ASSESSMENT OF KNOWN, APPARENT, AND LIKELY IMPACTS ASSOCIATED WITH GEODUCK MARICULTURE WITH EMPHASIS ON THE PROPOSED HALEY SHELLFISH FARM

SEPTEMBER 2014

Presented by
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OUTLINE PART I
BACKGROUND

➢ DEFINE AND DESCRIBE THE NEARSHORE
➢ BRIEF REVIEW OF NATURAL HISTORY
➢ REVIEW THREATS/CHALLENGES
➢ REVIEW PROTECTION AND RESTORATION MEASURES
OUTLINE PART II
IMPACT ASSESSMENT

- Methods for review
- Review of proposed project and procedures
- Impacts associated with individual activities
- Review of SEPA determination
- Summary and Conclusions
THE PUGET SOUND NEARSHORE ECOSYSTEM

- Bank
- Backshore
- Beach Face
- Low Tide Terrace

RIPARIAN ZONE
INTERTIDAL ZONE
SUBTIDAL ZONE

Nearshore
ECOSYSTEM

BIOTIC COMMUNITIES INTERACTING WITH ABIOTIC COMPONENTS
What Is the Nearshore?

The interface of the coastal land forms and marine waters, from the lower limit of the photic zone landward, including tidally influenced portions of rivers and streams.
Interface/Transition Zone

THE "NEARSHORE" IS THEREFORE A COMPLEX OF ECOSYSTEMS
The Puget Sound Ecosystem Puzzle
Lots of Parts: All Connected
Puget Sound and its Watershed

- 16,000 square miles land
- 10,000 streams and rivers
- 2,500 miles of shoreline

* all figures for WA state alone *
Ecological Interactions/Linkages

Occur at various spatial and temporal scales
Processes
- physical
- chemical
- biological

Structure
-sediment/substrates
-vegetation

Functions
-species diversity
-harvestable resources
-water purification
-soil stability
Hydrogeophysical processes

Geology/Geologic History

Wind and Waves
- Storms
- Wind speed
- Duration
- Fetch
- Angle of waves on beach

Circulation Model
Puget Sound topography (sills and basins, channels, and passages), tides, river discharge, wind and surface currents all affect the circulation patterns of Puget Sound.

Tides
Topographic & Bathymetric Relief
Bainbridge Island Nearshore Assessment
Nearshore Habitats

- Riparian Forest
- Bluffs
- Dune and strand
- Beach
- Estuary
- Tidal flats & wetlands
- Rocky intertidal and subtidal
- Water Column
- Eelgrass
- Kelp
HABITAT

A PLACE WHERE SOMETHING LIVES

Organisms live in a certain place under conditions in which they are adapted to thrive
ECOSYSTEM HEALTH

Healthy Systems are typically diverse

• BIOLOGICALLY
• STRUCTURALLY
• HABITAT COMPLEXITY (VS HOMOGENEITY)
• CONNECTIVITY (VS FRAGMENTATION)

ATTRIBUTES ARE FORMED AND MAINTAINED BY LOCAL CONDITIONS
Nearshore Habitat Diversity
HABITAT DIVERSITY DRIVES SPECIES DIVERSITY AND ABUNDANCE

- Marine and freshwater fishes
- Marine and terrestrial birds
- Marine and terrestrial mammals
- Amphibians
- Reptiles
- Marine and terrestrial plants
- Marine and terrestrial invertebrates
Puget Sound Supports

Over 200 spp. of fishes

100’s of spp. of wildlife

100’s of marine & terrestrial plants

>15 spp. of marine mammals

1000’s of spp. of aquatic invertebrates
Composition of substrate, energy, exposure, salinity, tides, etc. determined by controlling factors
HABITAT FUNCTIONS

A FEW EXAMPLES
Benthos

Functions: Feeding, refuge, reproduction, productivity
Surf smelt spawn
Salmonid Nearshore Dependence

- Rearing
- Feeding
- Refuge
- Migration
- Physiological transition

Benthic – Pelagic Coupling
Timing of Salmonid use in Shallow Marine Nearshore Waters

Weekly CPUE (SE) for Pink, Chum, and Cutthroat Salmon during April to September.
Overall diet composition based on prey ecology for juvenile Puget Sound chinook

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- **Numerical Composition**
  - Terrestrial riparian
  - Marine planktonic/neritic
  - Plant matter
  - Other

- **Gravimetric Composition**
  - Supralittoral/marsh
  - Marine benthic/epibenthic
  - Other

Notes:
- 2001: Leaf Hopper, Polychaete, Crab Larvae
- 2002: Other prey items

Images:
- Leaf Hopper
- Crab Larvae
- Polychaete
“…the importance of insects as high-quality prey highlighted the terrestrial link to the marine feeding of Chinook salmon and suggests that shoreline development and land use changes will affect feeding opportunities for these fish in Puget Sound.”

