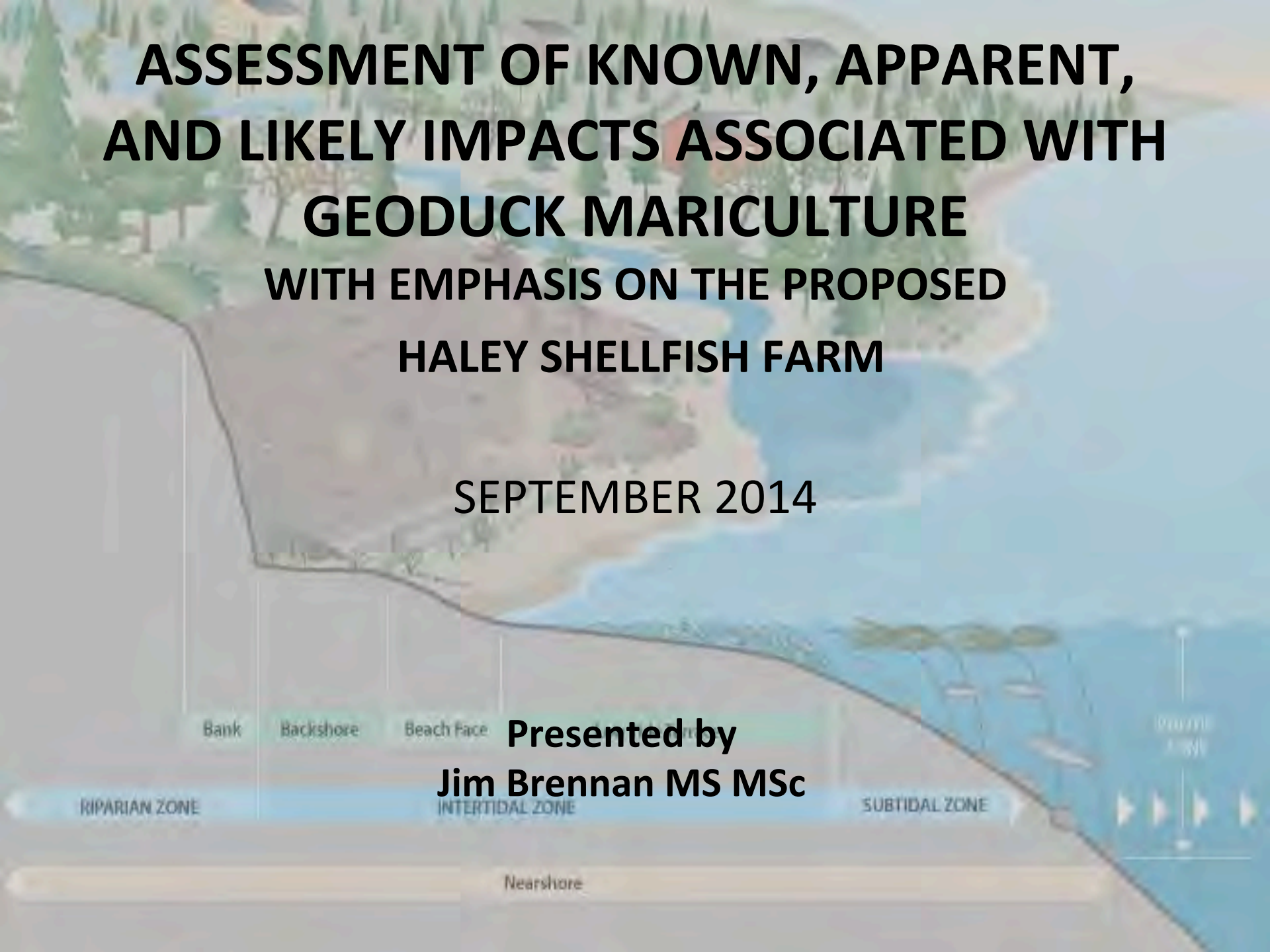
ASSESSMENT OF KNOWN, APPARENT, AND LIKELY IMPACTS ASSOCIATED WITH GEODUCK MARICULTURE

