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THE Current

October 21, 2010

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UCSB Scientists Document How Fishing on Coral Reefs Can Alter Ecosystems

Scientists at UC Santa Barbara have discovered that fishing for predators on coral reefs not only reduces the number of predators on the reef, but also affects the behavior of their prey -- and can have a significant impact on the ecosystem.

In a pair of studies published in the journals *American Naturalist* and *Ecology*, the scientists found that when hunted by large predators, such as sharks and snapper, small fish tend to hide in reefs and move around less. When the number of predators is reduced by fishing, their prey move greater distances, take more risks, and change their feeding behaviors. They also found that these individual behavior patterns can scale up to drive significant ecosystem changes.

Elizabeth Madin, who was a Ph.D. student in UCSB's Department of Ecology, Evolution & Marine Biology (EEMB) at the time of the research, is the lead author of both studies. Co-authors are Robert Warner, EEMB professor; Steven Gaines, dean of the Bren School of Environmental Science & Management; and Joshua Madin, of Macquarie University in Sydney, Australia. Elizabeth Madin is now a National Science Foundation International Postdoctoral Fellow based at the University of Technology in Sydney.

The scientists studied coral reefs of the central Pacific Ocean's Line Islands, a small equatorial archipelago, from 2005 to 2008. The islands are thousands of miles from the nearest landmass. Predators have been heavily fished near some islands and never fished near others.

"In more pristine areas, predators abound, and small prey fish are cautious and move only short distances from their hiding places," Warner said. "On heavily populated islands, where fishing has dramatically reduced numbers of predators, small fishes are much bolder. What we've seen is that these behavioral responses can lead to cascading effects through the ecosystem."

The scientists saw firsthand how fishing had decimated populations of sharks and other predators. "Like many of my generation, the movie 'Jaws' instilled in me an unfortunate, somewhat irrational fear of being eaten, and I began to wonder what would happen to the reef if the small, seaweed-eating fish had nothing to fear," said Elizabeth Madin. "What if they could graze more like cows in a pasture than wildebeest on a lion-infested African plain?"

They found that, by removing predators and changing the grazing behavior of small fish, there were dramatic changes in the seaweed patterns on coral reefs, giving the reefs a new look. Seaweed is important because areas of lush seaweed growth inhibit growth of coral, the important engineers of the reef. By changing where seaweed grows, fishing may inadvertently also be changing where coral can grow.

The scientists concluded that fishing can have important consequences not only for predators, but also for their prey and ultimately for entire reef communities by changing the behavior of small fish. When small fish are able to move freely over the reef without fear of being eaten, the scientists found the following consequences for the ecosystem:

- Prey fish may have more feeding and mating opportunities.
- Prey fish may consume their food, such as reef seaweed, more evenly across the reef, so seaweed is evenly grazed and less patchy.
- Coral, which competes for space on the reef with seaweed, could potentially find fewer bare patches of reef that it can settle in, so the places where new coral can grow could be more limited.

"What our results show is that fishing can have surprising, but very clear, effects throughout coral reef ecosystems," said Madin. "Hopefully, these results will help conservation practitioners and resource managers move toward true ecosystem-based management, where the full suite of ecological interactions and human impacts guide policy decisions."

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