

CHAPTER 5. STATUS OF CORAL REEFS IN SOUTHEAST ASIA

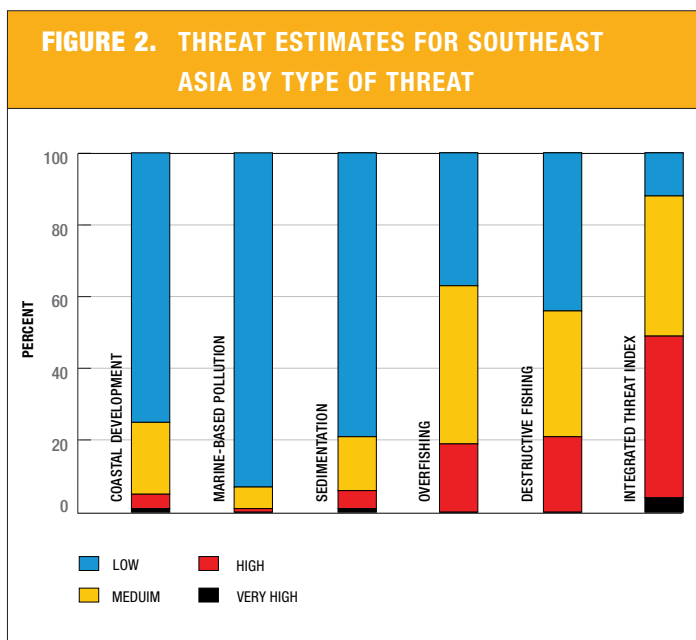


PHOTO: WOLCOTT HENRY

Although highly diverse and extraordinarily valuable, the coral reefs of Southeast Asia are also severely threatened. The heavy reliance on marine resources across the region has resulted in the overexploitation and degradation of many coral reefs, particularly those near major population centers.⁴⁵ The RRSEA analysis examined five broad categories of threat and then integrated them into the Reefs at Risk Threat Index, based upon the highest level of threat scored in any single category and with regard to cumulative threat. For example, a reef ranked as being under high threat for three different threats, ranks very high for integrated threat. Threats facing reefs in Southeast Asia are extremely pervasive. Coastal development, local overfishing, and sedimentation all damage corals near the shore. At the same time, remote and offshore reefs are buffeted by destructive fishing practices and commercial overfishing.

Overfishing is the most pervasive threat to reef health, putting 64 percent of reefs at risk. Although some remote reefs remain in pristine condition, destructive fishing practices are now threatening many of them. Poison and blast fishing techniques employed to collect fish for the live reef fish trade endanger 56 percent of the region's reefs. Coastal development and land-use changes also put significant pressure on coral reefs in the region, affecting 25 percent and 21 percent of reefs,

respectively. The combined sedimentation and pollution from these two activities place 37 percent of the region's reefs at risk. Compared to the other threats evaluated, marine-based pollution is the least pervasive threat, affecting only 7 percent of reefs. When all of these threats are aggregated, human activities threaten the vast majority of coral reefs in the region—88 percent. Nearly 50 percent of those threatened coral reefs are under high or very high threat. (See Figure 2.)



The reefs of the Philippines, Vietnam, Singapore, Cambodia, and Taiwan are some of the most threatened in the region, each with over 95 percent threatened. The reefs off the Nusa Tenggara chain in Indonesia; Okinawa, Japan; and Sabah, East Malaysia are also highly threatened. Malaysia and Indonesia each have over 85 percent of their coral reefs threatened. (See *Table 3 and Map 9.*) Because of the extent of their reef area and the high proportion of their reefs that are threatened, Indonesia and the Philippines alone account for much of the region's threatened reefs. Indonesia and the Philippines together possess 77 percent of the region's coral reefs and 79 percent of all threatened reefs in the region. (See *Table 3.*)

A small number of islands face low levels of threat. Reefs under relatively little pressure include some of those in the Makassar Straits, Flores Sea, and Banda Sea. Isolated areas off the Andaman Islands, West Papua, Myanmar, and Thailand are also under low stress. (See *Map 9.*) Even though they face little threat

from development and local overfishing, the reefs are not necessarily safe. If destructive fishing techniques were applied in these areas, the level of risk would quickly change from low to high.

This chapter contains country-specific discussions of coral reef status. It includes the limited data available through monitoring of current coral reef conditions and the RRSEA model's analysis of human pressure to provide the most complete picture of the likely status, threats, and future condition of the coral reefs of Southeast Asia. Country summaries are presented from south to north across the region.



For detailed summaries about the threat and status of specific coral reefs see www.wri.org/wri/reefsatrisk.

TABLE 3. REEFS AT RISK SUMMARY BY COUNTRY (OR AREA)

	REEF AREA ^a (KM ²)	REEF AREA AS PCT. OF TOTAL IN REGION	REEFS AT RISK THREAT INDEX								PERCENTAGE AT MEDIUM OR HIGHER THREAT
			LOW		MEDIUM		HIGH		VERY HIGH		
			KM ²	PCT.	KM ²	PCT.	KM ²	PCT.	KM ²	PCT.	
Indonesia	50,875	51%	6,930	14%	19,809	39%	23,403	46%	733	1%	86%
Philippines	25,819	26%	559	2%	7,099	27%	16,311	63%	1,850	7%	98%
Spratly and Paracel Islands	5,752	6%	0	0%	5,752	100%	0	0%	0	0%	100%
Malaysia	4,006	4%	533	13%	1,771	44%	1,541	38%	161	4%	87%
India (Andaman & Nicobar Islands)	3,995	4%	1,790	45%	2,119	53%	86	2%	0	0%	55%
Japan	2,602	3%	581	22%	983	38%	951	37%	87	3%	78%
Thailand	1,787	1.8%	419	23%	427	24%	917	51%	24	1%	77%
Myanmar	1,686	1.7%	742	44%	604	36%	336	20%	4	0%	56%
Vietnam	1,122	1.1%	43	4%	252	22%	551	49%	276	25%	96%
China	932	0.9%	71	8%	130	14%	706	76%	25	3%	92%
Taiwan	654	0.7%	0	0%	189	29%	367	56%	98	15%	100%
Brunei Darussalam	187	0.2%	147	79%	30	16%	10	5%	0	0%	21%
Singapore	54	0.1%	0	0%	0	0%	54	100%	0	0%	100%
Cambodia	42	0.0%	0	0%	0	0%	38	90%	4	10%	100%
Regional Total	99,513	100%	11,815	12%	39,165	39%	45,271	45%	3,262	3%	88%

SOURCE:

Reefs at Risk in Southeast Asia, WRI, 2002.

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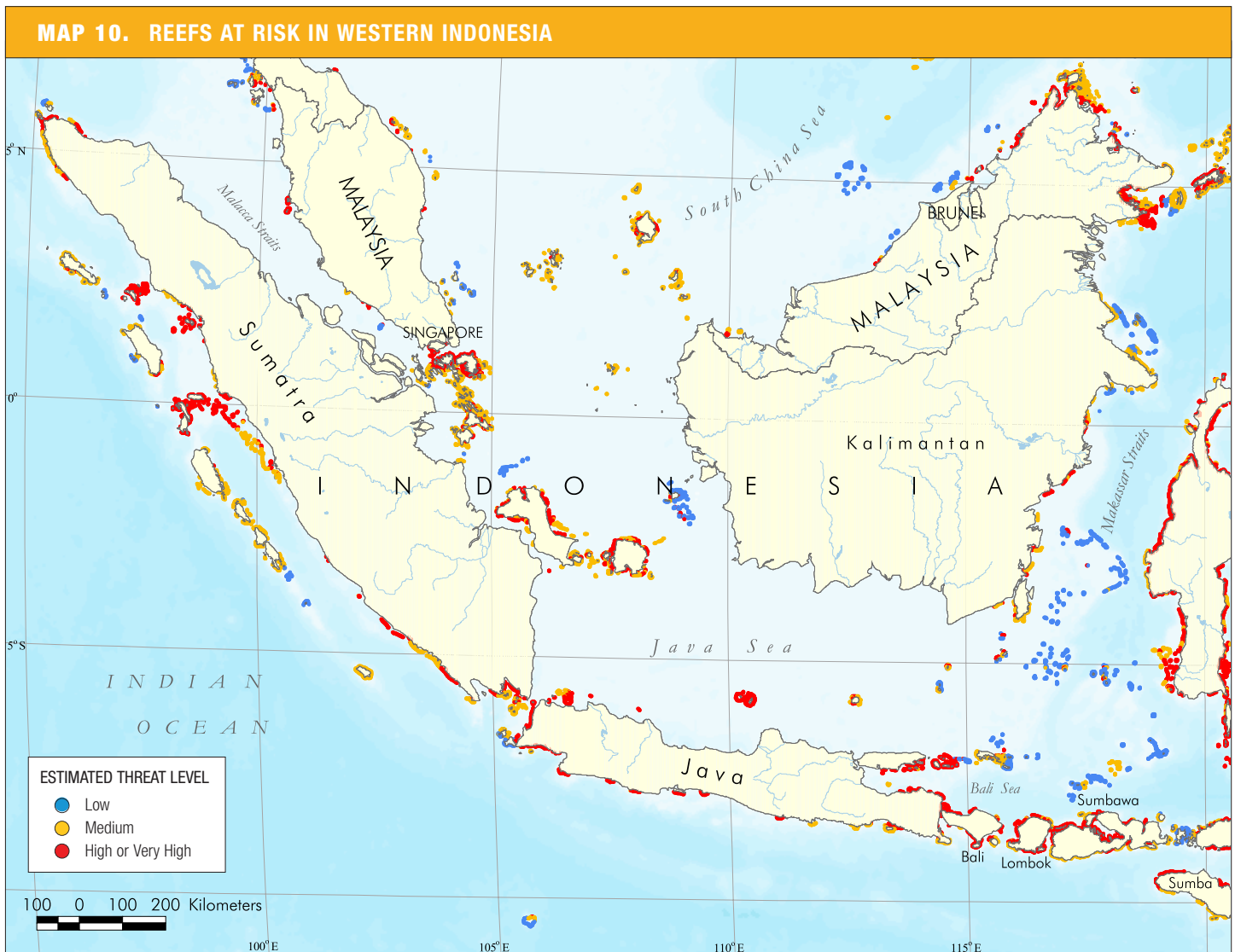
a. The RRSEA analysis was performed on grid cells that are 1 km resolution, so the grid cell counts presented on this table equate to reef area (km²). However, given the resolution and variation in the source data, reef area statistics are usually rounded to two significant digits (or the nearest 100 km²), as in Table 2.

