with explosives and poison.

Box 23.2. (Continued.)

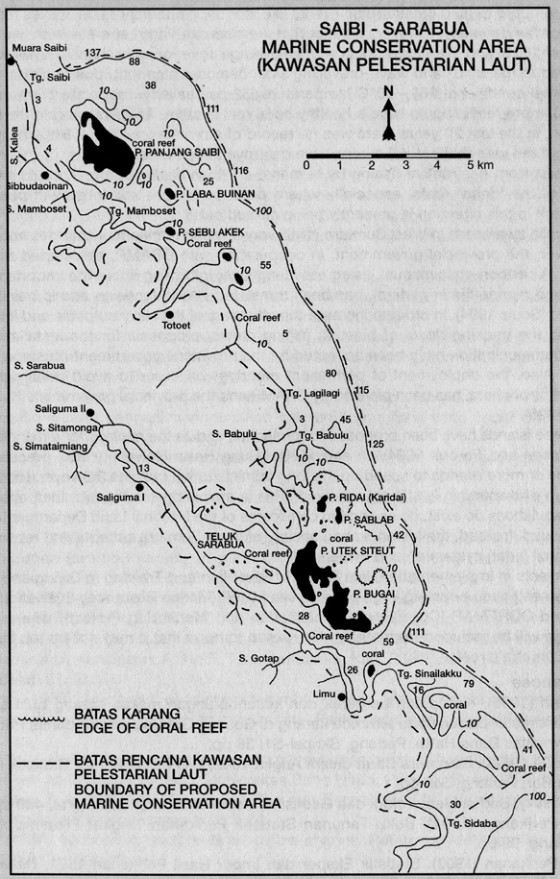

Figure 23.30. Map of the planned marine park area at Siberut Island; Muara Saibi, Teluk Sarabua and the northern part of Teluk Siberut.

Box 23.2. (Continued.)

Due to the extent of the destruction and disturbance of some reefs, people are easily tempted to hold catastrophic events like storms, typhoons or tidal waves responsible for the damage. However, the fact that we also can find reef areas with live coral cover of 100% and even large areas with an average cover of more than 70%, which are exposed to the wind- and wave-prevailing side, demonstrates that, due to similar environmental conditions (26° - 29°C temperature, 32 psu salinity, moderate currents and waves), more reefs should have a healthy coral reef system. As mentioned in the introduction, in the last 20 years there was no record of storms exceeding 9 Bft, which also rules out the idea that natural events have destroyed large areas.

Apart from destructive fishing by humans, an *Acanthaster* outbreak could explain some of the 'dead' reefs, especially where dead corals are still in growth position. Research in this direction is presently being carried out.

Public awareness in West Sumatra is still very low and marine tourism does not exist. However, the provincial government, in cooperation with CRAMP, has started to take action. A cartoon-style manual, using easy language, informing about the importance of reefs and marine life in general, has been translated into Indonesian and is being distributed (Soule 1994). In order to increase the efficiency of the Navy outposts and in order to ease the tracking down of blasting fishing crews, proposals for the installation of radio communication have been accepted by the provincial government (Kusuma et al. 1995). Also, the deployment of permanent moorings, in order to avoid coral damage caused by anchors, has been planned by CRAMP and the provincial government (Kusuma et al. 1995).

Three islands have been proposed for protection and as the nucleus for a marine park (Kunzmann and Farouk 1994). In early 1994, Bung Hatta University was prepared to buy one or more islands to speed up the long administrative process, however, today the problem of ownership is still not resolved. This is mainly due to the fact that, although clear regulations do exist, no ownership certificates of the National Land Department were ever issued. Instead, the Minangkabau society of West Sumatra accepts and respects a traditional (adat) system of land ownership.

Projects in implementation, like DIKLAT (Education and Training in Diving and Reef Assessment) and upcoming large projects like MREP (Marine Resources Evaluation Project) and COREMAP (Coral Reef Rehabilitation and Monitoring Project), where West Sumatra will be included from 1997, give reason to hope that it may not be too late for West Sumatra's reefs.

References

Arsonetri (1995). Kecepatan bergerak dan kecenderungan makan karang bulu seribu (Acanthaster planci) pada terumbu karang di Gosong Gabuo perairan pantai Padang. Universitas Bung Hatta, Padang, Skripsi-S1: 36 pp.

BAPPEDA (1993). Sumatera Barat dalam Angka 1992, BAPPEDA Kantor Statistik Prop. SumBar, Padang, 543 pp.

BMG (1994). Badan Meteorologi dan Geofisika, Dep. Perhubungan, Jakarta, 480 pp.

Dinas Perikanan (1994). Buku Tahunan Statistik Perikanan Tingkat Propinisi 1993, Padang, 95 pp.

Dirjen Perikanan (1993). Statistik Ekspor dan Impor Hasil Perikanan 1991, Direktorat Jenderal Perikanan, Dep. Pertanian, Jakarta, 516 pp.

DHI (1990). Handbuch der Suedkueste Asiens No. 2036, Deutsches Hydrographisches Institut, Hamburg, 396 pp.

