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Via email: pcd@ci.bainbridge-isl.wa.us
Bainbridge Island City Council
280 Madison Avenue North
Bainbridge Island, WA 98110

RE: Comments on the Bainbridge Island Draft Shoreline Master Program Update

Dear Councilmembers:

Thank you for the opportunity to comment on Bainbridge Island's Draft Shoreline Master Program ("SMP") update. We are submitting these comments on behalf of the Pacific Coast Shellfish Growers Association ("PCSGA"). Founded in 1930, PCSGA represents shellfish growers in Washington, Alaska, Oregon, California, and Hawaii. PCSGA works on behalf of its members on a broad spectrum of issues, including environmental protection, shellfish safety, regulations, technology, and marketing. Its members grow a wide variety of healthy, sustainable shellfish including oysters, clams, mussels, and geoduck.

The Washington State Department of Ecology ("Ecology") recognizes that shellfish aquaculture is of statewide interest, can provide long-term over short-term benefits, and can protect the resources and ecology of the shoreline. The best available science on shellfish aquaculture demonstrates that this shoreline use results in beneficial ecosystem services by improving water quality through filtration of nutrient pollution and providing three-dimensional habitat for a wide variety of species.

Shellfish aquaculture also provides a sustainable source of seafood. The Monterey Bay Aquarium's Seafood Watch lists farmed shellfish as a "Best Choice" to environmentally conscious consumers. Due to the sustainable nature of shellfish aquaculture, the green jobs shellfish aquaculture creates, and the ecosystem services provided by shellfish, Governor Gregoire recently launched the Washington Shellfish Initiative to promote this important activity.

PCSGA appreciates the City's extensive and thoughtful work developing an updated SMP. PCSGA shares with the City its concern for protecting the shorelines of the state and Washington

State's natural resources, including shellfish. It is also concerned, however, that many of the policies and development standards pertaining to shellfish aquaculture are inconsistent with state law and policy and are overly burdensome. Therefore, PCSGA requests the City amend the Draft SMP consistent with the proposed revisions contained in Appendix A to this letter. These revised policies and development standards are designed to ensure consistency with state law, reflect the best available science, and address the City's concerns regarding aquaculture activities.

A. The City's SMP Must Be Consistent with the Shoreline Management Act and Department of Ecology Guidelines.

The Shoreline Management Act ("SMA") establishes a cooperative program of shoreline management between state and local governments. RCW 90.58.080. The SMA and Ecology's guidelines establish the fundamental policies and regulations with which all SMPs must comply. RCW 90.58.020 ("[l]ocal government shall have the primary responsibility for initiating the planning required by this chapter and administering the regulatory program consistent with the policy and provisions of this chapter"); RCW 90.58.080 ("[l]ocal governments shall develop or amend a master program for regulation of uses of the shorelines of the state consistent with the required elements of the guidelines adopted by the department"). Therefore, one of the City's paramount objectives in developing an updated SMP is ensuring it complies with the SMA and Ecology's guidelines.

B. Aquaculture is a Preferred, Water-Dependent Use of the Shoreline that Provides Important Ecological Benefits and Must Be Protected.

Under the SMA, local governments must give preference to uses that are "unique to or dependent upon use of the state's shoreline." RCW 90.58.020. Ecology's guidelines specify that aquaculture is a water-dependent, preferred use of the shoreline that provides important ecological benefits. WAC 173-26-241(3)(b). This means water dependent uses must be granted priority over many other types of shoreline uses. RCW 90.58.020; *Nisqually Delta Ass'n v. City of DuPont*, 103 Wn.2d 720, 726, 696 P.2d 1222 (1985).

Ecology also recognizes that aquaculture can protect the statewide interest over local interest, preserve the natural character of the shoreline, result in long-term over short-term benefit, and protect the resources and ecology of the shoreline. WAC 173-26-241(3)(b)(i)(A) provides:

> Aquaculture is the culture or farming of fish, shellfish, or other aquatic plants and animals...
>
> This activity is of statewide interest. Properly managed, it can result in long-term over short-term benefit and can protect the resources and ecology of the shoreline. Aquaculture is dependent on the use of the water area and, when consistent with control of pollution and prevention of damage to the environment, is a preferred use of the water area. Local government should consider local ecological conditions and provide limits and conditions to assure appropriate compatible

types of aquaculture for the local conditions as necessary to assure no net loss of ecological functions.

Because aquaculture is a preferred use that can result in long-term benefits and protect the shoreline, Ecology's guidelines require that local governments foster aquaculture and protect it from damage by other activities. For example, WAC 173-26-241(3)(b)(i)(D) requires local government to "ensure proper management of upland uses to avoid degradation of water quality of existing shellfish areas." Moreover, WAC 197-26-221(2)(c)(iii) identifies shellfish beds as critical saltwater habitat. "Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide." *Id.* Therefore, "[m]aster programs shall include policies and regulations to protect critical saltwater habitats and should implement policies and programs to restore such habitats." *Id.*

Under this regulatory framework, a local government's SMP must do two things with respect to aquaculture. First, it must contain policies and regulations encouraging this preferred, water-dependent, and ecologically beneficial use. Second, it must protect aquaculture from activities that threaten water quality and critical saltwater habitat, including shellfish beds.

C. State and National Policies Promote the Restoration and Expansion of Shellfish Aquaculture Beds.

While the SMA expresses a preference for all types of aquaculture, federal and state governments have adopted policies specifically promoting shellfish aquaculture. The National Oceanic and Atmospheric Agency ("NOAA") recently announced a National Shellfish Initiative. "The goal of the National Shellfish Initiative is to increase shellfish aquaculture for commercial and restoration purposes, thereby stimulating coastal economies and improving ecosystem health." National Shellfish Initiative, p. 1.[1] This initiative recognizes that shellfish aquaculture provides a "broad suite of benefits" by improving water quality, conserving habitat, stabilizing coastlines, restoring depleted species, and creating jobs. *Id.*

To underscore the importance of shellfish aquaculture in Washington State, Governor Gregoire launched the Washington Shellfish Initiative in December 2011. The Washington Shellfish Initiative recognizes shellfish aquaculture is critically important to the state's ecology, economy, and culture. Washington Shellfish Initiative, p. 1.[2] Washington leads the country in the production of farmed clams, oysters, and mussels with an annual value of over $107 million and a total economic contribution to the state of $270 million. *Id.*, p. 1. Washington shellfish growers directly and indirectly employ over 3,200 people in the state and are among the largest private employers in some Puget Sound counties. *Id.* Further, shellfish help filter and improve the quality of marine waters and are an important part of the solution to restoring and preserving the health of endangered waters. *Id.* Accordingly, this initiative lists several programs to restore and expand shellfish resources throughout the state, including improved guidance for local SMPs "to protect against habitat impacts and planning to minimize conflicts with adjoining shoreline owners and other marine water users." *Id.*, p. 3.

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[1] The National Shellfish Initiative is attached to this letter as Appendix B.

[2] The Washington Shellfish Initiative is attached to this letter as Appendix C.

D. Washington Sea Grant Research Confirms Limited Impacts of Geoduck Aquaculture.

The SMA's preference for aquaculture as a water-dependent, beneficial use of the shoreline is consistent with the findings of recent research conducted by Washington Sea Grant.

In 2007, the Legislature directed Washington Sea Grant to review existing scientific information and commission scientific research studies related to geoduck aquaculture according to six priorities. Research conducted thus far establishes the commercial harvest of geoducks does not pose a risk of harm to the environment and limited disruptions are within the range of natural variation experienced by benthic communities in Puget Sound. Highlights from the most recent findings include:[3]

- Geoduck harvest practices have minimal impacts on benthic communities of infaunal invertebrates, with no observed "spillover effect" in habitats adjacent to cultured plots, suggesting that disturbance is within the range of natural variation experienced by benthic communities in Puget Sound.
- Differences in the structure of mobile macrofauna communities between planted areas with nets and tubes and nearby reference beaches do not persist once nets and tubes are removed during the grow-out culture phase.
- Nutrients released from a typical commercial geoduck operation are low and localized effects are likely to be negligible.
- High densities of geoducks filter out algae and their constituent nitrogen and phosphorus. In the absence of geoduck culture, algae may still be efficiently remineralized within the water column, processed in deeper water sediments or ingested by other organisms. Overall, aquaculture changes the location of nutrient recycling from the water column to the sediments, rather than fundamentally change the overall rate of nutrient release.
- Analyses of disease data for wild geoduck indicate no distinct patterns in the distribution of disease organisms as a function of geographic location or water depth.
- Geoduck aquaculture practices do not make sites unsuitable for later colonization by eelgrass.

This research addressed uncertainties regarding the potential impacts of geoduck aquaculture. The results dispense with the argument that geoduck aquaculture must be regulated assuming it will result in adverse impacts to the environment. Rather, the results thus far indicate that geoduck aquaculture will not cause a net loss of shoreline ecological functions.
The Draft SMP contains several development standards relating to geoduck aquaculture that are overly restrictive when viewed in light of the best available science. In additionally, as previously stated, many of these standards are simply infeasible from an operational standpoint.

[3] Attached as Appendix D to this letter is the February 2012 Interim Progress Report to the Washington State Legislature on the Geoduck Aquaculture Research Program.

Proposed revisions to these development standards contained in Appendix A modify infeasible provisions and are responsive to Washington Sea Grant findings on geoduck aquaculture.

E. Shorelines Hearings Board Has Confirmed Geoduck Aquaculture is a Preferred Shoreline Use with Insignificant Adverse Environmental Impacts.

In July 2012, the Washington State Shorelines Hearings Board ("Board") issued a decision confirming that aquaculture is a preferred use of the shoreline that has long-term benefits for the state and insignificant adverse environmental impacts. In *Coalition to Protect Puget Sound Habitat v. Pierce County*, SHB No. 11-019 (Findings of Fact, Conclusions of Law, and Order, July 13, 2012), the Board affirmed a shoreline substantial development permit ("SDP") and determination of nonsignificance ("DNS") for a 2.5-acre geoduck farm on Key Peninsula in Pierce County. The applicant, Longbranch Shellfish, applied for the farm in 2006 and Pierce County "spent several years analyzing the potential environmental impacts of the farm, frequently requiring and receiving additional studies and analysis from Longbranch Shellfish." *Id.*, at Finding of Fact ("FF") 2. The Board praised Pierce County's intense review of the application as "diligent, conscientious, and comprehensive . . ." *Id.* at FF 13.

Two groups appealed the SDP and DNS to the Board. In their appeal, the Petitioners challenged not just these two decisions, but "question[ed] the appropriateness of geoduck aquaculture as an industry," claiming it altered shoreline habitat, caused loss of habitat diversity, adversely impacted forage fish and salmon, and harmed the marine environment through plastic debris. *Id.* at Conclusion of Law ("CL") 22. The Board thoroughly analyzed and rejected each of these claims in the course of affirming the SDP and DNS. Among other things, the Board found and concluded:

- "Aquaculture is a desired and preferred water-dependent use of the shoreline." *Id.* at CL 12.
- Aquaculture is "an activity of statewide interest, and when properly managed, an activity that can result in long-term over short-term benefit and protection of the resources and ecology of the shoreline." *Id.*
- "The aquaculture gear used to culture geoducks, particularly the PVC tubes, creates artificial hard substrate, resulting, temporarily, in increased habitat diversity. This increased habitat diversity augments the presence of certain species at the farm site, including species important to juvenile salmon foraging along the nearshore." *Id.*
- "There is no evidence that farmed geoduck will cause adverse impacts to forage fish or salmon by depleting food resources." *Id.* at FF 7.
- "The use of PVC tubes for geoduck aquaculture will not adversely affect the environment." *Id.* at FF 11.
- "[A] recent scientific study conducted by the University of Washington Sea Grant . . . concludes that harvest impacts are of short duration and insignificant in consequence." *Id.* at FF 11.

As recognized by the Board, geoduck aquaculture is a preferred, water-dependent use that is in the statewide interest and can protect the resources and ecology of the shoreline. Other Shoreline Hearings Board decisions also recognize shellfish aquaculture, including geoduck aquaculture, as a preferred, water-dependent use. *Marnin v. Mason County*, SHB No. 07-021, Modified Findings of Fact, Conclusions of Law and Order, at Conclusion of Law 14 (February 6, 2008); *Taylor Shellfish Farms v. Pierce County*, SHB Nos. 06-039, 07-003, 07-005, Findings of Fact, Conclusions of Law, and Order, at Conclusion of Law 6 (January 23, 2009). The best information available demonstrates geoduck aquaculture has insignificant adverse impacts and can increase biodiversity. Therefore, in addition to ensuring its proper management, the City of Bainbridge Island must adopt policies and regulations to foster and encourage this preferred shoreline use.

F. Proposed Revisions to the City's Draft SMP Update.

Many of the City's policies and regulations pertaining to shellfish aquaculture are inconsistent with state law, the best available science, and relevant Shorelines Hearings Board decisions. To remedy these inconsistencies, PCSGA recommends the City amend the Draft SMP consistent with the proposed revisions set forth in Appendix A. As described in the Appendix, most of the proposed revisions are taken directly from the SMA and Ecology's guidelines. Other revisions are based on best available science and best management practices for shellfish aquaculture. All of these revisions are designed to ensure aquaculture activities can be successfully located and operated within the City while maintaining net shoreline ecological functions consistent with the SMA.

Thank you for your time and consideration of these comments. We look forward to working with you during this important process.