INDONESIA

Indonesia is the largest archipelagic nation in the world, with a coastline stretching over 95,000 km around more than 17,000 islands.⁴⁶ An extensive group of coral reefs protect these islands. RRSEA estimates that Indonesia has approximately 51,000 km² of coral reefs; this number does not include reefs in remote areas that have not been mapped or subsurface reefs. If this conservative estimate is accurate, 51 percent of the region's coral reefs and 18 percent of the world's coral reefs are found in Indonesian waters.⁴⁷ Most of these reefs are fringing reefs, adjacent to the coastline and easily accessible to coastal communities. Coastal and marine industries such as oil and gas production, transportation, fisheries, and tourism represent 25 percent of the nation's GDP and employ more than 15 percent of the workforce.⁴⁸

Although coastal communities have long extracted marine resources sustainably, population growth has put additional pressure on Indonesia's coral reefs.

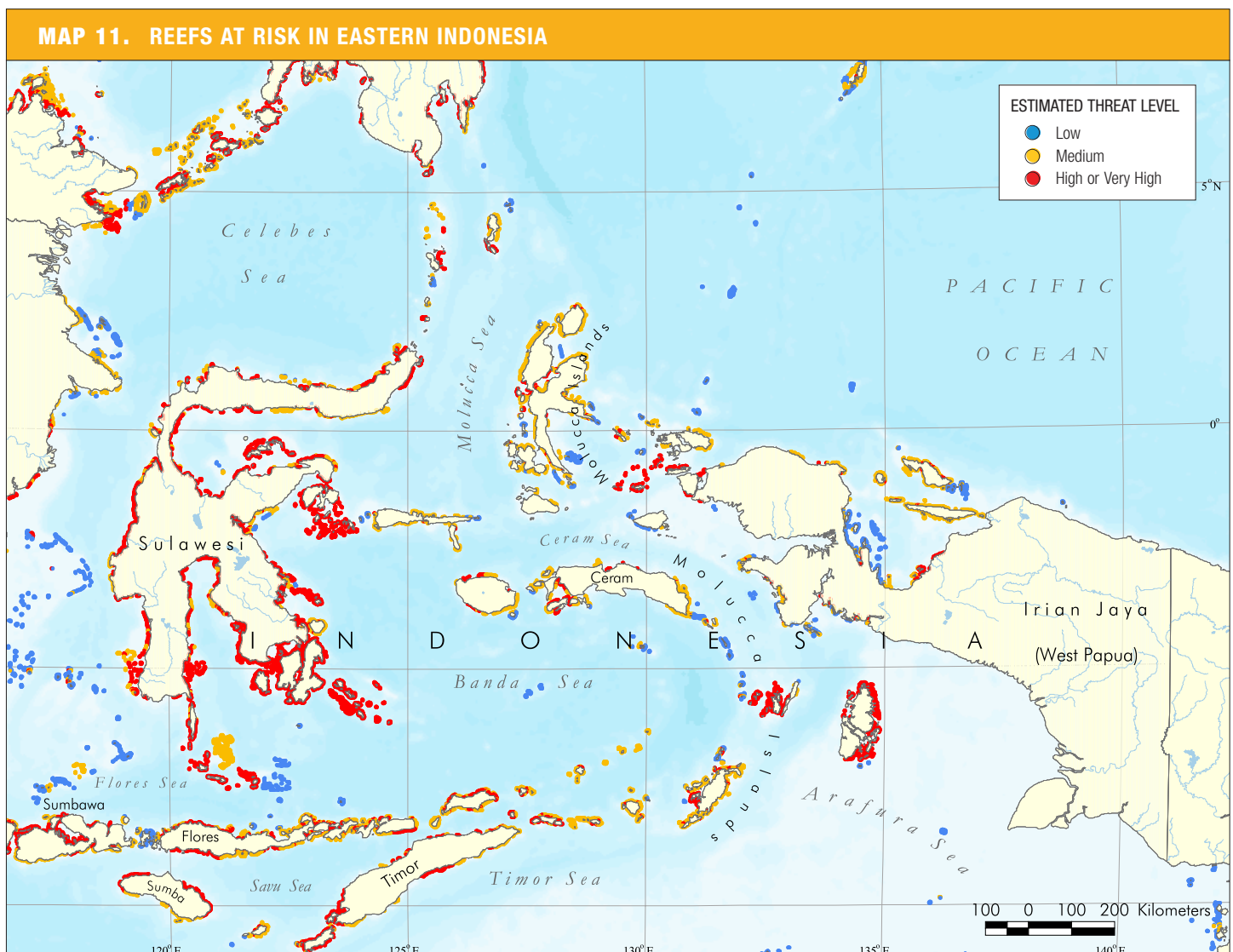
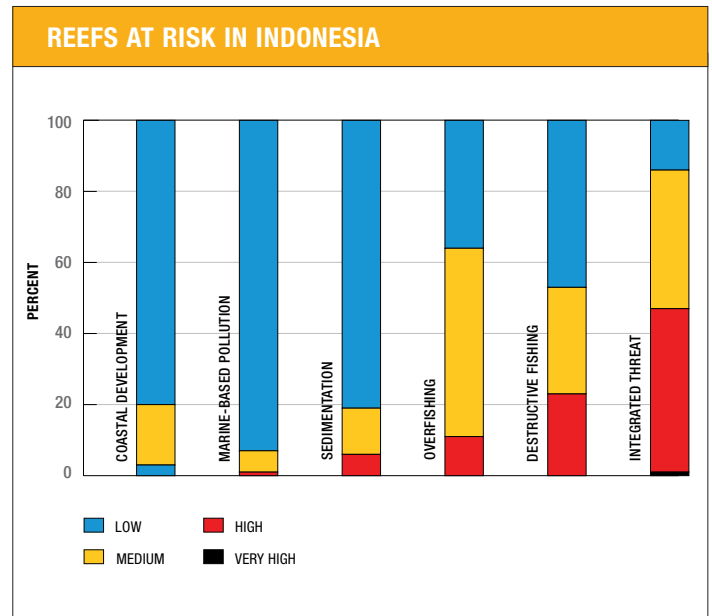
Aside from their sheer magnitude, Indonesia's coral reefs are also among the most biologically rich in the world, containing an extraordinary array of plant and animal diversity. Today, more than 480 species of hard coral have been recorded in eastern Indonesia, approximately 60 percent of the world's described hard coral species.⁴⁹ The greatest diversity of coral reef fish in the world are found in Indonesia, with more than 1,650 species in eastern Indonesia alone. In fact, Indonesia's coral reefs help to support one of the largest marine fisheries in the world, generating 3.6 million tonnes of total marine fish production in 1997.⁵⁰ Because many reefs in eastern Indonesia have yet to be



surveyed, the actual extent of Indonesia's biological endowment is still unknown.⁵¹

Indonesia's rich supplies of corals and reef fish are endangered by destructive fishing practices. Cyanide and blast fishing are widespread throughout the archipelago even in protected areas. In the early 1990's, around 65 percent of surveys in the Maluku islands had evidence of bomb damage.⁵² Despite the short-term profits, studies have shown that the economic costs of blast and poison fishing are prodigious.⁵³ RRSEA estimates that the net economic loss in Indonesia from blast fishing over the next 20 years will be at least US\$570 million. The economic loss from cyanide fishing is estimated to be US\$46 million annually.⁵⁴

Indonesian reefs are also subject to various pressures from inland activities. The average annual deforestation rate in



Indonesia between 1985 and 1997 was 1.7 million hectares.⁵⁵ Deforestation and other land-use changes have increased sediment discharge onto reefs, and pollution from industrial effluents, sewage, and fertilizer compounds the problem. Reefs affected by land-based pollution have shown 30–50 percent less diversity at depths of 3 m, and 40–60 percent less diversity at 10 m, in comparison to pristine reefs.⁵⁶

The 1997–98 ENSO event triggered widespread bleaching in Indonesia, with western and west-central Indonesia most affected. Bleaching was recorded in East Sumatra, Java, Bali, and Lombok. In the Seribu Islands northwest of Jakarta, 90 to 95 percent of the coral reef from the reef flat down to 25 m died. Two years later, the Seribu Islands had significant recovery, with live coral cover of 20–30 percent in 2000.⁵⁷

Cumulatively, these pressures appear to have significantly degraded Indonesia's reefs over time. Unfortunately, Indonesia has only limited monitoring. Few reefs are regularly studied, making the assessment of condition and change for the country quite difficult. Currently, most monitoring clearly indicates that reef condition is declining. In the past fifty years, the proportion of degraded reefs in Indonesia increased from 10 to 50 percent.⁵⁸ Between 1989 and 2000, reefs with over 50 percent live coral cover declined from 36 to 29 percent.⁵⁹ Western Indonesia, which is more developed and holds the majority of Indonesia's population, faces the greatest threats to its coral reefs. Surveys conducted between 1990 and 1998 show that reef condition improves from west to east. The percentage of reefs in good or excellent condition (live coral cover of more than 50 percent) is 23 percent in western Indonesia compared to 45 percent in eastern Indonesia.⁶⁰

RRSEA modeling suggests that human activities threaten over 85 percent of Indonesia's coral reefs, with nearly one half at high threat. The principal threats to Indonesian reefs are overfishing and destructive fishing, which threaten 64 and 53 percent of Indonesia's reefs, respectively. However, the areas at risk from destructive fishing are probably underestimated because information is not available for many areas. Both coastal development and sedimentation from inland sources threaten about 20 percent of the country's reefs.

