



PHOTO: WOLCOTT HENRY

Corals are found from the icy waters of the Arctic and Antarctic to the balmy, crystal-clear seas of the tropics. Yet coral reefs, with their majestic walls and enormous limestone skeletons, are found only in the swath of oceans around the equator. In this tropical band, biology, chemistry, and climate meet the exacting balance required for the survival of reef-building corals. Reef-building corals thrive in this delicate equilibrium, creating one of the most productive and diverse ecosystems in the world. Southeast Asia is the heart of this incredible diversity, holding more than 77 percent of the almost 800 reef-building coral species that have been described by scientists.

People have coexisted with coral reef ecosystems in Southeast Asia for thousands of years. With more than 350 million people living within 50 km of the coast,<sup>1</sup> coral reefs are important not only in local communities' cultures, but are also critical to the economic health of these nations. Coral reef fisheries, in particular, are a vital source of food and employment. Fisheries dedicated to the live food fish trade, the ornamental trade, and local subsistence economies generate billions of dollars each year. The total annual net benefit of sustainable coral reef fisheries across Southeast Asia is estimated to be US\$2.4 billion per year.

In addition to fisheries, coral reefs provide many other exceptionally valuable services. Their beauty draws millions of tourists from around the world each year. Corals themselves possess a yet untold value as biochemical material for pharmaceuticals and other products. Reefs also facilitate the growth of mangroves and seagrasses, provide sheltering habitat essential to a variety of marine species, and help prevent shoreline erosion. The coral reefs in the Malacca Straits alone have a total assessed economic value of US\$563 million for tourism, shoreline protection, fishery resources, and their research potential.<sup>2</sup>

Despite their worth, coral reefs in Southeast Asia and throughout the world face unprecedented threat from human activities. The population explosion during the last 50 years is driving many of the current pressures and is creating elevated, often unsustainable demand on both the terrestrial and marine resources of the region. These pressures are jeopardizing the incredible value of coral reefs, whose loss would have significant economic impacts for the region.

The most prevalent threat to coral reefs in Southeast Asia is overexploitation. Rapid population growth has vastly increased fishing pressure on reefs across the region. Lacking other sources of income, fishers have no incentive to leave the industry

## BOX 1. WHAT IS A CORAL REEF?

During the last several centuries and even today, corals have been mistaken for rocks or plants despite the fact that they are animals. In their simplest form, corals may only have a single polyp that has a tube-like body with a mouth on top that is surrounded by a ring of tentacles. In many coral species, these individual polyps form numerous, identical clones in dense formations called colonies.

Although all coral species can use stinging tentacles to catch prey, most tropical corals obtain a large proportion of their food from a unique symbiosis. Living within the tissues of corals are thousands of microscopic algae called zooxanthellae, which derive energy directly from sunlight through photosynthesis. Corals can obtain much of their energy and oxygen requirements directly from zooxanthellae. In return, the algae receive shelter from predators and use the carbon dioxide produced by the corals in their metabolic processes. This tight association is highly efficient, allowing corals to survive and grow even in nutrient-poor waters. The success of this relationship can be seen in the great diversity and ancient lineage of corals, which first evolved over 200 million years ago.

Many corals lay down some form of skeleton to support their simple bodies. Soft corals and fan corals have skeletons made of protein. However, those that build reefs are a subset of corals that lay down skeletons of calcium carbonate or limestone. These corals are mostly from the family Scleractinia and are sometimes known as hermatypic or reef-building. Today, almost 800 species of scleractinian corals have been described. Some reefs consist of small patches of coral and associated species, but others can be giant structures tens of kilometers wide.

Although corals may dominate specific zones of reefs, seagrasses and other organisms are also essential components of reef structures. Stress from storms, added nutrients, and increased sedimentation can cause naturally coral-dominated zones to be replaced with algae. When algae overtake former coral zones, it is often a sign that the reef is unhealthy. Healthy coral reefs constitute the most diverse of all known marine ecosystems, with a greater array of life forms than any other ecosystem on the planet.

or reduce fishing pressure. In addition, the enticing profits to be made in the live reef food fish and aquarium trades have led to widespread target species overfishing by both local and foreign vessels and to the proliferation of destructive fishing techniques. Practices like blast and poison fishing not only destroy the natural resource base for future fishing, but also have detrimental effects across the ecosystem. Even without these destructive methods, current fishing levels and methods are unsustainable in most areas. If fishing in Southeast Asia is not reduced to more sustainable levels, both coral reefs and food security will be further imperiled.

High levels of development and land-use changes in the last 20 years have also been major threats to coral reefs in the region. Massive deforestation and the construction of roads, airports, channels, ports, and buildings, including tourist resorts, have substantially increased sediment and nutrient loads in coastal areas. Increased sediments can smother corals, and added nutrients can cause the coral to become overgrown with algae. A major challenge for the region in the coming years will

be to restrict growth or manage development in ecologically sensitive areas before further degradation occurs.

One of the least understood threats to coral reefs is coral bleaching, a stress response that is often correlated to elevated sea surface temperatures and global climate change. The 1997–98 El Niño Southern Oscillation (ENSO) was the strongest on record, triggering massive coral bleaching throughout the Pacific and Indian Oceans.<sup>3</sup> Worldwide economic losses from this event are estimated between US\$700 million to US\$8 billion over the next 20 years.<sup>4</sup>

The cumulative threats of overexploitation, land-use changes, pollution, and coastal development, coupled with the effects of global climate change, foretell an uncertain future for Southeast Asia's coral reefs. Despite widespread recognition that coral reefs are severely threatened, information regarding particular threats to specific reefs is limited. Only a small percentage of reefs have ever been studied, and an even smaller number have been monitored over time using consistent methods.<sup>5</sup> In addition, these data are rarely consolidated in a central



Most corals are made up of thousands of tiny polyps, like those pictured above. Over 600 species of hard coral are found within Southeast Asia, growing in an incredible array of shapes and colors.

repository where copies would be widely accessible.

