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NORTHWEST WORKSHOP ON BIVALVE AQUACULTURE AND THE ENVIRONMENT

Talaris Conference Center, Seattle, September 13 and 14, 2007

The Northwest Workshop on Bivalve Aquaculture and the Environment was convened by Washington Sea Grant and the University of Washington, School of Aquatic and Fishery Sciences, in partnership with the Washington Department of Ecology, NOAA Fisheries Northwest Fisheries Science Center and the Northwest Regional Office, Washington Department of Natural Resources and Alaska Sea Grant College Program, on September 13th and 14th, 2007.

The workshop invited experts from the United States, Canada and Europe to share the latest research on a range of topics, including genetics and disease, culture of native species, use of predator exclusion structures, habitat utilization, water quality and public health. The information presented provided a baseline of current knowledge and the framework for identifying research and information needs.

This document provides a summary of the research and information needs identified during the workshop. Comments and recommendations are organized by panel theme. A full agenda and copies of presentations are available for download from the Washington Sea Grant Web site at: *www.wsg.washington.edu/research/geoduck/workshop_agenda.html.* The speakers are solely responsible for the contents of their materials. Washington Sea Grant, the University of Washington and partner workshop sponsors assume no responsibility for the contents, the accuracy of any information presented, or any views expressed. Questions regarding the presentation materials should be directed to the individual speakers. Comments and recommendations were recorded during the workshop discussion sessions and have not been subject to peer review or editorial revision.

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PANEL 1: GENETICS AND DISEASE

Presentations

Bivalve Life History and Genetics
Dennis Hedgecock (panel moderator), University of Southern California

Identifying Risks of Geoduck Aquaculture: The Role of Larval Transport
Juan Valero, School of Aquatic and Fishery Sciences, University of Washington

Geoduck Genetics: What We Know, What We Don't Know, and Why It Matters
Brent Vadopalas, School of Aquatic and Fishery Sciences, University of Washington

Discussion: Identification of research and information needs

Panel Recommendations

A summary of research and information needs identified by Panel 1 experts.

1. Investigate induction and consequences of triploid stock.
    a. Are triploids sterile?
    b. Do they undergo reversion?
    c. What is their growth and survival in different habitats?
    d. Can they give rise to tetraploids?
    e. In anticipation of the development of tetraploid stocks, can diploid geoducks be raised to maturity in captivity?
2. Make pedigreed families for investigation of the genetic basis of fitness traits.
    a. Estimate genetic and environmental components of variance for larval and adult traits important in aquaculture (growth, survival, tolerance of environmental extremes).
    b. Conduct a "common garden" experiment to determine the extent of local adaptation.
    c. Estimate inbreeding depression (requires spawning a second generation).
3. Modeling
    a. Hindcast spatial age-frequency distributions in Puget Sound geoduck populations to validate model.
    b. Determine "connectivity" management regions.
    c. What are the spawning source dynamics among geoducks at different depths? How does temperature come into play?
    d. Evaluate the relative contributions of larvae from farmed and wild stocks.

    e. What is the spatial and temporal variability in settlement/connectivity (e.g., with climate change)?
4. Is there post-settlement migration?
5. What is the size (age) / fecundity curve for geoducks?
6. Determine larval behaviors (salinity, temperature, geotaxis, phototaxis).
7. Determine larval settlement cues.

Group Discussion

Comments recorded during Panel 1 Q&A and general discussion.

- What is the congruence of larvae dispersal and salmon populations?
- What are the spawning source dynamics between geoducks at different depths? How does temperature come into play?
- Are there diploid life history traits that should be selected for to reduce interactions between cultured and wild stocks?
- Brood stock are slated to come from the same management region. Is that wise or important?
- Should we look at increasing the age-class variation instead of limiting to regions?
- Hindcast populations.
- What happens if there is post-settlement migration?
- What happens to settlement/connectivity in altered climate scenarios?
- How viable are larvae coming from young geoducks vs. older, more established clams?
- Do “young” geoduck larvae behave differently than “older” geoduck larvae (in terms of viability, etc.)?
- How do we differentiate hatchery spawn from natural populations?
- What is the size/fecundity curve for geoducks?
- Are geoducks at depth triggered to spawn by the same factors as geoducks at shallower locations?
- What is the field viability of tetraploid geoducks? What is the risk of using them to generate stock?

PANEL 2: EFFECTS OF AQUACULTURE STRUCTURES

Presentations

Intertidal Aquaculture as Habitat in Pacific Northwest Coastal Estuaries: Considering Scale
Brett Dumbauld, Hatfield Marine Center, Oregon State University

Environmental Effects of Shellfish Culture Structures along the Mid-Atlantic Region of the East Coast
Mark Luckenbach, College of William and Mary (panel moderator)

The net facts; or why a little bit of ecology is a good thing
Leah Bendell, Simon Fraser University

Effects of netting and other structures on benthic fauna
Michel Kaiser, School of Ocean Sciences, Bangor University, UK

Mud matters! The Importance of Unstructured Intertidal Habitats to a Mobile Benthic Predator, Cancer magister
Kirstin Holsman, People for Puget Sound

Discussion: Identification of research and information needs

Panel Recommendations

A summary of research and information needs identified by Panel 2 experts.