Very truly yours,

Amanda Stock
Jesse G. DeNike

JGD:tat
Attachments
cc: Margaret Barrette (w/atts.)

Appendix A

Proposed Revisions

Appendix A
Proposed Revisions

Section	Proposed Revision	Explanation
1.3.6 Program provisions	1. Exempt developments shall not be undertaken within the jurisdiction of the Act and this Master Program, unless a Letter of Exemption has been obtained documenting that the development is consistent with the policies and procedures of the Act, all applicable state regulations and this Master Program. A Letter of Exemption constitutes a valid authorization to conduct a development or activity.	This revision provides clarity that a Letter of Exemption constitutes authorization for an exempt proposal.
3.3.1.3 Management Policies	4. Aquaculture practices, should be limited to those activities that ~~can demonstrate that~~ do not significantly impacts ~~to~~ ecological functions, ecosystem-wide processes, and adjacent land uses ~~will not occur~~. Aquaculture should be encouraged in those tidelands, waters and beds most suitable for such use. ~~Prohibit intensive shellfish aquaculture.~~	If aquaculture activities do not significantly impact ecological functions, ecosystem-wide process, and adjacent land uses, there is no basis for prohibiting this use. Further, prohibiting shellfish aquaculture conflicts with the SMA and Ecology's guidelines, which identify this as a preferred use, and state policies designed to expand shellfish beds to improve habitat and water quality.
3.3.2.7 Priority Aquatic Category A Management Policies	2. Uses and activities which would ~~potentially degrade or~~ significantly alter the natural or visual character or ecological functions of the shoreline should be limited ~~severely restricted or prohibited~~ and only allowed if adverse impacts can be mitigated to ensure no net loss of ecological functions.	This is a highly subjective policy. All shoreline uses and activities could potentially degrade the natural or visual character of the shorelines. Therefore, as currently written this

		policy would lead to a practical prohibition on all uses and activities. This revision avoids this extreme result while allowing the City to prevent the significant alteration of the shoreline by ensuring no net loss of ecological functions.
3.3.2.8 Priority Aquatic Category B Management Policies	2. Uses and activities which would ~~potentially degrade or~~ significantly alter the natural or visual character or ecological functions of the shoreline should be limited and only allowed when adverse impacts can be mitigated to ensure no net loss of ecological functions.	See explanation for revision to Section 3.3.2.7 above.
Table 4-1	SHORELINE USE / PRIORITY AQUATIC A / PRIORITY AQUATIC B Aquaculture~~, Intensive~~ / ~~P1~~ C / ~~P1~~ C Aquaculture, Community Shellfish Garden / ~~P1~~ C / ~~P1~~ C	Allowing aquaculture as a conditional use in the Priority Aquatic designations is consistent with the purpose of this designation – to protect, preserve, restore and manage aquatic areas of sensitive and unique ecological value. Commercial shellfish beds are a type of sensitive area with unique ecological value and, when designed to comply with the use regulations contained in the updated SMP, will protect, preserve, and restore priority aquatic areas. See WAC 173-26-241(3)(b).
4.1.1.3 Policies (In order of preference)	4. Protect the resources and ecology of the shoreline.	If strictly interpreted and enforced, Policy 4.d

	. . . ~~d. Shoreline materials including, but not limited to, bank substrate, soils, beach sands, and gravel bars should be left undisturbed by shoreline development.~~	would be overly restrictive and fail to balance the various interests of the SMA.
4.1.5.5 Regulations - Fish and Wildlife Habitat Conservation Areas and Critical Saltwater Habitat	1. Water-dependent development and uses, other than aquaculture~~, including marinas, docks, piers, mooring areas, underwater parks, utility crossings, and shoreline modifications,~~ shall not intrude into or be built over critical saltwater habitat unless the applicant can show that all of the following criteria can be met: . . .	As written, this provision conflicts with WAC 173-26-221(2)(c)(iii), which states that commercial shellfish beds are a type of critical saltwater habitat. If approved as currently drafted, this provision could be construed to prohibit shellfish farming on all commercial shellfish beds, resulting in an effective prohibition on all shellfish farming. This revision ensures consistency with Ecology guidelines, which state that aquaculture must be fostered and encouraged as a water dependent use.
5.2.1 Applicability	These provisions apply to the ~~commercial cultivation and harvesting~~ culture of fish, shellfish or other aquatic animals or plants~~, but also to non-commercial harvesting, and to the incidental preparation of fish and shellfish for human consumption, or cultivation for restoration purposes~~. Incidental small-scale aquaculture that is strictly for personal consumption may be considered accessory to residential use and must adhere to all applicable regulations. Aquaculture, like all other uses, is subject to the provisions in Section 3.0, Environment Designations, including the standards in	These revisions ensure consistency with state law (WAC 173-26-241(3)(b)(i)(A)).

	Tables 4-1 through 4-3. Section 4.0, General Policies and Regulations also apply. Aquaculture activities are not considered dredging nor subject to the regulations found in Section 6.4, Dredging and Dredge Material Disposal.	
5.2.2 Policies	1. <u>Aquaculture is of statewide interest.</u> When properly managed, aquaculture can result in long-term ecological and economic benefits <u>and can protect the resources and ecology of the shoreline. Aquaculture is dependent on the use of the water area and, when consistent with control of pollution and prevention of damage to the environment, is a preferred use of the water area</u>. Identify and encourage aquaculture activities which may provide opportunities for creating ecosystem improvements. Engage in coordinated planning to identify potential aquaculture areas and assess regional long-term needs for aquaculture and coordinated education efforts to provide information on best practices to those operating small-scale aquaculture~~ for personal use and consumption~~. This includes working with the Department of Fish and Wildlife (DFW), the Department of Natural Resources (DNR), area tribes and shellfish interests to identify areas that are suitable for aquaculture and protect them from uses that would threaten aquaculture's long-term sustainability.	These revisions ensure consistency with state law (WAC 173-26-241(3)(b)(i)(A)). These coordination efforts can benefit all types of small-scale aquaculture, not just those for personal use and consumption.
	2. Experimental forms of aquaculture involving the use of new species, new growing methods or new harvesting techniques may be allowed when they are consistent with applicable state and federal regulations and this Program. Experimental aquaculture projects should be <u>monitored. Any significant, unforeseen environmental impacts</u>	As written, this policy erroneously assumes experimental projects will have significant impacts. As revised, it provides the City authority to address any unforeseen impacts while not requiring these

	should be mitigated. If such impacts cannot be adequately mitigated, the project~~limited in scale and~~ should be approved for a limited period of time. ~~When feasible, l~~Limit or restrict new development proposals in areas which would affect existing experimental monitoring programs.	projects to be automatically limited in scale and time. This is consistent with WAC 173-26-241(3)(b)(1)(B), which requires local governments to give latitude in the development of aquaculture as well as its potential impact on existing uses and natural systems.
	3. ~~Limit a~~Aquaculture~~, including intensive shellfish aquaculture to activities that do~~ should not be allowed where it would: a. Result in significant~~create~~ adverse impacts to ecological functions and ecosystem-wide process that cannot be mitigated;~~,~~ b. ~~Prohibit aquaculture where it would r~~Result in a net loss of shoreline ecological functions; c. Significantly adversely affect the quality or extent of habitat for native species including native eelgrass, kelp, and other macroalgae; d. Significantly adversely impact City and State critical habitat areas and other habitat conservation areas; or e. Significantly interfere with navigation or other water-dependent uses.	These revisions increase clarity and ensure consistency with state law and regulation, which typically require impacts to be significant to warrant prohibition of a use or development. See WAC 173-26-241(3)(b). In addition, as described in the Department of Ecology's Aquaculture Interim Guidance chapter of the SMP Handbook, non-native eelgrass is considered a noxious weed in commercially managed shellfish beds. Therefore, aquaculture is not required to protect non-native eelgrass.
	4. ~~Intensive a~~Aquaculture should be prohibited where such development or activity would: . . . b. ~~Where~~ Significantly impacts~~ to~~ other existing and approved ~~land and~~ water-dependent uses ~~would~~	Aquaculture is a water-dependent use, and should therefore be prioritized over non-water dependent uses and activities. RCW 90.58.020. This provision as currently

	~~substantially and materially conflict, including impacts to navigation, moorage, sport or commercial fishing, underwater utilities, active scientific research~~, and~~/or the aesthetic qualities of a project area~~ those impacts cannot be minimized; and/or . . .	drafted is inconsistent with that prioritization scheme. Aesthetics are highly subjective. Prohibiting aquaculture where there would be any aesthetic impact could preclude aquaculture in the City's shoreline jurisdiction and conflict with state law. See, e.g., WAC 173-26-241(3)(b)(i)(C) (stating aquaculture should not significantly impact the aesthetic qualities of the shoreline). Instead, aesthetic impacts should be required to be minimized.
	5. Community Shellfish Gardens should be prohibited where such development or activity would: . . . b. ~~Where~~ Significantly impacts ~~to~~ other existing and approved ~~land and~~ water-dependent uses ~~would substantially and materially conflict, including impacts to navigation, moorage, sport or commercial fishing, underwater utilities, and/or active scientific research~~; and/or . . .	See comments directly above.
	7. Preference should be given to those forms of aquaculture that have less environmental and/or visual impacts. ~~Preference is given to those projects that require fewer submerged or intertidal structures, fewer land-based facilities, limited substrate modification, and reliance on artificial feeding.~~	The second sentence of this provision erroneously assumes the listed types of aquaculture necessarily have fewer impacts than other types. In addition, state law expresses a

		preference for all types of aquaculture. See RCW 90.58.020; WAC 173-26-241(3)(b). Therefore, while the City may express a preference for aquaculture that has less environmental impacts, it may not target some forms as inherently more harmful and not preferred.
	7~~8~~. Ensure installation of net-pens, raft cultures or surface embedded structures do not cause significant cumulative environmental ~~impacts~~ and aesthetic impacts, or significantly interfere with navigation	Prohibiting aquaculture on the basis of any impacts violates the SMA. This revision ensures consistency with state law by requiring these impacts to be significant to warrant prohibition. WAC 173-26-241(3)(b)(i)(C).
5.2.3 Regulations – Prohibited	2. Aquaculture, except Shellfish Gardens, shall be prohibited in the following areas: a. Areas where ~~intensive~~ aquaculture development would have ~~potential~~ significant, adverse impacts on other existing and approved ~~land and~~ water-dependent uses, including navigation~~;~~, and on the aesthetic qualities of a project area, where such impacts cannot be avoided, minimized, or mitigated. ~~i. Community Shellfish Garden is prohibit in areas listed in (a) above except may be allowed when adverse aesthetic impacts are avoided or adequately mitigated through enforceable conditions of approval.~~	As described above, aquaculture projects cannot be prohibited merely on the basis of potential impacts or conflicts with land and non-water-dependent uses. These revisions are therefore necessary to ensure consistency with state law. They are also necessary to recognize that projects should not be prohibited where significant impacts can be avoided, minimized, or mitigated consistent with mitigation sequencing. See WAC 173-26-201(2)(e). Subsection

	. . . c. Areas devoted to established water-dependent uses ~~of the aquatic environment~~ with which the proposed aquacultural method(s) would substantially and materially conflict, where such conflicts could not be avoided, minimized, or mitigated. Such uses would include, but are not limited to navigation, moorage, sport or commercial fishing, log rafting, underwater utilities and active scientific research. . . . ~~e. Areas that have little natural potential for the type(s) of aquaculture under consideration.~~	2.a.i is unnecessary given the revisions to 2.a. The revisions to subsection 2.c ensure consistency with state law and the revisions to subsection 2.a above. Subsection 2.e is vague. Depending on how it is interpreted, it is either unnecessary (because shellfish growers would have no interest in pursuing aquaculture in areas with no potential to support the use) or inconsistent with state law (because Ecology's Guidelines recognize potential locations for aquaculture are restricted and requires local governments to provide latitude in the development of this use under WAC 173-26-241(3)(b)(i)(B)).
	4. Aquaculture that uses or releases herbicides, pesticides, antibiotics, fertilizers, ~~non-indigenous species,~~ parasites, pharmaceuticals, genetically modified organisms, feed or other materials known to be ~~potentially~~ harmful into surrounding waters is prohibited, except that the following may be allowed . . .	Various non-indigenous species of shellfish are currently being grown in Washington State waters. Moreover, the Washington Department of Fish and Wildlife has jurisdiction to approve the introduction of non-indigenous species into state waters, not local governments. WAC

		220-72-076. The prohibition on potentially harmful materials is vague and could be interpreted in an overly restrictive manner.
5.2.4 Regulations – General	1. Aquaculture may be allowed as a conditional use in the Island Conservancy, Shoreline Residential Conservancy, Shoreline Residential, Urban, Priority Aquatic, and Aquatic designations. Aquaculture shall be prohibited in the Natural ~~and Priority Aquatic~~ designations~~, except that Shellfish Gardens (Individual and Community) may be allowed as part of an approved restoration project in Priority Aquatic A and B and Shellfish Gardens incidental small-scale aquaculture for personal consumption may be allowed in the Priority Aquatic B as provided in Section 5.2.5(8), below~~.	These revisions ensure consistency with the revisions to Table 4-1 above.
	3. Aquaculture facilities shall avoid: a. Net ~~L~~loss of ecological functions, b. Adverse ~~I~~impacts to native eelgrass and macro algae, c. Significant conflict with navigation and water-dependent uses, d. The spreading of disease, e. ~~Introduction of~~ Establish new non-native species that cause significant ecological impacts, or f. Significant ~~I~~impacts to shoreline aesthetic qualities.	These revisions are necessary to ensure compliance with state law and track the language used in WAC 173-26-241(3)(b)(i)(C).
5.2.5 Regulations –	~~5. Aquacultural proposals that include net-~~	This regulation is overly

