CHAPTER 2. BIODIVERSITY OF SOUTHEAST ASIAN CORAL REEFS

PHOTO: WOLCOTT HENRY

Southeast Asia's coral reefs have the highest degree of biodiversity of all the world's coral reefs. This extraordinary diversity generates high productivity, providing food for millions of people within the region and beyond. Scientists are just beginning to understand the potential diversity of coral reefs; it is estimated that only 10 percent of marine species associated with coral reefs have been identified and described.[7]

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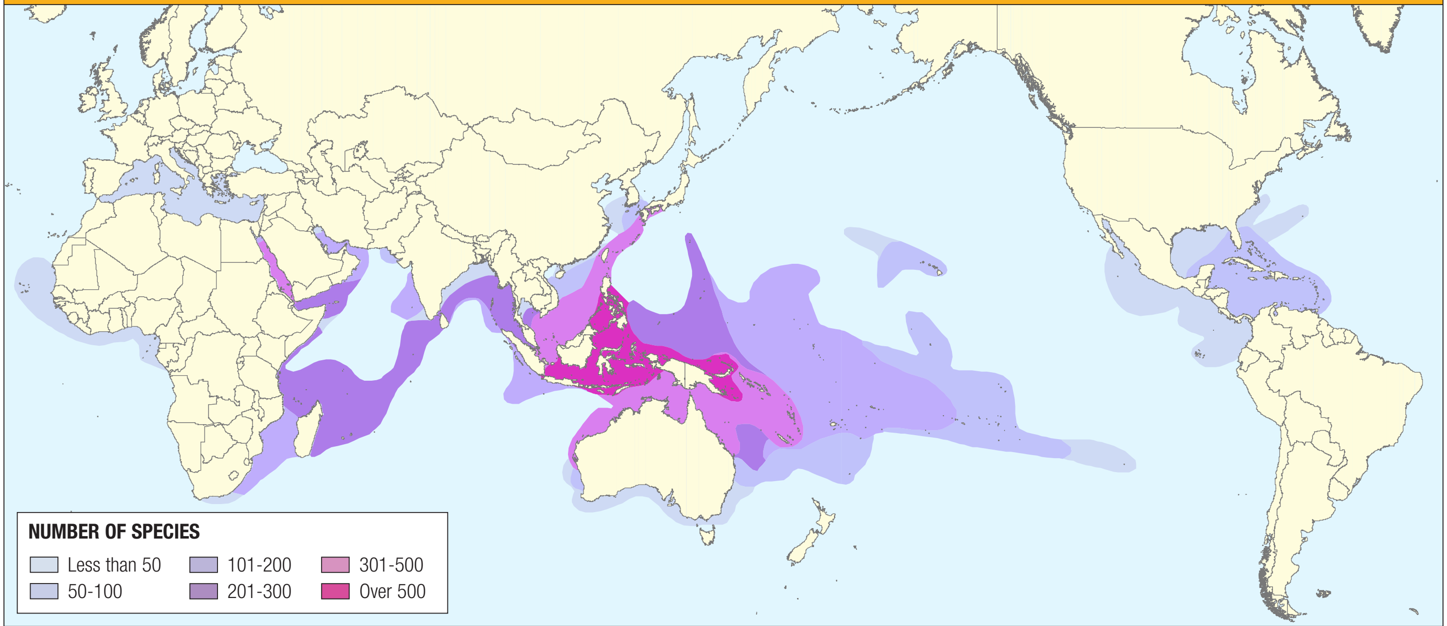
Scientists have found more coral species around a single island in Southeast Asia than have been identified for the entire Caribbean.[8] Map 1, which shows coral reef diversity worldwide, illustrates the high concentration of species in the region, particularly in the broad Indo-Malayan Triangle, stretching from the Philippines to the southern islands of Indonesia and encompassing all of Java east to New Guinea. This extraordinary diversity has built up over geological timescales, but it is maintained through the wide array of physical conditions—salinity, wave exposure, depth, temperature, and turbidity—found across Southeast Asia that fulfill the requirements of a broad range of species.[9] The region contains more than 600 of the nearly 800 reef-building coral species (Scleractinia) found worldwide.[10] *(See Map 1.)*

The diversity of coral reefs is not limited to coral species. Over 1,650 fish species have been recorded in eastern Indonesia alone, the majority of which are associated with reefs.[11] This same diversity is also found in related coastal ecosystems. Southeast Asia contains over 61,000 km^2 of mangroves, approximately 35 percent of the world's total. It holds nearly 75 percent of the world's mangrove species and over 45 percent of seagrass species.[12] *(See Box 2 and Table 2.)*

MAP 1. PATTERNS OF DIVERSITY IN REEF-BUILDING SCLERACTINIAN CORALS



Source: J.E.N. Veron and Mary Stafford-Smith. *Corals of the World* (Cape Ferguson: AIMS,2000).