This lack of information inhibits effective decisionmaking concerning coastal resources. The Reefs at Risk in Southeast Asia (RRSEA) project was designed to address this information deficiency through an extensive data compilation and improvement effort. Understanding which human activities negatively impact which reefs is key to future conservation and planning efforts. The goal of the RRSEA project is to raise awareness about threats to coral reefs and provide resource managers with specific information and tools to manage coastal habitats in Southeast Asia more effectively.

#### **ABOUT THE PROJECT**

The Reefs at Risk in Southeast Asia project is a follow-up to the global Reefs at Risk analysis completed in 1998.<sup>6</sup> The global analysis identified Southeast Asia as the region with both the highest level of biodiversity and the greatest degree of threat to its reefs. RRSEA began in 1999 with the objective of refining

the original data and model for the region and providing a tool for analyzing the impacts of human activities on coral reefs. The new analysis is 16 times more detailed than the global study and incorporates innovations like the consideration of natural vulnerability, management effectiveness of protected areas, and economic data. RRSEA was implemented in collaboration with more than 20 partner institutions in the region.

This two-year collaborative effort has resulted in the compilation and integration of far more information than can be presented in this report, which is designed as a summary of the project. Additional information is available at [www.wri.org/wri/reefsatrisk](http://www.wri.org/wri/reefsatrisk). Included on the RRSEA website is information about particular reefs, tourism, management, biodiversity, monitoring, and more. In addition, all datasets are available for downloading.

RRSEA is the first in a series of regional analyses. A similar project focusing on Caribbean reefs, Reefs at Risk in the Caribbean, was initiated in 2001.

## THE SOUTHEAST ASIA REGION

The region included in this study is larger than what is traditionally considered Southeast Asia, stretching from 30°N to 11°S latitude, including coral reefs as far north as Japan, Taiwan, and China and as far west as Myanmar and the Andaman Islands of India. It includes only small portions of China and Japan but the entirety of the other nations traditionally considered part of Southeast Asia. Throughout this study, the term Southeast Asia refers to this area, which possesses almost 34 percent of the world's coral reefs. Table 1 presents some important geographic and socioeconomic characteristics of the countries included in the RRSEA analysis.



PHOTO: WOLCOTT HENRY

Nudibranchs are one of the many amazing lifeforms found on coral reefs.

**TABLE 1. BASIC GEOGRAPHIC AND ECONOMIC INDICATORS<sup>a</sup>**

COUNTRY	COASTLINE LENGTH (KM)	POPULATION (2000) (THOUSANDS)	PER CAPITA GDP (1997) (CURRENT US\$)	PER CAPITA FISH CONSUMPTION (1997) (KG/YR)	FISH PROTEIN AS A PERCENTAGE OF TOTAL PROTEIN SUPPLY (1997)	FISH PROTEIN AS A PERCENTAGE OF TOTAL ANIMAL PROTEIN (1997)
Indonesia	95,181	212,107	1,124	18	10	53
Philippines	33,900	75,967	1,156	30	20	43
Sprattly and Paracel Islands	N/A	N/A	N/A	N/A	N/A	N/A
Malaysia	9,323	22,244	4,873	56	20	35
Japan <sup>b</sup>	N/A	N/A	42,719	66	25	46
Thailand	7,066	61,399	2,957	34	19	42
Myanmar	14,708	45,611	N/A	18	6	45
Vietnam	11,409	79,832	315	17	9	39
China <sup>b</sup>	N/A	N/A	671	26	8	24
Taiwan	2,007	N/A	N/A	39	11	22
Brunei Darussalam	269	328	N/A	21	7	14
Singapore	268	3,567	28,619	34	9	17
Cambodia	1,127	11,168	303	9	5	28

### SOURCES:

- Coastal length: Derived from "World Vector Shoreline," United States Defense Mapping Agency, 1989. L. Pruet and J. Cimino, "Global Maritime Boundaries Database (GMBD), Veridian-MRJ Technology Solutions," in Burke et al. *Pilot Analysis of Global Ecosystems: Coastal Ecosystems* (Washington, DC: WRI, 2001). This standardized estimate is different from previously published estimates for many countries.
- Population: United Nations (U.N.) Population Division, "Annual Populations 1950-2050 (The 1998 Revision)," on diskette (New York: U.N., 1999).
- Per Capita Gross Domestic Product (GDP): The World Bank, "World Development Indicators 1999," on CD-ROM (Washington, DC: Development Data Group, The World Bank, 1999).
- Per Capita Fish Consumption and Fish Protein as Percentage of Total Protein and Animal Protein: Edmondo Laureti, compiler, "Fish and Fishery Products: World Apparent Consumption Statistics Based on Food Balance Sheets (1961-1997)," FAO Fisheries Circular 821, Revision 5 (Rome: FAO, 1999).

### NOTES:

- a. Countries are ordered by reef area, as in Table 2.
- b. Because most of the coastline and population of Japan and China are outside of the RRSEA study area, coastline and population data are not included for these countries.
- N/A = not available