Few specific management measures exist to protect coral reefs

in Indonesia. Until 1999, no identifiable institution had oversight for the management of coastal resources.⁶¹ Owing to a lack of coordination and political upheavals, Indonesia is not achieving government management targets set in 1984. Originally, Indonesia had planned to have 85 marine protected areas covering 10 million ha by 1990 and 50 million ha by 2000.⁶² However, in 2000, Indonesia had just 51 marine protected areas (MPAs) that include coral reefs, covering an area of 6.2 million ha.⁶³

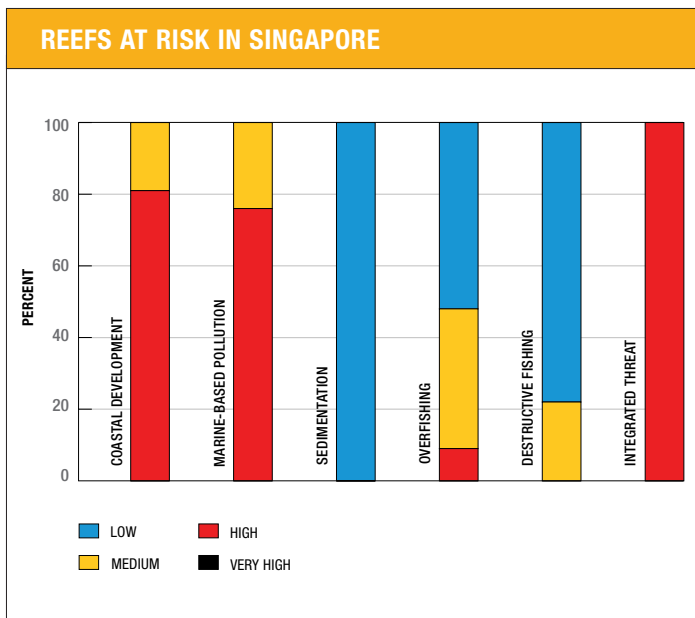
Governance responsibility for Indonesian coastal resources was given to the Ministry of Marine Affairs and Fisheries in 1999. The government has also sponsored the Coral Reef Rehabilitation and Management Program (COREMAP), a 15-year initiative aimed at strengthening the management of the country's coastal resources while considering the needs of coastal communities. However, to date, COREMAP has had only limited success. On a local scale, several NGOs have had success instituting collaborative and community management frameworks.⁶⁴ This bottom-up approach may become increasingly important as the Indonesian government continues to undergo decentralization.

SINGAPORE

The Republic of Singapore, despite its small size, is a focal point for trade and economic development in the region, with one of the world's busiest ports and largest oil refineries.⁶⁵ The income generated from industry and shipping traffic has helped it become one of the wealthiest nations in the region, with a per capita GDP second only to Japan. (*See Table 1.*)

Relative to its small land area, Singapore is endowed with considerable biological wealth. Fringing and patch reefs grow around both the main island and more than 60 small offshore islands. These reefs contain more than 197 hard coral species in 55 genera and 111 species of reef fish from 30 coral families.⁶⁶ Singapore's coral reef area is estimated to be about 54 km².

Singapore's coral reefs are not subject to the unsustainable fishing practices that are so pervasive throughout the rest of the region. Fisheries and the trade in aquarium fish are well controlled. Sewage and industrial waste treatment are relatively good, and marine pollution from ships is mitigated by effective regulatory measures.⁶⁷ However, the development required to



build and maintain its globally important port has taken a substantial toll on corals reefs.

During the past four decades, Singapore has engaged in extensive land reclamation and coastal development projects. Reclamation has been particularly devastating. Around 60 percent of total coral reef area has been lost owing to nearshore reclamation, and the accompanying sediment loads have triggered declines in coral cover in almost all sites monitored since 1987. Average visibility has been reduced from 10 m in the 1960s to about 2 m today.⁶⁸ Most reefs have lost up to 65 percent of their live coral cover since 1986. Experts estimate that about 70 percent of Singapore’s reefs are degraded compared to conditions 50 years ago. Singapore’s reefs were further damaged by the 1997–98 bleaching associated with ENSO. Nearly 90 percent of hard corals bleached, and 25 percent of these have failed to recover.⁶⁹

The RRSEA model indicates that all of Singapore’s reefs are threatened by human activities. The dominant threat is coastal development, with its associated sedimentation and pollution. (See Map 10.)

Currently, no national policy or specified agency exists to manage coral reefs. Nevertheless, strong measures and consistent monitoring of effluents throughout the nation help to curtail risks from marine pollution. Nongovernmental organizations are taking a strong role in raising awareness and protecting coral reefs through a wide range of activities.

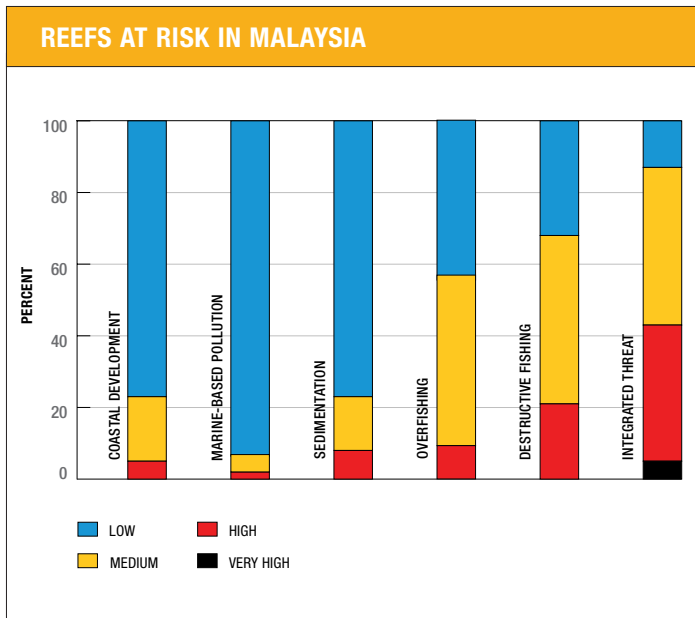
MALAYSIA

Malaysia encompasses 11 states and 2 federal territories on the Malay Peninsula and 2 states on the island of Borneo, 600 km to the east. (See Map 10.) The wide geographic range that Malaysia covers means that coral reefs can be found in varied conditions across the country. Little reef development occurs along the west coast of Peninsular (or West) Malaysia, but the east coast of West Malaysia has some fringing reefs along the coast and many reefs around the offshore islands. East Malaysia, which is comprised of the states of Sarawak and Sabah, makes up the northern one third of the island of Borneo. Because of high sedimentation, reef development around Sarawak is limited. However, Sabah contains more than 75 percent of all Malaysian reefs and has high levels of coral diversity. Overall, more than 350 coral species have been recorded in Malaysia.⁷⁰

Threats facing Malaysian reefs differ by location. Peninsular Malaysian reefs are most affected by development. High-traffic shipping lanes run along the western coast of Peninsular Malaysia through the Straits of Malacca. Reefs in this area can be subject to oil spills and anchor damage. Agriculture and development on the peninsula have caused increased sediment and nutrient runoff. Some west coast reefs are now damaged by seasonal macroalgae blooms.⁷¹ Destructive fishing practices are not widespread in Peninsular Malaysia due to higher enforcement and less dependence on coastal fisheries.⁷²

East Malaysian reefs are subject to different threats. Both blast and cyanide fishing methods are widespread around Sabah, particularly around Labuan. Blast and cyanide fishing have ruined formerly pristine reefs like those surrounding the islands off Semporna. In damaged sites like Boheydulang and Bodgaya Island, abundance and size of fish are markedly decreased. In Sarawak, river sedimentation is also an important threat. Reefs near the Miri River have 20–30 percent live coral cover and large amounts of algal growth.⁷³

Information about coral cover in Peninsular Malaysia is somewhat limited. Surveys of coral reefs along the east coast of Peninsular Malaysia suggest relatively high coral cover, 55–70 percent on most fringing reefs. On the west coast of the peninsula, the percentage of live coral cover is generally lower, from 25 to 45 percent.⁷⁴



Coral surveys are more extensive in East Malaysia. From 1996 to 1999, 49 coral reefs throughout Sabah were surveyed. Live coral cover ranged from 15 to 75 percent. Dead coral cover, which is indicative of recent damage, accounted for 10–20 percent of benthos cover at nearly 70 percent of surveyed sites.⁷⁵ Only 10 percent of reefs had dead coral cover under 10 percent.⁷⁶ Coral reefs on Sipadan Island are thought to be in the best condition among reefs off the coast of Sabah.⁷⁷ Bleaching surveys in East Malaysia during the 1997–98 ENSO event indicate moderate bleaching. At Pulau Gaya and Lahad Datu, approximately 30 percent of the coral cover was bleached.⁷⁸

The RRSEA project found that over 85 percent of Malaysian reefs are threatened by human activities. Destructive fishing and overfishing are the primary threats, impacting 68 percent and 56 percent of reefs, respectively. Coastal development and sedimentation from upland sources each affect approximately 23 percent of coral reefs in Malaysia.

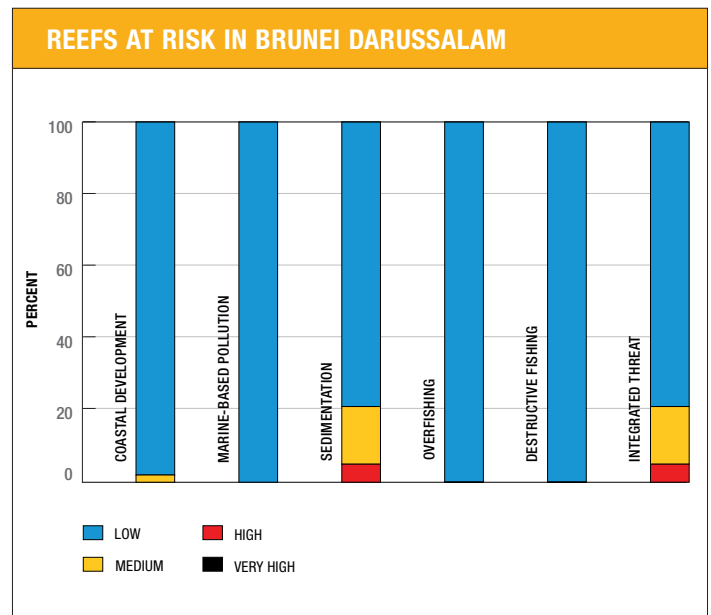
Malaysia has several marine protected areas, including the Turtle Islands Heritage Park, a historic transboundary park jointly administered with the Philippines. These MPAs vary in their management effectiveness; most marine parks in Malaysia suffer from issues such as inadequate personnel, logistical problems, and scarce financing. Enforcing regulations and monitoring reef status are particularly challenging.

BRUNEI DARUSSALAM

Brunei Darussalam is one of the smallest nations in Southeast Asia. Unlike other nations in the region, the people of Brunei are not as reliant on the biological resources in their coastal zone for their livelihoods because the country has lucrative offshore oil and gas industries. Brunei, however, has a trawling fleet to exploit offshore fisheries. Coral reefs cover roughly 200 km² and include fringing reefs, patch reefs, and one atoll.⁷⁹

Although Brunei’s reefs cover only a small area, they are fairly diverse. Surveys completed in 1987 and 1992 found 185 species from 72 genera in Brunei’s waters.⁸⁰ Coral cover, however, is relatively low—40 percent at Pelong Rocks and 27 percent at Two Fathom Rock.⁸¹ Because they are not commercially exploited, Brunei’s coral reefs remain in relatively good condition. Despite extensive oil drilling and coastal development, they are among the least threatened in the region. According to the RRSEA model, only about 21 percent of Brunei’s coral reefs are at risk from human activities, particularly from sedimentation as a result of upland activities. (See Map 10.)