Duffy et al. 2010
COMMONLY IDENTIFIED THREATS

- SHORE ARMOR
- OVERWATER STRUCTURES
- FILLING
- DREDGING
- DIKES
- POLLUTION
PROBLEM INDICATORS

• SPECIES POPULATION DECLINES; ESA Listings
• HABITAT MODIFICATION & LOSS
• BANK STABILITY
• POLLUTION
• INVASIVE SPECIES
• LOW DISSOLVED OXYGEN (e.g., Hood Canal)
• AIR QUALITY
• WATER SUPPLY
• CLIMATE CHANGE
LEGACY
Addressing The Threats

• Updates of SMPs
• Use of Science to Inform Decision Making (e.g., PSNERP)
• Development of Alternative Methods
• Restoration
• Increased Regional and National Programs (e.g., Puget Sound Partnership)
• Ecosystem Based Management

ALL EFFORTS TO INCREASE PROTECTION AND RESTORATION
AQUACULTURE/MARICULTURE: AN EMERGING THREAT

• As the supply of seafood has decreased and demand for food sources has increased, aquaculture has expanded globally, nationally, and regionally in recent decades.

• Aquaculture has been identified as a threat by scientists, managers, conservation organizations, and the general public.

• Impacts of aquaculture have not been adequately evaluated, or mitigated.
Mariculture is an increasing threat/stressor to nearshore ecosystem health, integrity, and function by altering the natural physical, chemical, and biological processes.

References: DeFur and Raider 1995; Krukeberg 1995; Hastings 1995; Simenstad and Fresh 1996; Drake 1997; Dethier 2006; Penttila 2007; Bendel and Wan 2010; Bouwman et al. 2013; Diana et al. 2013
OUTLINE PART II
IMPACT ASSESSMENT

- Methods for review
- Review of proposed project and procedures
- Impacts associated with individual activities
- Associated Impacts
- Review of SEPA determination
- Summary and Conclusions
EVALUATION METHODS

• LITERATURE REVIEW
• NATURAL RESOURCE MANAGEMENT EXPERIENCE
• FAMILIARITY WITH MARICULTURE PRACTICES
• PROFESSIONAL NEARSHORE EXPERIENCE & EXPERTISE
• PUGET SOUND NEARSHORE CONCEPTUAL MODEL
GENERAL QUESTIONS

• Do geoduck aquaculture practices result in impacts?
• If so, what is the likelihood, intensity, and duration?
• Are the impacts “significant”
• Are the impacts individual/independent, or cumulative?
• What can be learned from the literature?
• Which fishes, invertebrates, plants, and wildlife are associated with beaches where geoduck aquaculture occurs?
• Are the impacts to be mitigated? If so, appropriate/adequate?
• Has the County conducted an adequate level of environmental analysis in making their determination?
• Is the determination aligned with management goals and objectives (e.g., SMA, ESA, SEPA, etc)?
Puget Sound Nearshore Conceptual Model

A synthesis tool for understanding and nearshore systems and their response to stressors.

Underlying assumption is that alterations of natural hydrologic, geomorphologic, and ecological processes impair ecosystem structure and function.

Source: Simenstad et al. 2006.
Enables one to evaluate mechanisms of change, predict response, and examine linkages between nearshore ecosystems.
Similar Model Developed for Chinook and Bull Trout Recovery Plan, So. Puget Sound

Shellfish Aquaculture

Processes
- Erosion/Sediment Transport
- Nutrient & Sunlight Input

Land Use Stressor
- Shellfish Aquaculture

Physical/Chemical Effects
- Physical disturbance of substrate
- Physical displacement of beach material
- Altered beach sediment size/type
- Shading of substrate
- Water quality effects (reduced turbidity, nutrient recycling)
- Increased 3-D structure from shell

Habitat Effects
- Altered plant/animal assemblages
- Loss of shallow nearshore habitat
- Loss of habitat diversity
- Altered shoreline hydrodynamics/drift
- Frequency of disturbance increased
- Improved water quality

Salmon Population Effects
1. Reduced or increased prey availability
2. Increased predation
3. Altered migration and behavior

VSP Parameters
1. Reduced productivity/growth rate
2. Reduced abundance
3. Reduced spatial structure
4. Reduced diversity (genetic/life history)

Hypothesis:
Shellfish aquaculture in South Sound alters plant and animal assemblages and results in the loss of shallow nearshore habitat and habitat diversity important to salmon resources. These impacts may be potentially positive or negative depending on the type of aquaculture practice. We hypothesize that shellfish aquaculture reduces productivity, abundance, spatial structure, and diversity of salmon populations.
Geoduck Mariculture

- Beach Preparation – “Cleaning”
- Insertion of PVC Tubes – Pred. Exclusion device
- Seeding
- Installation of predator nets (individual and/or blanket)
- Maintenance
- Harvest
- Repeat…
IMPACT - Beach Preparation

- Is it likely that this activity will result in habitat alteration, changes in benthic habitat structure, community, and associated functions?
- Is it likely that this level of disturbance could adversely affect the beach community, structure, and function?
Beach Preparation

Removal of wood, rocks, debris, or organisms that would impede planting operations.
BEACH CLEANING IMPACTS

• Removal of habitat structure
• Trampling
• Raking - Physical disturbance/alteration
• Placement/dragging of equipment
• Relocation or disposal of living organisms
BEACH CLEANING IMPACTS

- Wood, rocks, and other objects are an important habitat component of beaches.
- Used for attachment, refuge from solar radiation/desiccation and predators, feeding, reproduction.
Summary