English, S., Wilkinson, C., Baker, V. (eds.) (1994) Survey manual for tropical marine resources. AIMS, Townsville, 368 pp.

Box 23.2. (Continued.)

Governor Decree 1993 No. 04/ISNT/GSB/1993, Padang, 2 pp.

Hantoro, W. S. and Naryanto, H. S. (1992). Late Quarterny vertical deformations along portions of the Central Sunda Volcanic Arc Southwest Coast (from Padang to Pacitan), as inferred from sea level indicators. *Baruna* Jaya Research Vessel management project, BPPT Jakarta, 39 pp.

Indrawadi (1995). Kondisi terumbu karang di perairan Kodya Padang menggunakan genus *Acropora* sebagai indikator utama kerusakan. Universitas Bung Hatta, Padang, Skripsi-S1: 44 pp.

Kunzmann, A. and Efendi, Y. (1994). Apakah terumbuh karang di perairan sepanjang pantai barat Sumatera Barat sudah rusak? *Jurnal Penelitian Perikanan Laut* 91:48-56.

Kunzmann, A. and Efendi, Y. (in press). Are the coral reefs of West Sumatra seriously damaged? IOC-WESTPAC, III Int. Sci. Symp., Bali, November 22-26, 1994, 12 pp.

Kunzmann, A. and Farouk (1994). Konservasi Alam dan Taman Laut Pulau Pieh, PSPP Univ. Bung Hatta, Padang, 6 pp.

Kunzmann, A., Zimmermann, C. and Efendi, Y. (1993). Are the coral reefs of West Sumatra endangered by pollution and fishing with explosives? Pre Indo-Pacific Fish Conference Workshop, Maumere, November 20-25, 1993.

Kusuma, H., Farouk, and Kunzmann, A. (1995) Pemasangan tempat lego jankar permanen (mooring) sebagai salah satu alternatif usaha pencegahan kerusakan terumbu karang. PSPP Univ. Bung Hatta, Padang, 3 pp.

Kusuma, H., Kunzmann, A., and Indrawadi (1995). Pencegahan peledakan ekosistem terumbu karang dengan menggunakan saluran komunikasi yang cepat dan tepat. PSPP Univ. Bung Hatta, Padang, 3 pp.

Mastaller, M. (1991). Management and conservation of tropical forest ecosystems and biodiversity, ADB/GOPA, Jakarta 66 pp.

McNeely, J. A. (1980). Saving Siberut, a conservation master plan. WWF/PHPA, Bogor, 134 pp.

Nusyirwan (1994). Pengaruh pembuangan limbah pabrik kayu Bungus terhadap kehidupan terumbu karang di perairan Bungus Teluk Kabung Padang, Propinsi Sumatera Barat. Universitas Bung Hatta, Padang, Skripsi-S1: 58 pp.

Salm R. V. (1984). A protected areas system plan for the conservation of Indonesia's marine environment. IUCN/WWF, Jakarta, seven volumes, 22 pp. summary.

Soule, S. M. (1994). Our coral reefs. ICLARM Educ. Ser. 15, 27 p. translated into Bahasa Indonesia by Kunzmann, A. 1995, Terumbu Karang Kita. PSPP, Bung Hatta University, Padang, 27 pp.

Sukarno (1993). Mengenal ekosistem terumbu karang. Materi pelatihan metodologi penelitian penentuan kondisi terumbu karang. Puslitbang Oceanologi LIPI, Jakarta, 96 pp.

Syarif, S. M. (1994). Komponen utama yang mempengaruhi kerusakan terumbu karang di perairan barat Kodya Padang. Universitas Bung Hatta, Padang, Skripsi-S1: 61 pp.

Umbgrove, J. H. F. (1931). De Koraalriffen van Emmahaven (W. Sumatra). Leidsche Geologische Mededeelingen IV(1):9-24.

UNEP (1993). Monitoring coral reefs for global change. Reference Methods For Marine Pollution Studies No. 61.

UNEP/IUCN (1988). Coral Reefs of the World. Vol. 2: Indian Ocean, Red Sea and Gulf. UNEP Regional Seas Directories and Bibliographies, IUCN, Gland, Switzerland and Cambridge, U.K., 389 pp.

Box 23.2. (Continued.)

Yennafri (1995). Keanekaragaman dan persentase tutupan terumbu karang di Gosong Gabuo Kodya Padang. Universitas Bung Hatta, Padang, Skripsi-S1: 40 pp.

Yusapri, A. (1995). Kepadatan dan sifat koloni bulu seribu *(Acanthaster planci)* di terumbu karang Gosong Gabuo Kodya Padang. Universitas Bung Hatta, Padang, Skripsi-S1: 39 pp.

Zimmermann, C. and Kunzmann, A. (1994). Zum Zustand der Korallenriffe der Padang Inseln (West Sumatra, Indonesien). 7. Jahrestagung der Deutschen Gesellschaft für Tropenökologie in Bremen, 17.-20.2.1994.