2016 Oyster Reef Ecosystem Services (ORES) Research Update

June 2016

In order to quantify the ecosystem benefits provided by restored oyster reefs (e.g., water filtration, habitat), the NOAA Chesapeake Bay Office (NCBO) initiated the Oyster Reef Ecosystem Services (ORES) project. ORES project consists of three primary efforts intended to quantify the ecosystem benefits provided by restored oyster reefs:

- an NCBO-implemented field study of fish utilization of a variety of sites in the Choptank River area;
- NOAA-funded research projects being carried out by research institutions on fish, crab, and other species' use of reef areas and denitrification carried out by reefs and their associated communities; and
- computer modeling to explore ecosystem and economic benefits of restored reefs.

Interest in the benefits restored oyster reefs bring to the ecosystem reaches beyond resource managers. The Choptank River watershed was designated a NOAA Habitat Focus Area in 2014; information gathered from the ORES project is of great interest to partners in the Choptank Habitat Focus Area effort, including community organizations, interested citizens, and educators and students.

Complete recovery of an oyster reef ecosystem does not happen overnight. While signs indicate that the restoration sites are providing new habitat, reef ecosystem may take years to fully mature. Other habitat restoration efforts, such as those in wetlands, have documented long time scales needed for restored systems to perform like natural systems.

NOAA Chesapeake Bay Office Fish Utilization Field Study

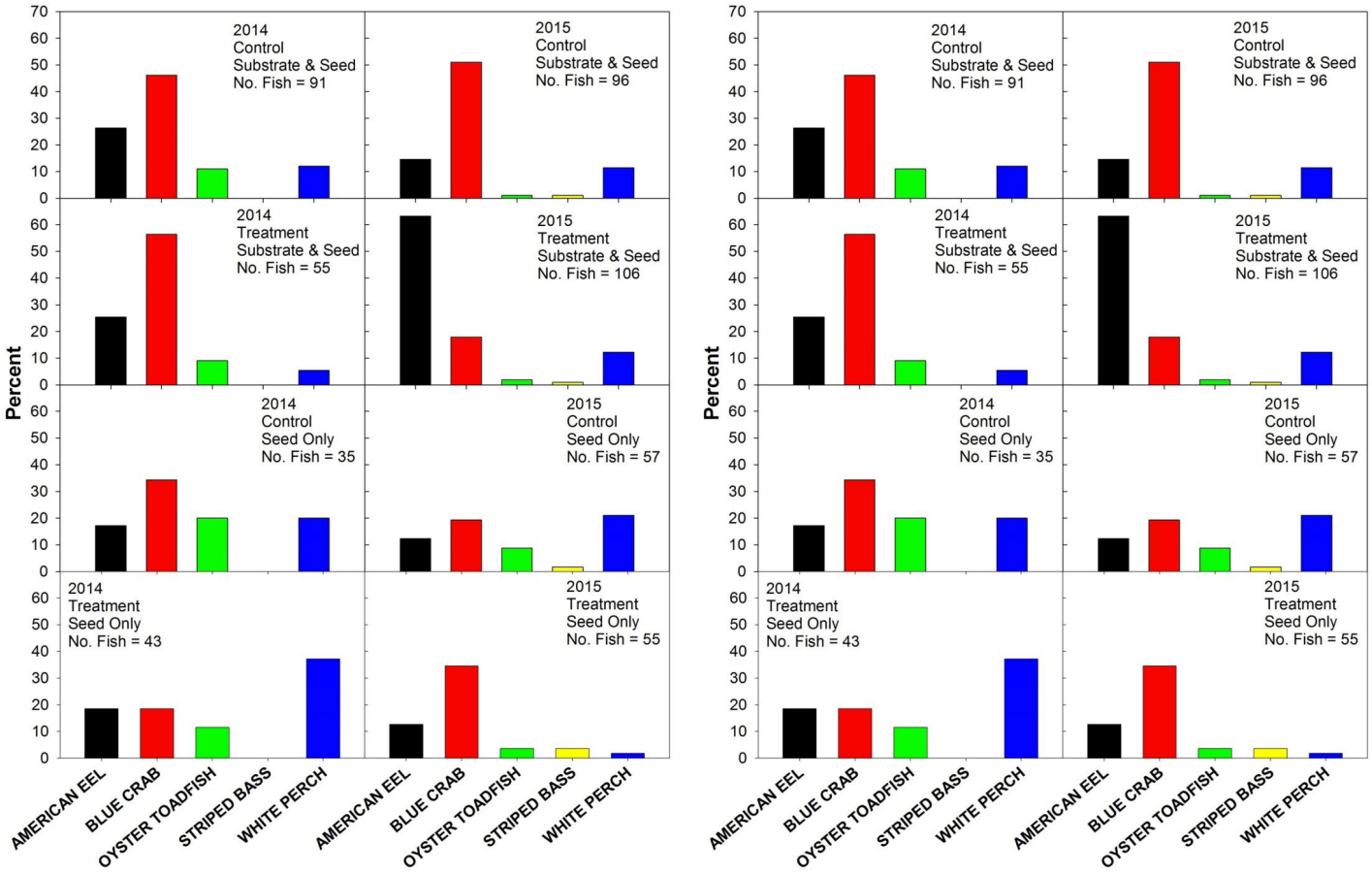
To identify the fish and other species that use oyster reefs as habitat in the Choptank River area, the NCBO ecosystem science team has conducted field work in Choptank tributaries since 2013. Working from on board NCBO's research vessel Bay Commitment, NCBO scientists deploy and then retrieve—after soaking for 24 hours—numerous lines of fish traps. Each line includes traps of different sizes, each designed to catch different types of fish. While retrieving traps, NCBO staff record the species, numbers, and size of each animal before returning them to the water.