BEACH CLEANING IMPACTS

• Organisms are not adapted to this type/intensity of disturbance
• Loss of habitat structure
• Change in physical & biotic processes, benthic/epibenthic community structure and function
• Likely injury and/or death for non-mobile, or slow moving organisms
• Alteration of food web
• Inconsistent with other permitted activities
• No specific studies/no mitigation
IMPACT - Anti-Predator Tubes

- Is the placement of PVC tubes likely to result in a change in habitat structure and function?
- Will the tubes likely change the intertidal/shallow subtidal community?
- Is the placement of tubes potentially lethal and/or impose an impediment to benthic organisms?
- Do the tubes pose a potential threat to water quality?
Mariculture structures are known to cause a modification of habitat and resulting changes to the benthic sediment composition, sediment chemistry, species composition, nutrient exchange, porosity of sediments, permeability, oxygen content, bacterial content, and other effects (Simenstad and Fresh 1995; Spencer et al. 1996; Spencer et al. 1997; Gouletquer et al. 1999; Bendell-Young 2006; Dumbauld et al. 2009; Straus et al. 2011).
PVC TUBE IMPACTS

• Foot traffic, delivery/dragging of equipment
• Placement (“stomping”) of tubes
• Injury or death of infauna/epifauna
• Aerial coverage (~ 43,000 tubes/acre, ~473,000 for the farm)
• Aerial loss/Impediment to movement, feeding, etc.
Tubes impede movement of water, sediments, food resources, biota; reduce area available for biota and associated ecological functions.

Illustration of how tube placement in the beach for geoduck planting is likely to impede benthic faunal utilization of the beach. Calculations of amount of PVC pipe required to plant the proposed 11 acres is also provided. Netting impediment not included.

43,560 ft\(^2\) per acre @ 1 tube/ft\(^2\)

36,300 ft of tube/acre X 11 acres = 399,300 ft of PVC pipe

75.63 miles of PVC pipe
PVC TUBE IMPACTS Cont’

• Alteration of physical structure
• Alteration of physical processes
• Alteration of community structure
• High potential for degradation and loss into the marine environment
• Potential for impacts to juvenile salmonids
• Aesthetics
Summary
PVC TUBE IMPACTS

• Structural impacts similar to other aquaculture structures
• Alteration of physical and biological processes
• Alteration of benthic structure, community, and associated functions
• Loss of habitat
• Impediment to movement, feeding
• Increased competition/change in food web
• Lack of studies (1), no mitigation
• Probable water quality/contamination
IMPACT – Predator Nets

• Will the presence of the predator nets change the benthic/epibenthic community structure?

• Does the presence and/or maintenance of the nets pose a threat to marine flora and fauna?

• Do the nets have probable effects on water and sediment composition or chemistry and/or quality?
NETTING IMPACTS

Multiple studies of netting on bivalve culture (zero for geoduck):

Bendell-Young (2006):
• Lower species richness, different bivalve composition, abundance, distribution
• Greater accumulations of organic matter and silt, suggesting simplification of benthic community
• Fouling with dense layers of algae further alter habitat
• Netting is possibly the most invasive of all aquaculture practices

Brown an Thuesen (2011)
Change in species richness (higher – likely an attractant for crabs), but number of taxa reduced
Spencer et al. (2011)
• Netting led to a change in benthic community composition consistent with organic enrichment
• Suggest that inter-specific competition is a likely outcome of netting-induced changes in benthic community

Simenstad and Fresh (1995)
• Mean grain size finer (muddier) from decreased resuspension and trapping of fines
• Distinct differences in species composition between netted and control plots, attributed to presence of nets
NETTING IMPACTS CONT’

• Artificial substrate/structure results in:
• Change in community structure
• Impediment to natural geophysical processes
• Change in sediment composition/structure
• Probable loss and degradation (water quality)
• Reduction in prey resource availability (exclusion)
• Risk of entanglement, injury, death
Entanglements: A Known Impact
Summary

PREDATOR NET IMPACTS

• Structural impacts similar to other aquaculture structures
• Alteration of physical and biological processes
• Alteration of benthic structure, community, and associated functions
• Loss of prey availability/feeding opportunities
• Alteration to food web, energetics, nutrient exchange
• Entanglement, injury, or death
• Threat to water quality
• No mitigation
IMPACT - Maintenance

- Do maintenance activities result in physical and noise disturbances?
- Will the physical removal of living organisms from the mariculture structures result in injury and/or death to marine organisms?
MAINTENANCE IMPACTS

• Pressure washing and/or brushing of netting to remove living “biofouling” organisms, including algae, invertebrates, eggs, and other matter.

• If activity is conducted on the beach, organic matter is left to rot.

• If done on dry beach, or uplands, exposure will desiccate organisms.

• Increases susceptibility to predation.

• Increased nutrient loading.

