

WASHINGTON SEA GRANT FINAL REPORT

for the period 2/1/2007 – 12/31/2007

WSG Project Number: **R/ES-62**
Project Title: Context-dependent impacts of an invasive predator on a threatened native oyster: implications for restoration

Principal Investigator(s) and Affiliation:
Jennifer Ruesink Department of Biology, University of Washington

1. ABSTRACT ELEMENTS

OBJECTIVES

Long term: Collaborate on regional restoration of Olympia oysters, particularly through mitigation of introduced predators. Short-term: Quantify the impacts of invasive drills (1) across sites and (2) relative to recruitment limitation of oysters. (3) Determine prey preferences of drills. (4) Experimentally examine per capita impacts of drills on oysters (drill functional response, size selectivity of predation, and the indirect effect of alternative prey on Olympia oyster mortality) and the reciprocal “bottom-up” influence of prey abundance on drills.

METHODOLOGY

(1) We will measure mortality of Olympia oysters outplanted in drill-infested sites, and test the relationship between drill predation rate and local drill density. We will also test whether per capita drill predation rates vary with natural densities of oysters and other prey. (2) Olympia oyster recruitment will be measured using standard substrates (shellstrings) to test the correlation between recruitment and local oyster density. (3) Prey preferences will be calculated using standard indices based on field observations of drill feeding and prey availability. (4) We will manipulate drill, oyster, and alternative prey densities in field enclosures and use the data to parameterize models of single- and multi-species functional response. These experiments will also test the effects of prey density on drill growth and fecundity. We will compare model predictions with field measurements of per capita and total drill effects in relation to prey availability.

RATIONALE

The Olympia oyster (*Ostrea conchaphila*) suffered major declines in the Pacific Northwest due to overexploitation and pulp mill pollution, and has largely failed to recover despite the removal of these stressors. Predation by the invasive Japanese oyster drill (*Ocenebrina inornata*) is one factor potentially keeping Olympia oysters locally scarce. As interest increases in restoring *O. conchaphila*, it is important to understand the severity of invasive predator impacts and how they can be mitigated. This project will quantify patterns of variation in drill impacts, and evaluate the relative importance of drill abundance vs. per capita effect as drivers of this variability. We will complement field measurements of oyster mortality and recruitment with small-scale

experiments to test the specific hypothesis that per capita drill impacts decline with increasing prey abundance due to drills' saturating functional response. This approach will yield a mechanistic understanding of predator-prey dynamics that could help to prioritize sites for drill control and identify possible thresholds for oyster recovery.

2. ACCOMPLISHMENTS AND OUTCOMES

We quantified key components of the predator-prey interaction between invasive Japanese drills and native Olympia oysters. Using a combination of comparative field observations and manipulative experiments, we found that drills exhibit a strongly nonlinear saturating functional response. This leads to depensatory mortality in oysters—that is, drill impacts are most severe at sites where oysters are rare. Drill predation may thus contribute to keeping oyster populations depressed. Our results also identified barnacles as an important and strongly preferred alternative prey item for drills. In the short term, high barnacle density can shelter native oysters from predation by swamping the feeding rate of drills. Together, drills' nonlinear functional response to oyster and barnacle density explained 65% of the variation in predation impacts on native oysters measured at seven sites in 2004-2005. In 2007 we conducted an experimental removal of drills at an active oyster restoration site to compare the efficiency and effectiveness of alternative control strategies (direct removal vs. baiting). Removals did not measurably reduce drill densities at the scale we examined, but per-capita predation impacts differed considerably between habitat patches in different successional stages, suggesting that mitigation of drill impacts may be a more successful management strategy than eradication.

3. IMPACTS

Sea Grant encourages ecosystem approach to native oyster restoration. The Olympia oyster (*Ostrea conchaphila*) suffered major declines in the Pacific Northwest due to overexploitation and pulp mill pollution, and has largely failed to recover despite the removal of these stressors. Predation by the invasive Japanese oyster drill (*Ocenebrina inornata*) is one factor potentially keeping Olympia oysters locally scarce. Sea Grant-supported researchers have developed predator-prey models to identify biological characteristics of sites where invasive drills pose a high risk to native oysters. **Impact:** State agencies and NGOs can use these models to develop mitigation strategies and to forecast where restoration efforts are likely to fail due to introduced predators. Ongoing native oyster restoration projects by The Nature Conservancy and Puget Sound Restoration Fund are specifically addressing potential risk from oyster drills.

4. PERFORMANCE MEASURES

Measure 2: Cumulative number of coastal, marine, and Great Lakes issue-based forecast capabilities developed and used for management.