Design Standards	~~pens or rafts shall not be located closer than one (1) nautical mile to any other aquacultural facility that includes net-pens or rafts, provided that a lesser distance may be authorized by the City if the applicant can demonstrate to the City's satisfaction that the environmental and aesthetic concerns expressed in the Master Program shall be addressed. If a lesser distance is requested, the burden of proof shall be on the applicant to demonstrate that the cumulative impacts of the existing and proposed operations would not be contrary to the policies and regulations of the Master Program.~~	burdensome and unnecessary, particularly given other policies and regulations in the SMP already require environmental and aesthetic concerns to be addressed. Therefore, it conflicts with state law and policy promoting the restoration and expansion of shellfish beds and must be stricken.
	6. Floating/hanging aquaculture facilities, and associated equipment, except navigation aids, shall use colors and materials that blend into the surrounding environment in order to minimize visual impacts. ~~All materials, including those used for incidental aquaculture for personal consumption, shall be marked with owners contact information to provide identification after storm disturbance.~~	Requiring individual markings serves no preventive function, is overly burdensome (especially on smaller growers), precludes cooperative use of equipment, and can require introducing additional foreign matter into the water solely for the purpose of identification.
	9. Except as provided in Regulation 5.2.6(7), aquaculture developments approved on an experimental basis shall ~~not exceed five (5) acres in area, except anchorage for floating systems, and five (5) years in duration, provided that the City may issue a new permit to continue an experimental project as many times as is deemed necessary and appropriate~~be monitored. Any significant, unforeseen environmental impacts should be mitigated. If such impacts cannot be adequately mitigated, the project should be approved for a limited period of time.	As originally written, this regulation erroneously assumes experimental projects will have significant impacts. As revised, it provides the City authority to address any unforeseen impacts while not requiring these projects to be automatically limited in scale and time.

	10. Shellfish Gardens for personal consumption is allowed as an accessory use to a primary residential use provided the following can be met: a. the cultivation and harvesting ~~is limited~~ does not establish ~~to~~ new non-native species of shellfish that cause significant ecological impacts; and . . .	This revision is necessary to ensure consistency with WAC 173-26-241(3)(b)(i)(C).
5.2.6 Regulations – Operational Standards	5. Predator control shall not involve the deliberate killing or abusive harassment of birds or mammals. Approved controls include, but are not limited to, double netting for seals, overhead netting for birds, fencing or netting for otters. ~~The use of other nonlethal, non-abusive predator control measures shall be contingent upon receipt of written approval from the National Marine Fisheries Service and/or the U.S. Fish and Wildlife Service, as required.~~	These revisions are necessary to clarify that predator control methods that are not intended to kill or harass animals are permitted and to reflect that predator control methods need not always obtain approval from federal agencies.
6.4.1 Applicability	Dredging is the removal of ~~material~~earth or sediments such as gravel, sand, mud or silt from the bottom of a water body. The purposes of dredging might include: deepening a navigational channel, berth, or basin; streambed maintenance; use of dredged material for fill or habitat enhancement (effective reuse); and removal of contaminated sediments.	This revision ensures consistency with the definition of "dredging" in Chapter 7.0 of the updated SMP.
7.0 Definitions	Aquaculture - The cultivation of fish, shellfish, and/or other aquatic animals or plants, including the harvesting and incidental preparation of these products for human use and consumption. Aquaculture does not include the harvest of free swimming fish or gathering of shellfish for non-commercial purposes. Activities include the hatching, cultivating, planting, feeding, raising and harvesting of aquatic plants and animals, and the maintenance and construction of necessary equipment,	PCSGA supports the City's effort to streamline permit and regulatory requirements for Shellfish Gardens. However, classifying all other types of aquaculture as Intensive suggests that such uses have an intense impact on the environment and other approved uses.

	buildings, and growing areas. Cultivation methods include, but are not limited to, fish pens, shellfish rafts, racks and long lines, seaweed floats and nets, and the culture of geoduck, clams and oysters on tidelands and subtidal areas. ~~Aquaculture includes Intensive Aquaculture and Shellfish Garden (Individual and Community).~~	This is inconsistent with state law, which classifies all types of aquaculture as preferred, water-dependent uses and states aquaculture can protect the resources and ecology of the shoreline. WAC 173-26-241(3)(b). It is also inconsistent with the Washington Shellfish Initiative, which recognizes shellfish aquaculture is critically important to the state's ecology, culture, and economy. Therefore, the Intensive Aquaculture classification should be stricken.
	~~Aquaculture, Intensive - Large scale cultivation of shellfish, or cultivation of fish and/or other aquatic animals or plants, or use of embedment structures, or mechanical extraction methods, including the harvesting and incidental preparation of these products for human use and consumption. Aquaculture does not include the harvest of freeswimming fish or gathering of shellfish for non-commercial purposes. Activities include the hatching, cultivating, planting, feeding, raising and harvesting of aquatic plants and animals, and the maintenance and construction of necessary equipment, buildings, and growing areas. Cultivation methods include, but are not limited to, fish pens, shellfish rafts, racks and long lines, seaweed floats and nets, and the culture of geoduck, clams and oysters on tidelands and subtidal areas.~~	See comments directly above.

	Development - A use consisting of the construction or exterior alteration of structures; dredging; drilling; dumping; filling; removal of any sand, gravel, or minerals; bulkheading; pile driving; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the Act at any state of water level.~~, subject to Chapter 90.58 RCW or its successor [RCW 90.58.030(3d) or its successor]~~. ~~This term may include activities related to subdivision and short subdivisions; planned unit developments; clearing activity; land modification (grade and fill work); building or construction; and activities that are exempt from the substantial development permit process or that require a shoreline variance or conditional use.~~	These revisions ensure consistency with the SMA's definition of "development" at RCW 90.58.030(3)(a).
	Dredging - Removal ~~or displacement~~ of earth or sediments such as gravel, sand, mud or silt~~, and/or other materials or debris~~ from any stream, river, lake or marine water body, and associated shorelines and wetlands. Dredging is normally done for specific purposes or uses such as constructing and maintaining navigation channels, turning basins, harbors and marinas; installing submarine pipelines or cable crossing; or repairing and maintaining dikes or drainage systems. Dredging can be accomplished with mechanical or hydraulic machines. Most dredging is done to maintain channel depths or berths for navigational purposes; other dredging is for ~~shellfish harvesting or~~ cleanup of polluted sediments. <u>Shellfish harvesting activities do not constitute dredging unless a mechanical or hydraulic dredge machine is used to remove earth or sediment, leaving a trench while dislodging shellfish.</u>	As recognized in Attorney General Opinion 2007 No. 1, shellfish harvest activities do not constitute dredging unless a hydraulic dredge machine is used to remove earth or sediment, leaving a trench while dislodging shellfish. These revisions ensure consistency with the Attorney General Opinion.

	Ecological functions or shoreline functions - The work performed or role played by the physical, chemical, and biological processes that contribute to the maintenance of the aquatic and terrestrial environments that constitute the shoreline's natural ecosystem. ~~See Section WAC 173-26-201(2)(c). Functions include, but are not limited to, habitat diversity and food chain support for fish and wildlife, ground water recharge and discharge, high primary productivity, low flow stream water contribution, sediment stabilization and erosion control, storm and water quality enhancement through biofiltration and retention of sediments, nutrients, and toxicants. These beneficial roles are not listed in order of priority.~~	These revisions ensure consistency with WAC 173-26-020(10).
	No Net Loss - As a public policy goal, the maintenance of the aggregate total of the City's shoreline ecological functions at its current level of environmental resource productivity. As a development and/or mitigation standard, no net loss requires that the impacts of a particular shoreline development and/or use, whether permitted or exempt, be identified and prevented or mitigated, such that ~~it has~~ there is no ~~resulting adverse impacts on~~ aggregate total loss of shoreline ecological functions or processes. Each project shall be evaluated based on its ability to meet the no net loss standard commensurate with its scale and character.	This revision ensures consistency between the concept of no net loss as a public policy goal and as a development and/or mitigation standard. The original no net loss development standard (no resulting adverse impacts) is different from the language of the public policy goal, overly restrictive, and inconsistent with the concept of net loss as an aggregate total of shoreline functions and processes.

Appendix B

NOAA's National Shellfish Initiative

The goal of the National Shellfish Initiative is to increase shellfish aquaculture for commercial and restoration purposes, thereby stimulating coastal economies and improving ecosystem health. The focus is on bivalves or mollusks, not on crustaceans. This initiative will help meet the growing demand for seafood while creating jobs, restoring depleted species, conserving habitat for important commercial, recreational, and endangered fish species, improving water quality, and stabilizing and protecting coastlines.

Overview of the National Shellfish Initiative

Put simply, this initiative recognizes the broad suite of benefits provided by shellfish aquaculture and aims to increase shellfish production and wild shellfish populations in U.S. coastal and marine waters. To that end, NOAA – in collaboration with public and private partners – will focus on a limited number of actions under each of the following five topics:

1. ***Enhanced shellfish restoration and farming*** – Support the authorization of shellfish sanctuaries/restoration sites and additional aquaculture permits/leases that are aligned with the twofold goal of providing environmental and economic benefits; build hatchery capacity to supply seed for commercial shellfish production and public/private restoration projects; and develop innovative culture and post-harvest processing methods.
2. ***Research on environmental effects*** – Conduct research on the interactions between shellfish and the environment in terms of climate change, ocean acidification, naturally occurring pathogens and parasites, and other factors; gather data needed to assess and refine restoration strategies and priorities; examine synergies with the shellfish industry.
3. ***Streamlined permitting*** – Improve coordination among federal agencies to facilitate timely permitting of shellfish farms and restoration projects; develop model permit processes; participate in reissuance of Army Corps of Engineers' Nationwide Permit 48 for commercial shellfish aquaculture.

4. ***Spatial planning*** – Engage in local and regional planning efforts to site commercial shellfish production and shellfish restoration projects. This will include engaging with the Regional Planning Bodies that carry out coastal and marine spatial planning under the National Ocean Policy.
5. ***Innovative financing*** – Develop indicators that "monetize" ecosystem services provided by shellfish aquaculture, such as nutrient reduction and carbon sequestration. (Payments for ecosystem services, were they available, may spur participation in both commercial and restoration aquaculture.)

NOAA is seeking to leverage its existing staff, science knowledge and capabilities, regulatory authorities, and grant programs in partnership with others to implement the Initiative. An internal staff work group led by the NMFS Office of Aquaculture (with participation from several NMFS headquarters and regional offices, NOAA science centers, and the National Sea Grant Program office) is coordinating NOAA's efforts. To identify priorities and specific opportunities, this staff group is

- reaching out to industry participants, restoration groups, states, and others;
- reviewing recommendations provided by the National Shellfisheries Association and the East Coast Shellfish Growers Association based on recent surveys of their membership;
- reviewing research priorities and restoration strategies identified by industry associations, restoration NGOs, and others;
- reviewing topics and priorities for upcoming NOAA grant competitions (budget permitting); and
- reaching out to other DOC (e.g., Economic Development Administration) and federal agencies (e.g., USDA and NSF) to identify and coordinate grant opportunities to support the Initiative.

For more information:

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Appendix C

Washington Shellfish Initiative

The Washington State Shellfish Initiative is a convergence of the National Oceanic and Atmospheric Administration's (NOAA) National Shellfish Initiative and the State's interest in promoting a critical clean water industry. While the initiative supports Governor Gregoire's goal of a "dig-able" Puget Sound by 2020, it also encompasses the extraordinary value of shellfish resources on the coast. As envisioned, the initiative will protect and enhance a resource that is important for jobs, industry, citizens and tribes.

I. Overview

Washington State is taking additional action to protect and enhance shellfish resources. This effort supports the long-term goal of abundant shellfish resources for Washington's residents and Native American tribes, as well as a thriving and healthy shellfish aquaculture industry. As an outcome of the 2007 treaty rights settlement, many Puget Sound tribes are undertaking shellfish aquaculture as a means of enhancing shellfish resources for cultural and economic gain.

We recognize and respect that shellfish aquaculture and commercial and tribal harvest of wild shellfish resources are water-dependent uses that rely on excellent water quality. Shellfish also can help filter and improve the quality of our marine waters thereby being part of the solution to restore and preserve the health of endangered waters. We can have healthy marine waters and productive shellfish beds for a growing industry, Native American tribes and for all the citizens of Washington.

The Puget Sound Partnership has targeted a net increase from 2007 to 2020 of 10,800 harvestable shellfish acres, which includes 7,000 acres where harvest is currently prohibited in Puget Sound. However, the recent shellfish downgrade in Samish Bay is a reminder of the constant vigilance needed by landowners, businesses and local, state, federal and tribal governments to protect and restore shellfish beds. Such efforts also are required on the coast where there is considerable opportunity to enhance shellfish resources.

To restore and expand shellfish resources, Washington must renew its protection, restoration and enhancement efforts. These efforts will pay off in increased recreation, additional clean water jobs, and a healthier Puget Sound and coastal marine waters.