The Department of Fisheries in the Ministry of Industry and Primary Resources is responsible for the management of coral reefs in Brunei. Although it developed an integrated coastal management plan, Brunei has yet to implement it proactively. The country is currently courting more tourism development, but new regulations will require projects to con-



MAP 12. REEFS AT RISK IN THE MALAY PENINSULA



duct an environmental impact assessment. However, technical capacity and scientific knowledge in the country are limited, and Brunei is seeking help from international organizations in executing comprehensive monitoring programs.

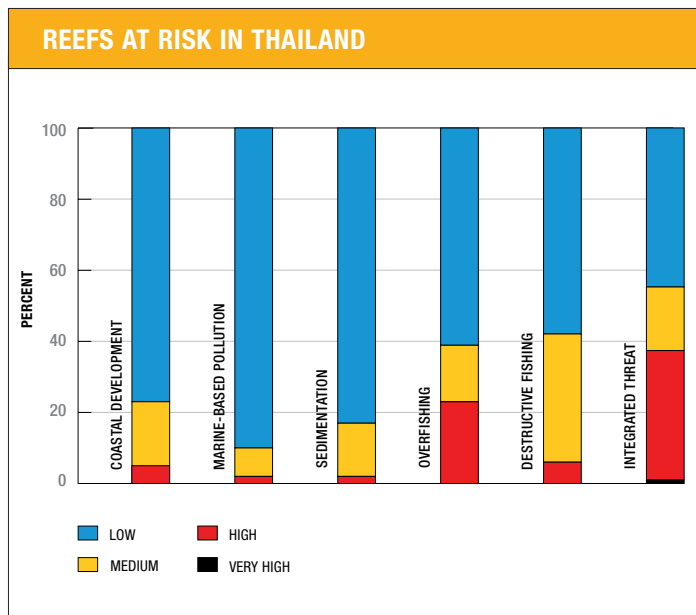
THAILAND

An estimated 1,800 km² of coral reefs grow along Thailand's coastline in the Gulf of Thailand and the Andaman Sea. The structure and distribution of coral reefs vary significantly between the two. Because of climatic and oceanographic variations in their water bodies, threats and reef condition can also be substantially different. (See Map 12.)

Fishing has long been an important economic activity in Thailand, but widespread destructive fishing techniques and trawling have had impacts on coral reefs since the early 1960s.⁸² Destructive fishing practices on both coasts have damaged countless reefs, but these activities are believed to have declined as the tourism industry has grown.⁸³ The rise in tourism and other population pressures, however, have caused sedimentation and wastewater pollution to increase, and damage from boat anchors, divers, garbage, erosion, and sewage and wastewater discharge is evident.⁸⁴

Significant coral bleaching episodes have also plagued Thai reefs. Coral reefs in the Andaman Sea suffered extensive coral bleaching and subsequent mortality in 1991 and 1995, and some bleaching was observed in 1998.⁸⁵ Coral bleaching during the 1997–98 ENSO event was widespread in the Gulf of Thailand, where it had not previously been recorded; as many as 60 percent of corals may have bleached in some locations.⁸⁶ Unfortunately, the frequency and intensity of bleaching in Thai waters appear to be increasing.

From 1995 to 1998, Thailand began a comprehensive reef survey program that included coral reef mapping and field surveying. Scientists surveyed 251 reef sites in the Gulf of Thailand and 169 sites in the Andaman Sea. Reef condition was evaluated based on a ratio of live to dead coral cover. Using this indicator, 16 percent of reefs in the Gulf of Thailand were rated as excellent, 29 percent good, 31 percent fair, and 24 percent poor. In the Andaman Sea, 5 percent of reefs were rated as excellent, 12 percent good, 34 percent fair, and 50 percent poor. Monitoring



suggests that the condition of coral reefs in the Gulf of Thailand has worsened since the late 1980s, while the condition of reefs in the Andaman Sea has remained stable or improved slightly.⁸⁷

The RRSEA model shows that about 77 percent of Thailand's reefs are threatened by human activities, with over 60 percent of corals in the Andaman Sea and nearly 90 percent in the Gulf of Thailand at risk. Overfishing is the most pervasive threat, affecting about one half of all reefs. Sedimentation and pollution associated with coastal development and inland activities threaten over 40 percent of the country's reefs. Destructive fishing activities have damaged many reefs in the past and may continue to be a problem in some areas.

The Department of Fisheries and the Royal Thai Forestry Department are responsible for enforcing coral reef protection regulations. Nonetheless, interpretation of the laws is complex and regulations are sometimes unclear. Designated marine protected areas cover nearly 40 percent of coral reefs, although sites in the Gulf of Thailand are underrepresented. Unfortunately, the effectiveness of Thai MPAs has been compromised by local conflicts, unclear boundaries, jurisdictional issues, and controversial priority setting that places more emphasis on tourism than conservation.⁸⁸ An active NGO network in Thailand is currently taking action to foster better community-based management of coral reefs and restoration of forests and mangroves.⁸⁹

INDIA (ANDAMAN AND NICOBAR ISLANDS)

The Andaman and Nicobar Islands are two chains of islands belonging to India. Located north of Sumatra, these 530 islands divide the Bay of Bengal from the Andaman Sea. Only 38 of the islands are inhabited, but the population is growing rapidly, from 279,000 in 1991 to a projected 405,000 in 2001. Most of the islands are forested, mountainous, and have extensive fringing reefs.⁹⁰ (See Map12.)

The biological importance of the islands is still being researched. Recent surveys have identified 219 coral species, 120 species of algae, 70 species of sponges, 571 species of reef fish, and 8 species of shark. The islands also contain dugong, dolphin, and turtle habitats. The Nicobars contain some of the best nesting sites for leatherback turtles in the Indian Ocean.⁹¹

Both chains of islands have remained relatively pristine, although development is encroaching on some areas with negative effects. On some islands, deforestation has significantly increased sediment outflows on nearshore reefs and turbid freshwater discharge has spurred algal growth. Industrial pollutants are affecting the area around Port Blair.⁹² The islands also support active fisheries. Nevertheless, the lack of comprehensive surveys of the islands makes assessment of threats and conditions difficult.

The 1997–98 ENSO event had less impact on the Andaman and Nicobar Islands than had been originally thought. Initially, 80 percent of corals were believed to be dead. However, recent

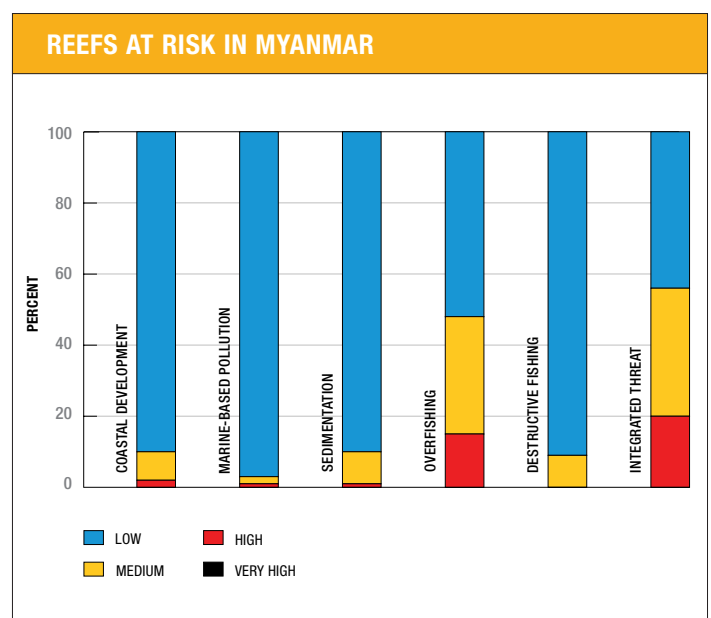
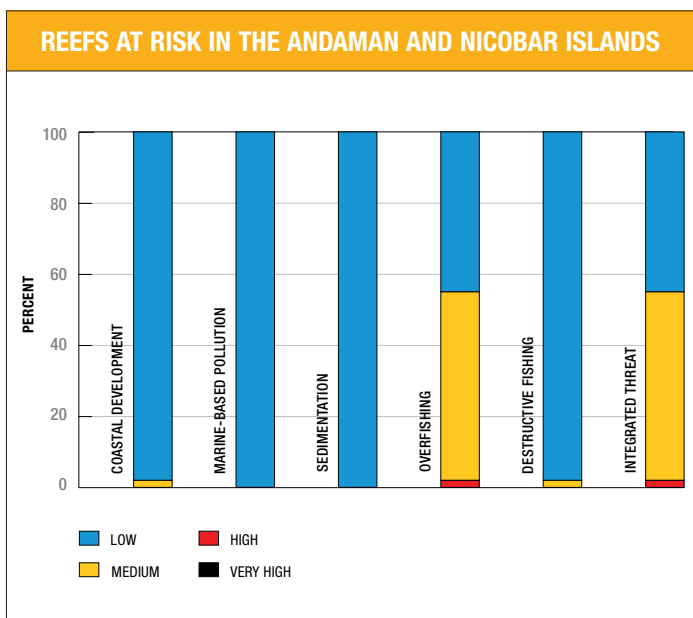
surveys in five sites indicate an average of 56 percent live coral cover, 20 percent dead coral cover, and 11 percent coral rubble.⁹³

The RRSEA analysis identifies overfishing, which may affect 55 percent of reefs, to be the only major threat to the Andaman and Nicobar Islands. The threats from sedimentation and inland pollution are underestimated in the analysis because of the islands’ small watershed size and limited landcover data.

The islands are covered by a network of more than 100 marine protected areas. Many of these MPAs include entire islands and extend into intertidal waters, but most do not include coral reef areas. In addition, management of the protected areas is weak and monitoring of condition is inconsistent.⁹⁴

MYANMAR (BURMA)

The coastline of Myanmar extends for approximately 15,000 km along the Bay of Bengal and the Andaman Sea.⁹⁵ The north-central part of the country is dominated by the vast delta of the Ayeyarwady (Irrawaddy) River, one of the largest rivers in Southeast Asia. The chain of islands between the Ayeyarwady Delta and the Andaman Islands contains coral reefs, but they have been only minimally surveyed. Along the southern coast is a complex of forested offshore islands known as the Mergui Archipelago, where the majority of Myanmar’s coral reefs are found. The Mergui reefs are thought to be similar in structure and diversity to the reefs around the offshore



islands of Thailand.⁹⁶ Currently, 65 coral species in 31 genera have been cataloged in Myanmar's reefs, but these figures are probably an underestimate.⁹⁷ Lack of surveys and scientific information impedes a true evaluation of the wealth of Myanmar's reefs. The RRSEA project estimates that Myanmar has 1,700 km² of coral reefs.