• Disturbance to wildlife, trampling.
Summary

MAINTENANCE IMPACTS

• Alteration of benthic structure and community composition
• Highly likely lethal or sublethal effects to organisms removed, additional trampling impacts
• Potential increase in nutrient input
• Potential disturbance to wildlife
• Known loss of equipment (i.e., maintenance does not prevent the loss of some materials)
• No specific studies of effects & no mitigation
IMPACT - HARVEST

• Is it likely that geoduck harvest and associated activities will result in temporal and spatial changes or harm to benthic communities?
• Is the extent and intensity of the impact likely to be significant?
HARVEST IMPACTS

• Liquefaction of the beach
• Walking, dragging equipment, placement of equipment, vehicles/vessels on beach all have the potential to crush or injure infauna/epifauna
• Change in benthic community composition and structure
• Siltation/water quality
Commercial geoduck harvest: summary of impacts from Willner (2006) and DNR (2001)

- Organisms are exposed to predation, may be crushed, injured, displaced, or killed;
- Habitats are destroyed by breaking up habitat structural complexity;
- Late successional assemblages of organisms are reduced, resulting in a change in species diversity and functions;
- Long-term changes (many months) in community structure and dynamics can be expected;
- A change in benthic systems results in a change in pelagic systems (i.e., feeding, growth, survival)
- The release of eggs and cysts stored in sediments may upset the pelagic community (e.g., low DO, increased HABs, food web interactions)
Ruesink and Rowell (2012) conducted the only study of geoduck harvest effects on eelgrass, showing that a sediment-liquefaction method similar to commercial techniques resulted in a 70% reduction in eelgrass density.

Price (2011) and VanBlaricom et al. (unpublished manuscript) concluded that differences between control and harvest areas was attributable to natural variation, and that the effect of geoduck harvest on benthic infauna on intertidal beaches is within the range of natural variation, and not of long-term ecological significance. They also caution that the projection of their results to larger temporal or spatial scales may be inappropriate, and are not sufficient for successive geoduck aquaculture cycles.
Summary
HARVEST IMPACTS

- Benthic communities are not adapted to this type or intensity of disturbance (equivalent to a large earthquake or tsunami)
- Causes injury, death, or relocation of benthic organisms
- Increases susceptibility to predation, injury, or death
- Substantial time is required to recolonize to a natural state (not likely to occur)
- Loss of ecosystem functions
- Few specific studies & no mitigation
ASSOCIATED RISKS

CLAM DENSITY

DISEASE AND PARASITES

GENETIC RISKS
CLAM DENSITY

- Cultured clams (estimated > 1 million) do not occur naturally in such densities resulting in competition for space and food resources
- Will consume vast amounts of phytoplankton and zooplankton, resulting in competition for food resources
- Likely to be consuming large amounts of eggs and larvae of other organisms
- Density increases disease and genetic risks
- Numerous studies support these conclusions (none from geoduck studies)
- No mitigation
DISEASE AND PARASITES

- Aquaculture has been an important vector in the introduction, transfer and spread of aquatic diseases and parasites.
- Contact/proximity greatly increases risk of disease and parasites and poses a significant threat to cultured and wild populations.
- The ease of transmission through water increases the risk.
- With unknown risks come unknown treatments or controls.
- No specific studies; No Mitigation.
GENETIC RISKS

• Selection of brood stock (and genetic composition) in a hatchery are, by design, vastly different from natural selection
• Wild stock genetic variability could be “watered down” by cultured stock
• Fertilization success is likely to be much higher in cultured than wild stock due to proximity
• Loss of genetic variability can result in increased susceptibility to disease, parasites, and other environmental perturbations
• No specific studies; No mitigation
ASSOCIATED IMPACTS

• BIRDS
• FISHES
• BENTHIC COMMUNITIES
• MARINE MAMMALS
• WATER QUALITY
• AESTHETICS
• PUBLIC ACCESS
BIRDS

Is intensive geoduck cultivation likely to result in impacts to marine nearshore birds?
Shorebirds

- Over 70 species of P.S. nearshore birds listed by Buchanan (2006)
- Many species are in decline
- All have direct or indirect associations with beaches (food production/feeding, breeding, resting, roosting, refuge, migration)
- All are sensitive to disturbance and habitat alterations
- In addition to intrinsic values, bird-watching is a significant economic activity in Washington
Shorebird Impacts

- Change in potential prey species abundance
- Exclusion; reduction in prey availability
- Disturbance
- Increased energy demand seeking food, shelter, etc elsewhere
- Potential entanglement in gear
- Potential ingestion of plastics
An American bald eagle is rescued by boaters after being trapped in a geoduck net on Harstine Island.
Summary
MARINE BIRD IMPACTS

• Likely to change prey species abundance
• Exclusion: Likely to reduce prey availability
• Cultivation activities likely to cause disturbance
• Likely to increased energy demand seeking food, shelter, etc elsewhere
• Potential entanglement in gear
• Potential ingestion of plastics
• No specific studies; No Mitigation
FISHES

• Are geoduck aquaculture practices likely to alter habitat and prey resources for nearshore fishes?
• Is there a potential for increased energy demand?
• Is there potential for increased predation?
Summary
FISH IMPACTS

• Nearshore fishes utilize nearshore habitats for feeding, reproduction, refuge, and migration. Alteration of nearshore habitats can alter prey production/availability and reduce opportunities for reproduction and refuge.