II. Shellfish: Jobs and Economic Opportunity

Shellfish are critical to the health of Washington's marine waters and the state's economy. Washington leads the country in production of farmed clams, oysters and mussels with an annual value of over $107 million. Washington shellfish growers directly and indirectly employ over 3,200 people and provide an estimated total economic contribution of $270 million. Surveys from the early 2000's indicate shellfish growers are the largest private employer in Pacific County and the second largest in Mason County. In just those two counties, they generate over $27 million annually in payroll. In addition there is ceremonial and subsistence harvest in Puget Sound and Coastal waters that tribes consider invaluable and unquantifiable.

Bivalves coming from Washington's cool clean waters are prized as some of the best in the world. This reputation has ensured that domestic and international demand for them has long exceeded supply. This strong demand has fostered continued growth of shellfish production and hiring even during the current economic downturn. Implementation of the NOAA's National Shellfish Initiative in Washington will enable shellfish aquaculture in the state to expand to meet the demand for quality shellfish providing critical new jobs in rural Western Washington.

Annually, tourists and residents purchase over 300,000 licenses to harvest clams and oysters from Washington waters, providing more than $3.3 million in state revenues. WDFW conservatively estimates that the 125,000 shellfish harvesting trips made each year to Puget Sound beaches provide a net economic value of $5.4 million to the region. On Washington's coast an average of 244,000 digger trips are made each season to harvest razor clams contributing an estimated $22 million value to the coastal economies.

III. Shellfish Initiative

1) **Create a Public/Private Partnership for Shellfish Aquaculture**
   a) *Federal, State, and Local Model Permitting Program.* Provide unified state leadership from state natural resource agencies by identifying a shellfish aquaculture coordinating lead for the State and a lead in each agency. Use the Governor's Office of Regulatory Assistance (ORA) to facilitate the State Team. Formalize clear and efficient coordination among state and federal agencies, tribes, and local governments for permitting and licensing. Develop and implement a Model Permitting Program that ensures early and continued coordination from all parties, with an Operational Agreement that commits all parties to see each project through from beginning to end. The goal of the Program is to develop a consistent process for improved timeliness of permit decisions while ensuring regulatory compliance. The process will address tribal notification and consultation protocols. The process also will address opportunities for early and ongoing dialogue with permittees and others. The Model Permitting Program will be based on existing, successful programs like the MAP Team (Multi-Agency Permitting) which has a proven record of promoting coordinated decision making. The permitting team has initiated work on a draft Operational Agreement.

   b) *Continue vital shellfish aquaculture research.* Sustain research on key issues related to aquaculture management and planning. Seek opportunities to partner with NOAA, Washington Sea Grant, USGS, and others to build on existing programs and to build our understanding of shellfish and aquaculture in the Pacific Northwest. Priority should be given to research on geoduck aquaculture, the role of shellfish in nutrient cycling, and other aspects of ecosystem services provided by shellfish. New research projects include:
      i. The Jamestown S'Klallam Tribe recently received their state 401 Water Quality Certification for a new geoduck farm which includes a significant monitoring component for evaluating potential impacts to adjacent eelgrass beds. The data from this monitoring will help improve understanding of the relationship between farms and eelgrass.
      ii. Washington Sea Grant will provide $79,198 over two years to support development of a model that will serve as an innovative tool to assess the risk of toxic blooms in Puget Sound. WSG funded research will study the cyst stage of the toxic algae Alexandrium catenella, responsible for paralytic shellfish poisoning, and evaluate the effectiveness of using cyst mapping as a tool for early warning of bloom events in Puget Sound.

iii. Washington Sea Grant will host a public symposium to share latest scientific research findings on shellfish production effects on the environment. The meeting will explore the scientific basis for management decisions to balance competing land use interests, environmental protection and coastal development needs

c) *Implement Pilots.* Implement pilot projects and use the Model Permitting Program to determine permitting efficiency, practicality and regulatory compliance (e.g., habitat protection). Potential pilots include a Washington Department of Natural Resources (DNR) lease site and North Sound restoration projects in bays like Sequim, Similk and Fidalgo.

d) *Improve Guidance for Local Shoreline Master Programs.* Increase local government and public understanding and application of the new shellfish provisions in State Shoreline Guidelines (Chapter 173-26 WAC). The Department of Ecology (Ecology) will publish an aquaculture Shoreline Master Program Handbook section with special emphasis on geoduck aquaculture and net pen operations, update its aquaculture web resources to make them more comprehensive, and provide direct technical assistance and training to local governments. The guidance will address regulatory and technical assistance to protect against habitat impacts and planning to minimize conflicts with adjoining shoreline owners and other marine water users.

e) *Review of Shellfish Ecosystem Services.* U.S. Geological Survey will conduct a review of available filter feeding models to quantitatively evaluate the capacity of cultivated shellfish to mitigate nitrogen pollution in Puget Sound. This work will be informed by NOAA research. If appropriate and feasible, Ecology will explore the possibility of implementing a nitrogen credit system using shellfish for pollution reduction. The credit system could stimulate new shellfish culture and jobs as well as identifying the role of shellfish in reducing nitrogen discharges.

2) Promote Native Shellfish Restoration and Recreational Shellfish Harvest

a) *Restore Native Shellfish.* Native shellfish restoration efforts will focus on two species: native Olympia oysters and pinto abalone.

Olympia oysters:

i. Restore 19 historic, large, Puget Sound natural oyster beds and associated local ecosystems by 2022.
ii. Direct a $200,000 NOAA grant to the Northwest Straits Commission for Olympia oyster restoration in the North Sound.
iii. Revise and update Washington Department of Fish and Wildlife's (WDFW) 1998 Native Oyster Rebuilding Plan by December 31, 2011. Share the revised plan with NOAA for inclusion in the national Oyster Restoration Plan. WDFW's standardized metrics will be used to determine success.
iv. NOAA is planning to host a hatchery breeding program for native oysters to increase seed production that meets established genetic conservation guidelines.
v. Increase collaboration with NOAA for assistance in funding and facilitating Olympia oyster research and restoration efforts conducted by WDFW, Puget Sound Restoration Fund (PSRF), tribal co-managers, shellfish growers and other partners.

Pinto abalone:

i. Use a $560,000 federal grant awarded by NOAA to WDFW in September to bolster the number of pinto abalone. The program aims to reestablish a self-sustaining population of pinto abalone without ESA protections. The NOAA-funded research coupled with continued state funding will advance abalone restoration efforts by developing hatchery and nursery programs for captive propagation and rearing. Priority abalone actions will be conducted by WDFW, Puget Sound Restoration Fund, University of Washington and non-profit organizations.

b) *Enhance Recreational Shellfish Harvest.* Improve and increase public access to shellfish on public tidelands for tribal and recreational harvest through signage, maps, acquisition and other efforts.

c) *Create Public Support for Shellfish Initiative.* Leverage Washington State Parks to engage the public in the initiative.

i. Washington Sea Grant will lead the state agencies and partners through a simple planning process to develop shellfish-related messages, publicize events, and otherwise develop materials to make connections between clean water, our region's shellfish resources, and jobs.

ii. State Parks will conduct shellfish interpretive programs and events to help forge personal connections between clean, productive Puget Sound waters, the shellfish we eat, and the iconic role shellfish occupy in Washington's cultural and culinary identity. State Parks will collaborate with other public/tribal/private interests and help promote support of public lands and the Discover Pass program.

3) Ensure Clean Water to Protect and Enhance Shellfish Beds

a) *Direct $4.5 million in Environmental Protection Agency funding to protect and improve water quality to meet state standards in commercial, recreational and Tribal shellfish growing areas.* Funds will be used to help reach the Puget Sound Partnership's shellfish indicator target of upgrading 10,800 acres of harvestable shellfish beds by 2020. The Department of Health (DOH) and the Washington Department of Ecology (Ecology) are managing this new funding, which includes the following:

i. More than $2 million to help local governments create sustainable pollution identification and correction programs (PIC programs). These programs will be designed to identify and address pathogen and nutrient pollution from a variety of nonpoint sources, including on-site sewage systems, farm animals, pets, sewage from boats, and stormwater runoff. Counties being offered funding pending negotiations are San Juan, Thurston, Pierce, Skagit, Kitsap, as well as the Hood Canal Coordinating Council, the consortium of counties and tribes that encompass the Hood Canal.

ii. More than $1 million to help Local Health Jurisdictions carry out onsite sewage system management plans that inventory, inspect, and fix failing onsite sewage systems in Marine Recovery Areas and other areas sensitive to pathogen pollution.

iii. $1.5 million to reduce pathogen and nutrient loading by improving manure management in those areas with PIC programs. The fund will pay for eligible agricultural best management practices including livestock exclusion fencing, off-stream watering, and livestock feeding. Interested land owners must work through a conservation district, local government, tribe, or other governmental entity. Some of this work can be implemented by putting the newly created Sound Corps to work.

iv. Increase local government understanding and application of practices for controlling pathogens, consistent with Chapter 173-201 WAC. Ecology will provide guidance on nonpoint source BMPs consistent with state water quality standards as well as training to local governments to ensure that PIC programs and federal funding implement these standards.

v. Develop economically viable strategies to address impacts from stormwater and wastewater treatment outfalls, which are a significant factor for shellfish bed prohibitions.

b) *Improve Shellfish Growing Area Protection and Restoration Efforts.* Additional efforts are needed at all levels of government to improve water quality protections for shellfish growing areas. Two immediate steps are to:

   i. Form an EPA and state (i.e., Ecology, DOH, Washington State Department of Agriculture) "pollution action team" to respond quickly when water quality problems are identified that threaten to shellfish areas. The team will focus in priority areas and support PIC programs where established. The team will work with technical staff from affected tribes with treaty reserved rights. Services provided by the team include pollution identification, inspections, enforcement, flyovers and technical assistance, consistent with guidance provided for use of federal funds. The team will focus initially in Drayton Harbor and Portage Bay. There has been a long struggle to protect the community shellfish beds in Drayton Harbor, and there are growing concerns over tribal resources in Portage Bay. The Whatcom Conservation District will be a key local partner in working with the state and federal pollution action team.

c) *Take Steps to Address Ocean Acidification.* Conduct research and develop recommendations to understand, monitor, mitigate and adapt to acidification in Puget Sound and Washington waters.

   i. Convene a Blue Ribbon Panel on Ocean Acidification including scientific experts, the relevant agencies and stakeholders to develop clear, actionable recommendations on understanding, monitoring, adapting, and mitigating ocean acidification in Puget Sound and Washington waters.

   ii. A new Washington Sea Grant research project will investigate the effects on Pacific oysters of exposure to natural water seawater that contains a high level of carbon dioxide. It will also explore new breeding programs for enhancing the tolerance of farmed Pacific oysters to higher CO_2 seawater. Washington Sea Grant will provide $112,693 over two years (2012-2014) for the project, building on 2010-2013 funding of $478,082 and a total four-year investment of $590,785 to address ocean acidification impacts on shellfish resources.

d) *Work with Boaters to Address Potential Pollution Impacts.*

   i. *Strategically Administer the Clean Vessel Program.* State Parks and Recreation Commission will target Clean Vessel Act grants towards marinas where significant recreational, commercial, and Tribal shellfish resources exist and are harvested. These grants will fund the construction, renovation, operations, and maintenance of boat pumpout stations and waste reception facilities for recreational boaters. State Parks will partner with the Washington Sea Grant, DNR, and other entities on educational outreach to marinas and boaters that will publicize these pump-out locations and the need for their use.

ii. *Complete No Discharge Zone Assessment.* Ecology will complete an assessment needed to establish a No Discharge Zone, which would ban sewage disposal from commercial and recreational vessels for all or parts of Puget Sound.

Appendix D

Interim Progress Report

October 1, 2010, through September 30, 2011

Geoduck Aquaculture Research Program

Report to the Washington State Legislature

Senate Agriculture, Water & Rural Economic Development Committee

Senate Energy, Natural Resources & Marine Waters Committee

Senate Environment Committee

House Agriculture & Natural Resources Committee

House Environment Committee

February 2012

Sea Grant Washington

University of Washington • Seattle, Washington

Interim Progress Report

Publication and Contact Information

This report is available on the Washington Sea Grant website at *wsg.washington.edu/research/geoduck/index.html*

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February 2012 • WSG-TR 12-01

Sea Grant Washington

Contents

I. Summary

The geoduck (*Panopea generosa*) is North America's largest burrowing clam. It is found in soft intertidal and subtidal marine habitats in the northeast Pacific Ocean to depths of more than 200 feet. In Washington state, this large clam has been cultured for enhancement of wild stocks since 1991 and on a commercial scale since 1996. However, there was little scientific information available on the ecological impacts of applicable culture practices. In 2007, at the direction of the State Legislature, Washington Sea Grant, based at the University of Washington, established a six-year research program to assess possible effects of geoduck aquaculture on the Puget Sound and Strait of Juan de Fuca environments. This interim report summarizes the progress of the program to date and provides detailed reports on studies conducted between October 1, 2010, and September 30, 2011.

