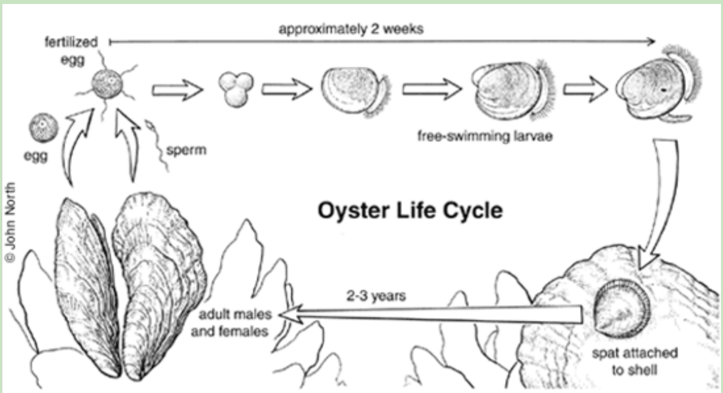
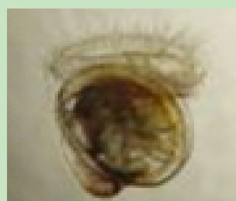
NOAA CHESAPEAKE BAY OFFICE

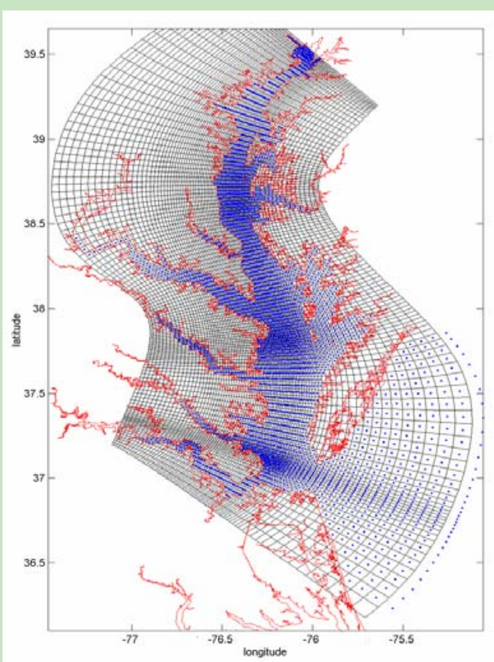
Non-native Oyster Research

Research Topics:

Oyster larval behavior and transport







Quarterly Review
Spring 2007

Background

Decline in abundance of the native oyster, *Crassostrea virginica*, in the Chesapeake Bay has led to the collapse of a formerly productive fishery and the loss of significant ecological services. Two oyster diseases, MSX and Dermo, have contributed at least in part to the decline, and continue to challenge oyster restoration efforts. In response to this situation the State of Maryland and Commonwealth of Virginia have proposed to intentionally introduce a non-native oyster species, *Crassostrea ariakensis*, which has greater resistance to the pathogens responsible for MSX and Dermo. Considerable controversy exists over the proposed course of action and many questions remain about the implications of such an introduction.

In 2003 the U.S. Congress authorized the Army Corps of Engineers to prepare an Environmental Impact Statement (EIS) to examine both the risks and benefits of introducing this species to the Chesapeake Bay. The EIS is being conducted by the Corps as the lead federal agency, with the Maryland Department of Natural Resources (MDNR) and the Virginia Marine Resources Commission (VMRC) serving as lead state agencies. The U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and Fish & Wildlife Service (FWS) are cooperating agencies on the EIS.

In 2004 the NOAA Chesapeake Bay Office (NCBO) initiated a 3-year Non-native Oyster Research program funded at $2M annually to obtain the scientific information needed to evaluate the proposed Asian oyster introduction. The program is aimed at research priorities recently identified by the National Research Council (NRC) and the Scientific and Technical Advisory Committee of the Chesapeake Bay Program (STAC), as well as guidance from the International Code of Practice on the Introductions and Transfers of Marine Organisms.

