TEAM LED BY AMERICAN MUSEUM OF NATURAL HISTORY SHOWS BIG FISH, SMALL FISH, REEF THRIVE WITHIN CARIBBEAN MARINE PARK

MARINE RESERVE IN THE BAHAMAS BENEFITS FISH PREDATORS, PREY, AND THE REEF

Two American Museum of Natural History biologists and their colleagues have conducted an in-depth study of Bahamian coral reefs, showing that marine reserves, in addition to protecting key species, can lead to healthier coral reefs. Knowing that marine reserves can be highly effective in protecting certain types of predator fish, such as Nassau grouper (an economically and culturally important Caribbean species), the researchers were interested in how a build-up of predators might affect the rest of the coral-reef ecosystem. For example, an abundance of predators could suppress populations of herbivores, allowing seaweed populations to bloom and overwhelm corals. Instead, they found that a 20-year-old fishing ban within a marine park, in addition to resulting in an expected increase in groupers (because they were protected from fishers in surrounding waters), has had positive effects on parrotfish, the primary grazers on Caribbean reefs. In turn, the parrotfish have contributed to a healthier reef by reducing algae and seaweed. This “win-win-lose” across the grouper-parrotfish-algae portion of the food web is ultimately possible because larger parrotfish within reserves are able to both avoid fishermen’s traps and “escape” the risk of predation from groupers by growing larger than groupers can swallow. This leads to more and larger parrotfish, increased parrotfish grazing, reduced algal coverage, and more free space for the establishment and growth of new corals on reefs within reserves.

The new study, led by Peter Mumby of the University of Exeter and including Dan Brumbaugh, Senior Conservation Scientist, and Katherine Holmes, Marine Biodiversity Specialist, of the American Museum of Natural History’s Center for Biodiversity and Conservation (CBC), along with Alastair Harborne and Steve Box of the University of Exeter, Craig Dahlgren and Kevin Buch of the Perry Institute for Marine Science in Florida, Carrie Kappel and Fiorenza Micheli of the Hopkins Marine Station at Stanford University, Judith Mendes of the University of the West Indies, Kenneth Broad of the University of Miami’s Rosenstiel School of Marine and Atmospheric Science, James Sanchirico of Resources for the Future, Richard Stoﬄe of the University of Arizona, and Andrew Gill of the Institute of Water and Environment is published in the latest issue of the journal Science. The Exuma Cays Land and Sea Park, the marine reserve featured in this research, is located in the central Bahamas and has had a no-take fishing policy since 1986. Within the reserve, the biomass of grouper is

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seven times greater than that observed in three other regions of the Bahamian archipelago. Some critics of fishing restrictions within marine reserves have claimed that such rules could indirectly damage coral reefs if predator fish populations go unchecked. For example, if grouper populations rebound so successfully that they can significantly reduce local populations of prey species—such as algae-eating parrotfish—this could have the unintended and unwanted consequence of damaging coral reefs by reducing the grazing that helps maintain the cover of living corals. The new findings undermine such concerns and suggest that no-take marine reserves benefit not just single species, but whole ecosystems. “Our team found that a long-term, no-take marine reserve enhances the process of parrotfish grazing on coral reefs in The Bahamas,” Dr. Brumbaugh said. “This grazing is key to the ecosystem functioning of coral reefs, since without it, reefs will continue to transform into algal lawns. Corals, of course, are important since they create the reefs over millennia, providing habitats for an astounding diversity of other animals and plants.”

How a reserve protects grazers and grazing seems key to the ability of coral reefs to recovery from both natural and man-made disturbances. “Caribbean reefs are still trying to recover from the devastating effects of an El Niño bleaching event in 1998 which caused widespread damage to coral around the world,” Dr. Mumby said. “What we have found is that marine reserves might provide exactly the right conditions to allow this recovery to happen.”

The study involved surveying fish, corals, and other reef organisms at various locations in and around the marine reserve and at additional reefs throughout The Bahamas. The research team found twice as many parrotfish predators, nearly half of which were Nassau groupers, inside the reserve as outside. Since larger parrotfish species escape grouper predation better than smaller parrotfish, smaller species of parrotfish fared less well in the reserve. Overall, though, the increased numbers of larger parrotfish outweighed the decreased sizes of the smaller parrotfish to produce a net doubling of grazing intensity within the reserve. Correspondingly, the cover of algae on reefs was reduced four-fold compared to outside the reserve.

“Better understanding of the dynamics of species interaction is crucial, but it is not the only part of the puzzle,” said Dr. Broad, one of the research project’s social scientists. “How reserves may affect the local human communities that rely on these fishing grounds must be considered. Will fishers shift effort toward other fishing grounds that may then suffer similar environmental consequences? Might they switch to activities and fishing methods even more damaging to the environment once their livelihoods are threatened? Given the lack of enforcement that exists in many parts of the world, how can local groups play a role in developing innovative approaches for managing the resources that they rely upon most directly? These and other questions are being addressed in other components of the larger research project.”