• As nursery areas, the addition of structure could increase risk of predation to juvenile fishes.
BENTHIC COMMUNITY

• Benthic infauna and epifauna comprise a diverse assemblage of taxa; play important roles in the food web, community dynamics, and provision of ecosystem processes and functions

• Anthropogenic stressors (e.g., physical disturbance, changes in habitat or habitat conditions) are known to effect the viability, stability, productivity and provision of ecosystem functions (Williams et al. 2001; Dethier 2006; and others)

• It has already been established that each of the geoduck mariculture activities impose a suite of stressors
- Sand dollars are native, patchy, and may be in decline
- They are important ecosystem engineers
- They are fragile and have specific habitat requirements
- Were found in very high density (dominant) at site

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Summary
BENTHIC/EPIBENTHIC IMPACTS

• Organisms will be crushed, cut, trampled, injured, or killed
• Organisms will be relocated, or otherwise displaced
• Habitat will be altered
• Benthic community structure and dynamics will be changed
• Activities will result in competition for food and space resources
• Result will be an alteration/loss of ecological processes, structure, and functions
• No Mitigation
NEARSHORE MAMMALS

Can intensive geoduck mariculture impact nearshore mammals? If so, how? (Includes both terrestrial and marine spp.)
Summary

NEARSHORE MAMMAL IMPACTS

- Altered habitat, food availability and supply
- Exclusion from food supply and foraging or resting area as a result of disturbance (people, vessels) & alteration of beach
- Entanglement in nets
- No specific studies
- No mitigation
WATER QUALITY

• How will water and sediment quality be affected by the proposed geoduck farm?
• Does the introduction of plastics, as a method of predator exclusion, increase the risk of pollution (and associated changes in water and sediment quality) in the marine environment?
IMPACTS – WATER QUALITY

- Aquaculture can be a significant contributor of plastics debris in the ocean; the most likely site for generation of microplastics in the marine environment is the beach (Andrady et al. 2011)
- Biodeposition and artificial structures alter sediment chemistry and composition (Straus et al. 2008)
- Harvest releases silt, eggs and cysts (Willner 2008)
- Microplastics laden with high levels of POPs can be ingested by marine biota (Andrady et al. 2011)
- Activities result in altered nutrient exchange/loading
Summary

WATER QUALITY IMPACTS

- Intensive cultivation of geoduck clams has a high likelihood of adverse impacts to both sediment and water quality.
- The large amount of plastics used in intensive geoduck farming is highly likely to result in the release of plastic particles, meso- and microplastics into the marine environment, especially considering their position in the intertidal and shallow subtidal nearshore environment, where wind, waves, currents, sand abrasion, ultraviolet light, driftwood and other debris are likely to cause degradation and loss of plastics.
- Alteration of sediment and water chemistry changes habitat conditions, which is likely to result in a change in species composition and habitat utilization.
• Cultivated geoduck clams may contribute (via biodeposition of feces and pseudofeces) to altered sediment conditions (chemistry, habitat quality for other organisms), including higher sediment ammonia concentrations, increased organic carbon, sediment oxygen demand, anoxia, increased dissolved nutrients in the water.

• Mariculture is an important vector for diseases and parasites, especially with intensive, high density operations. Such operations are highly likely to greatly increase the risk of disease and parasites in cultured and wild stocks.

• No specific studies; No Mitigation
AESTHETICS

The aesthetic value of the Puget Sound nearshore is a commonly identified societal value and environmental quality element, with requirements for protection under State (e.g., SMA, SEPA) and Federal (e.g., NEPA) regulations. Considering the high values of shoreline property, tourism, and recreation in Washington State, it also has a very high economic value.
Summary

AESTHETIC IMPACTS

• The aesthetics of the nearshore will be modified as a result of the modification of the beach and placement of predator exclusion structures

• It is likely that wildlife viewing may be altered as a result of geoduck mariculture disturbances

• No specific studies; No Mitigation
PUBLIC ACCESS

Mariculture projects require that such public waters be closed to public access. However, coastal waters have traditionally been considered public property, with access and harvesting (both recreational and commercial) available to all (Hastings and Heinle 1995)
Summary
PUBLIC ACCESS IMPACTS

• Public access will be restricted/removed, including walking, navigation, fishing/harvesting, and other forms of recreation.

• No specific studies; No Mitigation
CYCLE OF MODIFICATION/ DISTURBANCE

- Each activity in the process of geoduck mariculture has its own set of impacts, which results in various temporal and spatial effects.
- These individual activity effects are likely to be additive or synergistic with other activities, resulting in cumulative impacts and causing further alteration to nearshore ecosystems, likely beyond the temporal and spatial scale of the farm.
- Since it can be anticipated that the farm will not be used for a single planting-to-harvest cycle, the modifications, and resulting changes in nearshore processes, structure, and functions, will likely be altered beyond the life of the project.
ENVIRONMENTAL POLICY AND REVIEW

SMA (among others)
SEPA CHECKLIST
SEPA Determination
The Shoreline Management Act of Washington State (SMA) was adopted by voters in 1972. It is intended "...to prevent the inherent harm in an uncoordinated and piecemeal development of the state’s shorelines" [RCW 90.58.020] through establishment of a planning process to balance both utilization and protection of shoreline areas throughout the state. There are three main policies to the Shoreline Management Act:

- Establish preferred uses of the shoreline
- Environmental protection
- Public access
SMA POLICY

• “The legislature finds that the shorelines of the state are among the most valuable and fragile of its natural resources and that there is great concern throughout the state relating to their utilization, protection, restoration, and preservation."

• "This policy contemplates protecting against adverse effects to the public health, the land and its vegetation and wildlife, and the waters of the state and their aquatic life. . ."
SMA POLICY cont’

• "To this end uses shall be preferred which are consistent with the control of pollution and prevention of damage to the natural environment."

