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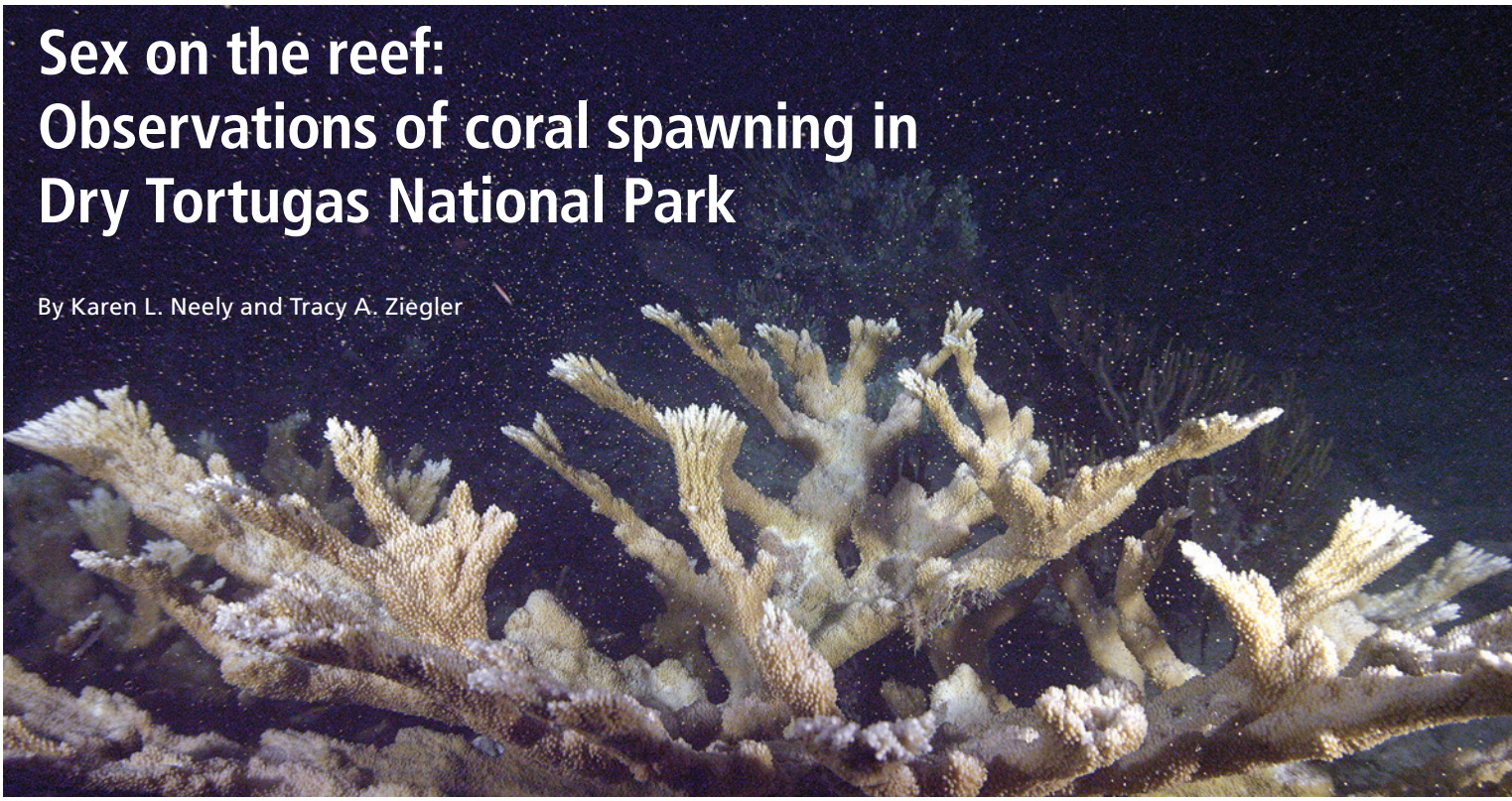
Sex on the reef: Observations of coral spawning in Dry Tortugas National Park

By Karen L. Neely and Tracy A. Ziegler



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A colony of elkhorn coral (*Acropora palmata*) releases thousands of egg-sperm bundles into the water column.

Abstract
In Florida's remote Dry Tortugas National Park, coral reefs are an important management priority. Reproduction of coral species is difficult to monitor, however, and the reproductive potential of coral colonies at the park has been a matter of concern for several years. Two threatened species, elkhorn coral (*Acropora palmata*) and pillar coral (*Dendrogyra cylindrus*), were targeted for observation during their predicted annual spawning event in August 2014. Over a three-night period, both species were observed releasing gametes in near synchrony with observations at other sites in the Florida Keys. That these organisms are capable of being reproductive within the park provides hope for the future of these threatened species in the region.

