Update on NOAA Chesapeake Bay Office-funded ORES Research Projects

Natural Engineers in Ecosystem Restoration: Modeling Oyster Reef Impacts on Particle Removal and Nutrient Cycling
Lora Harris, University of Maryland Center for Environmental Science

What questions are you trying to answer through your research?
Recent research has shown that oyster reefs are hotbeds of biogeochemical processes, especially for nitrogen. High levels of nitrogen entering the Chesapeake Bay have led to eutrophication; where increased phytoplankton production contributes to poor water quality. We are developing a numerical model that will help us to better quantify the impact of oyster reef restoration on nitrogen removal and cycling. Our model includes details related to the oyster reef structure, interaction with the water column, and the age structure of the oysters on the reef. We are interested in understanding whether different approaches to restoration (reef size, dimensions, etc.) may be optimized to increase nitrogen and particle removal.

Why do you think your research is important—how do you envision decision makers or other scientists using your results?
A numerical model offers a community the opportunity to quantitatively test hypotheses through simulations. In this way, a model can be a diagnostic tool for testing our understanding of a system or process. We envision our interactions with decision makers and other scientists to include opportunities to scale up empirical results to whole-reef estimates, to test our approaches to restoration by leveraging the ability of a model to simulate longer time scales, and to help identify questions and challenges that may need to be answered with future research.

What is your rough timeline, from determining your research process, to field work, to lab work, to analysis and conclusions?
Because we are not carrying out empirical work, our timeline focuses on improvements to an existing advection-diffusion model. Model development typically follows a cycle of first describing the problem to model and conceptually characterizing the processes and state variables that should be included; we have done much of this work as part of the proposal process. We then move on to model formulation, parameterization, calibration/skills assessment, and finally to simulation. In this first year, we are focused on development of nitrogen cycling biogeochemistry in the model, as well as simulating primary production by the phytoplankton flowing around the oyster reef, and bioenergetics for the oysters themselves. We expect to have a working model by the end of this first year of the project.

Are you using any new/innovative technologies or methods in your research?
Coupling the physical mechanisms of how the rough oyster reef affects water flowing over the oysters and their access to particles with a numerical model is an innovative tool for simulating these processes. A key aspect of our model is the individual-based modeling we are doing of the oysters, which is then coupled to systems-level processes related to nutrient cycling and hydrodynamics—this is a new approach to modeling biogeochemistry along with physics that we think represents an exciting way forward for exploring how oyster reef restoration may be optimized for positive impacts to water quality and fisheries goals.

Integrated Assessment of Oyster Reef Ecosystem Services: Quantifying Denitrification Rates and Nutrient Fluxes
Jeff Cornwell, University of Maryland Center for Environmental Science

What questions are you trying to answer through your research?
The fundamental question of my research is whether the restored oyster communities in Harris Creek efficiently remove nitrogen through incorporation into biomass or by facilitating microbial denitrification. Results in a Choptank River oyster reef near Cambridge have suggested that denitrification rates are exceptionally high; Harris Creek represents an opportunity to assess nitrogen ecosystem services as the restored reefs mature.

Why do you think your research is important—how do you envision decision makers or other scientists using your results?
The retention and transformation of nitrogen in oyster reefs has been cited as a way to curb eutrophication in coastal estuaries ranging from coastal Texas to the Potomac River. The one published study in the upper Choptank River is being extrapolated to many different estuarine settings; we need more data now to assess whether the enthusiasm for this approach to mitigating eutrophication is warranted. We expect these results to directly feed into decision making regarding the efficacy of oyster restoration for nutrient "offsets" from other activities within the watershed.

What is your rough timeline, from determining your research process, to field work, to lab work, to analysis and conclusions?
This program is designed to follow the Harris Creek oyster reef development for four years. We expect to have significant conclusions by the end of 2015, and already have data that provides insights into where denitrification occurs in the reef setting. Our NCBO program will provide the backbone data of Harris Creek oyster nitrogen assessments, with supplemental funding from TNC and the National Science Foundation to expand our understanding of fundamental processes.

Are you using any new/innovative technologies or methods in your research?
We are applying techniques developed in our earlier Choptank oyster work that provided the first reef measurements of denitrification. By including the whole reef community, our results suggest that the interplay between animal and microbial communities is key to efficient nitrogen removal. We will be developing a host of different incubation approaches to tease out the underlying biological and biogeochemical controls of nitrogen cycling processes. Sort of "it takes a village," if that village also includes polychaete worms that inhabit oyster shell!

Ecosystem Services of Restored Oyster Reefs in Lower Chesapeake Bay
Rochelle Seitz, Virginia Institute of Marine Science

What questions are you trying to answer through your research?
How do finfish and blue crabs utilize oyster reefs in relation to reef characteristics, environmental conditions, geographic location and prey availability in the Great Wicomico, Lynnhaven, Lafayette, and Piankatank Rivers of the lower western shore of Chesapeake Bay? What is benthic prey availability at the various reefs? What is the bias of baited traps in estimating use of reefs by finfish and blue crabs? What is the diet of finfish and blue crabs at the reefs?

