ICES CM 2014/ 3867 K:03

Shellfish aquaculture at the confluence of science, policy, and conflicting stakeholder interests: lessons learned from geoduck farming in the northeastern Pacific.

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Summary

Commercial aquaculture of geoduck clams (*Panopea generosa*) in the northeastern Pacific is an intertidal, multi-year operation characterized by repeated punctuated habitat disturbance events that frequently raises tension among resource managers, environmental organizations, and the general public. Yet, the cultivation of this valuable, long-lived, native species has the potential to relieve commercial harvest pressure on wild populations and reduce disturbance of subtidal soft-bottom habitats. As part of a state-mandated research program to evaluate potential environmental impacts of geoduck culture methods, we collected data describing the diversity and abundance of resident fauna within beach sands and the larger fish, crabs, and other animals that visit these areas during high tide. Our results show short-lived, localized effects to some groups of organisms in a few areas. Despite evidence of minimal ecological impact, conflict among stakeholders continues unabated. Here we describe the ecological assessment of geoduck farming practices as well as an ongoing investigation into the complexities of the social landscape. We underscore the importance of using a multidisciplinary approach to assess stakeholder perspectives and integrate science and policy.

Introduction

In Puget Sound, Washington USA, geoduck clams have been cultured in the intertidal environment on a commercial scale since 1996. Culture operations involve several procedures that disturb ecological communities, habitats, and processes. Culture operations entail large-scale, high-density out-planting of juvenile geoducks, installation and subsequent removal of predator exclusion structures (polyvinyl chloride [PVC] tubes and netting), and harvest following a grow-out period of several years. Harvest is done by sediment liquefaction using large volumes of low-pressure water.

While there is potential for considerable aquaculture expansion, the issue is complicated by a complex permitting process, limited scientific information to guide decision making, and vocal public opposition to certain aspects of geoduck farming. Specific concerns initially centered on potential ecological impacts. In response, the Washington State Legislature passed legislation to commission a series of scientific studies, collectively termed the Geoduck Aquaculture Research (GAR) Program to measure and assess possible effects (Washington Sea Grant 2013). Yet despite advancements in scientific understanding, key uncertainties remain regarding the broader ecosystem effects of continued aquaculture expansion. These uncertainties fuel opposition to the industry and present a major obstacle to aquaculture proponents. As part of an ongoing investigation, we examine geoduck aquaculture using a multidisciplinary approach to determine the ecological and social implications of an expanding industry in this urban/suburban fjord estuary system.

Materials and Methods

Our research group has collected data since 2008 describing the effects of geoduck planting, grow-out, and harvest at multiple ecological scales. We used a before-after control-impact (BACI) design of paired plots within each site: a commercial aquaculture area and an adjacent reference beach. Benthic infauna and epifauna/epiflora communities were sampled with cores and pumps, respectively, and snorkeling and SCUBA were used to evaluate mobile macrofauna at high tide. The effects of geoduck aquaculture were also investigated on ecological linkages. We compared the trophic relationships of a local ubiquitous consumer, Pacific staghorn sculpin (*Leptocottus armatus*), to its invertebrate prey using a combination of traditional diet analyses and stable isotopes. These empirical field data have been integrated into a published food web model of central Puget Sound, developed in the Ecopath with Ecosim (EwE) software (Harvey *et al.* 2012). EwE simulates production, mortality, predator-prey interactions, habitat effects, and fishery effects in aquatic food webs. To investigate the broader policy and social dimensions of the issue, a concurrent social science study is being performed. As part of a multidisciplinary team, we are conducting a policy analysis of the aquaculture issue and performing a situation assessment using semi-structured interviews to identify stakeholder interests and concerns, examine areas of consensus and dissent, and provide information necessary for developing a potential resolution framework useful to managers and decision makers.

Results and Discussion

Results indicate significant differences in the abundance and composition of macrofauna (e.g., crabs, sea stars, fish) between aquaculture areas with PVC tubes and netting and nearby reference beaches (McDonald *et al.* in press). Structure additions also impact abundance of a variety of infauna and epifauna prey groups. Community differences do not persist once tubes and nets are removed from aquaculture areas during grow-out, and the abundance of many species recovers to pre-disturbance levels. McPeek *et al.* (in press) observed that changes in habitat structure and prey abundance elicit diet shifts in the most abundant intertidal fish in the area, Pacific staghorn sculpin. However, stable isotopes revealed that general food web function remained unchanged. Results of our harvest study suggest minimal impact of harvest practices on benthic communities, likely due to high natural variability in abundance and distribution of these species, as well as the effects of the prevailing natural disturbance regime in the region (VanBlaricom *et al.* in press).

Altogether, we see evidence that shifts in the structure of predator and prey communities at certain stages in the aquaculture cycle may modify ecosystem responses at a local scale. This information has been incorporated into the EwE food web model. Based on discussions and “gaming” workshops with stakeholder groups, we will build and test scenarios that address the ecosystem-scale effects of potential future aquaculture operations. The complimentary policy analysis and interview-based situation assessment specifically evaluate the influence of the aforementioned scientific results on responses by resource managers and other stakeholders. Once completed, synthesis of social science results and ecological research will yield a more comprehensive understanding of the natural and societal environment to support sustainable geoduck aquaculture.

References

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