WITH EMPHASIS ON THE PROPOSED HALEY SHELLFISH FARM

SEPTEMBER 2014

Presented by
Jim Brennan MS MSc



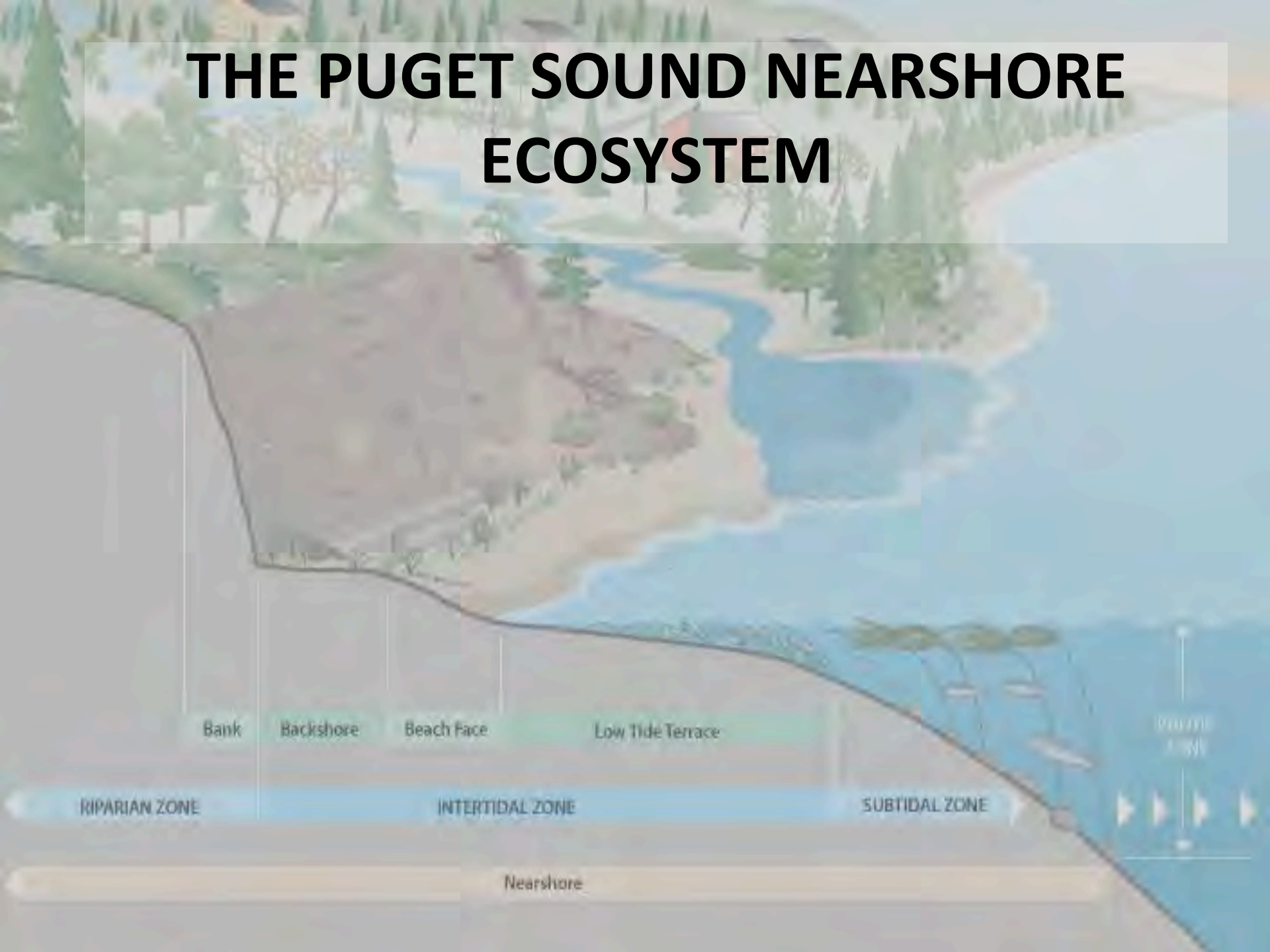
OUTLINE PART I
BACKGROUND

- 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