Sampling work was done in the Little Choptank and Tred Avon Rivers in 2014 before any oyster reef restoration work was done in those rivers. Some reef construction did take place before and during the 2015 sampling season, which ran from June through September. Reef construction took place in the Little Choptank River before the NCBO fish utilization study got under way for the year. In the Tred Avon River, one reef was constructed before the June 2015 sampling session, while a second was completed before the July 2015 session. While some hatchery oyster seeding took place on reefs in both the Little Choptank and Tred Avon, none of the seeding was done on reefs involved in the ORES study, and for this reason restoration cannot be considered complete.

The NCBO ecosystem science team—augmented by summer interns—continued fish utilization studies in summer 2015. Team members deploy and retrieve fish traps; they document each animal before returning it to the water.

In each location, fish traps were set on eight sites (minimum two lines/site, each line consisting of five different trap types) in four categories:

- Existing oyster shell bottom to be restored by augmentation with hatchery oyster seed,
- Sandy bottom to be restored by substrate reef construction and hatchery seed,
- Sandy bottom, suitable for substrate reef construction, but not to be restored, and
- Oyster shell bottom, suitable for hatchery oyster augmentation, but not to be restored.



The above charts show the five most abundant species observed during NCBO ORES field work in in the Little Choptank (left) and Tred Avon (right) rivers in 2014 and 2015. "No. Fish" is the total number of fish collected, and treatment type indicates whether any restoration--and if so, what kind--had taken place at those sampling sites.

This is a before-after, control-impact (BACI) study design, which allows comparison of fish abundance before and after restoration in addition to comparisons between restored and unrestored, or control, sites.

In total, 314 fish and crabs were collected in the Little Choptank River and 200 in the Tred Avon River. Nine species were observed in the Little Choptank samples and eight in the Tred Avon; blue crab were the most frequently encountered in both tributaries. Also of note:

- While striped bass were less than 2% of the collected fish and crabs in the Little Choptank River, in the Tred Avon, they made up 20%.
- While American eel were only 11% of the catch in the Tred Avon, they were just over 30% in the Little Choptank.
- In both tributaries, catch per unit effort—essentially, the number of fish and crabs caught per trap line deployment—was higher than it was the previous year.
- Average catch per unit effort on un-seeded reef sites was slightly higher than on control sites in both the Little Choptank and the Tred Avon. These differences were not statistically significant, however.
- The NCBO field team also conducted trawl surveys to determine if using trap lines might be missing some species. Some taxa were only collected in trawls—some of which, for example, Atlantic menhaden and bay anchovies, which would not be expected to be attracted to the bait in fish traps.