Key words
coral reefs, coral spawning, Dry Tortugas National Park, endangered species

MANAGEMENT OF CORAL REEFS IS A high priority for many national parks within tropical and subtropical areas; examples include Virgin Islands National Park, National Park of American Samoa, Biscayne National Park (Florida), Kaloko Honokōhau National Historical Park (Hawaii), and Dry Tortugas National Park (Florida). The coral reef ecosystems these parks protect are often small in area but hugely important for their biodiversity, ecosystem services, and aesthetic value (National Park Service 2010). Coral reefs, however, are in serious decline worldwide. Within the well-studied Caribbean, the coverage of hard corals on reef environments has declined from approximately 50% in the 1970s to approximately 10% today (Gardner et al. 2003). The causes are many and varied, but include storm damage, altered ecological interactions, poor water quality, elevated water temperatures, pollution, and sedimentation. These stressors in turn contribute to more proximal causes of death like increased algal competition, higher disease incidence, and heat-related coral bleaching (Pandolfi et al. 2005).

These decadal-scale declines are increasingly worrisome and increasingly well documented. Pockets of resilient reef communities and restoration projects provide beacons of hope for the interim survival of these systems, but what of longer-scale trends based on natural propagation of species? Reproduction of coral colonies frequently occurs asexually through broken fragments growing into new colonies, but for many coral species, sexual reproduction—and the resultant benefits of genetic recombination—is limited to a once-a-year opportunity (Szmant 1986).

Reproductive strategies

In the Caribbean, that once-a-year opportunity occurs during the warm-water months of August and September. Being stationary organisms, coral reproduction relies upon the release of gametes—sperm, eggs, or a combination of the two—into the water column. Some species (about 50% of Caribbean species and 15% worldwide) are "brooders," meaning that eggs are held within the coral polyps, and only sperm is released with the hope of drifting over an egg-bearing individual. In these brooders, fertilization is internal, and the coral release larvae that are ready to settle and grow into adults. Other coral species (about 50% of Caribbean species and 85% worldwide) are "broadcast spawners" (Baird et al. 2009). Within these species, both eggs and sperm are released and externally fertilized in the water column to form larvae that drift in search of places to settle. For these broadcast spawners to reproduce successfully, individual corals must synchronize gamete release with their neighbors. An individual that spawns even an hour later than those around it will have a near-zero chance of successful fertilization (Levitan et al. 2004). Each species depends on environmental cues to time gamete release, such as water temperature, lunar cycle, time of sunset, and chemical signals from surrounding individuals (Levitan et al. 2011). Though the exact mechanisms governing each individual's timing are not fully known, a successfully reproducing population can launch millions of gametes into the water column within minutes.

These gametes and the coral larvae they produce are the next generation of reef-building corals. They can recruit locally to repopulate the reefs from which they spawned and create new genetic combinations that may be resistant to present and future threats. They can also flow downstream to help repopulate more distant reefs and introduce new genotypes to other regions (Jones et al. 2009). Due to the location and oceanographic features of Florida's remote Dry Tortugas National Park, both processes are of the utmost importance to both local and regional populations.

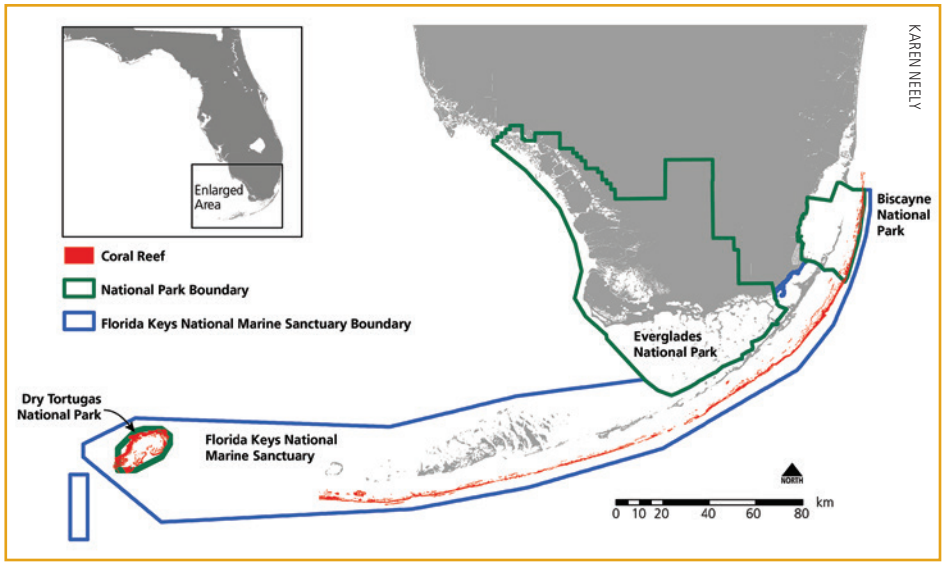


Figure 1. The coral reefs of Dry Tortugas National Park lie 60 km (37 mi) west of the main Florida Reef Tract. Numerous agencies manage the marine resources of the region.