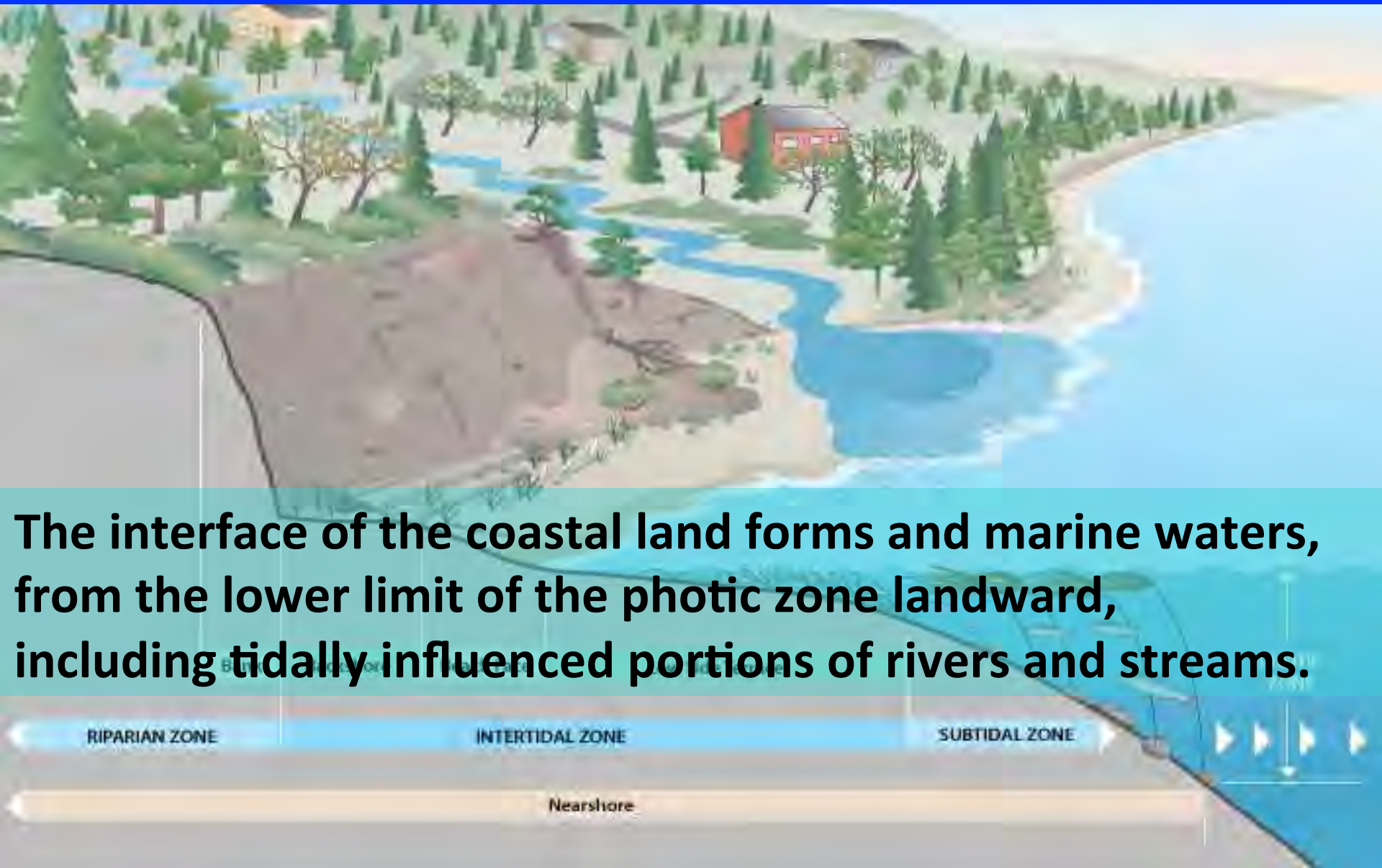
THE PUGET SOUND NEARSHORE ECOSYSTEM



ECOSYSTEM

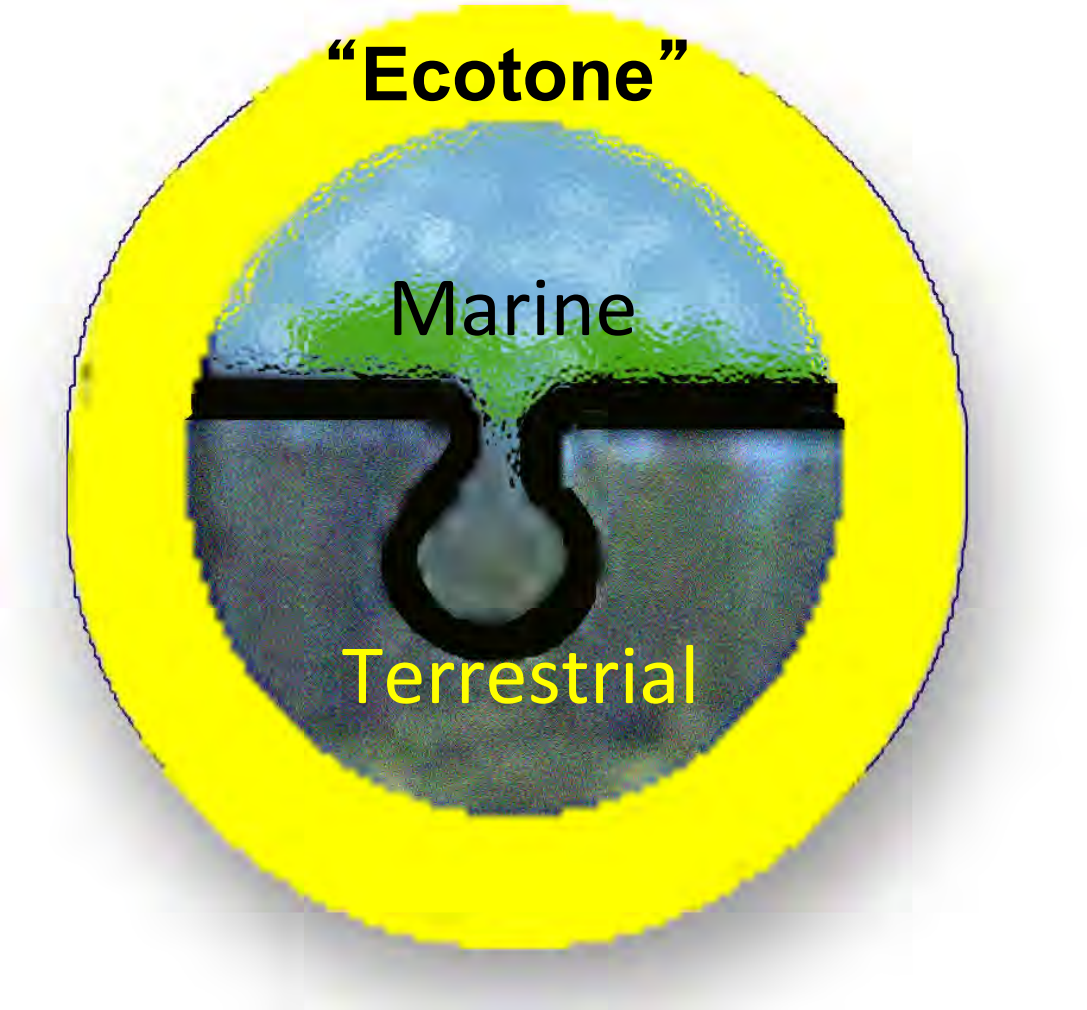
BIOTIC COMMUNITIES INTERACTING WITH ABIOTIC COMPONENTS

What Is the Nearshore?