Why do you think your research is important—how do you envision decision makers or other scientists using your results?
These findings are expected to provide the scientific basis for determining the ecological value and benefits of different types of restored oyster reefs, and subsequently to estimate the economic return of public investment in oyster reef restoration. This information will facilitate decision making by managers. This will aid in optimizing oyster reef design to maximize ecosystem services. This will provide the basis for ecosystem-based fishery management, particularly in lower Chesapeake Bay.

What is your rough timeline, from determining your research process, to field work, to lab work, to analysis and conclusions?
Field work has already started (fall 2013). Lab work is under way through winter months (sorting samples in the lab, examining video, gut-content analysis). Analyses are continually occurring; graduate students and faculty are preparing results for scientific presentations at conferences.

Are you using any new/innovative technologies or methods in your research?
Yes, we are using underwater video to view fish and crab utilization of the reefs. We are collaborating with the NOAA mapping team to use detailed side-scan sonar maps to examine oyster reef features and get estimates of “rugosity” (i.e., structural complexity). We may use sonic tracking of fish and/or crabs if funds allow.

Pathways to Production: An Assessment of Fishery Responses to Oyster Reef Restoration and the Trophic Pathways That Link the Resource to the Reef
Stephen McIninch, Virginia Commonwealth University

What questions are you trying to answer through your research?
Basic questions: 1) How does reef construction alter riverine fish communities? 2) How do fishes benefit from oyster reefs? To what degree do benefits extend beyond the reef? Do species that use the reef "in passing" benefit significantly and can that benefit be quantified? 3). Can we connect isotopic signatures of oyster reef inhabitants to its basal food source and to those fishes that are resident and/or visitors to the habitat?

Why do you think your research is important—how do you envision decision makers or other scientists using your results?
The ecosystem services of oyster reefs, as they pertain to fishery resources, have mostly been documented qualitatively and with some difficulties associated with the more transient species. Many of our commercially and recreationally important species are, at most, part-time residents of oyster reefs. We hope that our research will help better quantify the use of reefs by these important fishes and the benefits they obtain from reefs. This, in turn, will allow restoration efforts to more precisely define the benefits of their services to the ecosystem as a whole.

What is your rough timeline, from determining your research process, to field work, to lab work, to analysis and conclusions?
The first year or two will focus on documenting patterns of fish movements around existing reefs habitats, control areas and those reefs in various stages of production (soon to be built through completion). As fishes are captured, tissue and gut contents will be collected and analyzed in the lab (mostly second and third year). Stable isotope analysis will likely be performed in year three. As fishes are captured, tissue and gut contents will be collected and analyzed in the lab (mostly second and third year). Stable isotope analysis will likely be performed in year three followed by conclusions and final report.

Are you using any new/innovative technologies or methods in your research?
While we are not necessarily using new technologies, we are using a few technologies in different ways. We will be using echosounders to provide us with underwater acoustic surveys of reef and non-reef habitats. Instead of deploying the transducers to assess the water column from top to bottom, we will be surveying horizontally across the various habitats (control, new reef, old reef). This will allow us to be more quantitative in our assessment of habitat usage by transient fish species. We will also be measuring stable isotopes (C, N, and perhaps S) in order to assess ratio in the context of trophic level and food web interactions in and around reef habitats. We will use preliminary diet data, along with the stable isotope analysis (SIA), to identify the organic matter source(s) and energy flow of the riverine community and estimate proportion of energy derived from the oyster reef habitat. These data will be used to assess/model the contributions from basal source to fishery resource (i.e. our target species, Bluefish, Striped Bass, Atlantic Croaker and others).

Application of Dual-Frequency Imagine Sonar to the Study of Oyster Reef Ecosystem Services
Matt Ogburn, Smithsonian Institution

What questions are you trying to answer through your research?
Our study is designed to help quantify the fishery resource productivity of restored oyster reefs as compared to unrestored control sites. Our study uses multi-beam sonar to achieve two main objectives. The first is to document behavioral interactions of fish with traps used to assess fish abundance. The second is to conduct a multi-year, trap-independent study of finfish and crab abundance and size distribution that complements the current trapping study.

Why do you think your research is important—how do you envision decision makers or other scientists using your results?
The results of this study will both aid in the interpretation of fish abundance data from traps and provide a second, independent assessment of fishery resource productivity of restored oyster reefs.

What is your rough timeline, from determining your research process, to field work, to lab work, to analysis and conclusions?
We anticipate that project design will begin in February 2015 and will include discussions with other scientists and decision makers to determine the optimal study design. Field work will take place from June-November each year, and extensive data analysis will be required in the lab. We anticipate that conclusions regarding fish behaviors will be available in early 2016 and final conclusions on fishery production will be available by early 2018.

Are you using any new/innovative technologies or methods in your research?
We are using multi-beam imaging sonar, also known as Dual-frequency Identification Sonar (DIDSON). This technology allows for real-time recording of fish abundance, size distribution, and behavior. More information can be found at www.soundmetrics.com.