• "Permitted uses in the shorelines of the state shall be designed and conducted in a manner to minimize, insofar as practical, any resultant damage to the ecology and environment of the shoreline area. . . ."
SEPA DETERMINATION

• SEPA checklist included errors and omissions (e.g., A.7, additions/expansion; 3.a.4, surface water withdrawals; B.5b&c, ESA-listed species; B.5.d, preserve/enhance; etc.)

• SEPA official apparently disregarded public comments ("vast majority opposed")

• SEPA official erred in their statement/assumptions that: "detailed studies have been conducted regarding geoduck and geoduck-related issues...at this point, it appears that many impacts from geoduck farms are temporary, insignificant, and/or indistinguishable from natural levels of disturbance"

• SEPA official did not give due consideration to the sensitive nature of shorelines, as required in SEPA rules
Environ Report

• Not a thorough biological assessment, but rather an assessment of effects on ESA-listed species and EFH

• No ESA or EFH consultation for this project
MITIGATION SEQUENCE
WAC 197-11-768

• (1) Avoiding the impact altogether by not taking a certain action or part of an action;
• (2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;
• (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
• (4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;
• (5) Compensating for the Impact by replacing, enhancing, or providing substitute resources or environments;
• (6) Monitoring the Impact and taking appropriate corrective measures;

Mitigation is a sequence of actions required by NEPA, SEPA, Governor's Executive Order 90-04
Summary
SEPA REVIEW

• The Project proponent and County apparently failed to identify or conduct an adequate review of probable impacts.

• The County apparently made a determination of non significance based upon misinformation, or a lack of information.

• The County did not require mitigation for the large number of probable and known impacts associated with the project; required mitigation is inadequate.

• The Project proponent and County made no effort to account for and mitigate cumulative impacts (including aquaculture and non-aquaculture, additive and/or synergistic effects).
“Significance”

• (1) "Significant" as used in SEPA means a reasonable likelihood of more than a moderate adverse impact on environmental quality.

• (2) Significance involves context and intensity (WAC 197-11-330) and does not lend itself to a formula or quantifiable test. The context may vary with the physical setting. Intensity depends on the magnitude and duration of an impact. The severity of an impact should be weighed along with the likelihood of its occurrence. An impact may be significant if its chance of occurrence is not great, but the resulting environmental impact would be severe if it occurred.
CONCLUSIONS

• Based upon my review of the literature, mariculture practices, familiarity with nearshore ecosystems, and professional experience, the proposed geoduck mariculture farm is highly likely to result in significant impacts, both from individual activities and cumulative effects.

• There is a high probability that impacts will include both additive and synergistic effects.

• The County erred in their assumptions, did not conduct an adequate environmental review, and did not require adequate mitigation. Therefore, their determination was incorrect.
## Summary Impact and Significance Table

<table>
<thead>
<tr>
<th>ACTION/IMPACT</th>
<th>IMPACT INTENSITY/ DURATION</th>
<th>SIGNIFICANT</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach Preparation</td>
<td>Moderate-High/Short-term activity, latent effects</td>
<td>Yes</td>
<td>Permanent alteration of habitat and species composition</td>
</tr>
<tr>
<td>PVC Tubes</td>
<td>High/2-3 yrs, latent effects</td>
<td>Yes</td>
<td>Individual and cumulative, cyclical</td>
</tr>
<tr>
<td>Predator Nets</td>
<td>High/2-3 yrs, latent effects</td>
<td>Yes</td>
<td>Individual and cumulative, cyclical</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Moderate/Periodic during 3-yr period</td>
<td>Possibly</td>
<td>Individual and cumulative, cyclical. Direct mortality could lead to determination of significance</td>
</tr>
<tr>
<td>Harvest</td>
<td>High/Duration of harvest, latent effects</td>
<td>Yes</td>
<td>Individual and cumulative, cycical</td>
</tr>
</tbody>
</table>

**ASSOCIATED RISKS**

<table>
<thead>
<tr>
<th></th>
<th>IMPACT INTENSITY/ DURATION</th>
<th>SIGNIFICANT</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clam Density</td>
<td>High/5-7yrs</td>
<td>Yes</td>
<td>cumulative, cyclical</td>
</tr>
<tr>
<td>Disease and Parasites</td>
<td>High/5-7yrs</td>
<td>Yes</td>
<td>cumulative, cyclical</td>
</tr>
<tr>
<td>Genetic Risks</td>
<td>High/5-7yrs</td>
<td>Yes</td>
<td>cumulative, cyclical</td>
</tr>
</tbody>
</table>
### Summary Impact and Significance Table Cont’