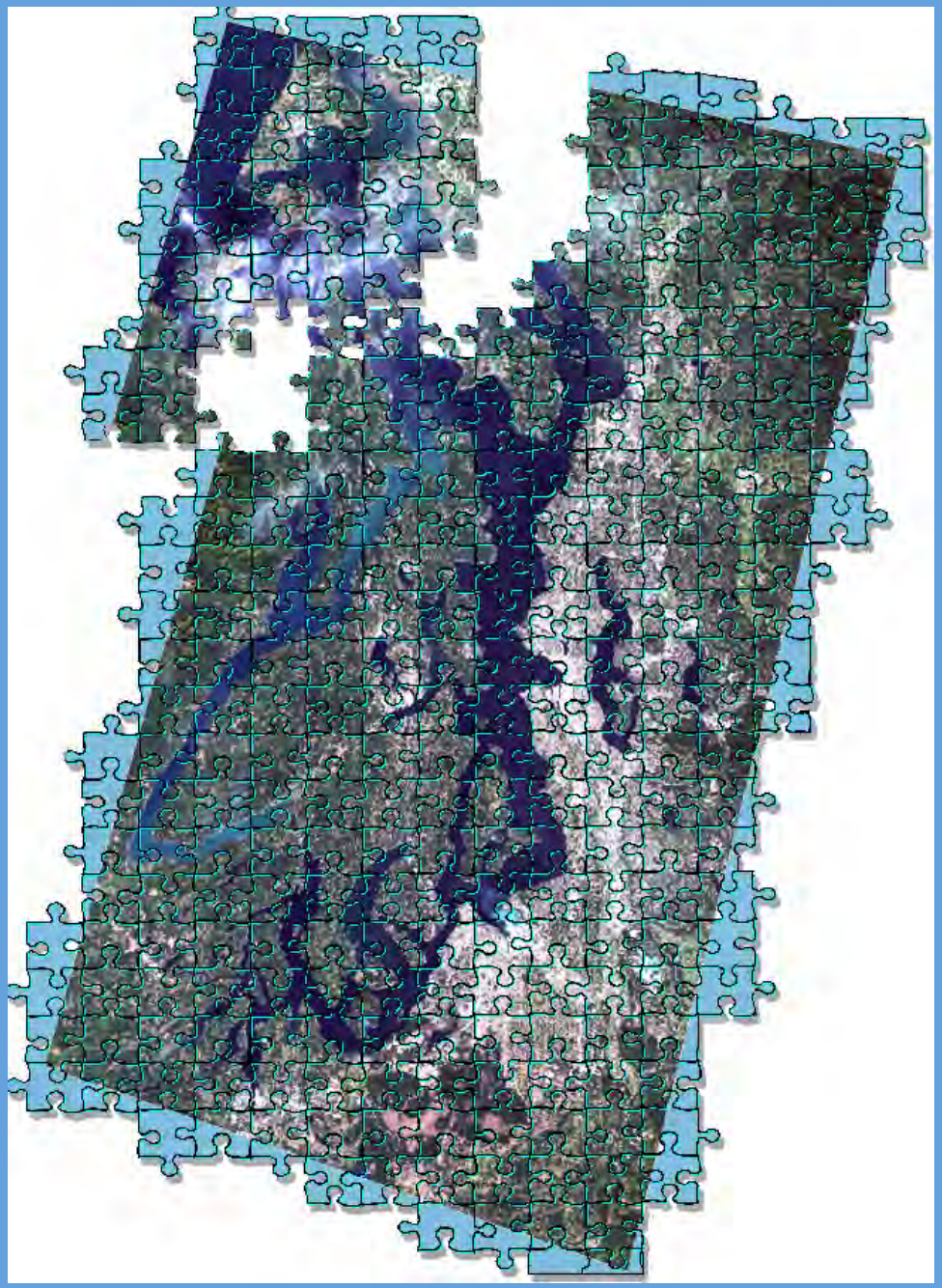


The interface of the coastal land forms and marine waters, from the lower limit of the photic zone landward, including tidally influenced portions of rivers and streams.