The current government, which is led by a military junta, has been in power since 1988. Because movement within the country is restricted, scientific surveys and conservation projects have been limited in scope. Most development occurs around the capital of Yangon (Rangoon), but it is beginning to spread to more rural areas. Tourist operators from Thailand are now being allowed to take groups to the Mergui Archipelago. However, the paucity of information about development, biology, and ecosystem change has made assessing the threats to Myanmar's reefs difficult.

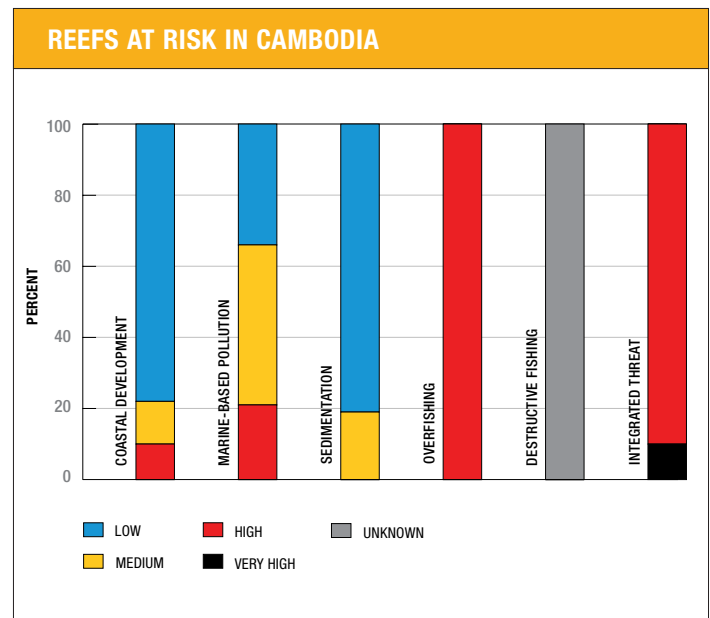
According to the Reefs at Risk analysis, 56 percent of Myanmar's reefs are threatened. The RRSEA model suggests that overfishing is the primary threat to nearly one half of Myanmar's reefs. Destructive fishing, coastal development, and sedimentation each threaten an estimated 10 percent of Myanmar's reefs. Marine-based pollution impacts only 3 percent of reefs. (See Map 12.)

CAMBODIA

Information on the distribution and condition of Cambodia's coral reefs is still very limited. Most corals are found on rocky bases and a few are organized into fringing reef formations. Surveys on Koh Tang, one of the 52 islands offshore of Cambodia, indicate 70 species of coral from 33 genera.⁹⁸ Islands farther inshore generally support lower diversity because of turbid waters unfavorable for coral growth. Cambodia has relatively limited coral reef areas, estimated by the RRSEA study to be under 50 km².

Cambodia's coral reefs have been subject to a variety of human pressures, particularly those related to unsustainable fishing practices and poor land management. Blast fishing has been reported, and fishers have depleted lucrative commercial fish.⁹⁹ Overfishing and illegal fishing from foreign vessels are thought to be a problem, but statistics are incomplete.

Bleaching from the 1997–98 ENSO event affected



Cambodian reefs, with one survey indicating that 80 percent of corals in Sihanoukville bleached during 1998.¹⁰⁰ However, national bleaching and coral mortality statistics are not available.

Surveys of coral condition are limited to a few sites within Cambodia. Studies in four locations in Koh Kong province in 2001 found live coral cover ranging from 23 to 42 percent.¹⁰¹

The RRSEA model suggests that all of Cambodia's coral reefs are at high risk from human activities. Overfishing is believed to affect all reefs in Cambodia's waters. Limited data suggests that many reefs are threatened by destructive fishing. Coastal development, sedimentation, and marine-based pollution are also significant threats. (See Map 12.)

Management for conservation of coral reefs in Cambodia is still rudimentary. Most laws relate to the protection of fisheries rather than coral reefs. However, the government is making strides in some areas. Coral collection, an important threat from 1995 to 1997, is declining because the Fisheries Department has tightened controls and confiscated coral from vendors.¹⁰²

VIETNAM

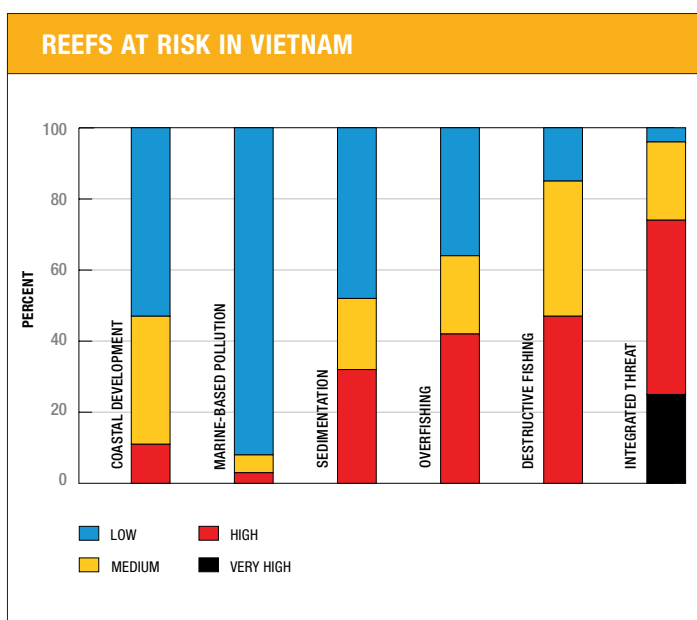
Vietnam has an extensive coastline that stretches from north to south across more than 15° of latitudinal variation. Scientists have described more than 300 species of scleractinian corals in Vietnamese waters. The southern reefs are the most diverse, with 277 species of coral that form both fringing and platform reefs. Fringing reefs in the north are typically less diverse, with only

165 species.¹⁰³ Vietnam's estimated 1,100 km² of coral reefs face a variety of threats, particularly in areas of high population density.

Vietnam has a long history of traditional marine fisheries, with many local communities relying on coastal resources for their livelihoods. However, increases in population, the poverty of small-scale fishers, and the arrival of nonresident harvesters from nearby China and Hong Kong have taken a huge toll on marine fisheries. During interviews conducted in early 1999, overfishing, the decline in marine resources, and destructive fishing were cited as problems in the vast majority of provinces.¹⁰⁴

Vietnam's reefs are affected by sedimentation from many rivers throughout the country, especially the Mekong and the Red rivers. Coastal development only compounds this pressure. Scientists have observed frequent algal blooms around Binh Thuan province, Khanh Hoa province, and Ho Chi Minh City as well as marine pollution around the northern areas of Quang Ninh and Hai Phong.¹⁰⁵

Recovery from damage associated with the 1997–98 ENSO event has been slow. Because of stresses from human activities and bleaching, coral cover in most areas has been declining since the ENSO event, and sedimentation has caused coral loss in Ha Long Bay and the Cat Ba Islands. Reefs around Binh Thuan, which are near an upwelling, are a notable exception. Bleaching has also caused decreased fish diversity, especially among butterfly fishes.¹⁰⁶



Coral reef condition in Vietnam is declining. Surveys conducted from 1994 to 1997 from over 142 sites portrayed a grim picture. Only 1 percent of reefs were found to be in excellent condition (i.e., with over 75 percent live coral cover). Reef classified as good (with 50–75 percent coral cover) accounted for 26 percent of reefs. Of the remaining areas, 41 percent were found to be in fair condition (with 25–50 percent coral cover) and 31 percent were found to be in poor condition (with under 25 percent coral cover).¹⁰⁷

The RRSEA model found 96 percent of the coral reefs in Vietnam to be threatened by human activities, with nearly 75 percent at high or very high threat. Destructive fishing is the most pervasive and significant threat, with 85 percent of the reefs at medium or higher threat from this activity. Overfishing was estimated to threaten more than 60 percent of Vietnam's reefs, and sediment from upland sources was estimated to threaten 50 percent of the country's reefs. Coastal development is a threat to over 40 percent of the reefs. (*See Map 12.*)

Vietnam is addressing coral reef issues with two national strategic plans focusing on fisheries and tourism. Tourism, which accounted for approximately 6 percent of GNP in 2000, is expected to grow to 12 percent by 2010. Through zoning and the creation of natural reserves and classified sites, Vietnam hopes to have models for sustainable tourism in Con Dao, Cat Ba, and Ha Long Bay National Parks. Out of Vietnam's 20 MPAs, only these 3 parks contain reefs. An additional proposal recommends a national system of 30 coastal and marine reserves, which would increase the areas protected from 1,528 ha to 3,118 ha.¹⁰⁸

PHILIPPINES

Philippine coral reef area, the second largest in Southeast Asia, is estimated at 26,000 km² and holds an extraordinary diversity of species. Scientists have identified 915 reef fish species and more than 400 scleractinian coral species, 12 of which are endemic.¹⁰⁹

A large coastal population, rapid population growth of about 2.3 percent per year, high poverty rates, and fisher overcapacity have resulted in major overexploitation of Philippine reef fisheries.¹¹⁰ Demersal fish stocks are biologically and economically overfished in almost all areas other than eastern Luzon, Palawan, and the southern Sulu Sea.¹¹¹