Actual (reporting period covered by this report):

1 new forecast capability applied to use - model that predicts native oyster survival as a function of invasive drill and prey densities was used to increase the chances of successful oyster restoration in Liberty Bay, Puget Sound

Anticipated (12-month period following this reporting period):

1 new forecast capability will be developed and applied to use - model evaluating the efficacy of alternative invasion control techniques at improving native oyster survival and restoration

Measure 3: Percentage/number of tools, technologies, and information services that are used by managers (NOAA and/or its partners and customers) to improve ecosystem-based management.

Actual (reporting period covered by this report):

1 service provided and applied - collaborative project with Puget Sound Restoration Fund and The Nature Conservancy to control drills and enhance native oyster recovery in Liberty Bay (summer 2007).

Anticipated (12-month period following this reporting period):

5. PUBLICATIONS

(Please provide a list of ALL publications derived from this project. i.e. for the full project duration. Please refer to instructions for hardcopy reprint requirements and citation formats).

A. Journal articles:

Buhle ER and Ruesink JL (2009) Impacts of invasive oyster drills on Olympia oyster (*Ostrea lurida* Carpenter) recovery in Willapa Bay, Washington, USA. Journal of Shellfish Research, in press

White JM, Buhle ER, Ruesink JL, and Trimble AC (2009) Evaluation of Olympia oyster (*Ostrea lurida* Carpenter 1864) status and restoration techniques in Puget Sound, Washington, United States. Journal of Shellfish Research, in press

Buhle, ER (In prep) Variation in the impact of an invasive marine predator on a threatened native prey: the role of nonlinear species interactions

B. Theses and dissertations:

Buhle ER (2007) The role of nonlinear feedbacks in the establishment, impact, and control of marine invasive species. PhD dissertation, University of Washington, Seattle, WA

Henson KD (2007) Control Strategies for Japanese Oyster Drill and Implications for Restoration and Management of Olympia oyster (*Ostrea conchaphila*) in Liberty Bay, Washington. MSBT dissertation, University of Washington, Seattle, WA

E. Paper in Proceedings

Henson KD and Buhle ER (2008) Control strategies for Japanese oyster drill and implications for restoration and management of Olympia oyster (*Ostrea conchaphila*) in

Liberty Bay, Washington. In: West Coast native oyster restoration: 2007 workshop proceedings. US Department of Commerce, NOAA Restoration Center, Silver Spring, MD, p. 42

Buhle, ER and Ruesink JL (2007) Impacts of invasive drills on Olympia oysters in Puget Sound: implications for restoration. In: West coast native oyster restoration: 2006 workshop proceedings. US Department of Commerce, NOAA Restoration Center, Silver Spring, MD, p. 31

6. PRESENTATIONS - inc. Conference (Poster or Oral), Seminar & Public

Buhle ER and Henson KD (2008) Variable impacts of an invasive marine predator on a threatened native prey. Oral presentation at the Ecological Society of America, Milwaukee, WI, August 7

Henson KD. Control Strategies for Japanese Oyster Drill and Implications for Restoration and Management of Olympia oyster (*Ostrea conchaphila*) in Liberty Bay, Washington (M.S. defense). Presentation to the Department of Biology, University of Washington, Seattle, WA, November 29 2007

Buhle ER. Invasive species and the resilience of coastal ecosystems (Ph.D. defense). Presentation to the Department of Biology, University of Washington, Seattle, WA, September 24 2007

Henson KD and Buhle ER (2007) Control strategies for Japanese oyster drill and implications for restoration and management of Olympia oyster (*Ostrea conchaphila*) in Liberty Bay, Washington. Oral presentation at the West Coast Native Oyster Restoration Workshop, Shelton, WA, August 14

Buhle ER and Ruesink JL (2006) Impacts of invasive drills on Olympia oysters in Puget Sound: implications for restoration. Oral presentation at the West Coast Native Oyster Restoration Workshop, San Rafael, CA, September 7

Buhle ER (2005) Variable impacts of an invasive predator on a threatened native oyster in Puget Sound, Washington, USA: patterns and mechanisms. Oral presentation at the 4th International Conference on Marine Bioinvasions, Wellington, New Zealand, August 25

Buhle ER (2005) Impacts of an invasive drill on a threatened native oyster: patterns and mechanisms. Oral presentation at the Pacific Coast Shellfish Growers Association 59th Annual Conference, Hood River, OR, September 27

Buhle ER. Variable impacts of an invasive drill on a threatened native oyster: patterns and mechanisms. Presentation to the Biology Department Graduate Student Symposium, Seattle, WA, December 2005

9. LIST ALL STUDENTS SUPPORTED BY OR AFFILIATED WITH THIS PROJECT

Student Name: Eric R. Buhle
Department: Biology
Major/Degree field: Biology
Major Professor: Jennifer Ruesink
Degree (Ph.D., M.S., M.A., B.S., B.A., etc): Ph.D.
Dissertation/Thesis title: The role of nonlinear feedbacks in the establishment, impact, and control of marine invasive species
Date of graduation (actual or anticipated): 2007
Approximate support or affiliation period (e.g., Jan – June 2005): June 2005 - November 2007
Type of support (RA, research costs, conferences – list all that apply): RA, Research costs
Current employment if applicable: National Research Council postdoctoral associate, NOAA Fisheries Northwest Fisheries Science Center