BOX 2. RELATED ECOSYSTEMS: MANGROVES AND SEAGRASSES

In addition to coral reefs, two other coastal ecosystems are commonly found in tropical areas — mangrove forests and seagrass beds. Mangrove forests grow in the intertidal range, lining considerable areas of the coasts of Southeast Asia. Farther offshore, groups of flowering plants known as seagrasses form extensive “meadows” over soft sediments. In many areas, the typical coastal profile moves from mangroves to shallow waters with seagrass beds to offshore coral reefs. Mangroves, seagrasses, and coral reefs can all occur in isolation, but research has shown substantial interaction among the ecosystems where they exist together.

These interactions are both physical and biological. Mangroves and seagrasses bind soft sediments, facilitating coral reef development in areas that might otherwise have too much silt for coral growth. Mangrove and seagrass ecosystems are also highly productive and play a significant role in the health of some fisheries. They not only support substantial fisheries within their waters, but they also help maintain many commercially important offshore species that utilize mangrove or seagrass areas as spawning and nursery grounds. Like coral reefs, mangroves protect coastal communities by stabilizing sediments and preventing shoreline erosion. In turn, reefs buffer wave impacts, helping to minimize erosion of the soft sediments that mangroves and seagrasses need to grow.

Mangroves and seagrasses are being destroyed by many of the same activities that threaten coral reefs. Land reclamation, pollution, sedimentation, dredging, and trawling can all damage seagrass beds. Clearcutting for timber, fuelwood, and the creation of aquaculture farms particularly endangers mangroves.[a] Recent estimates indicate that by the early 1990s both Malaysia and Myanmar had lost almost 75 percent of their original mangrove cover; Thailand had lost 84 percent; and Vietnam 37 percent. Older estimates have suggested that by the late 1980s, the Philippines had lost 67 percent of its mangroves, Brunei 20 percent, and Indonesia 55 percent.[b] The lack of adequate maps thwarts efforts to calculate seagrass losses accurately.

a. M.D. Spalding, F. Blasco, and C.D. Field, eds., *World Mangrove Atlas* (Okinawa: The International Society for Mangrove Ecosystems, 1997).
b. L. Burke et al., *Pilot Analysis of Global Ecosystems: Coastal Ecosystems* (Washington, DC: WRI, 2001), p. 19.

TABLE 2. CORAL, MANGROVE, AND SEAGRASS BIODIVERSITY IN SOUTHEAST ASIA

COUNTRY	REEF AREA (KM^2)[a]	PREDICTED CORAL DIVERSITY[b]	MANGROVE AREA (KM^2)	NO. OF MANGROVE SPECIES	NO. OF SEAGRASS SPECIES[c]
Indonesia	51,000	581	42,550	45	13
Philippines	26,000	561	1,610	30	19
Spratly and Paracel Islands	5,700	362	N/A	N/A	N/A
Malaysia	4,000	>550[d]	6,420	36	12
Japan	2,600	420	4	11	8
Thailand	1,800	357	2,640	35	15
Myanmar	1,700	270	3,790	24	3
Vietnam	1,100	355	2,530	29	9
China	900	150	340	23	N/A
Taiwan	700	389	340	23	5
Brunei Darussalam	200	N/A	170	29	4
Singapore	50	186	6	31	11
Cambodia	40	272	850	5	1
Regional Total	**95,790**	**N/A**	**61,250**	**51**	**23**

SOURCES:

1. Reef area estimates: calculated by WRI based on 1 km resolution gridded data sets assembled under the RRSEA project, rounded to two significant digits.
2. Predicted coral diversity: J.E.N. Veron and Mary Stafford-Smith, *Corals of the World* (Cape Ferguson: Australian Institute of Marine Science, 2000), subsequently revised by J.E.N. Veron.
3. Mangrove area and number of mangrove species: largely derived from M.D. Spalding, F. Blasco, and C.D. Field, eds., *World Mangrove Atlas* (Okinawa: The International Society for Mangrove Ecosystems, 1997), with updates by M.D. Spalding.
4. Number of seagrass species: World Conservation Monitoring Centre, unpublished data.