<table>
<thead>
<tr>
<th>ASSOCIATED IMPACTS</th>
<th>Impact Duration</th>
<th>Significance</th>
<th>Impact Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td>Moderate-High</td>
<td>Possibly</td>
<td>Declining populations; Sensitive to disturbance; Reduced access/food supply; cumulative, cyclical</td>
</tr>
<tr>
<td></td>
<td>Duration of</td>
<td></td>
<td>project, latent effects</td>
</tr>
<tr>
<td>Fishes</td>
<td>Moderate-High</td>
<td>Yes</td>
<td>Alteration of habitat, food supply; cumulative, cyclical</td>
</tr>
<tr>
<td></td>
<td>Duration of</td>
<td></td>
<td>project, latent effects</td>
</tr>
<tr>
<td>Benthic Communities</td>
<td>High</td>
<td>Yes</td>
<td>Permanent alteration of habitat, community dynamics, ecological processes, structure, and functions; direct mortality; cumulative, cyclical</td>
</tr>
<tr>
<td></td>
<td>Duration of</td>
<td></td>
<td>project, latent effects</td>
</tr>
<tr>
<td>Marine Mammals</td>
<td>Low to Moderate</td>
<td>Not likely</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duration of</td>
<td></td>
<td>project</td>
</tr>
<tr>
<td>Water Quality</td>
<td>High</td>
<td>Yes</td>
<td>Altered benthos, plastic pollution, silt, release of toxins, cysts, eggs</td>
</tr>
<tr>
<td></td>
<td>Duration of</td>
<td></td>
<td>project, latent effects</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>High/3-4 yrs</td>
<td>Yes</td>
<td>Mariculture structures</td>
</tr>
<tr>
<td>Public Access</td>
<td>High</td>
<td>Yes</td>
<td>Exclusion</td>
</tr>
</tbody>
</table>
References
100. Willner, G. The Potential Impacts of the Commercial Geoduck Hydraulic Harvest Method
101. Simenstad, May 1999, DSEIS Geoduck Harvesting
102. FEIS-State of Washington Commercial Geoduck Fishery
116. Dethier, Concerns and Questions Relevant to Infaunal and Epibenthic Impacts of Geoduck Aquaculture
121. Pentilla, D., 2007 Marine Fish in Puget Sound
125. Wong and Levinton, 2006
126. Troost, Kammans and Wolff. 2008
127. Lonsdale, Cerrato, et al., 2009
128. Troost, Stamhuis and Van Duren
129. Perhada, Ezgeta-Balie, et al., 2012
150. Van Blaricom “In Press” Evaluation of Ecological Effects
151. Bendell, Contrasting the Community Structure and select geochemical characteristics of three intertidal regions in relation to shellfish farming
156. Bendell, Determining the ecological role of euspira Lewish
258. Price, J.2011. Quantifying the ecological impacts of geoduck aquaculture harvest practices on benthic infauna
EDUCATION
M.S. Marine Science, Moss Landing Marine Laboratories, San Jose State University, California 1986.
B.A. Psychology/Biology, Creighton University, Nebraska, 1977.

WORK HISTORY
MARINE ECOLOGIST/BIOLOGICAL CONSULTANT, Alto Marine Consulting, Bainbridge Island, WA. 2014-Present.

MARINE HABITAT SPECIALIST, Washington Sea Grant, University of Washington
Marine Advisory Staff responsible for nearshore program development and implementation throughout the Puget Sound region. Programs include research, education and outreach, technical assistance, restoration design and implementation, guest lectures, and technical review and assistance for Federal, State, and Local agencies, Native American Tribes, Ports, businesses, conservation groups, and private landowners. 2005-2014.

SENIOR MARINE ECOLOGIST, King County Department of Natural Resources and Parks
Senior Science Staff responsible for marine nearshore component of watershed and salmon recovery planning efforts, including: Analysis of nearshore conditions; Develop and conduct original research to fill data gaps; Design and conduct restoration projects; Project management; Report writing; Public education and outreach; Supervise junior staff. Also participated in regional assessment and restoration programs (e.g., PSNERP) and provided consulting services to other King County Departments (e.g., DDES, Roads, Wastewater) on individual projects. June 1999-December 2004.

FISH AND WILDLIFE BIOLOGIST 3, Washington Department of Fish and Wildlife
Area Habitat Biologist responsible for independently developing regulatory permits, policy recommendations, environmental review, and providing technical assistance for landowners, local, state and federal governments and Native American Tribes for the management, protection, preservation, and enhancement of multi-species assemblages of fish and wildlife habitat. May 1994-June 1999.

PRIVATE CONSULTANT, Fisheries Research and Marine Education

REGULATORY AFFAIRS MANAGER, Morning Star Fisheries
Government Affairs Representative for commercial fishing company. November 1991-July 1993. Regulatory liaison and company representative for commercial fishing industry and commercial fisheries regulatory agencies. Responsibilities included attendance at North Pacific and Pacific Fisheries Management Council meetings, fish stock assessment reviews, regulatory analysis and advice on fishing seasons, quotas, areas, and bycatch, occasional on-board duties while at sea (e.g., Purser, product QA/QC testing), assistance with logistics.
FISH AND WILDLIFE BIOLOGIST III - PROJECT LEADER, Oregon Department of Fish and Wildlife

PROGRAM MANAGER, ECOS, Inc. Environmental Consultants
Senior Staff Fisheries Biologist responsible for environmental review and reporting for public and private clients, including fisheries, aquatic ecosystems analysis, and water quality contracts. October 1989-December 1990.

RESEARCH ASSOCIATE, Moss Landing Marine Laboratories

RESEARCH ASSISTANT, Moss Landing Marine Laboratories
Assistant to principle investigators in marine research contracts. Also awarded Sea Grant Marine Education and Research Program trainee position for thesis research. 1983-1986.