ORES research is under way in tributaries around the Chesapeake Bay.

NCBO-Funded Research by Academic Partners

NCBO funded projects to be conducted by academic research institutions that are complementary; these projects cover different geographic areas and different types of ecological and economic benefits of oyster reef habitats. NCBO and researchers from these academic institutions collaborate throughout their research to share information and discuss implications of their findings and develop a holistic picture of the ecosystem services provided by Chesapeake Bay oysters. The following projects are working to quantify various aspects of oyster reef ecosystem services:

- **Virginia Institute of Marine Science (VIMS), "Ecosystem Services of Restored Oyster Reefs in the Lower Chesapeake Bay,"** uses fish traps and underwater video in the Great Wicomoco, Lafayette, Piankatank, and Lynnhaven Rivers, Virginia, to quantify fish and crab use of different kinds of reefs. Researchers are also quantifying how use of oyster reefs by fish and crabs varies based on reef height and type, prey availability, and geographic location. Prey availability is being quantified via benthic macrofaunal sampling. In general, researchers found that macrofaunal density and biomass are a positive function of oyster biomass on the reefs where experiments were conducted.
- **University of Maryland/VIMS, "Integrated Assessment of Oyster Reef Ecosystem Services: Macrofaunal and Productivity Utilization, Secondary Production, and Nutrient Sequestration,"** also seeks to quantify macrofaunal communities in relation to oyster biomass density on restored reefs. Sampling baskets were deployed in eight sites in Harris Creek. Sampling was accomplished in May, June, August, October, and December; species identification, enumeration, and biomass analyses are complete for the dominant macrofaunal species. In addition, three reef areas representative of low, medium, and high oyster biomass were selected; baskets were deployed in these locations and left to equilibrate for roughly a month before being analyzed. Initial processing of these samples is complete; identification of samples (number, species, biomass) is still under way.
- **VIMS, "Integrated Assessment of Oyster Reef Ecosystem Services: Fish and Crustacean Utilization, Secondary Production, and Trophic Linkages,"** samples for fish utilization and analyzes gut content to compare finfish and crustacean communities at restoration sites and nearby nonrestored sites in Harris Creek, Maryland. While gillnets and trawls were successful at capturing a variety of species, fish traps and crab pots were not. Only white perch and striped bass were sufficiently abundant to support analysis, and there was no clear relationship between oyster biomass density and the striped bass or white perch that were caught. However, gut content analysis did suggest that those species used the oyster reefs as a foraging ground. Following suggestions from a previously funded study, in summer 2015, researchers performed parallel creek-level sampling efforts to compare utilization of Harris Creek and the nearby Tred Avon River, where less reef restoration has taken place. Previous research also indicated that adult toadfish were being undercounted using proposed sampling gear, so in collaboration with North Carolina State University's Center for Marine Science and Technology, hydrophones were deployed in Harris Creek May-June 2015. Preliminary results indicate that toadfish vocalizations were recorded—and abundant. Results from earlier years' sampling efforts will help researchers fine-tune when during the year they will focus their future sampling work. The project also examines macrofauna on reefs; last year the researchers deployed baskets into the bottom that were then retrieved at a later date for analysis. While some information was gleaned from this effort (including a positive correlation between oyster reef biomass and mud crab abundance), next year, researchers will explore using suction sampling rather than deployed baskets. Baskets often showed signs of interference—whether intentionally, as by toadfish looking for food, or unintentionally, as by fishing gear.