II. Background

The 2007 law (Second Substitute House Bill 2220; Chapter 216, Laws of 2007) directed Washington Sea Grant (WSG) to review existing scientific information and commission scientific research studies to examine key uncertainties related to geoduck aquaculture that could have implications for the health of the ecosystem and wild geoduck populations. The legislation established six priorities to measure and assess:

1. The effects of structures commonly used in the aquaculture industry to protect juvenile geoducks from predation;
2. The effects of commercial harvesting of geoducks from intertidal geoduck beds, focusing on current prevalent harvesting techniques, including a review of the recovery rates for benthic communities after harvest;
3. The extent to which geoducks in standard aquaculture tracts alter the ecological characteristics of overlying waters while the tracts are submerged, including impacts on species diversity and the abundance of other organisms;
4. Baseline information regarding naturally existing parasites and diseases in wild and cultured geoducks, including whether and to what extent commercial intertidal geoduck aquaculture practices impact the baseline;
5. Genetic interactions between cultured and wild geoducks, including measurement of differences between cultured and wild geoduck in term of genetics and reproductive status; and
6. The impact of the use of sterile triploid geoducks and whether triploid animals diminish the genetic interactions between wild and cultured geoducks.

The Legislature assigned top priority to the assessment of the environmental effects of commercial harvesting (2) and directed WSG to complete the research studies and report the results to the Legislature by December 1, 2013. The Shellfish Aquaculture Regulatory Committee (SARC), established by the 2007 law, and the Department of Ecology (Ecology) were tasked with overseeing the program.

In October 2007, WSG issued a request for proposals and, after rigorous scientific review, selected four projects for funding, two of which were combined to develop a more integrated and comprehensive study. Selected projects addressed five (1, 2, 4, 5, 6) of the six legislatively established priorities. Funding for priority 6 and selection of a project to address the remaining priority (3) were deferred until later in the program, subject to the availability of additional resources. Project titles, principal investigators, research institutions and a brief description of the studies are as follows:

1. **Geochemical and Ecological Consequences of Disturbances Associated with Geoduck Aquaculture Operations in Washington.** (Glenn VanBlaricom, University of Washington; Jeffrey Cornwell, University of Maryland) The project is examining all phases of the aquaculture process — geoduck harvest and planting, presence and removal of predator exclusion structures and ecosystem recovery. It will assess effects on plant and animal communities, including important fish and shellfish, in and on Puget Sound beaches, as well as the physical and chemical properties of those beaches.
2. **Cultured-Wild Interactions: Disease Prevalence in Wild Geoduck Populations.** (Carolyn Friedman, University of Washington) The study is developing baseline information on pathogens to improve understanding of geoduck health and management of both wild and cultured stocks.
3. **Resilience of Soft-Sediment Communities after Geoduck Harvest in Samish Bay, Washington.** (Jennifer Ruesink, University of Washington) Capitalizing on eelgrass colonization of an existing commercial geoduck bed, this project is examining the effect of geoduck aquaculture on soft-sediment tideflat and eelgrass meadow habitats.

The current program schedule and funding are summarized in Table 1. Funding for research and related program activities initially was provided through a state appropriation to the geoduck aquaculture research account established under the 2007 law. This state funding of $750,000 supported the program through June 30, 2010. Although no additional monies were deposited in the account in fiscal year 2010-2011, the Department of Natural Resources (DNR) provided $300,827 through an interagency agreement with the University of Washington (UW). The largest project, the VanBlaricom-led disturbance study, also secured $39,972 from the UW's Royalty Research Fund and $22,207 from Ecology to supplement student and technical support that was not included in the DNR agreement.

Scientists have adjusted their efforts to minimize research costs, and DNR, UW and Ecology funding has ensured continuation of the three ongoing research studies and program support. In October 2010, the National Sea Grant College Program awarded the VanBlaricom research team a competitive aquaculture grant to investigate the effects of aquaculture structures on related predator-prey interactions and food web dynamics in geoduck aquaculture. While the goals of the new project differ somewhat from the priorities established in the 2007 law, the studies are complementary and permit resources to be leveraged as part of a shared program infrastructure. In the meantime, delays in the growers' harvest schedule in the VanBlaricom study area necessitated an extension in the study duration and collection of more samples to ensure continuity of measurements. The situation has created a budget shortfall of $60,000-$75,000, and WSG is working with state agency partners to ensure that funds are available to process samples, analyze data and fully evaluate results.

As directed by the 2007 law, the final results of the three funded studies will be reported to the Legislature by December 2013. Deferred priorities (3, 6) that address the effects of geoduck aquaculture on overlying waters and the use of sterile triploid geoduck may be discussed as part of a general research overview. However, they are outside the direct scope of the report on this six-year research effort.

Table 1. Funding Source, Timing and Level

Project Title	Study Duration	Funding Source, Timing and Level				
		WA State Geoduck Research Account 7/1/2007 – 6/30/2010	Ecology Agreement 4/1/2010 – 6/30/2010	DNR Agreement 7/1/2010 – 6/30/2011	UW Royalty Research Fund 7/1/2010 – 6/30/2011	National Sea Grant Strategic Investment in Aquaculture Research (competitive grant) 10/1/2010 – 9/30/2012
Ecological and Geochemical Consequences of Disturbances Associated with Geoduck Aquaculture	Apr 2008 – June 2013	$459,935	$22,207	$210,390	$39,972	$397,672
Cultured-Wild Interactions: Disease Prevalence in Wild Geoduck Populations	Apr 2008 – July 2011	$104,000		$65,688		
Resilience of Soft-Sediment Communities after Geoduck Harvest in Samish Bay, Washington	Apr 2008 – July 2011	$86,612		$11,000		
Program Administration	Jul 2007 – Dec 2013	$99,453		$13,749		
TOTAL		**$750,000**	**$22,207**	**$300,827**	**$39,972**	**$397,672**

III. Summary of Research Progress

In 2010 and 2011, field samples continued to be gathered and analyzed, with initial results providing some indication of environmental response to geoduck aquaculture activities. It is important to note that these results remain preliminary and must be confirmed by additional fieldwork, analyses of full sample sets and peer review of final reported results. Among the observations for the October 1, 2010 to September 30, 2011 reporting period:

- Infaunal communities at all three harvest study sites show high spatial and seasonal variability; such variability is common to benthic communities in Puget Sound.
- Results of the geoduck harvest study suggest that current practices have minimal impacts on benthic communities of infaunal invertebrates, with no observed "spillover effect" in habits adjacent to cultured plots. These results suggest that disturbance at the scale of current harvest practices is within the range of natural variation experienced by benthic communities in Puget Sound.
- Preliminary statistical analyses suggest significant differences in the structure of mobile macrofauna communities between planted areas with nets and tubes and nearby reference beaches. These differences do not persist once nets and tubes are removed from aquaculture areas during the grow-out culture phase.
- Nutrients released from a typical commercial geoduck operation are low. Moderate concentrations of nitrogen and phosphorus found in sediments and released during harvest make a relatively small contribution to overall nutrient discharges into Puget Sound. Localized effects are likely to be negligible.
- High densities of geoducks filter out algae and their constituent nitrogen and phosphorus in shallow intertidal areas and the digested algae are incorporated into geoduck biomass or remineralized to inorganic nitrogen and phosphorus. In the absence of geoduck culture, algae may still be efficiently remineralized within the water column, processed in deeper water sediments or ingested by other organisms. The overall effect of aquaculture is to change the location of nutrient recycling from the water column to the sediments, rather than fundamentally change the overall rate of nutrient release.
- Analyses of disease data for wild geoduck indicate no distinct patterns in the distribution of disease organisms as a function of geographic location or water depth. The occurrence of two organisms (*Rickettsia*-like and protozoans) show seasonal influences. Three remaining parasites — in the siphon muscle, intestine and ova — have no distinct environmental drivers (season, collection depth or geographic location).
- In Fisk Bar, where eelgrass recruited to the area after geoducks were planted, harvest activities produced effects on almost every measured biological and physical parameter of the farmed and reference sites with limited "spillover effects" from the farmed site to adjacent reference areas. However in 2011, one year after the removal of tubes and nets from the new culture cycle, the first signs of eelgrass recovery were observed, indicating that current farming practices do not make sites unsuitable for later colonization by eelgrass.

Detailed project descriptions and overviews of research progress as of September 30, 2011, are presented in Section IV of this report. Detailed technical progress reports are available in the "project updates" section of each project on the WSG website, at *www.wsg.washington.edu/research/geoduck/current_research.html*. A list of presentations and communications products generated by the program during this reporting period (October 1, 2010, to September 30, 2011) is contained in the appendix to this report.

During the report period, WSG continued to work with Ecology, SARC and other interested parties. WSG staff and program researchers provided an update to the full SARC on April 4, 2011. Copies of presentations are available on the SARC website at *www.doe.wa.gov/programs/sea/shellfishcommittee/meetings.html#4-11*. Copies of additional relevant research and public presentations are available on the WSG website at *www.wsg.washington.edu/ research/geoduck/current_research.html*.

Copies of the 2009 and 2010 Geoduck Aquaculture Research Program reports are available in downloadable PDF formats on the WSG website at *http://wsg.washington.edu/research/geoduck/index.html* or as hard copy on request.

IV. Detailed Research Reports

1. Geochemical and Ecological Consequences of Disturbances Associated with Geoduck Aquaculture Operations in Washington

Glenn VanBlaricom, David Armstrong and Tim Essington, School of Aquatic and Fishery Sciences, University of Washington, and Jeffrey Cornwell and Roger Newell, Horn Point Marine Laboratory, University of Maryland

This large-scale multidisciplinary study will contribute to improved understanding of the effects of geoduck production and harvesting on key marine nearshore and intertidal animal communities and their habitats. Initiated in 2008, the project will be conducted over a six-year period to ensure investigation of all stages of culture activity and provide balanced scientific information to make better-informed management decisions. The study seeks answers to several pressing questions:

- What are the effects of geoduck aquaculture structures on plant and animal communities in or on Puget Sound beaches?
- Do structures change the behavior or movements of commercially and ecologically important fish and shellfish?
- How does disturbance during geoduck harvesting affect plant and animal communities and subsequent recovery of the ecosystem?
- How does the disturbance alter the physical and chemical properties of harvested beaches?

The study is divided into two components:

- Ecological effects, focusing on densities and diversity of soft-sediment invertebrates (infauna and sedimentary epifauna) and densities and diversity of mobile invertebrates (epifauna on culture-associated structures) as well as sessile, attached invertebrates (fouling organisms) dwelling on culture-associated structures.
- Geochemical effects, focusing on changes in geochemical attributes of sediments and overlying water as a consequence of culture activities.

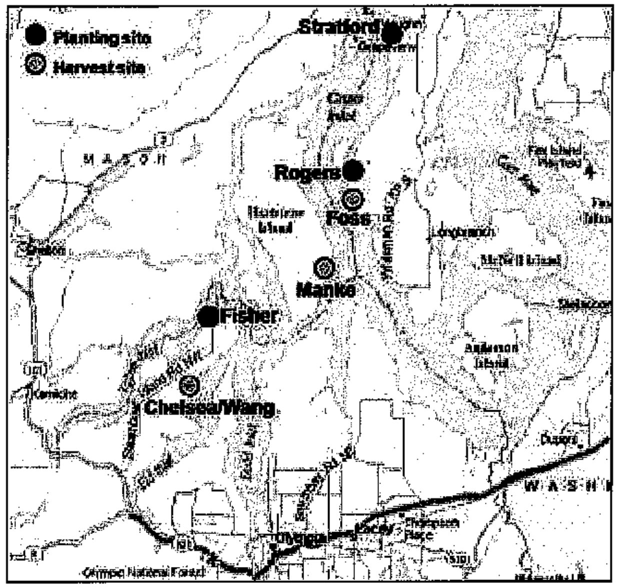


Figure 1. Map of sites currently established in southern Puget Sound to study planting effects (red circles) and harvest effects (yellow circles). The Rogers and Stratford sites were outplanted in November 2008 and June 2009, respectively; planting at the Fisher site was completed in December 2009. Harvest of mature geoducks at Foss/Joemma (i.e., Foss) was completed in December 2008, and harvest at the Chelsea/Wang and Manke sites was completed in March 2010. Sampling continued for at least six months after gear removal or harvest, at planting and harvest effects sites, respectively.

Approach

Research is conducted in active commercial geoduck aquaculture plots to ensure that spatial and temporal scales of the research match those of a typical geoduck aquaculture operation. In cooperation with growers and as a result of extensive survey work, six study sites were selected (Figure 1) that represent all stages of culture activity and have environmental conditions that allow meaningful comparisons among sites.

Ecological effects. To accommodate the fact that different sites are at different stages of the culture cycle, researchers are employing two sampling approaches:

- Field experiments that sample before and after a specific culture activity (e.g., harvest), known as "before-after control-impact" (BACI) design.
- Comparative analytical approaches that focus on multiple sites in various stages of culture activity, sampling in a manner that effectively substitutes spatial variation for temporal variation.

Work has focused on the resident communities of infauna and epifauna at harvest and planting sites. It also has focused on fish and mobile macroinvertebrates that visit planting sites during high tides. Infaunal and epifaunal communities were sampled using sediment cores for smaller invertebrates, excavation samples for larger invertebrates (e.g., sand dollars) and photo quadrats to assess sediment types and percentages of vegetation cover and to make estimates of densities of burrows, such as those made by ghost shrimp.

Samples were taken randomly from within the farmed and unfarmed plots at each site, and additional core samples were taken at set intervals on either side of the farmed plot to determine whether effects extend beyond the farmed area (Figures 2 & 3). All research sites were visited and sampled extensively during the summer months of 2008 to 2011, with post-gear-removal sampling of planted sites initiated in April 2011 at the Rogers and Stratford sites and in May 2011 at the Fisher site after partial gear removal (Table 2). Mobile organisms were surveyed using two techniques: shore-based surveys, developed as a method of monitoring fine-scale use of shallow nearshore areas by juvenile salmonids; and diver surveys (Figure 4), conducted to assess the presence of bottom-dwelling fishes and small benthic invertebrates during high tides. Surveys were conducted monthly during March to September and bimonthly during October to February in 2009-2011.

