

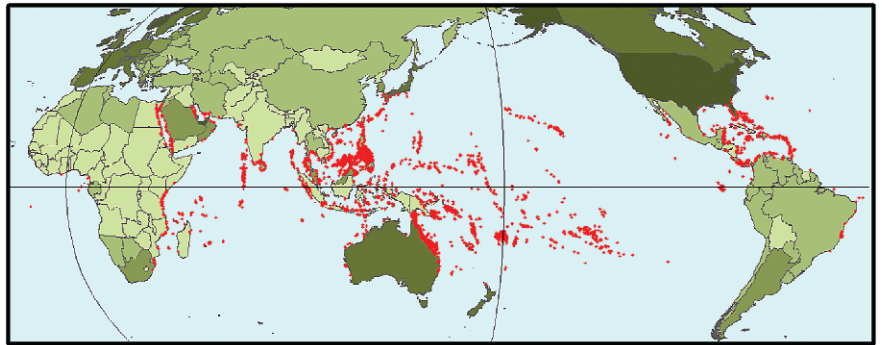
The Inequity of the Global Threat to Coral Reefs

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Human activity threatens coral reef ecosystems worldwide through overfishing, marine pollution, and disease (Hughes et al. 2003). In recent years, climate change also has emerged as a possible threat to coral reefs. Warming ocean temperatures have been blamed for mass coral bleaching events in the past decade, and this warming may lead to a rapid increase in the frequency and severity of coral bleaching in coming decades (Donner et al. 2005). Over the next century, higher concentrations of atmospheric carbon dioxide, and associated changes in ocean chemistry, may also reduce coral calcification rates and rates of reef accretion, further endangering coral reef ecosystems (Kleypas et al. 1999). Although the ability of different corals and their symbionts to adapt to changes in climate and ocean chemistry is a source of debate in the scientific community (Baker et al. 2004), climate change is expected to pose a serious threat to the function—and potentially even to the survival—of many of the world's coral reef ecosystems.

Coral reefs have been adopted as an iconic “flagship” ecosystem in the effort to encourage reductions in greenhouse gas emissions. It's simply good marketing. Coral reefs are charismatic: Colorful underwater images of corals, sponges, and reef fish are bound to draw a strong emotional response from even the most hardened audience. Who among us would want to be blamed for killing Nemo?

With all this focus on the aesthetics of coral reefs, the potential *human* inequity of the threat posed by climate change is often ignored. The majority of the people who depend on coral reef ecosystems for shoreline protection, fisheries, and tourism revenue live in poor, developing countries that are responsible for only a



The world's coral reefs (in red) and national per capita GDP (the darkest shades have the highest values). The coral reef locations are derived from ReefBase data; the reef points are magnified. National GDP (in 2003 US dollars) is obtained from the CIA's World Factbook (2006).

tiny fraction of the world's greenhouse gas emissions.

Overlaying a human population map (compiled from the 2004 LandScan Global Population Database, www.ornl.gov/sci/landscan) with a coral reef map (derived from ReefBase, www.reefbase.org) reveals that 655 million people, or approximately 10 percent of the world's population, live within 100 kilometers (km) of coral reefs. Over 91 percent of these people live in what are classified as developing nations. Naturally, the “developing” classification includes many reasonably wealthy nations in the Caribbean and Middle East, as well as some densely populated countries like China and Brazil with limited dependence on coral reef resources. If these nations are excluded from the analysis, the population data indicate that 75 percent of the people living within 100 km of coral reefs (424 million) are in the poorest developing countries. Of these people, 65 to 70 percent live outside of very high-density urban areas (> 10,000 people per km²) in settings where they are

more likely than high-density urbanites to be dependent on reef resources.

National economic data further illustrate the poverty level of the majority of people expected to be dependent on coral reef ecosystems. Over 63 percent of the people living within 100 km of coral reefs, a total of 415 million people, reside in countries with a per capita GDP (gross domestic product) less than US\$5000 (in 2003 dollars). Countries in which more than 75 percent of the population lives within 100 km of coral reefs have a mean per capita GDP of US\$7990, less than one-quarter that of the United States (CIA 2006).

This includes small-island developing states in the Pacific and Caribbean and large Southeast Asian nations such as Indonesia and the Philippines, where many

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communities are directly dependent on reef resources. Unfortunately, the importance of reef fisheries to local populations is often underestimated because subsistence catch is not included in national statistics (Whittingham et al. 2003). In island nations where agricultural land is limited, fisheries are the primary source of protein and, often, the only source of income. Subsistence or small-scale fishing may comprise 80 percent of the total coastal fisheries catch in parts of the South Pacific (Dalzell et al. 1996).

Ironically, the people who are most dependent on coral reef ecosystems are responsible for only a small fraction of the world's greenhouse gas emissions. The per capita greenhouse gas emission rate of the 424 million people living within 100 km of reefs in developing countries is 1.78 metric tons per person of carbon dioxide-equivalent (figures are based on 2003 data from the United Nations; see http://unfccc.int/ghg_emissions_data/items/3800.php). By comparison, greenhouse gas emissions average 20.1 metric tons per person—11 times higher—in

the United States and 11.4 metric tons per person in Europe, Japan, Russia, and the other nations party to the Kyoto Protocol.

Although the vulnerability to climate change of a particular coral reef ecosystem and the adjacent human communities must be studied at the local level, this simple global analysis demonstrates a clear inequity between the nations most responsible for greenhouse gas emissions and the communities that would suffer the most from any long-term coral reef degradation.

There is still debate within the scientific community over the future impact of climate change on coral reef ecosystems. But there is no debating the social and economic importance of coral reef ecosystems. If the projections of reduced calcification rates, more frequent mass coral bleaching events, and associated declines in live coral cover over the next few decades come true, it is the developing world that will suffer the greatest consequences.

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