1. Identify some of the ecological alterations (or lack thereof) associated with the various phases of current and alternative geoduck aquaculture practices, including predator exclusion, harvesting practices and farm management.
    a. Evaluate changes in abiotic and biotic characteristics of the environment associated with culture structures.
    b. Determine potential impacts on prey species, target predator species and migratory species.
    c. Consider the spatial and temporal extent of direct and indirect effects on 1a & 1b.
2. Improve our understanding of how spatial scale, fragmentation and habitat heterogeneity associated with geoduck culture structures and competing uses of tidal flats affects ecological functions within the landscape.

   a. Relate spatial scale of effects (from #1) to meaningful regional scales, e.g., Drift cell dynamics
   b. Develop and utilize benthic habitat maps to evaluate landscape-level effects of geoduck farming and to inform managers about spatial considerations (such as sensitive areas, Endangered Species Act (ESA) listed species, eelgrass, social considerations).
3. Evaluate alternative farming practices (e.g., predator exclusion and harvesting techniques), both for their effectiveness and their potential to reduce undesirable impacts.
   a. Evaluate alternative approaches (structures and strategies) towards predator exclusion.
   b. Determine actual losses to predators under alternative exclusion methods.
   c. Evaluate the impacts and recovery times from alternative harvesting techniques. (Time constraint: outside the funding cycle.)
4. How do we make management decisions about geoduck aquaculture in the face of limited knowledge of ecological effects?
   a. Develop decision trees or matrices for managers, based on the current state of knowledge.
   b. Such a tool could be useful for management, given the range of jurisdictions involved.
   c. Could be used to identify important research gaps.

Group Discussion

Comments recorded during Panel 2 Q&A and general discussion.

- How do we regulate something [such as ecological effects of geoducks aquaculture] when we don't know anything [corrected to "limited information"] about it?
- Questions of scale and intensity, not necessarily for all of Puget Sound but for specific regions.
- What is the effected area, in terms of direct and indirect effects?
- Could Dungeness crab distribution into the noncomplex areas be a function of competition with the red rock crabs?
- How do you see [predator control] technology evolving? Are there any options for biodegradable materials that can be used for this?

PANEL 3: WATER COLUMN EFFECTS

Presentations

Water Column Dynamics in the Pacific Northwest
Jan Newton, Applied Physics Lab, University of Washington

Shellfish Restoration and Aquaculture Projects as a Means to Mitigate Coastal Nutrient Pollution
Michael Rice, University of Rhode Island

Understanding Shellfish Aquaculture Environments in North America and Europe by Combining Field Measurements with Computational Fluid Dynamics and Bioenergetic Models
Carter Newell, Blue Hill Hydraulics Incorporated

Early Warning of Toxins in Puget Sound Shellfish - SoundToxins
Vera Trainer, Northwest Fisheries Science Center

Scale and location influence the role of bivalves in mediating Benthic-Pelagic coupling
Roger Newell, Horn Point Laboratory, University of Maryland Center for Environmental Science

Discussion: Identification of research and information needs

Panel Recommendations

A summary of research and information needs identified by Panel 3 experts.

1. Obtain data on nutrient fluxes to the adjacent water and sediment effects of the main harvesting methods (e.g., collection of individual clams or harvesting the entire site completely). Undertake these studies at a diversity of existing geoduck aquaculture sites.

2. Develop geographic information system (GIS) with physical data layers of Puget Sound to identify all possible areas that are suitable for geoduck aquaculture, based on physical factors (water flow, salinity, sediment grain size, etc.) that are known determinants of geoduck growth. Survey state archives and other sources for locations of past bivalve aquaculture sites and landing/sales records as an index of past shellfish productivity, both within and outside areas planned for

geoduck production. Use this GIS to estimate if the scale and location of possible new geoduck aquaculture sites is of a magnitude and in locations that differ substantially from past shellfish production. Use this information to inform the public of the maximum possible extent of geoduck aquaculture in Puget Sound.

3. Identify new "experimental" geoduck aquaculture sites on state lands, close to where extensive water quality monitoring efforts are already underway. Undertake extensive initial site monitoring (for sediment chemistry, benthic communities, nutrient fluxes to the water column, etc.) and at suitable adjacent reference sites. Place monitoring devices/probes onsite and adjacent to site and perform long-term monitoring (seston and nutrient concentrations, water flow, etc). Initially integrate these data using GIS-based models with data layers including high resolution (e.g., 50 m grid) flow models, hydrodynamic effects of structures, seston concentrations, and shellfish biomass, to estimate site-level ecosystem effects. Ultimately, use these data to parameterize "ecological carrying capacity" models—create a framework for developing "ecological carrying capacity" mathematical models for bivalve mollusc aquaculture that can be used by managers to assess the influence of geoduck aquaculture on basin-level ecosystem processes in Puget Sound.