Interface/Transition Zone



THE “NEARSHORE” IS THEREFORE A COMPLEX OF ECOSYSTEMS



The Puget Sound Ecosystem Puzzle

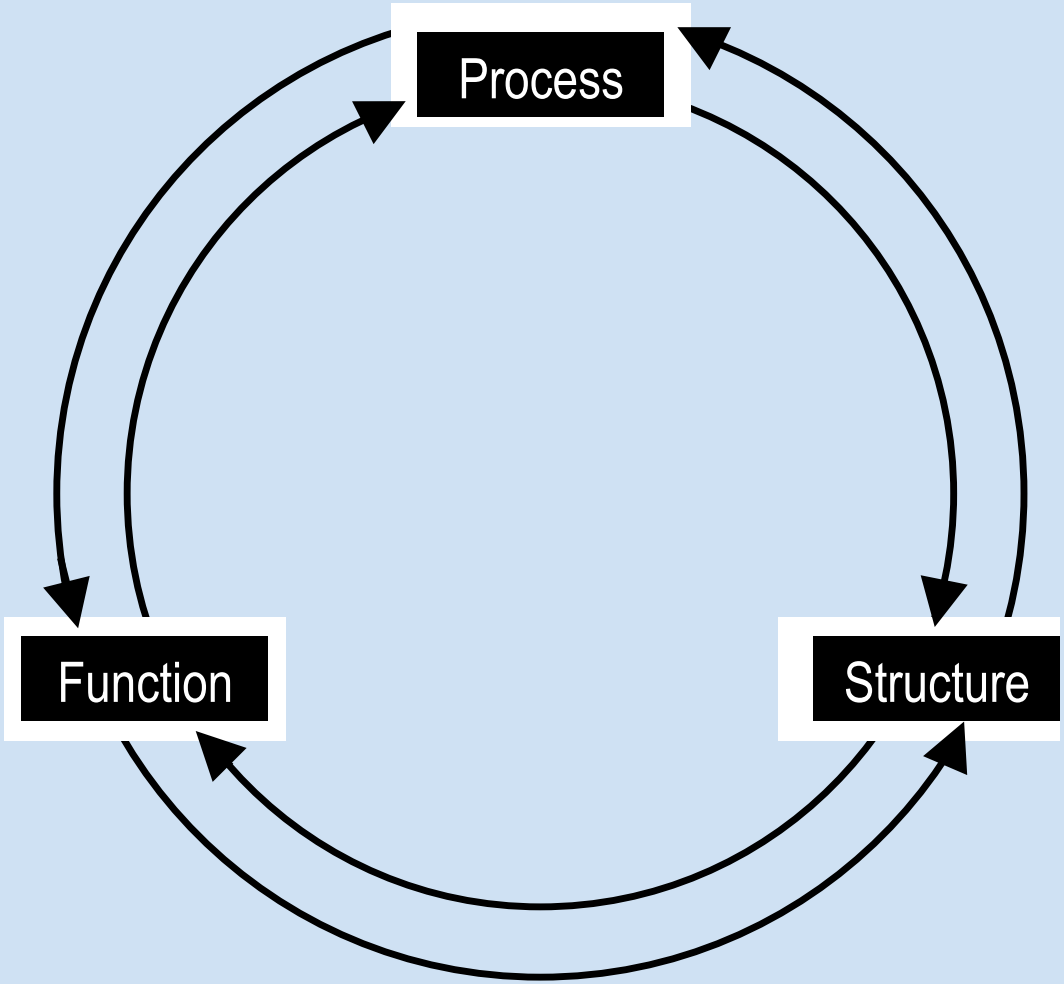
Lots of Parts:
All Connected

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

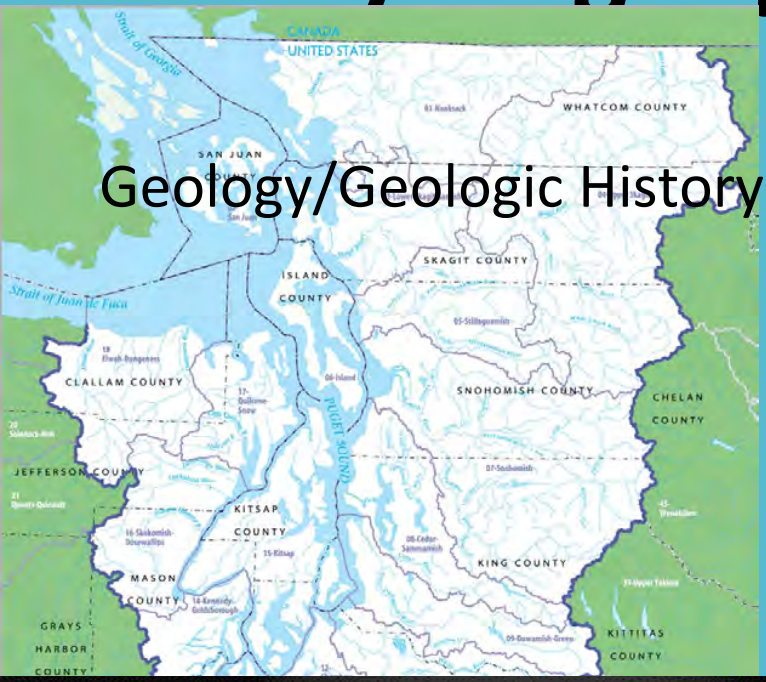
-harvestable resources