Research team members have also conducted three pilot studies to investigate recruitment by fouling organisms on predator exclusion devices, effects of aquaculture practices on the survival and growth of non-target species, including Manila clam (*Venerupis philippinarum*), and trophic linkages between resident prey and mobile predators.

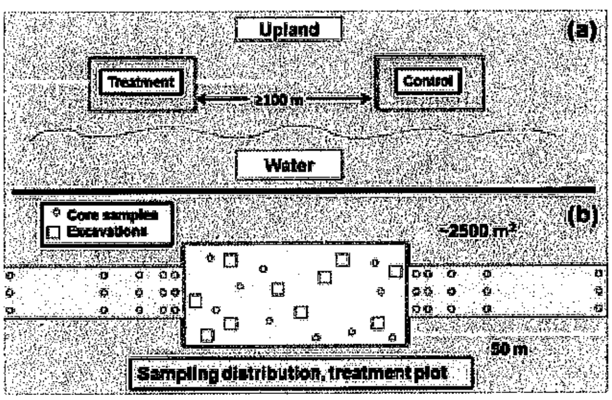


Figure 2. Schematic showing (a) site design and (b) the two categories of samples collected at each site — randomly distributed, within-plot samples and linear arrays that begin at the edge of a cultured plot and extend away from the plot, parallel to the shoreline.

Figure 3. Technician Brittany Cummings collects core samples at a planting effects site in Case Inlet. Core samples are sieved and processed in the laboratory to investigate the effects of aquaculture gear on the community of organisms living within the beach sand (photo credit: P. Sean McDonald).

Figure 4. UW SCUBA divers prepare to collect survey data at the Stratford planting effects site in September 2011. Surveys are done regularly to investigate the response of fish and mobile invertebrates (crabs, sea stars, snails) to aquaculture gear (photo credit: Ava Fuller).

Table 2. Summary of samples collected and processed to date. Samples collected and processed since September 30, 2010 are shown in parentheses.

	Site	Type	# Collection Trips	# Samples Collected	# Samples Processed
Core Samples					
	Chelsea/Wang	Harvest	14	583	91
	Foss/Joemma	Harvest	13	720	612
	Manke	Harvest	18	700	700
	Fisher	Planting	13 (+9)	560 (+315)	49 (+315)
	Rogers	Planting	13 (+9)	745 (+315)	521 (+315)
	Stratford	Planting	10 (+8)	350 (+280)	4 (+315)
Excavation Samples					
	Chelsea/Wang	Harvest	11	220	220
	Foss/Joemma	Harvest	9	180	180
	Manke	Harvest	12	240	240
	Fisher	Planting	6	120	120
	Rogers	Planting	8	160 (+140)	160 (+140)
	Stratford	Planting	5	100 (+160)	100 (+160)
Photo Samples					
	Chelsea/Wang	Harvest	13	260	40 (+159)
	Foss/Joemma	Harvest	9	180	180
	Manke	Harvest	13	260	180 (+80)
	Fisher	Planting	12	240	100 (+109)
	Rogers	Planting	11	220	160 (+61)
	Stratford	Planting	10	200	100 (+102)
Macrofauna Surveys*					
	Chelsea/Wang	Harvest	--	--	--
	Foss/Joemma	Harvest	--	--	--
	Manke	Harvest	--	--	--
	Fisher	Planting	13 (+9)	416 (+332)	100
	Rogers	Planting	13 (+10)	416 (+366)	20
	Stratford	Planting	14 (+10)	448 (+368)	120

*Surveys only conducted at planting sites.

Geochemical effects. This component of the research is designed to quantify the extent to which culturing and harvesting of geoducks increases the release of inorganic nutrients into the surrounding water. Initial work conducted in 2008 focused on evaluating a variety of methods for collecting pore water (the water contained in sediment samples) at various depths and on methods for evaluating nutrient release during geoduck harvest. For this study, samples of deep pore waters were collected from intertidal environments without geoduck aquaculture, with intact geoduck aquaculture, during harvest and after harvest. To quantify nutrient release during harvest operations, the rate of water flow from high-water-volume hoses used to remove geoducks from the sediment was measured and nutrient concentrations in small rivulets flowing away from the harvest area were assessed. To understand the physical conditions at each site, the water level in sediments at low tide and the grain size of sediments were measured.

Work in fall 2008 and summer 2009 focused on harvest operations at the Foss/Joemma and Chelsea/Wang sites and at an additional site in Thorndyke Bay. Pre- and post-harvest pore water samples were collected, and samples of water runoff were collected during harvest operations. Samples were analyzed for concentrations of pore water nitrogen (ammonium, nitrate) and soluble reactive phosphorus (SRP).

To determine the exchange of nutrients between the sediment and overlying water during the geoduck grow-out phase, sediment cores were collected from farmed and unfarmed locations at the Thorndyke Bay site, incubated under laboratory-controlled conditions and analyzed for changes in the concentrations of oxygen, nitrogen, silicate and SRP over time.

One additional field-sampling trip was conducted in November 2009 during harvest activities at the Manke site. Samples of pore water from transects in harvest and reference areas were analyzed for nitrogen and SRP.

Project status

Ecological effects. The initial phase of this component of the project, including refinement of sampling techniques and three pilot studies, has been completed. Substantial progress has been made on the final two phases of the project: measuring effects of harvest and planting on infaunal and epifaunal communities; and observing the response of mobile fish and macrofauna to aquaculture structures.

- *Effects of harvest and planting on infauna and epifauna.* Sampling at planting sites (Fisher, Rogers and Stratford) is ongoing. Sampling and processing at all three harvest sites (Foss/Joemma, Manke and Chelsea/Wang) have been completed (Table 2). These data have been analyzed by graduate student Jennifer Price and form the basis of her recently completed thesis (cited in the appendix of this report) for the UW School of Aquatic and Fishery Sciences. Patterns in taxa richness and species abundance of infauna within and among sites indicate high degrees of seasonal and spatial variation in community structure. Each site presents a slightly distinct benthic community structure and, therefore, responds to harvest practices differently. Statistical analyses indicate that variance in infaunal data is primarily attributable to time of year (season), plot status (cultured versus uncultured) and harvest state (pre- versus post-harvest). However, there are no significant statistical interactions between plot status and harvest state, suggesting that harvest itself does not significantly alter the benthic invertebrate assemblages under study. Transect data were also analyzed and indicate substantial temporal and spatial variation, even over tens of meters. There were no patterns of increasing or decreasing organism density or species diversity as the distance from cultured plots increased, except for the Foss south transect during the mid-harvest period. All other variations within transects at all three sites appeared to be random or were caused by as-yet unknown processes not accommodated in the study design.
- *Response of mobile organisms to presence of aquaculture structures.* SCUBA surveys at planted sites, focusing on demersal fishes and invertebrate macrofauna, are ongoing. Preliminary analyses of shore survey data have not indicated differences in use of habitats by juvenile salmonids, although these data are presently limited by low sample sizes. As the data set of SCUBA surveys increases, observations suggest a pronounced seasonal response of mobile macrofauna found within planted areas and reference beaches. Observations also suggest increased use of planted areas by kelp crabs (*Pugettia producta*) and red rock crab (*Cancer productus*) during autumn and winter (October-March). Graceful crab (*Cancer gracilis*), Pacific staghorn sculpin (*Leptocottus armatus*) and speckled

sanddab (*Citharichthys stigmaeus*) are apparently ubiquitous at Fisher, Rogers and Stratford sites. Data collected to date suggest that structures associated with geoduck aquaculture may attract species observed infrequently on reference beaches (e.g., bay pipefish, *Syngnathus leptorhynchus*) but may displace species that typically occur in these areas (e.g., starry flounder, *Platichthys stellatus*). Preliminary statistical analyses suggest significant differences in the structure of macrofauna communities between planted areas with nets and tubes and nearby reference beaches. These differences do not persist once nets and tubes are removed from aquaculture areas during grow-out.

- *Pilot study on fouling community recruitment.* In May-August 2010, Erika Pinney, an undergraduate at the UW, conducted an experimental investigation of recruitment by fouling plants and animals to predator exclusion devices, specifically, PVC tubes and three varieties of aquaculture netting — large-mesh fiber net covers, small-mesh plastic net covers and small-mesh plastic net caps. Across the four-month sampling period, small-mesh plastic net caps developed fouling community assemblages that were more diverse and contained a higher abundance of taxa than large-mesh fiber net covers and small-mesh plastic net covers. Conversely, the large- and small-mesh net covers accumulated more fouling green algae (*Enteromorpha spp.*) than did net caps, with peak biomass occurring in July. This effort will be expanded during summer 2012 to investigate the effects of fouling algae on geoduck growth and carbon sources in fouled aquaculture plots.
- *Pilot study of the survival and growth of non-target clams.* In July 2010, UW undergraduates Hans Hurn and Julia Eggers investigated the effects of aquaculture practices on the survival and growth of non-target clams within cultured plots of geoducks and adjacent reference beaches at the Rogers, Fisher and Stratford sites. Survival of non-target clams was lower within planted areas than on adjacent beaches and, when combined with results from predator exclusion cages, suggests higher predation in the aquaculture areas. Non-target clams showed a tendency toward slower growth in aquaculture areas than on adjacent beaches; however, results were not statistically significant. The students presented results of the experiment at the American Fisheries Society meeting in Seattle in September 2011. They are currently preparing a manuscript for submission to a peer-reviewed research journal.
- *Pilot study on the trophic linkages between resident prey and mobile predators.* Pilot work conducted in 2008 by Rachel Smith, a National Science Foundation Research Experience for Undergraduates Program participant, was recently published in Northwestern University's Northwestern Undergraduate Research Journal. This work was continued in 2009 by UW volunteer Kristin Larson and formed the basis for a new ongoing project funded through NOAA Sea Grant and the NOAA Aquaculture Program as part of the National Marine Aquaculture Initiative. The project, which supports thesis work for a UW graduate and undergraduate student, continues to investigate the effects of geoduck aquaculture structures on trophic relationships in intertidal communities.

Geochemical effects. At all sites, nitrogen concentrations in pore water samples consisted primarily of ammonium. At the Chelsea/Wang site, ammonium concentrations were higher in sediment where geoducks had been previously harvested and at sites where harvest-sized geoducks were still being grown than in adjacent reference areas (where geoducks were not being grown or harvested). Similarly at the Thorndyke Bay site, high ammonium concentrations were observed only in plots with geoducks. High concentrations of SRP were observed at harvest, grow-out and reference sites at the Chelsea/Wang site. Silicate concentrations in pore water were variable across sites but very high at the Chelsea/Wang sites with little apparent relationship to geoduck culture. Elevated silica concentrations suggest that diatoms are dissolving in the geoduck beds. Both diatoms and phosphorus bound to inorganic particles would be focused by geoduck filter feeding from the water column into the sediment.

Nutrient data analyses are now complete, and data clearly show that nutrients (nitrogen and phosphorus) released from a typical commercial geoduck operation into Puget Sound are low — 40 μmol L^{-1} dissolved inorganic nitrogen and less than 5 μmol L^{-1} SRP. The total release into Puget Sound during one tidal cycle in which two geoduck harvesters were at work was ~9 g phosphorus and 32 g nitrogen. On a whole-system basis, this is a very small release. Even in a small, poorly flushed embayment, this level of input is unlikely to result in any local change in water quality.

Harvest effluent SRP concentrations were not high relative to pore water observations; however, SRP measurements suggest an imbalance in the regeneration of nitrogen and phosphorus in the sediment. The molar ratio of SRP to dissolved inorganic nitrogen (ammonium plus nitrate) was observed to be < 0.062, which is much lower than the expected ratio if nitrogen and phosphorus concentrations were derived solely from decomposing algae (0.10-0.71). One possible explanation for such an imbalance is the release of mineral-bound phosphorus.

The results of laboratory incubations of sediment cores from Thorndyke Bay under dark conditions, indicated generally low exchange of ammonium and SRP between the sediment and overlying water, but the SRP fluxes were significantly higher in geoduck culture areas than in control areas. Oxygen consumption also was significantly higher in geoduck culture areas than at the reference site. Increases in nitrogen and phosphorus release from the sediment, as well as the increased oxygen uptake by the sediment, are consistent with increased inputs of algal-derived organic material into geoduck culture areas.

Research Highlights

Ecological effects

- Infaunal communities at all three harvest study sites show high spatial and seasonal variability; such variability is common to benthic communities in Puget Sound.
- Results of the geoduck harvest study suggest that current practices have minimal impacts on benthic communities of infaunal invertebrates, with no observed "spillover effect" in habits adjacent to cultured plots. These results suggest that disturbance at the scale of current harvest practices is within the range of natural variation experienced by benthic communities in Puget Sound.
- Preliminary statistical analyses suggest significant differences in the structure of mobile macrofauna communities between planted areas with nets and tubes and nearby reference beaches. These differences do not persist once nets and tubes are removed from aquaculture areas during the grow-out culture phase.
- Fieldwork for the geoduck planting study is ongoing.
- Additional funding from the NOAA Aquaculture Program has been secured to conduct a separate but related study on the effects of geoduck aquaculture structures on trophic relationships in intertidal communities.