RESEARCH TECHNICIAN, Moss Landing Marine Laboratories
Technical expert for marine research and education field programs. Responsibilities included vessel operation, sampling gear deployment and retrieval, species identification and interpretation for academic, research, and private entities. 1982-1986.

TEACHING EXPERIENCE
Fish Biology, University of California, Santa Cruz, 1986.
Fish Biology, University of California, Santa Cruz, 1985.
Tropical Marine Biology, Hofstra Marine Station, Jamaica, 1984.
Fish Biology, University of California, Santa Cruz, 1984.
Marine and Desert Ecology of Baja California, Mira Costa College/Vermillion Sea Field Station, Baja California, Mexico, 1982-83.

PUBLIC EDUCATION AND OUTREACH
Invited speaker/lecturer for citizens and professional practitioners at over 100 workshops throughout Puget Sound; 1999-Present.
Technical advisor/guest speaker for King County marine nearshore public education and outreach programs, including public meetings, development of informational brochures and beach signage, interpretation of technical information and development of language and graphics for regional distribution. 1999-2005.
Private consultant providing public education and outreach services to local jurisdictions, commercial and sport fishing organizations, and environmental organizations. 1993-1994.
Annual Open House Coordinator and/or Assistant, Moss Landing Marine Laboratories, 1985-1989.
Public Education Program Assistant, Ocean Education, Moss Landing Marine Labs, California Sea Grant Program. 1983.

DIRECT INVOLVEMENT IN COMMITTEES, WORKSHOPS, MEETINGS 1999-PRESENT

- Member, Marine Regulatory Effectiveness Program Technical Review Panel; 2011-2014
- Member, Salmon Recovery Funding Board Technical Review Panel; 2009-2011
- Member, City of Bainbridge Island Environmental Technical Advisory Committee; 2011-2014
- Steering Committee Member and Invited Speaker, Bainbridge Environmental Conference; 2010
- Member, Proposal Review Panel for NOAA SARP (Climate Change) research proposals, 2009
- Co-Chair, Pacific Estuarine Research Society Annual Conference; 2009
- Editorial Review Board, Coastal and Estuarine Science News; 2008-2009
- Monitoring and Adaptive Management Plan Team, Under contract to NOAA Fisheries; 2008
- ESRP (Estuary and Salmon Habitat Restoration Program) Review Panel; 2007
- Washington State Department of Natural Resources HCP Science Review Panel; 2006-2007
- Puget Sound Nearshore Ecosystem Restoration Program (PSNERP) Nearshore Science Team; 2002-2004
- WRIA 8 Technical Advisory Committee; 1999-2004
- WRIA 9 Technical Advisory Committee; 1999-2004
- Seattle Aquarium “Citizen Science” Steering Committee; 2004-2005
- Estuarine Research Federation Conference Planning Committee Member, Poster Session Chair, 2003
- Central Puget Sound Forum, Nearshore Technical Committee, Chair; 1999-2001
- City of Bainbridge Island, Environmental Technical Advisory Committee; 2001-2008
- Convener/Co-Chair, Marine Riparian Workshop, Tsawwassen, B.C.; 2004
- Program Committee, Estuarine Research Federation 17th Biennial Conference; 2003
- Poster Program Chair, Estuarine Research Federation 17th Biennial Conference; 2003
- City of Bainbridge Island, Harbor Commission; 2002-2003
- Convener/Chair, Nearshore Data Workshop, 2000
- Presenter, Puget Sound Research Conference, 2001
- Presenter, Puget Sound Research Conference, 2003
- Presenter, Estuarine Research Federation Conference; 2001, 2003, 2005

HONORS/AWARDS

2011 Exceptional Work as Project Manager, Bainbridge Island Land Trust
2010-2012 Past President/Board of Directors, Pacific Estuarine Research Society
2008-2010 President/Board of Directors, Pacific Estuarine Research Society
2008-2010 Member, Governing Board, Coastal and Estuarine Research Federation
2007 Outstanding Stewardship, Bainbridge Island Shoreline Stewardship Program
2007 Environmentalist of the Year, Association of Bainbridge Communities
2007 Outstanding Service Award, Nominee, University of Washington
2003 Appreciation for Leadership and Outstanding Contributions, Estuarine Research Federation
2003 Award of Excellence (shared) for Shoreline Stewardship Guidebook, King County Department of Natural Resources and Parks.
2003 Award of Excellence (shared) for Nearshore Interpretive Signage, King County Department of Natural Resources and Parks.
2003 Award of Excellence Appreciation Award, King County Department of Natural Resources and Parks.
2002 Puget Sound Hero Award, People for Puget Sound.
1987 Best Presentation Award, American Institute of Fisheries Research Biologists.
1986 American Fisheries Society Graduate Scholarship Award, American Fisheries Society.
1986 Kim Peppard Memorial Scholarship Award, Moss Landing Marine Laboratories.
1985 Student Body President, Moss Landing Marine Laboratories.
1985 Packard Student Research Grant Award, Packard Foundation.

PROFESSIONAL AFFILIATIONS
Coastal and Estuarine Research Federation (Governing Board Member)
Pacific Estuarine Research Society (President, Board Member)
American Fisheries Society
Ecological Society of America
American Society of Ichthyologists and Herpetologists

PUBLICATIONS


and 9). **J.S. Brennan, Editor.** Report prepared for King County Department of Natural Resources, Seattle, Washington.


References available upon request