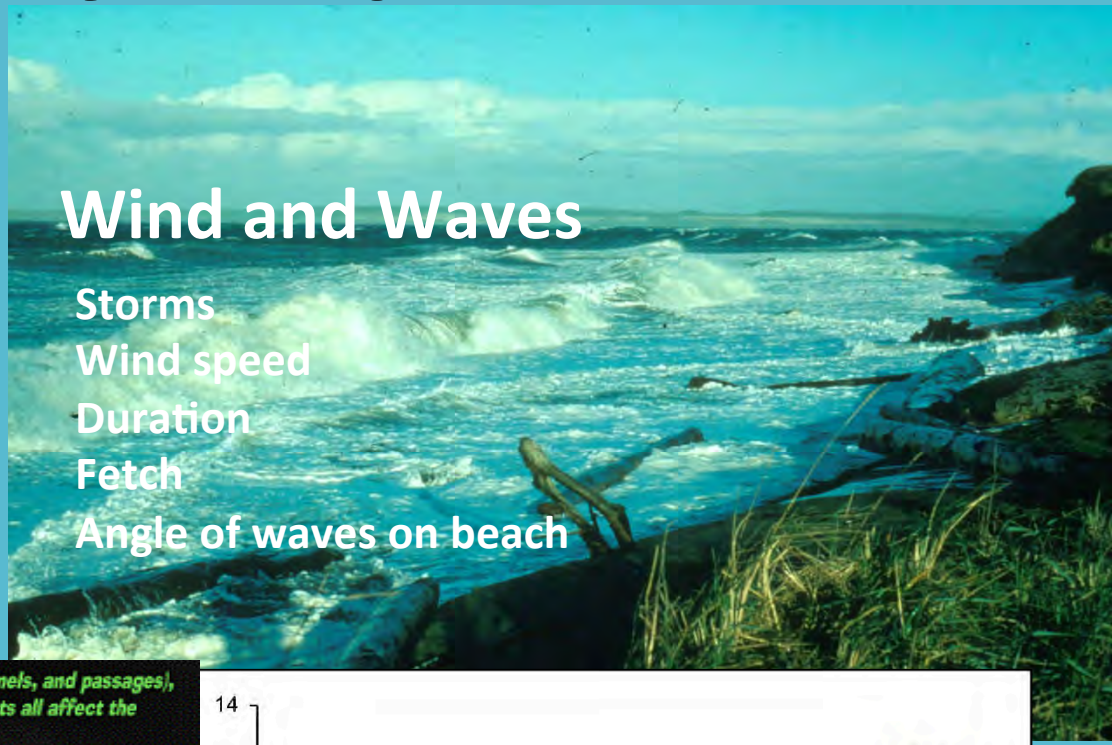
-water purification

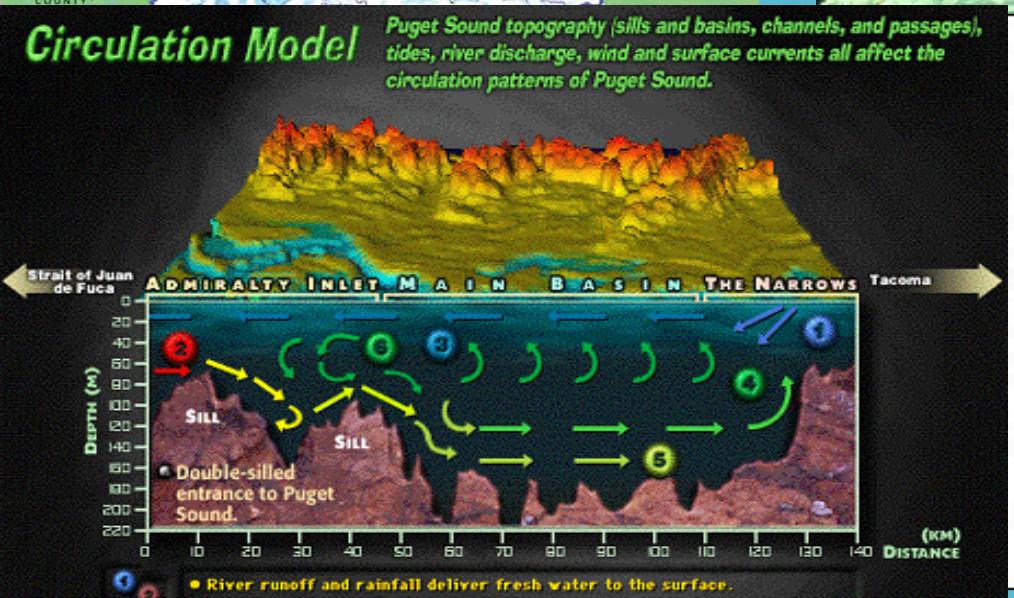
-soil stability

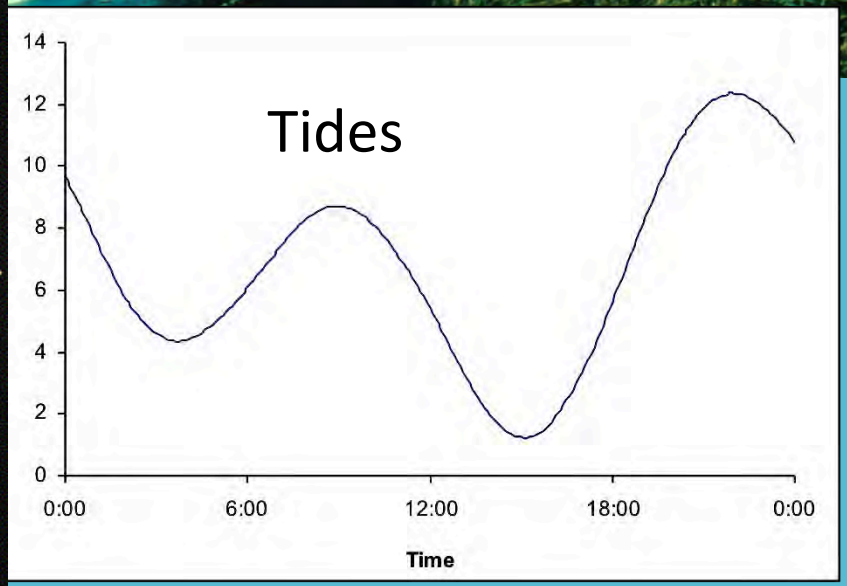
Photo by Wolf Bauer

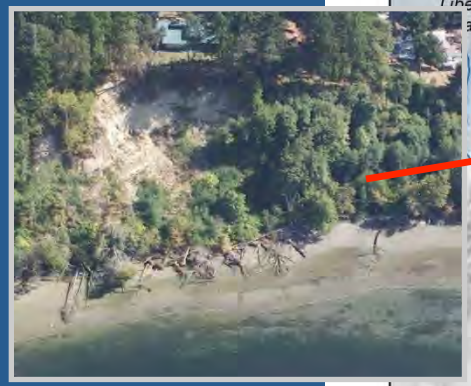
Hydrogeophysical processes











Liberty Bay

Port Madison

CITY OF BAINBRIDGE ISLAND