4. Establish different stocking densities on these experimental farm systems and then, in the request for proposals, ask/require that funded projects work at these sites, when feasible. In this way, the individual data sets can be combined and used for assessing the effects of culture and harvest methods.

5. Determine rates of domoic acid depuration in commercially viable Puget Sound shellfish.

6. Determine influence of anthropogenically-derived nutrients (as well as other factors) on the occurrences of harmful algal blooms (especially new events in new places) by measuring ammonium/urea concentrations at the same sites where phytoplankton monitoring is in place.

Group Discussion

Comments recorded during Panel 3 Q&A and general discussion.

- How does urban development in the Puget Sound region compare to shellfish aquaculture production activity in terms of relative effects on water quality, etc.?
- What is the recycling of nitrogen in the overall watershed?
- Monitoring of nitrogen from septic tanks and other point sources.
- How has the Growth Management Act facilitated a pattern of development that increases runoff bearing pollution?
- Can planting densities be scaled in relation to the amount of food available, hydrography, etc.?
- Do we need baseline studies to quantify biomass at locations before we determine the extent to which aquaculture is appropriate at any given location?
- Keeping efficiency in mind, what are the most crucial variables/best parameters to monitor that can provide the most useful set of relevant information for baseline monitoring?
- How can coastal monitoring arrays be best designed to meet our needs?
- What is the residence time of Domoic Acid or other toxins in different bivalve species? How frequently do those toxins need to be monitored?
- Need better characterization of sites, e.g., biogeochemical factors.
- Can we evaluate/characterize carrying capacity at different scales for planning and regulatory purposes?

PANEL 4: BENTHIC EFFECTS

Presentations

Overview of Pacific Northwest Benthic Habitats Used for Bivalve Aquaculture
Megan Dethier, Friday Harbor Labs, University of Washington

Conceptual Approaches to the Differentiation of Natural and Anthropogenic Disturbances in Benthic Ecosystems, with Considerations of Impacts of Geoduck Aquaculture Operations
Glenn VanBlaricom, School of Aquatic and Fishery Sciences, University of Washington

Habitat-Mediated Differences in the Response of Benthos to Harvesting Disturbance
Michel Kaiser, School of Ocean Sciences, Bangor University, U.K.

*Geoduck clam (*Panopea abrupta*) aquaculture as press and pulse perturbations to eelgrass (*Zostera marina*)*
Jennifer Ruesink, Department of Biology, University of Washington

Discussion: Identification of research and information needs

Panel Recommendations

A summary of research and information needs identified by Panel 4 experts.

1. Important to characterize the natural disturbance regime in as many areas as possible that are being contemplated for aquaculture development in the intertidal zone
    a. Important to do it in as many sites as possible, not only in selected sites.
2. Multi-scale experimental approach to the problem, to look at affects of the process on benthic ecosystems
    a. Effects of structures and placement of structures
    b. Effects of harvesting
    c. Look not only at effects within immediate area of contact but also at buffers — how far away is the effect detectable in the ecosystem? Conceptually straightforward.
    d. Need to work closely with growers to create a scenario with true replication and experimental rigor on a large scale (different growers, different tracts, different parts of Puget Sound)
    e. Needs to be a seasonal component to this design, because when the disturbance is created, it can make a huge difference in the response

    f. Dilemma: multi-year experiments but culture methods change with time. How do we mesh this experimentally? What sort of methods do we build into our experimental design if those methods are dynamic?
3. Discussed the mapping issue; this is an important set of research activities that should be pursued.
4. Put some effort towards nearshore flow models.
    a. "Dig holes and determine how long they take to fill in" (simple, elegant approach to answer a challenging question)
    b. Look at sediment density
    c. Match this with flow models
    d. Somewhere between "digging a hole" and making a full-blown index of biological integrity, some basic benthic surveys can tell you a lot about disturbance regimes
5. Link the planting density in aquaculture plots to ecological responses.
    a. Perception that planting density as it is presently viewed is oriented towards productivity and yield.
    b. There may be a disconnect between what is most productive and what minimizes ecological impacts.
    c. Very likely that some tube densities will have different effects on benthic ecosystems more than others. We must consider the ecological response as well as the productivity response.
6. Looking at both habitat type and geographic location within Puget Sound. What is the proportion, by region and habitat type, that is slated for development?

Group Discussion

Comments recorded during Panel 4 Q&A and general discussion.

- What best management practices should be employed to minimize disturbance to eelgrass beds/rhizome matrices, etc.?
- Does the presence of a rhizome mat aid eelgrass recovery?
- How well can eelgrass serve as a predator exclusion device for geoducks?
- Catalogue spatial and temporal disturbances caused by varied culture practices; effective modeling of impacts
- There are at least three different types of harvest methods employed in geoduck aquaculture. How do they differ in frequency and thoroughness of disturbance?
- What are we protecting with best management practices? (This may be either a rhetorical or practical question).