NOTES:

a. Ownership of large areas of reefs in the South China Sea is disputed by two or more nations. These areas include the Spratly and Paracel Islands, which have been treated separately in this analysis.
b. These data represent predicted numbers of species by country. They are estimates, rather than observed species counts and are based on predicted species distributions. The estimates are a sum of all predicted species, so they may be exaggerated for some countries.
c. This database is still under development and estimates are likely to be conservative.
d. Predicted coral diversity is 367 for Peninsular (West) Malaysia and 550 for East Malaysia.
N/A = not available

PHOTO: MARK SPALDING

Mangrove roots trap sediments, reducing silt in water, and thereby enhancing areas for coral reef development.

SETTING PRIORITIES FOR CONSERVATION

Few coral reef areas in Southeast Asia remain unaffected by human activities. In the past, reefs in remote locations were relatively pristine. However, isolation is no longer a guarantee of good reef condition, as evidenced by the degradation of reefs in the Morotai Islands (North Maluku).[13] Even reefs in good condition like the Spratly Islands, Tubbataha, and eastern Indonesia are threatened by human activities such as destructive fishing practices. The reefs that are still largely unaffected by people may be particularly important to the survival of species and the recovery of neighboring areas. Relatively "pristine" reefs not only harbor a diverse suite of corals and fish, but they also provide an important source of larvae for degraded reefs.

PHOTO: WOLCOTT HENRY

The eggs and larvae of corals and fish can be carried by currents hundreds of kilometers, making them important potential genetic sources for other locations.

Active management and protection are key to maintaining the ecological integrity of the region. Priority areas should include not only places that have high species richness, but also locations that contain a broad diversity of habitat types or unique species or assemblages. The location of protected areas should also consider factors of connectivity between reefs. *(See Box 3.)*

Many conservation organizations are developing and applying prioritization schemes for marine conservation, typically focusing on biodiversity. The Reefs at Risk Threat index makes it possible to integrate socioeconomic considerations and human pressures in prioritization efforts.

BOX 3. LARVAL CONNECTIVITY

Maintaining and restoring natural biodiversity to degraded reefs relies on the availability of new juveniles. Almost all reef organisms have a larval phase; the larvae can drift through the ocean, often for days or weeks. In the majority of cases, the larvae settle on the reef where they were produced.[a] Yet, ocean currents can sweep some larvae over considerable distances to new reefs. In this way, they may be critical to genetic flow and the repopulation of damaged reefs. Identifying reefs that are "larval storehouses," particularly "source" reefs that lie upstream of others in the main current flow, is part of the emerging study of larval connectivity. Such information has important implications for proposed marine protected area networks, reef rehabilitation projects, and fisheries management.[b]

Regional-scale patterns of larval connectivity are not well understood. Many larvae do not reach other reefs because they face unfavorable currents or cannot survive because of pollutants or a lack of nutrients. Studies on the mantis shrimp, *Haptosquilla pulchella*, in 11 reef systems of central Indonesia have shown highly distinctive genetic structures on either side of the Makassar Strait, where currents run north and south but not crosswise.[c] Thus reefs on one side of the Strait probably cannot be relied on to reestablish populations on the other side. However, there is evidence that larval sources from the South China Sea[d] and the Northern Philippines[e] supply the surrounding reefs.

Few, if any, existing management regimes consider larval connectivity during planning. This shortcoming may leave certain reefs vulnerable to degradation even when they are officially protected.

a. S.E. Swearer et al., "Larval Retention and Recruitment in an Island Population of a Coral-Reef Fish," *Nature* 402 (1999): 799-802.
b. J.A.H. Benzie, "Genetic Structure of Marine Organisms and Southeast Asian Biogeography," in R. Hall and J.D. Holloway, eds., *Biogeography and Geological Evolution of Southeast Asia* (Leiden, The Netherlands: Backhuys Publishers, 1998).
c. P.H. Barber et al., "A Marine Wallace's Line?" *Nature* 406 (2000): 692-93.
d. J.W. McManus, "The Spratly Islands: A Marine Park?" *Ambio* 23 (1994): 181-86.
e. J.E.N. Veron, *Corals in Space and Time: The Biogeography and Evolution of the Scleractinia* (Sydney: University of New South Wales Press, 1995); J.E.N. Veron and P.R. Minchin, "Correlations Between Sea Temperature, Circulation Patterns, and the Distribution of Hermatypic Corals of Japan," *Continental Shelf Research* 12 (1992): 835-57.