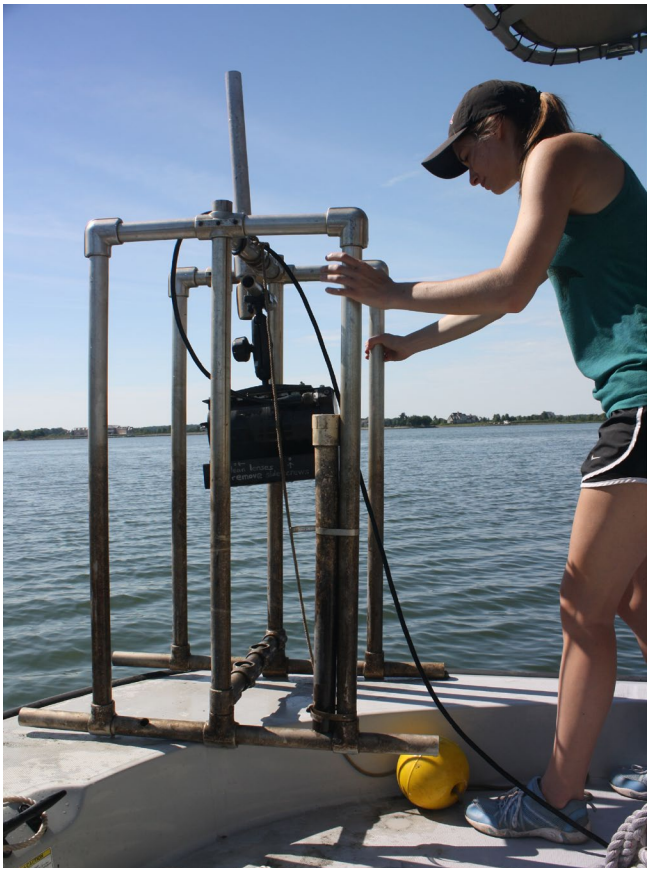
Virginia Institute of Marine Science's Eastern Shore Lab staff collect fish from a gillnet. (VIMS photo)

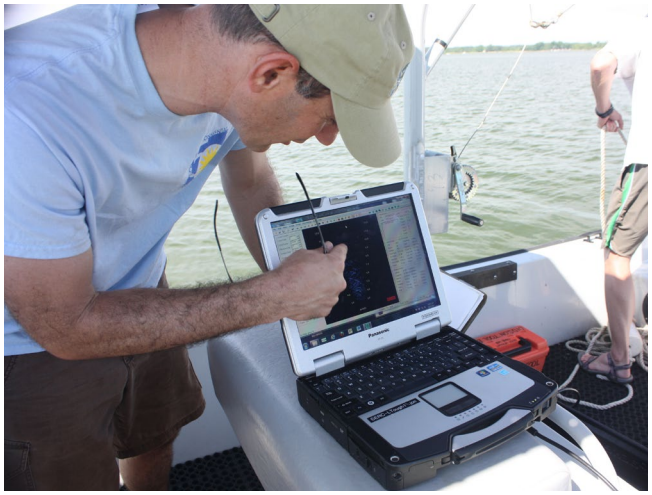
- **University of Maryland Center for Environmental Science (UMCES)/VIMS, "Integrated Assessment of Oyster Reef Ecosystem Services: Quantifying Denitrification Rates and Nutrient Fluxes,"** seeks to quantify denitrification rates in relation to oyster biomass density, and to track seasonal patterns and determine annual rates of denitrification and nutrient fluxes. This research will help quantify the uptake and storage of nutrients and elements (like nitrogen) by oyster reefs that could otherwise potentially contribute to algal growth and dissolved oxygen problems. Samples were collected from eight reef sites in Harris Creek that include a range of biomass density in May, June, August, October, and December, and lab work was completed. Additional research was conducted in summer 2015 on three of those eight reefs that represent low, medium, and high oyster biomass density. Analysis shows that the rates of oxygen uptake and metabolism in sediments associated with reefs are much higher than in non-reef sediments. Rates of reef denitrification in Harris Creek are already quite high; the existing reef area in Harris Creek is sufficient to exert an important effect on carbon and nitrogen balances.