Research findings are reviewed quarterly at meetings or web conferences sponsored by NCBO and hosted by the Chesapeake Research Consortium. Invitees include scientists conducting research relevant to the EIS, representatives from federal and state agencies, and other interested management groups. These quarterly review sessions are designed to facilitate timely discussions of research results among scientists and managers, and speed the transfer of information to the EIS evaluation process. It must be emphasized that the findings of ongoing research are preliminary. Additional time will be required for the projects to be completed, and the results to be peer reviewed.

Summary reports of all Quarterly Reviews and additional information on NOAA's Non-native Oyster Research initiative are available at http://chesapeakebay.noaa.gov/.

Spring 2005	Overview of research topics: Taxonomy, genetics, disease, human health, ecology, interspecific interactions, ecosystem services and functions
Summer 2005	Aquaculture options: Biological and economic factors affecting aquaculture production of native and non-native oysters in the mid-Atlantic
Fall 2005	Potential for *Crassostrea ariakensis-C. virginica* interactions: Larval substrate selection, post-settlement competition, and fertilization interference
Winter 2006	Evaluating human health risks: Uptake, depuration, and post-harvest levels of waterborne human pathogens in *Crassostrea ariakensis* compared with *C. virginica*.
Spring 2006	Special session on *Crassostrea ariakensis* at the 98th Annual National Shellfisheries Association meeting
Summer 2006	Comparative growth and mortality of *Crassostrea ariakensis* and *C. virginica*: Providing additional data for the oyster demographic model
Fall 2006	Understanding *Crassostrea ariakensis* within its native range in Asia
Winter 2007	Oyster Pathogens: Susceptibility and transmission; Effects of harmful algal blooms
Spring 2007	Oyster larval behavior and transport

Oyster larval behavior and transport

Why is this research important for the EIS?

Many aspects of larval behavior such as vertical migration, responses to environmental conditions, substrate preferences, and settlement cues are fundamental for understanding and predicting oyster population dynamics. However, little was previously known about how *C. ariakensis* larvae behave, or how their behavior compares to that of *C. virginica*. Rates of larval mortality due to predation are also important, since most oysters die as larvae before they even settle.

Differences in larval survival, dispersal, and recruitment could affect whether or not *C. ariakensis* will be able to establish a reproducing population, or how it might compete with *C. virginica* if it is introduced into the Chesapeake Bay. Understanding the settlement preferences of *C. ariakensis* will also help us predict if it is likely to become a fouling nuisance.

While some larval behavior can be observed in the lab, predicting patterns of dispersal and settlement on a Bay-wide scale requires the use of a model. The 2004 STAC report, *Identifying and Prioritizing Research Required to Evaluate Ecological Risks and Benefits of Introducing Diploid* C. ariakensis *to Restore Oysters to Chesapeake Bay*, identified as a high priority for the EIS "models to predict larval dispersal, the potential for population growth, and habitat effects on these processes". Another high priority was research on physiological and behavioral characteristics of *C. ariakensis* and *C. virginica* larvae such as growth, environmental tolerances, settlement, and post-settlement mortality to parameterize these models.

Presentations at this quarterly review included recent findings from research on these important parameters, as well as a larval transport model that has been developed to support the EIS evaluations. This model has provided some interesting insights into how *C. ariakensis* and *C. virginica* larval behavior might influence their dispersal and recruitment patterns in Chesapeake Bay under varying environmental conditions. Results of larval behavior studies and the larval transport model have significant implications for both the EIS and native oyster restoration efforts.

Presentations:

Denise Breitburg and Richard Fulford (UMCES) – Will predation mortality differ for larvae of native and non-native oysters? (PIs: Breitburg, Fulford, Luckenbach, Newell)

Joan Manuel (UMCES) – Behavioral responses of *Crassostrea ariakensis* and *Crassostrea virginica* larvae to environmental change under spatially realistic conditions (PIs: Manuel, Newell, Kennedy)

Mario Tamburri (UMCES) – Settlement of *Crassostrea ariakensis* larvae: Effects of substrate, biofilms, sediment and adult chemical cues (PIs: Tamburri, Luckenbach, Breitburg, Boniwell)

Elizabeth North (UMCES) – The influence of larval behavior on spatial patterns in settlement and population connectivity (PIs: North, Schlag, Hood, Li, Zhong, Gross, Kennedy)

Some preliminary findings:

Larval settlement

- Laboratory experiments have shown many similarities in the settlement behavior of *C. ariakensis* and *C. virginica*. Larvae of both species prefer to settle on substrates that are free of sediment, and favor natural substrates (such as shell or granite) over manmade surfaces (such as PVC, fiberglass, or steel). The presence of a biofilm on the substrate also greatly enhances larval settlement in both species.
- One significant difference in settlement is that *C. ariakensis* had a greater tendency than *C. virginica* to settle on manmade surfaces (in particular fiberglass) but it is unclear if this difference would result in an increased potential to become a fouling nuisance.
- The settlement of both species was found to be significantly greater in the presence of waterborne chemical cues. *C. ariakensis* and *C. virginica* larvae settled more often on shell surfaces when the scent of oysters was present in the water but the cues were not species-specific.

Larval predation

- There are significant differences in coloration, size, and swimming behavior between *C. ariakensis* and *C. virginica* larvae, and among *C. ariakensis* larvae from different source populations. Such differences are likely to affect their encounter rates with predators, capture rates, and hence their mortality rates. Observations of larvae reared under identical conditions of salinity (20ppt), temperature (24-25^{o}C), and diet found the following characteristics:

Oyster species/stock	Coloration	Mean shell length at eyed stage (std. deviation)	Swimming behavior
C. virginica	Light brown to tan	273.3 (16.5)	Swim near surface until late stage of development
C. ariakensis South China strain	Salmon to pink	330.4 (17.7)	Swim consistently near the bottom throughout development
C. ariakensis West Coast strain	Rust colored to dark brown	367.2 (13.7)	Larvae distributed throughout, water column but most near bottom

- Preliminary results from experiments on larval predation of *C. virginica* and *C. ariakensis* indicate that the common ctenophore (*Mnemiopsis leidyi*, a gelatinous zooplankton predator) has a tendency towards higher predation on *C. ariakensis* larvae than on *C. virginica* larvae. Differences were not statistically significant, however, and additional replicates are being conducted during Summer 2007. Predation rates increase with increasing prey densities.

Behavioral response to environmental changes

- Laboratory experiments in both acrylic columns (45 cm depth) and mesocosms (200 cm depth) have revealed that vertical migration patterns of oyster larvae are complex, and are clearly altered by the presence of haloclines (vertical salinity gradients in the water column). Larval distribution within the water column is altered by haloclines as weak as 0.25 ppt.
- In general, *C. virginica* larvae tend to be evenly distributed from the surface to 200 cm depth in the absence of a halocline, but will aggregate above the halocline when one is present. In contrast, *C. ariakensis* larvae always tend to aggregate near the bottom even in the absence of a halocline, and the presence of a halocline increases their bottom-hugging behavior.
- Larvae of *C. ariakensis* and *C. virginica* do not appear to differ in swimming speed during vertical migrations. Thus, interspecific differences in vertical distribution of larvae are due to behavioral differences, rather than species-specific swimming capabilities.
- *C. virginica* larvae from source populations in different tributaries within Chesapeake Bay exhibit different behavior patterns. This is not only important for parameterizing larval transport models, but also suggests the need to use local (e.g., tributary-specific) brood stock for native oyster restoration projects.

Modeling larval behavior, settlement, and population connectivity

- Results from the larval transport model developed for the EIS indicate that larval behavior influences settlement success, larval dispersal distance, and population connectivity. A management implication is that spatial patterns in oyster harvest will not have the same impact on species or strains that have different larval behaviors.
- Successful recruitment of oyster larvae is influenced by environmental conditions such as freshwater flows and hydrodynamic patterns. As a result, modeled predictions of oyster recruitment differ between basins and years.
- Some bars act as more effective larval sinks than others, and conversely, some bars are better producers of larvae than others. These differences between basins or bars are due to their location relative to suitable habitat and flow patterns. Improved understanding of these relationships would help guide the placement of sanctuaries and other oyster restoration strategies.

- Model runs also demonstrate low 'natal returns' (i.e., recruitment of larvae to the same bar from which they were produced), indicating dependency of populations on multiple bars. This result suggests that restoring isolated bars may not be the most effective strategy for oyster population restoration.

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