Importance of Dry Tortugas coral populations

The Florida Reef Tract is the world's third largest barrier reef (following those in Australia and Belize) and the only coral reef in the continental United States (fig. 1). It stretches like a protective shield from the southern tip of Florida down the Florida Keys, terminating past Key West (Florida Fish and Wildlife Conservation Commission 2015). Tracing this trajectory across deeper waters for another 60 km (37 mi) leads to one more set of coral-rich islands: the Dry Tortugas. This region, which expanded in 1992 from a national monument protecting the 1840s–era Fort Jefferson into a national park that is 99% submerged, is host to a variety of marine life-forms, including numerous corals, sea turtles, and other species listed under the Endangered Species Act (ESA). The location of the Dry Tortugas makes reproduction of any marine species here important. The islands' remoteness means that populations rely heavily on local recruitment for the next generation. Their position at the upstream end of the Florida Current also makes them a potential source of gametes for the rest of the Florida Reef Tract (Domeier 2004).

Dry Tortugas reefs have been regularly monitored since 1999. The National Park Service South Florida/Caribbean Inventory and Monitoring Network (http://science.nature.nps.gov/im/units/sfcn) and the State of Florida's Coral Reef Evaluation and Monitoring Program (http://ocean.floridamarine.org/FKNMS_WQPP/pages/cremp.html) both document coral cover, species diversity, and coral health on an annual basis. Though far from many human influences, the remoteness of these waters does not make them immune to the decline of reef systems. Twenty-five percent of sites have shown significant coral decline since 1999 (Ruzicka et al. 2014). Of the nearly 40 species of coral documented within Dry Tortugas National Park, 7 are listed as threatened under the Endangered Species Act (http://www.nps.gov/drto/learn/nature/tespecies.htm). Researchers selected two of these, elkhorn coral (*Acropora palmata*) and pillar coral (*Dendrogyra cylindrus*), for spawning observations (fig. 2).

KAREN NEELY (2)