Geochemical effects

- Nutrients released from a typical commercial geoduck operation are low. Moderate concentrations of nitrogen and phosphorus found in sediments and released during harvest make a relatively small contribution to the overall nutrient discharges into Puget Sound. Localized effects are likely to be negligible.
- High densities of geoducks filter out algae and their constituent nitrogen and phosphorus in shallow intertidal areas, and the digested algae are incorporated into geoduck biomass or remineralized to inorganic nitrogen and phosphorus. In the absence of geoduck culture, algae may still be efficiently remineralized within the water column, processed in deeper water sediments or ingested by other organisms. The overall effect of aquaculture is to change the location of nutrient recycling from the water column to the sediment, rather than fundamentally change the overall rate of nutrient release.
- The results of this component of the project are being readied for a January 2012 submission to the peer-reviewed research journal *Aquaculture*.

2. Cultured-Wild Interactions: Disease Prevalence in Wild Geoduck Populations

Carolyn Friedman and Brent Vadopalas, School of Aquatic and Fishery Sciences, University of Washington

The lack of baseline information on geoduck health and condition hinders its management. Without prior knowledge of parasites and disease prevalence, it can be difficult to identify the causative agent of an epidemic. Baseline data provide information on possible pathogens and also provide insights into whether the initial outbreak or re-emergence of a disease is related to an endemic or recently introduced parasite.

In this three-year project, researchers have characterized parasites and other disease organisms associated with wild geoducks and determined their prevalence in three wild geoduck populations representing southern Puget Sound, Hood Canal and the Strait of Juan de Fuca. Geoducks were collected in summer and winter to facilitate detection of both warmwater and coldwater infectious organisms. The researchers are using multivariate statistical techniques to explore trends of parasite presence within geoduck populations and to identify the environmental factors (geographic distribution, sample depth, date/season) that influence the occurrence and diversity of parasite assemblages.

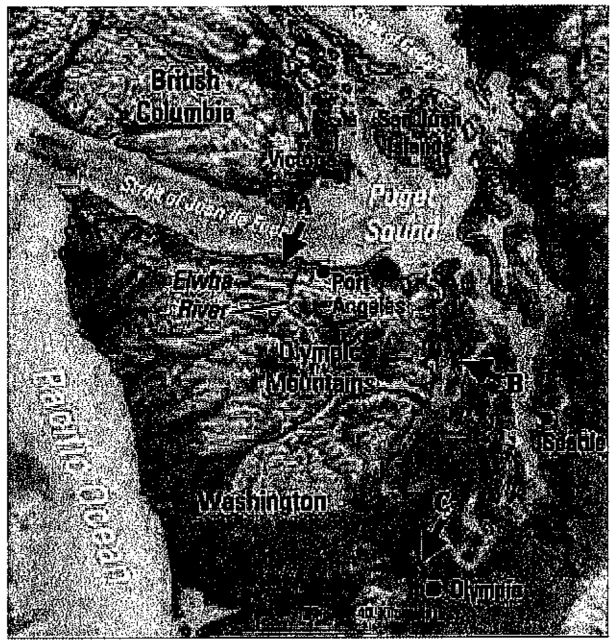


Figure 5. Map of sample sites. Source: soundwaves.usgs.gov/2005/01/puget-soundLG.jpg.
A — Freshwater Bay; B — Thorndyke Bay; C — Totten Inlet

Approach

For this project, three sites reflecting the geographic range of geoduck aquaculture in Washington were selected (Figure 5). Samples from each site were taken in summer (July-August 2008) and winter (February 2009) to determine seasonality in disease prevalence, should it exist. The samples were collected with assistance from the Washington Department of Natural Resources, Washington Department of Fish and Wildlife, Jamestown S'Klallam Tribe and Lower Elwha Klallam Tribe. All samples have been processed, slide-mounted, stained and analyzed.

Project Status

Examination of stained tissue sections from wild geoducks collected from Thorndyke Bay, Freshwater Bay and Totten Inlet revealed the presence of a microsporidian-like parasite resembling *Steinhausia* sp. The biology of *Steinhausia*-like parasites is poorly understood, but the existence of these organisms may impact reproductive success if present at high infection intensity. Although microsporidia have been reported in oysters, mussels and cockles from Europe, Australasia, California and the eastern United States, no molluscan microsporidia have been previously reported from Canada or Puget Sound. The most common abnormalities observed include: microsporidia-like protists in the siphon and intestine; a *Steinhausia*-like parasite in ova; a *Rickettsia*-like organisms in the gills; and nephrocalcinosis and inflammation in both the digestive gland and gills. Further analyses are needed to determine the taxonomy of these parasites. For example, it is unclear whether the microsporidian-like protists found in the geoduck ova, siphon and intestine are life-stages of a single microsporidian, three different species or a combination of the two possibilities. Researchers also observed a possible ciliate within gill tissues as well as numerous other parasites in association with the surface epithelium of the siphon. Several other parasites or diseases were also observed, including the presence of "warts" and a possible fungus associated with dark discoloration on the siphon and exposed mantle surface.

The most common parasites, their prevalence and seasonal occurrence are presented in Table 3.

Multivariate analyses of data indicated no distinct patterns as a function of site or sample depth. The presence of the *Rickettsia*-like organism is influenced by winter and summer seasons, with winter acting as a stronger driver than summer. The presence of protozoa in geoduck is more likely to occur during the spring season. Protozoa are not likely to appear during summer months. The remaining three parasites — microsporidia-like species in the siphon muscle, another microsporidia-like species in the intestine and the *Steinhausia*-like parasite in ova — all share similar community assemblages with no distinct environmental driver (season, collection depth or geographic location).

Table 3. Most commonly observed pathogens, their prevalence and seasonal occurrence.

Parasite	Tissue	Number of Samples	Prevalence	Seasonal Occurrence
Rickettsia-like organism	Gill	247	39.0%	Present in Winter and Summer
Protozoa	Siphon Epithelium	220	34.7%	Primarily in Spring
Microsporidia-like organism	Intestine	104	16.4%	No seasonal driver
Microsporidia-like organism	Siphon Muscle	27	4.3%	No seasonal driver
Steinhausia-like organism	Ova (egg)	99	15.6%	No seasonal driver
Bacteria	Intestinal Epithelium	3	0.5%	No seasonal driver

Molecular characterization of parasites will continue in 2012, to provide definitive identification and to assess parasite impact to wild geoduck health in the Northwest. Additional correlations of each parasite to individual drivers will be performed to supplement multivariate analyses.

Research Highights

- Analyses of disease data for wild geoduck indicate no distinct patterns in the distribution of disease organisms as a function of site or water depth. The occurrence of two organisms (*Rickettsia*-like and protozoans) show seasonal influences. Three remaining parasites — in the siphon muscle, intestine and ova — have no distinct environmental drivers (season, collection depth or geographic location).

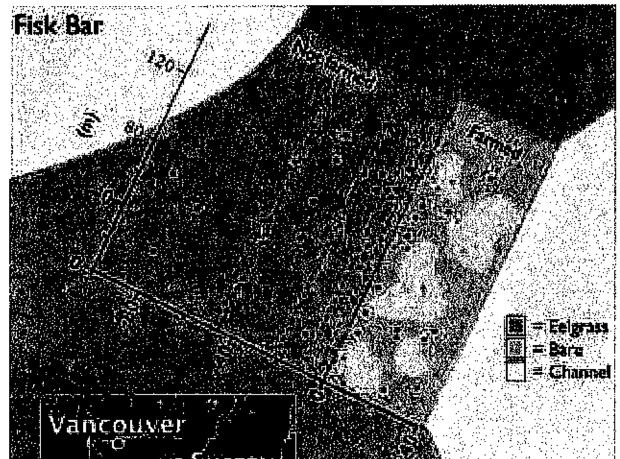
3. Resilience of Soft-Sediment Communities after Geoduck Harvest in Samish Bay, Washington

Jennifer Ruesink and Micah Horwith, Department of Biology, University of Washington

Commercial geoduck beds share waters with soft-sediment tideflats and eelgrass meadows — two habitat types that host diverse communities of plants and animals. In 2002, geoducks were planted in a soft-sediment tideflat in Samish Bay to establish a commercial shellfish bed. Since then, eelgrass has colonized the bed. The 2008 harvest and replanting of geoducks offered a unique opportunity to study the effects of geoduck aquaculture on soft-sediment tideflat and eelgrass meadow habitats. This project is exploring habitat changes associated with a commercial geoduck bed during the aquaculture cycle, from harvesting through replanting. Detailed surveys from before and after these events, both inside and outside the geoduck bed, will produce data on initial impacts on and rates of recovery for eelgrass meadow and soft-sediment invertebrate communities. These data will shed light on interactions between commercial geoduck aquaculture practices and local marine habitats.

Approach

Two research locations were established on Fisk Bar in Samish Bay: within an active geoduck aquaculture operation (farmed plot) and within an adjacent unfarmed area (control plot). The location and characteristics of the plots are provided in Table 4 and Figure 6. To determine the response of the local marine habitat to geoduck aquaculture practices, 15 surveys were conducted between April 2008 and July 2011, timed to coincide with geoduck harvest, planting, placement and removal of predator exclusion devices (PVC tubes and netting) (Figure 7).



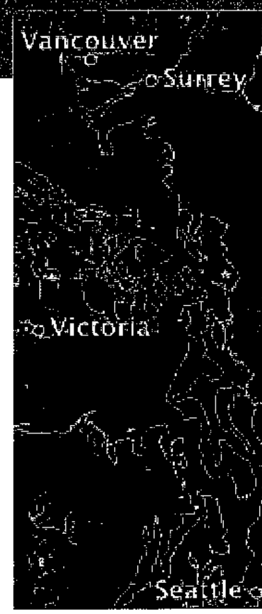


Figure 6. Fisk Bar, Samish Bay, WA (48°36'N, 122°26'W). Upper schematic represents a simplified birds-eye view of Fisk Bar on 4/9/2008, showing adjacent farmed and unfarmed areas. Points represent the placement of quadrats. The dotted line represents the harvest boundary, and dashed lines demarcate portions of the unfarmed area that are sampled equally through the stratified random design of quadrat placement. Left schematic represents the geographic location of Fisk Bar as a yellow star.

Table 4. Locations and characteristics of "Farmed" and "Unfarmed" research sites

Site Name	Location	Site Description
Fisk Bar (Farmed Area)	Samish Bay, WA (48°36'N, 122°26'W) -1.5ft MLLW	Taylor Shellfish geoduck farm, approximately 140 m x 36 m, adjacent to channel and colonized by *Z. marina* between the summers of 2002 and 2008. When *Z. marina* occurred on the bar, summer shoot densities averaged ~360/m^2. This site was harvested, reseeded, and netted in the summer of 2008, with new nets installed in the summer of 2009. All nets and tubes were removed in the summer of 2010. This serves as the impact site for the project.
Fisk Bar (Unfarmed Area)	Samish Bay, WA (48°36'N, 122°26'W) -1.5ft MLLW	Extensive *Z. marina* meadow, where shoot densities average ~400/m^2 in summer. This serves as the control site for the project.

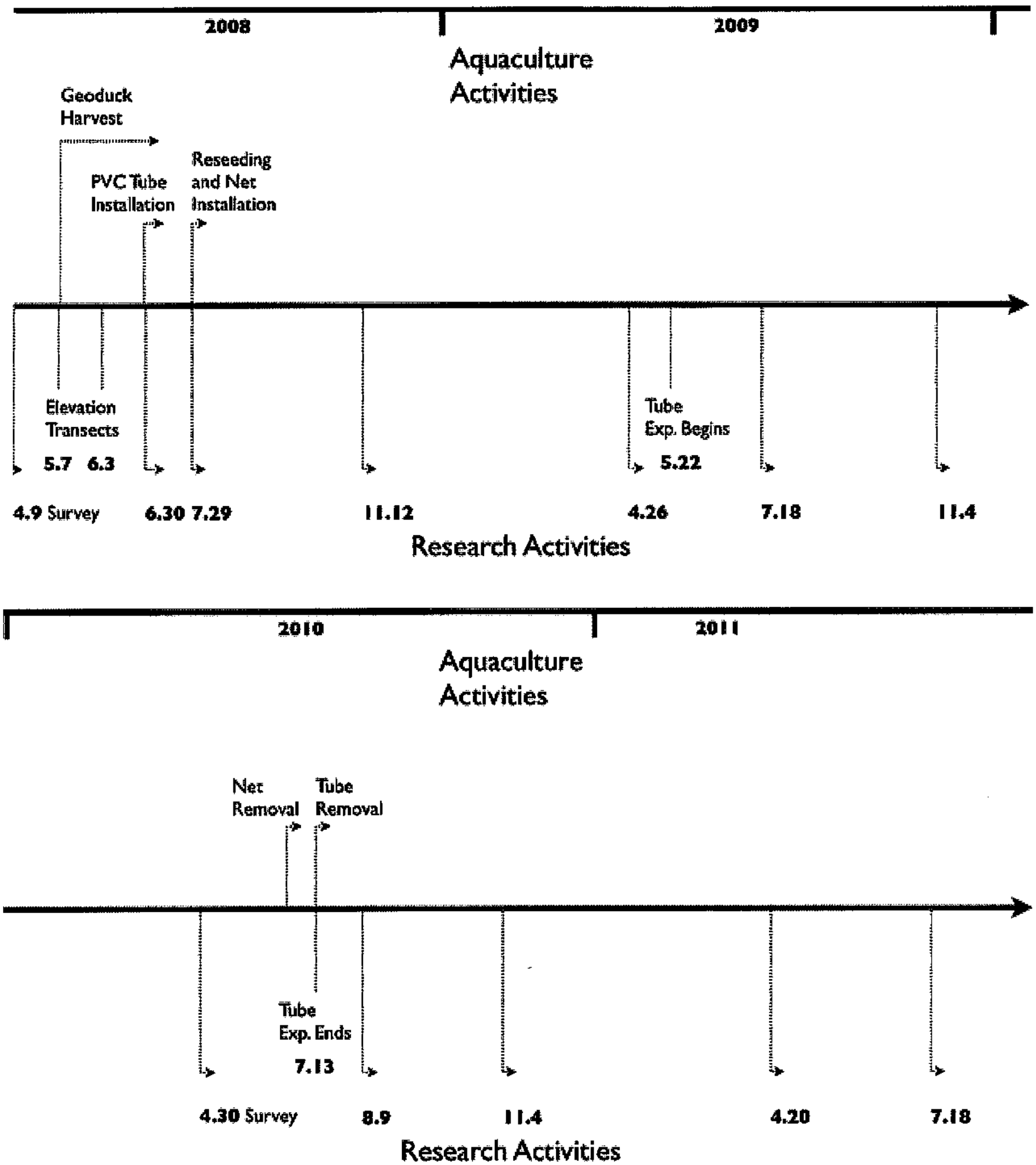


Figure 7. Timeline for aquaculture activities (above arrow) and research activities (below arrow) completed to date.