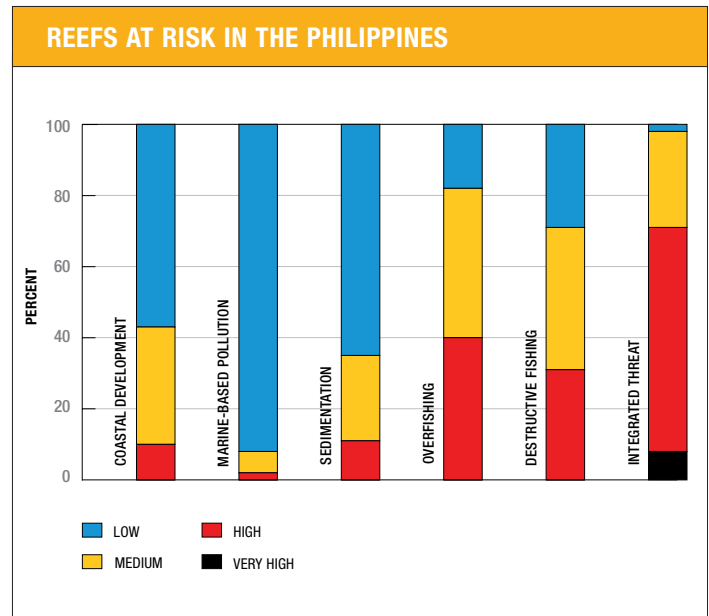
Destructive fishing techniques are thought to be the largest contributor to reef degradation in the Philippines.¹¹² *Muro-ami*, a technique that involved sending a line of divers to depths of 10–30 m with metal weights to knock on corals in order to drive fish out and into waiting nets was extremely damaging to reefs, leading to its ban in 1986. Rampant blast fishing and sedimentation from land-based sources have destroyed 70 percent of fisheries within 15 km of the shore in the Philippines, which were some of the most productive habitats in the world.¹¹³ Although increased enforcement, larger penalties, and educational campaigns slowed the damage in the 1990s, many fishers have brought destructive practices to new areas. Reports indicate that many operations have shifted to more remote, pristine areas such as the Palawan group of islands, the Sulu Archipelago, parts of the Visayas, and western Mindanao.¹¹⁴

Coastal development, agriculture, aquaculture, and land-cover change threaten many Philippine coral reefs. Over 80 percent of original tropical forests and mangroves in the Philippines have been cleared, increasing sediment outflow onto reefs.¹¹⁵ Mangroves continue to be cut and converted to fish ponds, allowing more nutrients and sediment to reach reefs.¹¹⁶ Domestic and industrial wastes are rarely treated in the Philippines and are often discharged directly into the sea.

The first ever mass-bleaching event in the Philippines was reported in 1998–99. It began at Batangas, off Luzon, in June 1998 and then proceeded nearly clockwise around the Philippines, correlating with anomalous sea-surface temperatures.¹¹⁷ Reefs off northern Luzon, west Palawan, the Visayas, and parts of Mindanao were affected. Subsequent mortalities were highly variable, but Bolinao was among the worst areas with 80 percent coral bleaching.¹¹⁸

In the late 1970s, the most extensive survey of coral reefs conducted in the Philippines showed widespread human impact on the reefs. The Inventory of the Coral Resources of the Philippines (ICRP) found only about 5 percent of reefs to be in excellent condition, with over 75 percent coral cover (both hard and soft).¹¹⁹

More recent surveys in 1997 found a slightly lower percentage of reefs to be in excellent condition. They found only 4 percent of Philippine reefs in excellent condition (i.e., over 75 percent hard or soft coral cover), 28 percent in good condition

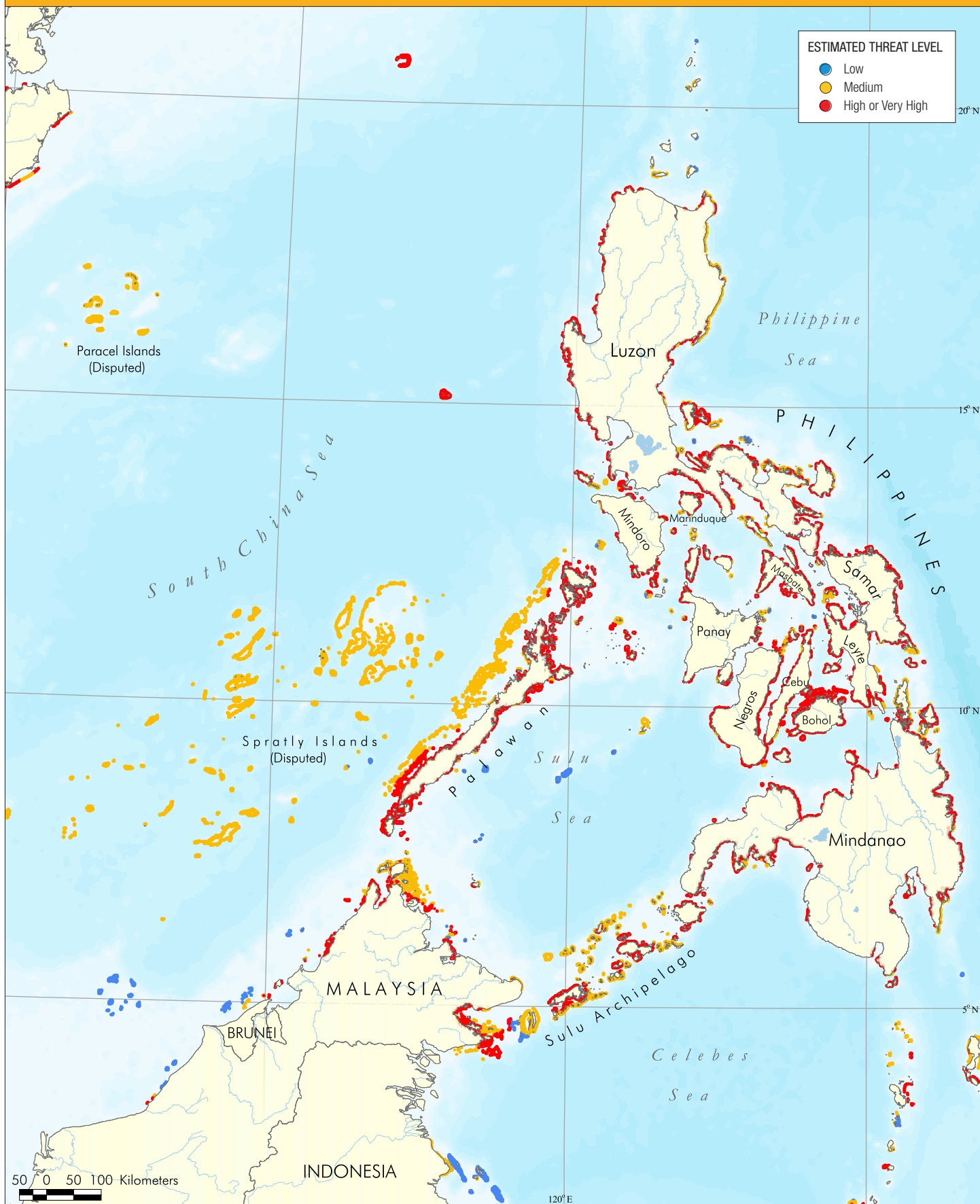


(50–75 percent coral cover), 42 percent in fair condition (25–50 percent coral cover), and 27 percent in poor condition (less than 25 percent coral cover). The Visayas have experienced the most significant decline in coral cover, exhibiting an average of only 11 percent hard coral cover. Coral status information for Mindanao and the Sulu Archipelago is limited.¹²⁰

The RRSEA model suggests that overfishing and destructive fishing are the most severe threats to coral reef health. Over 80 percent of Philippine reefs are threatened by overfishing, although this figure is likely to be an underestimate because it only accounts for nearshore fishing pressures. The model's mapping of areas at risk from blast fishing and fishing with poisons suggests that over 70 percent of Philippine reefs continue to be at risk from these practices. In addition, coastal development pressures threaten over 40 percent of Philippine reefs, and about 35 percent of reefs are under pressure from sedimentation and pollution associated with land-use changes. When the various threats from human activities are combined, the model estimates that 98 percent of Philippine reefs are at risk from human activities, with 70 percent at high or very high risk.

Government agencies managing coral reefs in the Philippines are generally understaffed and insufficiently funded for effective management and monitoring of coral reefs. Many laws and regulations concerning coral reefs already exist, including bans on cyanide fishing, blast fishing, and the collection or export of hard (*Scleractinia*) corals. For the most part, though, these laws

MAP 13. REEFS AT RISK IN THE PHILIPPINES AND THE SOUTH CHINA SEA



are not adequately enforced.¹²¹ About 500 MPAs are currently listed in Philippine records, but many were never actually established and even fewer are effectively managed.¹²² The Philippine government has actively encouraged local management of reefs, and there have been some outstanding success stories.¹²³

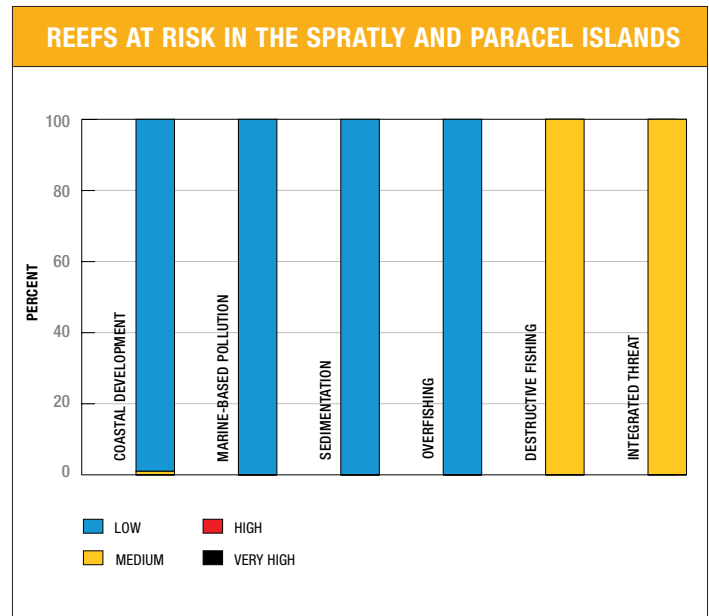
SPRATLY AND PARACEL ISLANDS (SOUTH CHINA SEA)

The biologically and geologically rich resources of the South China Sea (SCS) have been the source of intense territorial disputes. The People's Republic of China, the Philippines, Vietnam, Malaysia, and Brunei Darussalam all claim some of the islands and reefs of the area, particularly in the area known as the Spratly Islands. Many of these claims are overlapping.

The strategic and economic importance of the SCS is clear. Total fisheries production is estimated at 30 million tons annually, only 13 percent of which is currently harvested.¹²⁴ Fishing provides both a substantial portion of animal protein intake for the countries surrounding the SCS, and work for approximately 2 million people in the region.¹²⁵ In addition, the SCS is rich in petroleum. Oil and natural gas rigs dot the periphery of the basin. In 1982, the offshore petroleum in the SCS was valued at US\$76 billion.¹²⁶ Because it lies in the heart of Southeast Asia, the SCS is also a major navigational shipping highway, with more than 300 ships passing through each day.¹²⁷

The SCS also has vast ecological wealth.¹²⁸ The nearshore areas of the SCS contain more than 70 coral genera.¹²⁹ The biodiversity of the SCS has potentially important benefits for the entire region; research indicates that currents carry fish and coral larvae from reefs in the south-central portion of the SCS to surrounding damaged reefs.¹³⁰ Thus destruction of coral reefs in the SCS affects biodiversity and reef health on a regional scale.