Student Name: Kyla Zaret
Department: Environmental Studies Program, The Evergreen State College
Major/Degree field: Environmental Studies
Major Professor:
Degree (Ph.D., M.S., M.A., B.S., B.A., etc): M.S.
Dissertation/Thesis title:
Date of graduation (actual or anticipated):
Approximate support or affiliation period (e.g., Jan – June 2005): June - September 2005
Type of support (RA, research costs, conferences – list all that apply): hourly technician

Student Name: Max Whetstine
Department: Biology Department, The Evergreen State College
Major/Degree field: Biology
Major Professor:
Degree (Ph.D., M.S., M.A., B.S., B.A., etc): B.S.
Dissertation/Thesis title:
Date of graduation (actual or anticipated): 2007
Approximate support or affiliation period (e.g., Jan – June 2005): June - September 2006
Type of support (RA, research costs, conferences – list all that apply): hourly technician

Student Name: Kate Henson
Department: Biology Department, University of Washington
Major/Degree field: Masters Program in Biology for Teachers
Major Professor: Jennifer Ruesink
Degree (Ph.D., M.S., M.A., B.S., B.A., etc): M.S.
Dissertation/Thesis title: Control Strategies for Japanese Oyster Drill and Implications for Restoration and Management of Olympia oyster (*Ostrea conchaphila*) in Liberty Bay, Washington
Date of graduation (actual or anticipated): 2007
Approximate support or affiliation period (e.g., Jan – June 2005): April - September 2007

Type of support (RA, research costs, conferences – list all that apply): research costs - Master's thesis research on drills and native oyster restoration in Liberty Bay

Student Name: Adam Shimer

Department: School of Fisheries and Aquatic Sciences, University of Washington

Major/Degree field: Fisheries

Major Professor: Jennifer Ruesink (capstone advisor)

Degree (Ph.D., M.S., M.A., B.S., B.A., etc): B.S.

Dissertation/Thesis title: The effectiveness of removal for the introduced Japanese Oyster Drill (*Ocenebrina inornata*) in Liberty Bay, Washington

Date of graduation (actual or anticipated): 2008

Approximate support or affiliation period (e.g., Jan – June 2005): June - September 2007

Type of support (RA, research costs, conferences – list all that apply): no monetary support - undergraduate capstone research on drills and native oyster restoration in Liberty Bay

Student Name: Alicia Godersky

Department: Biology Department, University of Washington

Major/Degree field: Biology

Major Professor: Jennifer Ruesink (independent research supervisor)

Degree (Ph.D., M.S., M.A., B.S., B.A., etc): B.S.

Dissertation/Thesis title:

Date of graduation (actual or anticipated):

Approximate support or affiliation period (e.g., Jan – June 2005): April - September 2007

Type of support (RA, research costs, conferences – list all that apply): no monetary support - independent research credits received for work on drills and native oyster restoration in Liberty Bay

10. INTERACTIONS

We applied our understanding of Japanese drill - Olympia oyster interactions in the context of an ongoing habitat enhancement project designed to rebuild the Olympia oyster population in Liberty Bay, Puget Sound. Working in collaboration with the Puget Sound Restoration Fund and The Nature Conservancy, we conducted an experiment comparing the effectiveness of alternative control methods for reducing drill densities, and evaluating the consequences for native oyster persistence and rebuilding. Results of this work are being used to help inform ongoing restoration efforts by these NGOs in Liberty Bay and elsewhere.

11. OUTREACH AND INFORMATION/TECHNOLOGY TRANSFER

We have presented our results at regional meetings (Pacific Coast Shellfish Growers Association, West Coast Native Oyster Restoration Workshop). We also worked closely with Puget Sound Restoration Fund and The Nature Conservancy to assess the impact of invasive drills on native oyster restoration at a project site where drill predation is an important factor limiting oyster survival. Our models and experimental results have been used to help design efficient strategies to mitigate these impacts. Continued monitoring (benthic sampling and measurement of predation rates on oysters in habitat enhancement plots) would help to place our results in a broader temporal context and ensure that restoration efforts continue to account for predation impacts.

12. FUTURE ACCOMPLISHMENTS AND IMPACTS

Our results will be directly applicable to ongoing, NOAA-funded efforts by Puget Sound Restoration Fund and The Nature Conservancy to restore native oysters in Liberty Bay, and more broadly to oyster restoration efforts throughout the region. More generally, our data and models will contribute to ecological understanding of the processes that drive variability in the impacts of aquatic nuisance species, and help inform effective management strategies.