- **UMCES, "Natural Engineers in Ecosystem Restoration: Modeling Oyster Reef Impacts on Particle Removal and Nutrient Cycling"** is developing an enhanced computer model to describe how oyster reefs benefit the ecosystem. Researchers made improvements to an existing model, highlighted by making significant headway in characterizing the biodeposition aspects of the model, and by making important decisions about links between sediments and phytoplankton in the water column. Researchers also implemented the current version of the model in Harris Creek in order to identify ideal site locations for validation of the model.

- **Virginia Commonwealth University (VCU), "Pathways to Production: An assessment of fishery responses to oyster reef restoration and the trophic pathways that link the resource to the reef"** is focusing on fish utilization of reefs in the Piankatank River. Using gill nets and fish traps, they have captured 33 different species, representing a wide and interesting array of fish. Many of the fish have been tagged before being released; 6 have been recaptured. While the project is designed to track fish use of reef areas before and after restoration, and researchers will continue to do so at existing control sites and restored reefs, no reef building was performed during the past year. VCU researchers are in touch with U.S. Army Corps of Engineers, The Nature Conservancy, and Virginia Marine Resource Commission to try to determine plans for new restoration work in the Piankatank.

- **Smithsonian Environmental Research Center (SERC), "Application of Dual-frequency Imaging Sonar to the Study of Oyster Reef Ecosystem Services,"** is conducting a study to determine how many fish and crabs encounter—and then enter and get trapped in—fish traps in several tributaries. While analysis of data is still under way, daytime deployment of fish traps in Harris Creek at a variety of sites for 2 ½ hours at a time during the day yielded no trapped fish or crabs. Another trapping experiment, in the Tred Avon River, left the traps for 24 hours; while crabs entered traps in both day and night, fish only entered from dusk to dawn. Both fish and crabs had a very low capture rate—only one of 13





Data acquired by DIDSON (Dual-Frequency Identification Sonar, top) can be viewed as a "video" to track fish and crab abundance on oyster reefs.

fish and one of 16 crabs that entered the trap were actually "trapped"; the others made their way back out. To augment research, SERC researchers are also using a DIDSON (Dual-Frequency Identification Sonar—essentially video captured by sonar) to track fish and crab abundance at restored and unrestored sites. DIDSON was used monthly from June to October in the Tred Avon River at NCBO fish trapping sites, within a week of the NCBO field work each month. They conducted similar sonar surveys at VIMS's Harris Creek sites, alternative substrate reefs in Harris Creek, and both power-dredge and hand-tong areas of Broad Creek. SERC has analyzed data on fish and crabs observed by the DIDSON; preliminary analysis does not indicate consistent differences between control sites and sites where restoration work has taken place. SERC researchers also explored using GoPro video cameras to investigate restored reefs, and determined that while this video is potentially highly useful for tracking visual differences among sites and changes to the bottom habitat, it was not possible to use the GoPro video to count live oysters.

NCBO and Partner Ecosystem and Economic Modeling

Experts at NCBO and partner organizations are using results from ORES field studies and literature to develop a food web model of a typical Chesapeake oyster reef. Scientists at NCBO and partner organizations are working to quantify ecological production functions of oyster reefs before and after large-scale restoration in selected Bay tributaries. As these production functions are defined, economists from the NOAA Fisheries Office of Habitat Conservation and academic partners at Morgan State University's Patuxent Environmental and Aquatic Research Laboratory will be able to develop socioeconomic models that will be able to put dollar values on the reefs' ecosystem services.

Next Steps

Work in all three aspects of ORES will continue in 2016. NCBO study sites will be seeded with juvenile hatchery oysters prior to the summer sampling season, and are thus a step closer to full restoration status. In addition to continuing the standard ORES trap line sampling from June through September, the NCBO team intends to continue exploring gear efficiency in collaboration with ORES partners and will examine whether time of day the traps are deployed and retrieved affects numbers and variety of fish and crabs collected.