The controversial issues of ownership have prevented long-term monitoring of reef condition. A proposal to create a marine park has been examined by claimant nations in a series of workshops.¹³¹ In the meantime, however, uncoordinated enforcement throughout the area makes the SCS susceptible to unsustainable commercial fishing and destructive fishing practices. The RRSEA analysis concludes that the only significant threat facing the coral reefs of the SCS is destructive fishing. However, the project was not able to assess the impact of commercial

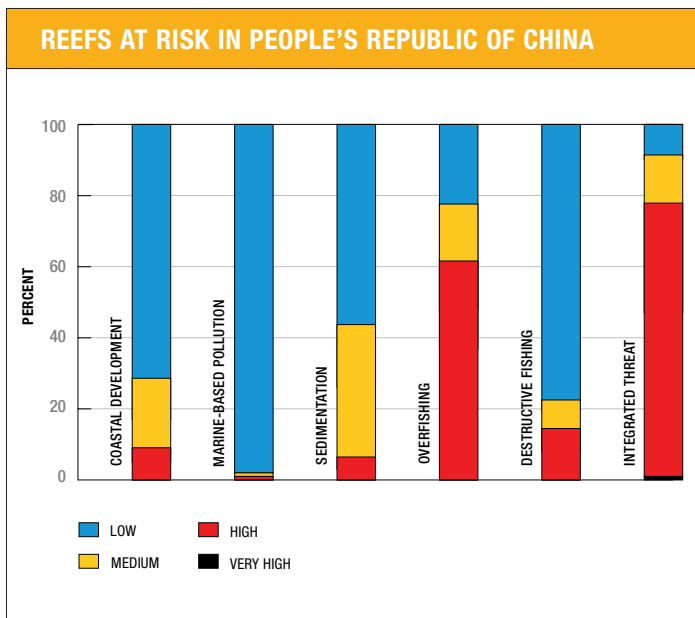


fishing or marine-based pollution from shipping due to lack of data. Minor pressures from military bases may also be present. (See Map 13.)

Until an agreement can be reached on creating a marine park, claimant countries have proceeded with joint research expeditions. The advancement and success of these joint oceanographic and marine scientific research expeditions (JOMSRE) are important milestones in the confidence-building efforts among nations with overlapping claims in this disputed area. Through bilateral arrangements, the Philippines and Vietnam successfully conducted two JOMSREs in the SCS during the summers of 1996 and 2000, in which they undertook studies on the physical, chemical, and biological oceanography of the area as well as its coral reef ecology.

PEOPLE'S REPUBLIC OF CHINA

China has an extensive coastline that stretches from its border with Vietnam along the northern South China Sea to the Korean peninsula. However, unlike Taiwan and Japan, China does not benefit from warm-water currents. The lack of warm water along much of China's coast has inhibited coral reef growth. Reefs do not grow north of Guangdong Province.¹³² The most extensive reefs grow around Hainan Island and the surrounding 300 small islands. Initial surveys reveal 150 hard coral species,¹³³ 30 soft coral species, 569 fish species, and 700 species of molluscs.¹³⁴



China's reefs have been particularly targeted for valuable edible fish and mollusc species. Overfishing and destructive fishing practices have badly damaged coral communities around Hong Kong, causing most high-value fish species to become locally extinct.¹³⁵ Around Hainan Island, illegal fishing activities and the sale of living corals for the aquarium trade are also problems.¹³⁶

Sedimentation, freshwater incursion, and sewage outflows have adversely impacted China's reefs, particularly near the mainland. Reefs around Hong Kong had up to 80 percent coral mortality in 1994, when the swollen Pearl River caused freshwater upwellings and algal blooms.¹³⁷

Few coral reef surveys have been carried out in China, with more information available about the reefs in the Sanya Reserve than anywhere else. Reefs in the Ya Long Bay area of the reserve have high live coral cover at 80–90 percent, and they are in good condition.¹³⁸ Coral cover in the Qionghai Coral Reserve on the eastern Hainan Islands averages between 60 and 70 percent.¹³⁹ Reefs outside of reserves are probably not faring as well.

The RRSEA analysis finds that 92 percent of China's reefs are under significant threat. Overfishing is the most pervasive, threatening over three-quarters of China's reefs. Sedimentation from upland sources is estimated to impact 40 percent of all reefs, and coastal development endangers over 28 percent.

(See Map 14.)

Monitoring capacity in China is generally low, and coral reefs have not been a key issue in policy negotiations. Localized efforts to protect reefs, however, have had some success. On Hainan, marine authorities have strictly enforced a law banning coral mining, closing some 90 kilns throughout the island.¹⁴⁰ Cooperation between hotel operators and the Hainan Marine Department have helped to reduce illegal fishing activities that damage reefs.¹⁴¹

TAIWAN

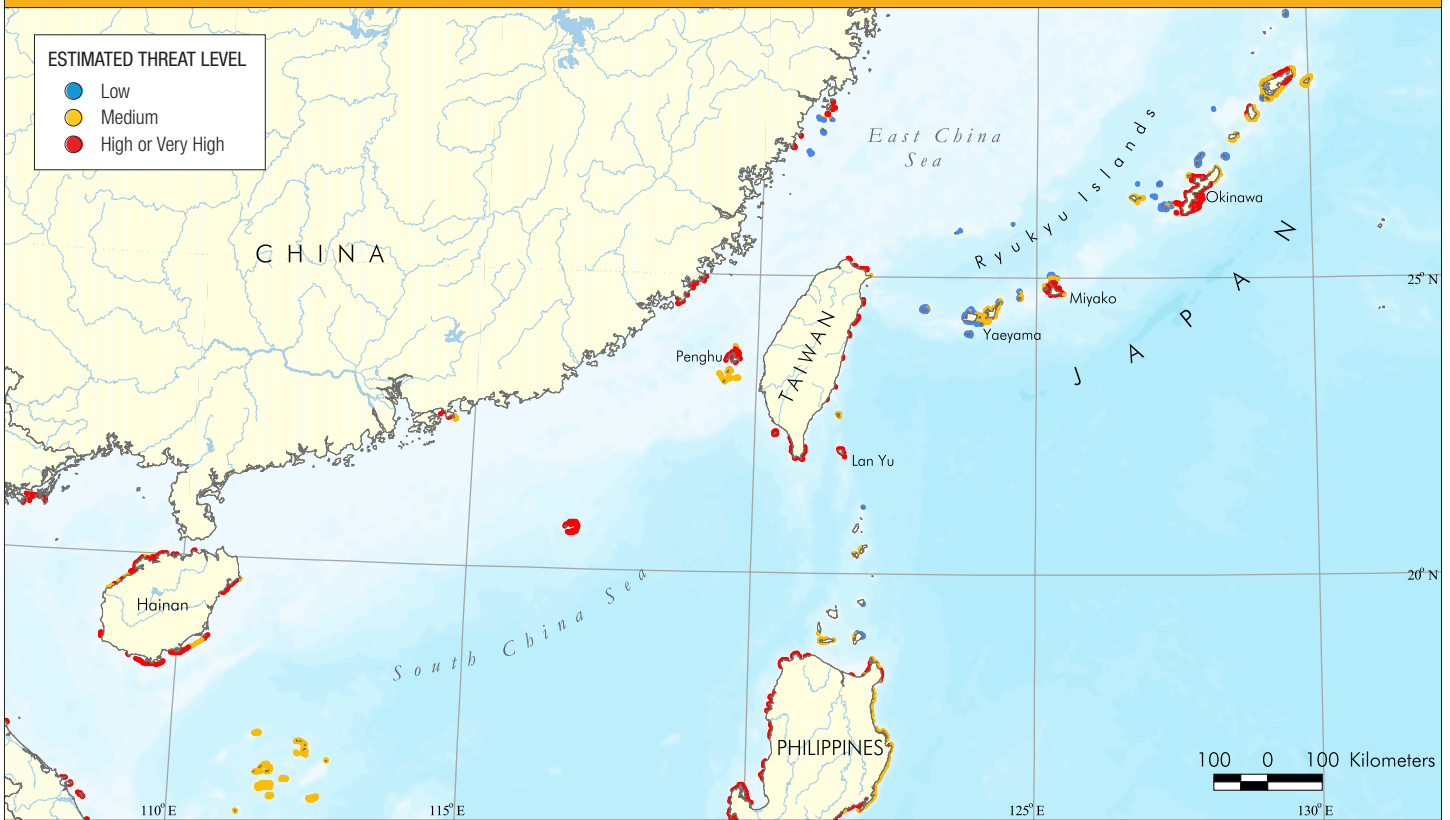
Taiwan is near the thermal boundary where coral reefs can no longer grow. The southern tip of the island and many offshore islands have numerous well-developed fringing reefs. However, along the northeast and east coasts, corals form patchy communities rather than reefs. Fish and coral larvae carried by the Kuroshio, a warm-water current originating in the North Equatorial Current, help to give Taiwan's reefs relatively high biodiversity despite their proximity to the boundary where reef can no longer grow.¹⁴² Taiwan's reefs hold approximately 300 species of scleractinian corals and 1,200 species of reef fish.¹⁴³

Taiwan's biodiversity has traditionally been important for tourism and fishing. Approximately 150,000 people are dependent on coral reefs for some aspect of their livelihoods.¹⁴⁴ The Taiwanese rely on fish for a sizable amount of their protein intake; in 1997, per capita fish consumption was 39 kg per year. (See Table 1.) Coral reefs also attract tourists for recreational fishing, diving, swimming, and snorkeling.