Bahamas Biocomplexity Project (BBP)
These new findings on the ability of the Exuma Cays Land and Sea Park to enhance a critical ecosystem function are part of a five-year, first-of-its-kind study of how networks of marine protected areas (MPAs) can conserve biodiversity, sustain fisheries, and enhance local economies in the Caribbean.

The project, funded by a $2.5 million Biocomplexity in the Environment grant from the National Science Foundation (NSF), is headed up by Dr. Brumbaugh at the CBC. The study focuses on The Bahamas, an archipelagic nation of hundreds of islands. In 2000, the Bahamian government declared its intention to protect 20 percent of its marine environment within a network (an ecologically connected system) of MPAs, and is currently in the process of implementing five new reserves. At the same time, the Bahamas National Trust, a non-governmental organization that manages the country’s national park system, is in the process of enhancing its management of its system of marine parks, including the Exuma Cays Land and Sea Park.

This setting provides the real-world management context for the BBP’s ambitious efforts to synthesize theories, methods, and data from oceanography, marine ecology, population genetics, anthropology, and economics, as the researchers address important questions about the design of effective MPA networks. The research team is focusing particularly on understanding, through direct observation and simulation modeling, the complex interactions and feedbacks between coastal peoples and their marine environment, and the ripples and cascades of these human-ecosystem interactions within and across an archipelago.

“In addition to looking at how single protected areas may influence ecological and human dynamics, we are also looking at the ecosystem across larger seascapes—how the living fabric of habitats, organisms, and human uses functions across the shallow banks of The Bahamas,” said Dr. Brumbaugh. “In marine systems, the connectivities—the movements of water, organisms, and people throughout these seascapes—frequently affect the health of the overall system, so we’re trying to understand the consequences of these dynamics to the health and well-being of the ecological, social, and economic systems.” In addition to containing tremendous biodiversity, coral reefs throughout the Caribbean support local fisheries and important tourist industries. BBP researchers are in the process of building statistical and theoretical models of the natural and human processes that can influence the conservation and economic functions of a network of MPAs. This research will both help support ongoing decision-making in The Bahamas as well as provide new underpinnings to the science of conserving coral-reef ecosystems worldwide.

Dr. Brumbaugh is leading the interdisciplinary and inter-institutional data collection and assimilation effort, coordinating the work of research groups across multiple institutions, including the College of The Bahamas, the Perry Institute for Marine Science, Resources for the Future, Stanford University, the University of Arizona, the University of California, Davis, the University of Exeter, and the University of Miami.

The Center for Biodiversity and Conservation (CBC)

The Center for Biodiversity and Conservation, established at the American Museum of Natural History in 1993, is dedicated to the study and conservation of biological diversity. The survival and protection of global biological resources depend on wise policy decisions that are based on scientific
knowledge. The CBC draws on the strengths of the Museum’s research, education, and exhibition departments to integrate this information into the conservation process and to disseminate it widely.

Current CBC initiatives include field programs in The Bahamas, Bolivia, Madagascar, Pacific islands, Vietnam, and the New York metropolitan area.

**Web Site Features Bahamas Biocomplexity Project**

The Bahamas Biocomplexity Project (BBP) research has recently been featured in video bulletins and online as part of Science Bulletins, an innovative Museum program (http://sciencebulletins.amnh.org/bio/) that brings the excitement of research and discovery in the natural world to an audience of more than five million people at a variety of public venues, including museums, science centers, NASA visitor centers, and the Internet. People of all ages and backgrounds can learn about BBP research and other current science through in-depth stories featuring scientists at work, nature news, and satellite images illustrating changes in the biosphere.

**American Museum of Natural History**

The American Museum of Natural History is one of the world’s preeminent scientific, educational, and cultural institutions. Since its founding in 1869, the Museum has advanced its global mission to explore and interpret human cultures and the natural world through a wide-reaching program of scientific research, education, and exhibitions. The Museum accomplishes this ambitious goal through its extensive facilities and resources. The institution houses 45 permanent exhibition halls, state-of-the-art research laboratories, one of the largest natural history libraries in the Western Hemisphere, and a permanent collection of more than 30 million specimens and cultural artifacts. With a scientific staff of more than 200, the Museum supports research divisions in Anthropology, Paleontology, Invertebrate and Vertebrate Zoology, and the Physical Sciences. Home for more than three decades to the Museum’s celebrated 94-foot-long blue whale model, the Milstein Hall of Ocean Life reopened on May 17, 2003, transformed through current scientific research and cutting-edge exhibitry into a fully immersive oceanic environment. The Museum shares its treasures and discoveries with approximately four million on-site visitors from around the globe each year. In addition, the Museum’s Web site, www.amnh.org, extends its collections, exhibitions, and educational programs to millions more beyond the Museum’s walls.

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