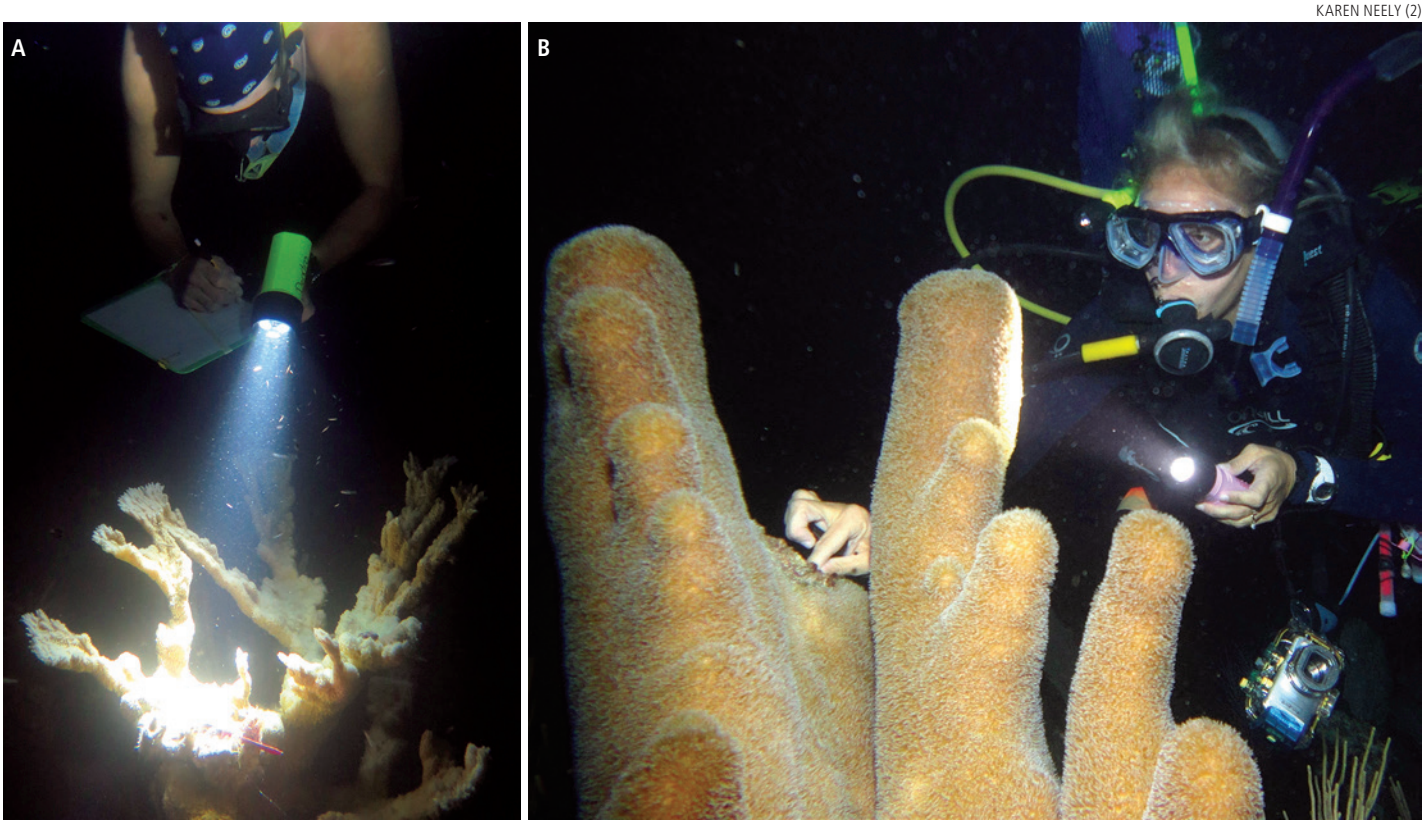


Figure 2. Researchers from Dry Tortugas National Park and Florida's Fish and Wildlife Research Institute observe and document the spawning of (A) *Acropora palmata* and (B) *Dendrogyra cylindrus*, both ESA-listed coral species.

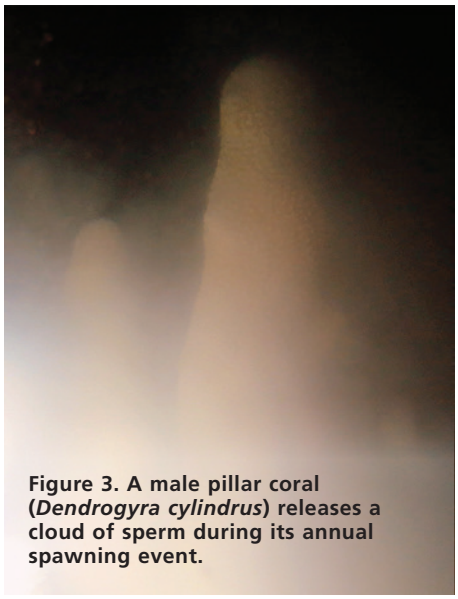
The two species are of interest for several reasons. Both have a single, small, clumped population in the park, making the reproductive success of those individuals indispensable for natural population recovery. Both are also the targets of Florida Fish and Wildlife Research Institute monitoring programs that have looked at individual colony health for 10 (*A. palmata*) and 5 (*D. cylindrus*) years. In addition, though the species are both broadcast spawners, they have slightly different sexual strategies. *A. palmata* is hermaphroditic, meaning eggs and sperm are released together in packed bundles that break apart at the surface where they mix with those of other individuals. In contrast, *D. cylindrus* is gonochoric, meaning colonies are either male or female. In this case, both male and female colonies must be present within a population for successful fertilization.

Pockets of resilient reef communities and restoration projects provide beacons of hope for the interim survival of these systems, but what of longer-scale trends based on natural propagation of species?

New observations

Until recently, logistical difficulties prohibited observations of spawning within Dry Tortugas National Park. It was unknown whether these populations were reproductive and whether they would spawn in synchrony with the rest of the Florida Reef Tract. A collaborative team composed primarily of National Park Service and Florida Fish and Wildlife Research Institute divers selected a five-night window in August 2014 to hover over the target species. The window was identified based on previous years' phenological spawning observations elsewhere in the region, with each species expected to follow a pattern of gamete release determined by the number of nights since the full moon and the number of hours after sunset (Fogarty et al. 2012; Neely et al. 2013).