To determine the spatial extent of the habitat response to aquaculture practices, each plot was sampled during each survey using randomly positioned quadrats. The quadrats in the control plot were placed at set distances from the farm boundary. Within each quadrat, the number of native eelgrass (*Zostera marina*) vegetative shoots, flowering shoots and seedlings were counted, as well as the number of non-native Japanese/dwarf eelgrass (*Zostera japonica*) shoots, if present. Samples of sediment, infauna and eelgrass were collected for later analysis in the laboratory. In addition, pre- and post-harvest sediment height was measured to assess whether harvest practices result in a change of sediment elevation. Such change would indicate a loss or addition of sediment to the harvest location.

All fieldwork and full analyses of *Z. marina* and sediment samples (for organic content and grain size) have been completed. Analysis of infaunal samples is ongoing (Table 5).

In an accessory experiment conducted from May 2009 to July 2010 to determine the effect of installation of predator exclusion structures on sediment stability and eelgrass growth (Figure 8), four 10 x 5 m plots were selected outside the eelgrass meadow that mimicked conditions on Fisk Bar prior to geoduck planting in 2002. PVC tubes were installed over half of each plot (16 tubes per m^2 in a 5 x 5 m area), while the other half was left bare. In each plot, 40 *Z. marina* seedlings were transplanted into the center of the area with tubes installed, and 40 seedlings were transplanted into the bare area. Changes in sediment elevation and seedling growth were assessed monthly during the summer of 2009 and in July 2010 when the PVC tubes were removed.

Table 5. A summary of surveys conducted and samples collected and processed to date.

Sample type	# Surveys	# Samples Collected	# Samples Processed
Quadrat: In-place assessment of # of *Z. marina* vegetative shoots, flowering shoots, seedlings, and *Z. japonica* shoots	12	580	N / A
Quadrat: Laboratory assessment of *Z. marina* size and branching rate	12	580 bags, 4,874 *Z. marina* shoots	580 bags, 4,874 *Z. marina* shoots
Quadrat: Laboratory assessment of sediment organic content	12	580	580
Quadrat: Laboratory assessment of infauna	12	580	80
Transect: In-place assessment of sediment elevation	5	360	N / A

Figure 8. Tube installation experiment, July 12, 2010. The farmed area of Fisk Bar is approximately 20 m to the right of the standing individual (photo credit: Micah Horwith).

Project status

The initial, pre-harvest survey in April 2008 found little difference between the farmed and control plots of Fisk Bar in sediment organic content, mean *Z. marina* size, reproductive activity of *Z. marina*, or *Z. marina* shoot density. However, eelgrass was patchily distributed in the farmed plot and uniformly distributed in the control plot. After geoduck harvest, reseeding and net installation (summer 2008), a range of effects on ecologically relevant aspects of Fisk Bar was detected. Within the farmed plot, an immediate and significant reduction in shoot density, rate of flowering and size of aboveground structures was observed for *Z. marina*, along with a delayed and significant reduction in belowground branching activity. *Z. marina* was lost from the farmed plot between April 26, 2009, and July 18, 2009, in part because of reduced light levels created by a thick covering of *Ulva* algae on the predator exclusion nets. After harvest, the farmed plot had a significantly lower sediment organic content than the control plot on every survey date. The farmed plot also demonstrated a significant post-harvest loss of elevation that was not evident in one subsequent survey, suggesting a quick recovery.

Preliminary analysis indicates some evidence of minor "spillover effects" of geoduck aquaculture on the adjacent eelgrass meadow. Effects included smaller, more densely packed *Z. marina* shoots and increased organic content of sediment nearer the farm. Together, these patterns may represent typical "edge effects," in which geoduck aquaculture has effectively formed a meadow edge where none existed before (Figure 9).

Figure 9. Fisk Bar on July 28, 2011. The standing individual is within the farmed area, with dense eelgrass in the unfarmed area (photo credit: Micah Horwith).

In the summer of 2011, there was preliminary evidence of recolonization of Fisk Bar by *Z. marina*. Although plant densities were low, small numbers of shoots were recorded across the farmed plot. Because these shoots were often too far from the control plot to be the product of vegetative propagation, it is likely that their recruitment was through seeds and seedlings (Figure 10).

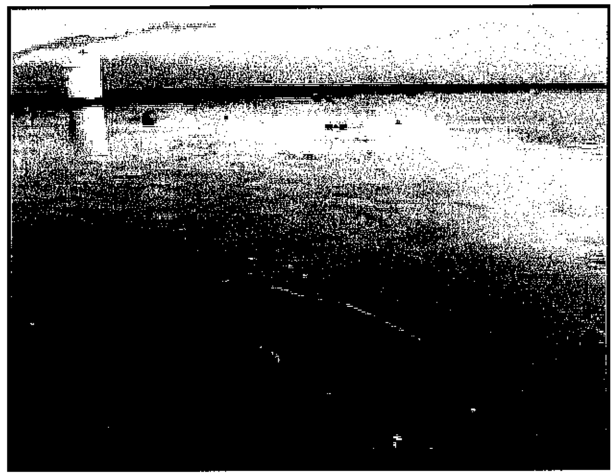


Figure 10. Eelgrass growing within the farmed area of Fisk Bar on July 28, 2011, approximately 8 m from the unfarmed area (photo credit: Micah Horwith).

In the accessory PVC tube installation experiment, the transplanted seedlings perished within four months in all four plots, both experimental (with tubes) and control (no tubes). A higher rate of decline was observed in plots with tubes installed. These results indicate that this location was not favorable to eelgrass recruitment and growth. After 14 months, the plots with tubes demonstrated a significantly greater loss of sediment elevation, suggesting that tube installation and a lack of eelgrass may increase rates of scour on surrounding sediment. These results, however, are for the specific study area and may not be characteristic of all geoduck aquaculture locations.

Research Highlights

- In Fisk Bar, where eelgrass recruited to the area after geoducks were planted, harvest activities produced effects on almost every measured biological and physical parameter of the farmed and reference sites with limited "spillover effects" from the farmed site to adjacent reference ares. However in 2011, one year after the removal of tubes and nets from the new culture cycle, the first signs of eelgrass recovery were observed, indicating that current farming practices do not make sites unsuitable for later colonization by eelgrass.

V. Appendix

Program-Related Communications, October 1, 2010 to September 30, 2011.

Copies of representative presentations and publications are available on the WSG website at *www.wsg.washington.edu/research/geoduck/current_research.html.*

1. VanBlaricom et al.

Publications (not peer reviewed)

Smith, R. and McDonald, P.S. (2010) *Examining the effects of predator exclusion structures associated with geoduck aquaculture on mobile benthic macrofauna in South Puget Sound, Washington.* Northwestern Undergraduate Research Journal 5(2009-2010): 11-16.

Presentations

VanBlaricom, G.R. *Evaluation of ecological effects of geoduck aquaculture operations in intertidal communities of southern Puget Sound.* Invited presentation at the Environmental Science Seminar Series, Environmental Program, Interdisciplinary Arts and Sciences Program. University of Washington, Tacoma, WA. Feb. 7, 2011.

VanBlaricom, G.R. *Ecological effects of geoduck aquaculture operations in southern Puget Sound.* Invited presentation to the Panel on Aquaculture Research and Technical Support, Washington Sea Grant Program Site Review. Seattle, WA. Mar. 3, 2011.

Price, J.L., McDonald, P.S., Essington, T.E., Galloway, A.W.E., Dethier, M.N., Armstrong, D.A. and VanBlaricom, G.R. *Benthic community structure and response to harvest events at geoduck aquaculture sites in southern Puget Sound, Washington.* Invited presentation to the Joint Annual Meeting, Society for Northwestern Vertebrate Biology and Washington Chapter of The Wildlife Society, Gig Harbor, WA. Mar. 24, 2011.

Price, J.L., McDonald, P.S., VanBlaricom, G.R., Cordell, J.R., Essington, T.E., Galloway, A.W.E., Dethier, M.N. and Armstrong, D.A. *Benthic community structure and response to harvest events at geoduck* (Panopea generosa) *aquaculture sites in southern Puget Sound, Washington.* Oral presentation to the National Shellfisheries Association Annual Meeting. Baltimore, MD. Mar. 30, 2011.

Price, J.L. *Geoduck Harvest in Puget Sound: Is it an ecological problem?* Invited presentation to the State Capital Seminar Series, Washington Department of Fish and Wildlife. Olympia, WA. Jul. 13, 2011.

Price, J.L. *Quantifying the ecological impact of geoduck* (Panopea generosa) *aquaculture harvest practices on benthic infauna.* Master's Thesis Defense. School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA. Aug. 8, 2011.

VanBlaricom, G.R. *Ecological disturbances associated with harvests of cultured geoduck clams in southern Puget Sound, with implications for sustainability.* Invited presentation to the Workshop on Washington State Environmental and Sustainability Learning Standards. Washington State Office of Public Instruction, Olympia, WA. Aug. 24, 2011.

Hurn, H., Eggers, J., McDonald, P.S. and VanBlaricom G.R. *Effects of geoduck aquaculture on predation and growth of non-target clams.* Oral presentation to the American Fisheries Society Annual Meeting. Seattle, WA. Sept. 6, 2011.

McDonald, P.S., Galloway, A.W.E., Price J.L., McPeek K., Armstrong D.A., VanBlaricom G.R. and Armintrout K. *Effects of geoduck aquaculture practices on habitat and trophic dynamics of nekton and macroinvertebrates in Puget Sound.* Oral presentation to the American Fisheries Society Annual Meeting. Seattle, WA. Sept. 6, 2011.

McDonald, P.S., Galloway A.W.E., Price J.L., McPeek K., Armstrong D.A. and VanBlaricom G.R. *Patterns in abundance of fish and macroinvertebrates associated with geoduck aquaculture.* Oral presentation to the 65nd Annual Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association – Pacific Coast Section. Salem, OR. Sept. 20, 2011.

Armintrout, K., McDonald, P.S., McPeek, K., Beauchamp, D. and VanBlaricom, G.R. *Trophic ecology within geoduck aquaculture habitat.* Oral presentation to the 65th Annual Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association – Pacific Coast Section. Salem, OR. Sept. 20, 2011.

VanBlaricom, G.R., Price J.L., McDonald, P.S., Cordell, J.R., Essington, T.E., Galloway A.W.E., Dethier, M.N. and Armstrong D.A. *Geoduck aquaculture harvest impacts: The results.* Oral presentation to the 65th Annual Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association – Pacific Coast Section. Salem, OR. Sept. 20, 2011.

Theses and dissertations

Price, J. (2011) *Quantifying the ecological impacts of geoduck* (Panopea generosa) *aquaculture harvest practices on benthic infauna.* Master's Thesis, University of Washington, Seattle, WA.

Media placements

Stang, John. *Economic benefits, ecological questions stall geoduck industry's growth.* The Kitsap Sun, Kitsap County, WA. Jul. 23, 2011

2. Friedman et al.

Presentations

Dorfmeier, E., Friedman, C., Frelier, P. and Elston, R. *Examining seasonal patterns of Pacific geoduck* (Panopea generosa) *disease using a multivariate approach.* Oral presentation to the 65th Annual Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association – Pacific Coast Section. Salem, OR. Sept. 20, 2011.

3. Ruesink and Horwith

Presentations

Ruesink, J. *Resilience of eelgrass following multiple disturbances.* Oral presentation to 65th Annual Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association – Pacific Coast Section. Salem, OR. Sept. 20, 2011.

Horwith, M. Ph.D. Dissertation Defense. *Plant behavior and patch-level resilience in the habitat-forming seagrass* Zostera marina. Department of Biology, University of Washington, Seattle, WA. Jun. 23, 2011

Theses and dissertations

Horwith, M. (2011) *Plant behavior and patch-level resilience in the habitat-forming seagrass* Zostera marina. Ph.D. dissertation, University of Washington, Seattle, WA.

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