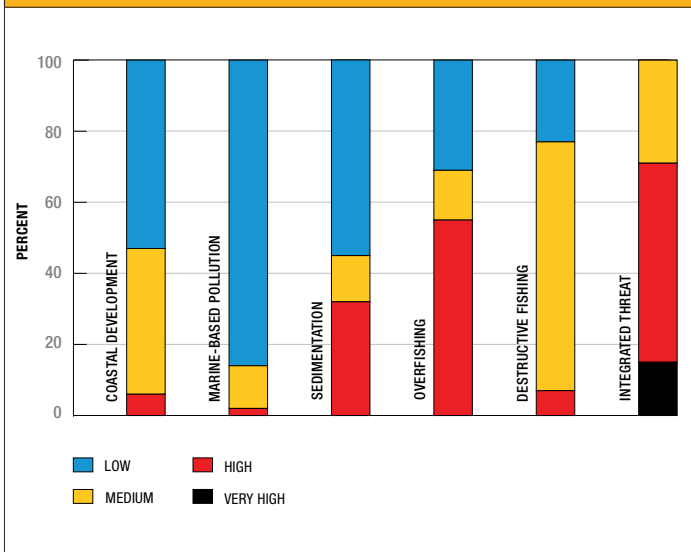
Aside from natural disturbances like typhoons, the largest threats to Taiwan's nearshore coral reefs are dynamite fishing, sedimentation, and wastewater pollution from expanding urban development. Dynamite fishing has become a threat, particularly since 1987, when enforcement was transferred to local authorities. Evidence of dynamite fishing has been reported in Keelung, Kenting, and Penghu.¹⁴⁵ Thermal effluents from a power plant in Nanwan Bay are so high that they have caused coral bleaching every summer since 1987.¹⁴⁶ In some locations, live coral cover has dropped from 50 percent to 30 percent in the last 10 years.¹⁴⁷

The 1997–98 ENSO event caused extensive coral bleaching on southern Taiwan reefs. In the Penghu Islands, Luta, and Lanyu, approximately 30–50 percent of coral colonies

MAP 14. REEFS AT RISK IN THE FAR NORTH



REEFS AT RISK IN TAIWAN



bleached. According to surveys in 1999 and 2000, 20 percent of coral colonies died.¹⁴⁸

The RRSEA analysis of human pressures finds that all of Taiwan’s reefs are threatened, with destructive fishing threatening 75 percent of reefs, overfishing 70 percent, and sedimentation and coastal development each threatening about 45 percent of the reefs.

The management effectiveness of marine protected areas in Taiwan has been rated as poor. Most MPAs lack adequate laws to protect the environment, and enforcement of laws that do exist is lax. However, members of the scientific community, government, and local communities formed the Taiwanese Coral Reef Society (TCRS) in 1996, which is helping to raise awareness about the threats to coral reefs and their value to Taiwan.

JAPAN

Japan is on the edge of a delicate mix of biology, climate, and chemistry that coral reefs need to form. The Kuroshio current allows reefs to grow at some of the highest latitudes in the world and carries reef larvae from the Philippines.¹⁴⁹ In fact, the Kuroshio is so efficient at larval transport that Japanese waters support coral biodiversity nearly equal to that of the Philippines.¹⁵⁰

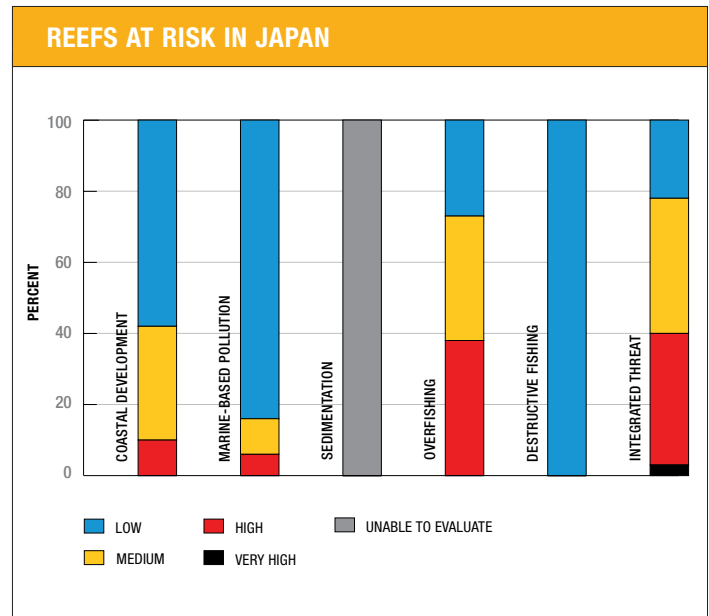
Although Japan’s reefs are often endangered by tropical typhoons and Crown-of-Thorns starfish (*Acanthaster planci*) infestations, sedimentation, pollution, overfishing, dredging, trawling, poorly managed tourism, port and seawall construction, and other threats caused by human activities are more pervasive and damaging.

Sedimentation from terrestrial runoff of red clay soils remains one of the most serious threats to Japanese reefs. Poor land-use practices, road building, coastal development, and river modification projects have all led to increased sediment loads on coral reefs. Between 1981 and 1990, 19 percent of Japanese reefs were removed to dredge harbors or build erosion barriers.¹⁵¹ Airport construction and land reclamation projects planned on Ishigaki Island and Henoko, Okinawa, may release further sediment onto already vulnerable reefs.¹⁵²

From 1990 to 1992, the Japan Environment Agency conducted extensive surveys to examine live coral cover throughout the islands. The Agency found that coral cover in the reef flats was typically quite low. The surveys indicated that 61 percent of communities in the Nansei Islands had under 5 percent coral cover, 30 percent had coral cover between 5 and 50 percent, and only 8 percent of communities had over 50 percent coral cover. On Okinawa reef edges, 67 percent of reefs had under 5 percent cover.¹⁵³ Surveys from 1972 and 1990 in the Ryukyu Islands indicate that during that time a substantial number of reefs dropped from over 50 percent coral cover to under 25 percent cover. One third of coral species in Japan are now at risk of becoming locally extinct.¹⁵⁴

The 1997–98 ENSO bleaching was the most severe coral bleaching and mortality event ever observed in southern Japan. Severity and mortality varied owing to variations in local conditions, with Okinawa and the Kume islands hardest hit. Yoron Island was also particularly affected, exhibiting 70–90 percent mortality in the south and 30–60 percent in the north.¹⁵⁵ Bleaching in the Nansei Islands was between 40 and 60 percent. In Koshikijima Island, western Kyushu, eastern Shikoku, and Kushimoto, bleaching typically affected under 20 percent of corals. The Kerama Islands experienced the lowest degree of bleaching.¹⁵⁶

The RRSEA model suggests that nearly 80 percent of Japan’s reefs are at risk from human activities. (See Map 14.) Overfishing is the most pervasive cause, threatening over 70 percent of Japan’s reefs. Coastal development pressure, including accompanying sedimentation, threatens over 40 percent of coral reefs. The project was not able to evaluate sedimentation from upland sources for these areas of Japan because the watershed size is below the minimum used in the analysis.



In the last decade, Japan has increased its monitoring capacity and its reef protection programs and has established a center for coral reef information. Japan has six Natural Parks located in the Amami, Ryukyu, and Ogasawara Islands. However, the natural park system covers a relatively small area of coral reefs, only 1.7 percent of the country’s total coral reef area.¹⁵⁷ A higher percentage of coral reefs is included in other parks that are more focused on tourism but whose management effectiveness in terms of conservation is not known.

BOX 6. THREAT ANALYSIS AT LOCAL SCALES

The RRSEA analysis contains a standardized, consistent analysis of human pressure on coral reefs across the region. It is primarily based upon 1:1 million scale data sets. (See Appendix 1.) This scale of analysis is useful for comparisons among countries and for subnational examination within most countries. However, more refined data are needed for detailed local planning. The RRSEA project is working with local partners to improve data and apply some of the threat analysis techniques to smaller areas. These studies will incorporate local information on location, status, and protection as well as observed impacts on coral reefs; they will provide a more detailed examination of human pressure on coral reefs.

Reef Threat Analysis in Sabah, East Malaysia

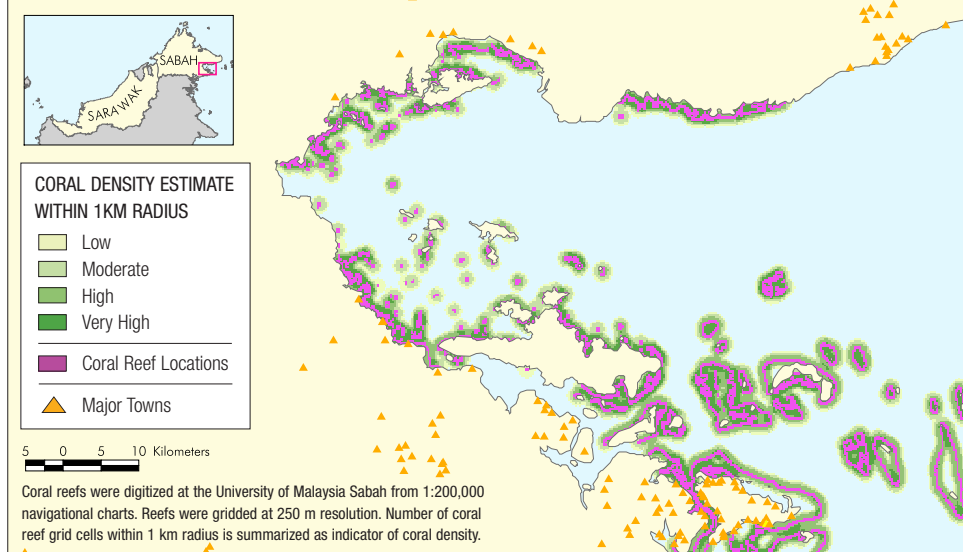
Sabah has high reef diversity and contains 3,000 km² of reefs, 75 percent of all reefs in Malaysia. Destructive fishing and sedimentation are key pressures currently threatening reefs in Sabah. The government of Sabah is addressing these threats with two distinct activities, one focused on better enforcement of regulations on destructive fishing and one on improved coastal management (described below).

In 1997, the Town and Regional Planning Department began leading an 11-agency working group to improve coastal management and mitigate sedimentation with an Integrated Coastal Zone Management (ICZM) plan. The project has developed extensive sets of maps and GIS data. (See www.iczm.sabah.gov.my.) Thus far the work has focused on the terrestrial environment, with few data developed on seagrasses or coral reefs. However, the University of Malaysia Sabah (UMS) developed a base data set on coral reef locations under the RRSEA project and provided it to the Department of Planning. This base data set on coral reef locations is being ground-truthed and updated using aerial photographs, and it will help to guide future coastal development away from sensitive coastal areas. The Department of Planning, the 11-agency working group, UMS, and WRI initiated a joint activity to examine threats to coral reefs from human activities in Sabah; the information will feed into the development of the ICZM statutory plan for Sabah.



For additional information on application of RRSEA data and model techniques, see www.wri.org/wri/reefsatrisk.

MAP 15. REEF DENSITY IN SABAH



This simple mapping of coral reefs and reef density is a starting point for ground-truthing and further analysis to identify sensitive areas.