Bathed in the warm waters and under the glow of the recent full moon, the divers waited. Two nights after the full moon, colleagues 270 km (170 mi) away in Key Largo announced *D. cylindrus* spawning success. The Dry Tortugas group waited with bated breath until, 30 minutes later, the observed colonies followed suit (fig. 3). The process and time lag were repeated the next night with *D. cylindrus*. And the following night,



KAREN NEELY

Figure 3. A male pillar coral (*Dendrogyra cylindrus*) releases a cloud of sperm during its annual spawning event.

four nights after the full moon, *A. palmata* did the same (photo, page 13), synchronized with the date of their Key Largo conspecifics, but with a 30-minute lag. As the gametes were released, divers recorded the timing of each spawn, the reproductive output of each colony, and, for *D. cylindrus*, the gender of each individual. Though the team was pleased to find reproductively active colonies, they were concerned to discover that all of the nine *D. cylindrus* colonies in the Dry Tortugas were male.

Conclusion

The spawning observations pose just as many questions as they provide answers. Are the gametes successfully fertilizing and settling? Can these clumped individuals seed other areas of the park to increase population size? How will genetic diversity affect reproductive potential now and in the future? And from a management perspective, should measures such as transplantation of "nursery-raised" corals be used to supplement the natural processes to promote species' survival? These questions demonstrate that there is still much to learn, but certainly knowing the corals are making the most of their once-a-year opportunity is a good start.

Acknowledgments

This work was funded by Florida State Wildlife Grant #F13AF01085 to Florida Fish and Wildlife Research Institute. Work was conducted under NPS Permit #DRTO-2014-SCI-0010.

References

Baird, A. H., J. R. Guest, and B. L. Willis. 2009. Systematic and biogeographical patterns in the reproductive biology of scleractinian corals. Annual Review of Ecology, Evolution, and Systematics 40:551–571.

Domeier, M. L. 2004. A potential larval recruitment pathway originating from a Florida marine protected area. Fisheries Oceanography 13:287–294.

Florida Fish and Wildlife Conservation Commission. 2015. The unified Florida Reef Tract map. Accessed 30 September 2015 from http://ocean.floridamarine.org/IntegratedReefMap.

Fogarty, N. D., S. V. Vollmer, and D. R. Levitan. 2012. Weak prezygotic isolating mechanisms in threatened Caribbean *Acropora* corals. PLoS ONE 7(2):e30486. doi:10.1371/journal.pone.0030486.

Gardner, T. A., I. M. Côté, J. A. Gill, A. Grant, and A. R. Watkinson. 2003. Long-term region-wide declines in Caribbean corals. Science 301:958–960.

Jones, G. P., G. R. Almany, G. R. Russ, P. F. Sale, R. S. Steneck, M. J. H van Oppen, and B. L. Willis. 2009. Larval retention and connectivity among populations of corals and reef fishes: History, advances and challenges. Coral Reefs 28:307–325.

Levitan, D. R., N. D. Fogarty, J. Jara, K. E. Lotterhos, and N. Knowlton. 2011. Genetic, spatial, and temporal components of precise spawning synchrony in reef building corals of the *Montastraea annularis* species complex. Evolution 65:1254–1270.

Levitan, D. R., H. Fukami, J. Jara, D. Kline, T. M. McGovern, K. E. McGhee, C. A. Swanson, and N. Knowlton. 2004. Mechanisms of reproductive isolation among sympatric broadcast-spawning corals of the *Montastraea annularis* species complex. Evolution 58:308–323.

National Park Service. 2010. Explore water: Discover the beauty and value of coral reefs in your national parks. Accessed 30 September 2015 from http://www.nature.nps.gov/water/coralreefs/.

Neely, K. L., K. S. Lunz, and K. A. Macaulay. 2013. Simultaneous gonochoric spawning of *Dendrogyra cylindrus*. Coral Reefs 32:813. doi:10.1007/s00338-013-1034-0.

Pandolfi, J. M., J. B. C. Jackson, N. Baron, R. H. Bradbury, H. M. Guzman, T. P. Hughes, C. V. Kappel, F. Micheli, J. C. Ogden, H. P. Possingham, and E. Sala. 2005. Are U.S. coral reefs on the slippery slope to slime? Science 307:1725–1726.

Ruzicka, R., V. Brinkhuis, M. Colella, J. Kidney, C. Bradshaw, N. Sheridan, K. Lunz, J. Morrison, L. Bartlett, K. Macaulay, and K. Neely. 2014. Long-term monitoring and assessment of selected coral reef sites in the Dry Tortugas National Park. 2011–2012 Final Report. Fish and Wildlife Research Institute and Florida Fish and Wildlife Conservation Commission, Saint Petersburg, Florida, USA.

Szmant, A. M. 1986. Reproductive ecology of Caribbean reef corals. Coral Reefs 5(1):43–53.

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