

Researchers Seeking to Tame Oyster Disease in Delaware Bay

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Delaware Bay oyster (*Crassostrea virginica*) populations are influenced by two lethal parasites, *Perkinsus marinus* and *Haplosporidium nelsoni*, which cause Dermo and MSX (Multinucleated Sphere Unknown) diseases in oysters, respectively. The diseases do not affect humans, but they do affect oyster populations. Both diseases respond to environmental conditions, typically becoming more severe as temperature and salinity (salt level) rise.

Delaware Bay oyster populations have battled MSX disease since 1957 and Dermo disease since 1990. Both diseases typically retreat to higher salinity in the lower part of the Bay following spring floods. But after a year of unusually low flows in the Delaware River from August 1984 to August 1985, MSX intensified in the upper Bay and killed 70 to 75% of the oysters. MSX disease prevalence fell dramatically after this drought and has never regained its preeminence in population control, suggesting that the oysters that repopulated the Bay after 1986 were dominated by MSX disease-resistant individuals.

Yet MSX is still present because oysters with no history of MSX disease exposure quickly become heavily infected and die when exposed in the Bay. Such a system-wide population response has not been observed in other estuaries.

As part of the National Science Foundation Ecology of Infectious Diseases (EID) initiative, we have developed a program to understand how parasites and their hosts interact in dynamic estuarine systems like Delaware Bay, and how these interactions might be modified by climate change. We combined expertise in shellfish disease, genetics, and modeling in a collaborative effort to investigate: 1) the timeline of natural selection to establish disease resistance; 2) the role of disease refugia (disease-free areas within a habitat) in the adaptation of the genetic structure of a population; 3) the relationship between range contraction of a species and disease resistance in preventing local extinction of oysters; and 4) the effects of a warming climate on oyster lifespan, oyster reproduction, parasite transmission, and the consequences of shifts in the genetic structure of oysters.

Our EID group has undertaken field and laboratory studies focused on oyster genetics and disease dynamics designed to determine: 1) if suspected disease refuges harbor susceptible oyster populations and the mechanisms that create and maintain them; 2) if disease-resistant genes exist and disproportionately affect oyster diversity; and 3) if the number of parents that successfully produce offspring vary in space and time. The laboratory and field studies have identified genes related to

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Credit: Haskin Shellfish Research Laboratory, Rutgers University

Graduate student, Emily Scarpa (left), of Rutgers-Camden, and Jenny Paterno (right), a Stockton College intern, harvest eastern oysters from Delaware Bay using a dredge in June of 2009.

Native Mussel Species

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tion strategy, the PDE is advocating for the restoration of native freshwater-mussel species and populations. To fully recover these important animals, we will need healthy riverside corridors, suitable water quantity and quality, and native fish hosts that pass freely up and down the rivers.

The good news is that once mussel communities begin to be reestablished, they will help do the work for us by improving water quality and enriching the habitat. For this reason, they are one of the few animals that are labeled "ecosystem engineers," because like oyster reefs, they build and maintain their own habitat that benefits other species.

In 2007, the PDE launched the Freshwater Mussel Recovery Program in collaboration with Cheyney University, The Academy of Natural Sciences, the U.S. Fish and Wildlife Service, and many others. New tactics were devised to decide which streams to target for mussel restoration based on their suitability for sustaining mussels. Hatchery techniques were developed using the latest science and focusing first on a common mussel species that has become impaired and patchy in distribution. Unlike oysters and other marine species, which have spawned and grown in the hatchery for over 100 years, only recently have scientists learned how to successfully produce baby freshwater mussels in hatcheries. Freshwater mussels have a complicated life history whereby a specific size and species of fish is needed as a host for the mussel's larval phase.

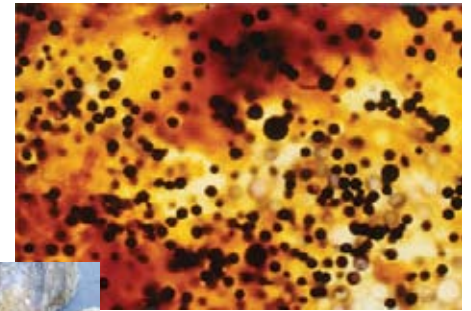
We are delighted to report that in 2009, we produced baby mussels and reared them through the crucial early-life stages at our Cheyney-based hatchery. This success was thanks in large part to scientists from The Academy of Natural Sciences and U.S. Geological Survey, who collected and supplied appropriate fish hosts, and funding from ConocoPhillips and the National Fish and Wildlife Foundation. We hope to repeat this success in 2010 and beyond, but with larger numbers so that we can rear juvenile mussels until they are ready for transplanting into selected streams, where no mussels have lived for quite some time. Eventually, we hope to expand this program to include other species to begin to rebuild the native-mussel population that once thrived across the Delaware Estuary's watershed.

For more information about this initiative, please visit www.DelawareEstuary.org/Science_Projects_Mussel_Restoration.asp. ■

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MSX and Dermo disease resistance, potential disease refugia and the mechanisms that allow them to exist, the differences among oysters from suspected refugia and high-disease areas, and the effect of space and time on the size of spawning populations.

We are integrating and extending the laboratory and field results using numerical models that include explicit genetic structure, disease processes, and post-settlement, oyster-population changes. These biological models are being coupled with a Delaware Bay circulation model to test scenarios of disease transmission, "larval," or baby-oyster transport, and current and future climate conditions on oyster diversity. Numerical particle-tracking experiments using the simulated circulation fields are providing potential transport pathways of oyster larvae and free-living disease pathogens, illustrating the importance of freshwater discharge rates and wind in determining these transport pathways, and



Seen here under a microscope, oyster meat shows one sign of *Perkinsus marinus*, or Dermo disease: black spots. While proven to have no effect on humans, Dermo disease can be fatal to oysters.



Eastern oysters, or *Crassostrea virginica*

highlighting the importance of oyster-larvae behavior in determining retention and final settling region.

The findings noted above are promising. They clearly illustrate the need for multidisciplinary research to provide improved understanding of oyster disease dynamics in Delaware Bay. By extending field and laboratory findings with numerical modeling, our EID project provides an example of the type of research program necessary to allow for the development of a strategy; a strategy that will project the effects of a warming climate on Delaware Bay oyster populations in the coming decades. This knowledge will then inform management strategies to help protect the valuable resources of the Delaware Bay.

To learn more, please call Dr. Eileen Hoffman at (757) 683-5334. Hoffman is a member of the Delaware Bay EID Group, which includes scientists from Old Dominion University's Center for Coastal Physical Oceanography, Rutgers University's Haskin Shellfish Research Laboratory, Rutgers University's Institute of Marine and Coastal Sciences, and the University of Southern California's Department of Biological Sciences. ■

Credit: Haskin Shellfish Research Laboratory, Rutgers University