N

Port Orchard Bay

Bainbridge Island

Puget Sound

Sinclair Inlet

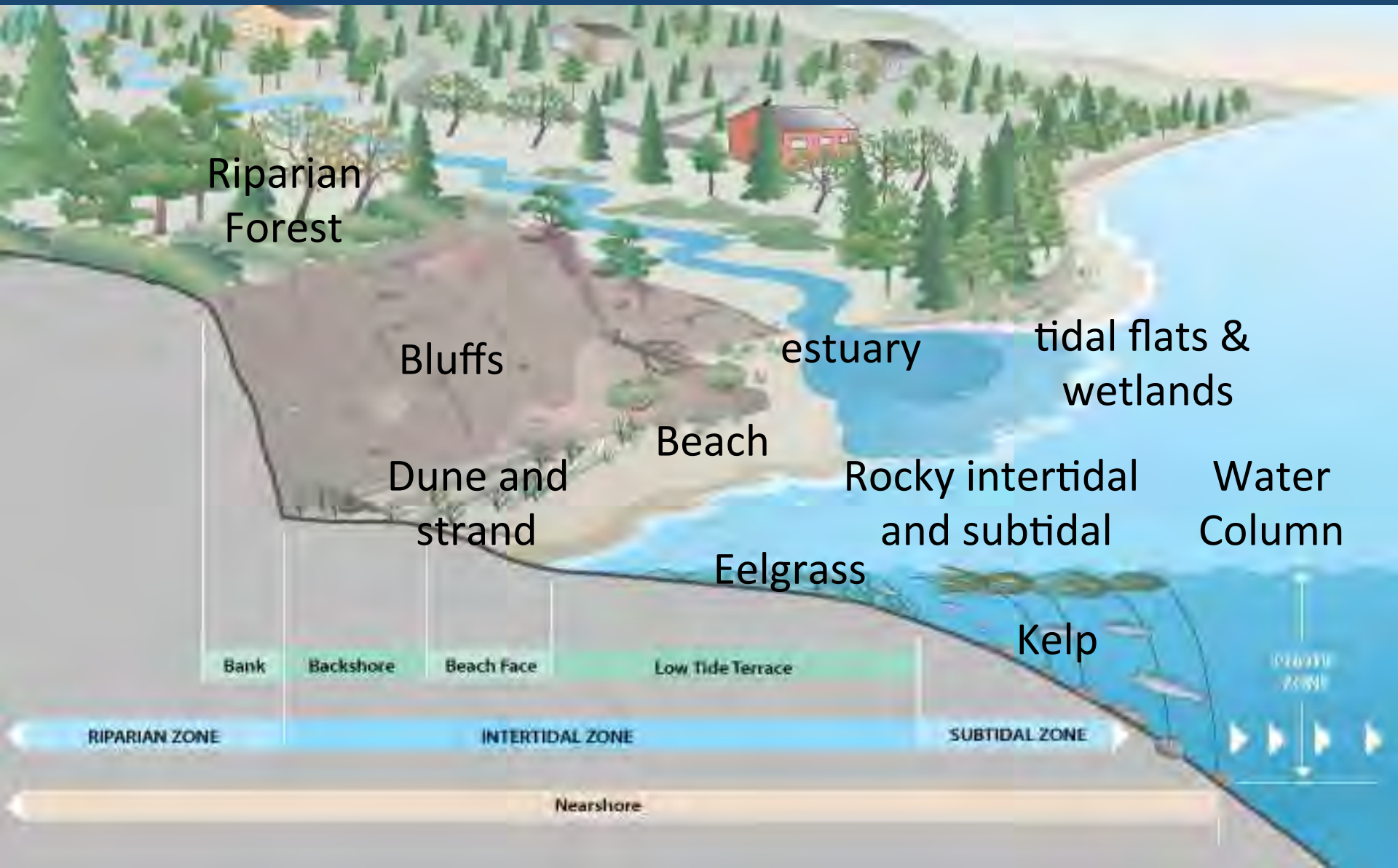
Rich Passage

0 0.5 1 2 Miles

ce:
yson, D.P., Haugerud, R.
Greenberg, R. 2001.
ing a Seemless Digital
ition Model of the Puget
d Basin. In: Puget Sound
onal Research. 2001.
acts & Biographies. Puget
d Water Quality Action
: Olympia, Washington.

Topographic & Bathymetric Relief
Bainbridge Island Nearshore Assessment

Nearshore Habitats



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
- STRUCTURAL LY
- 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

100's of spp. of wildlife

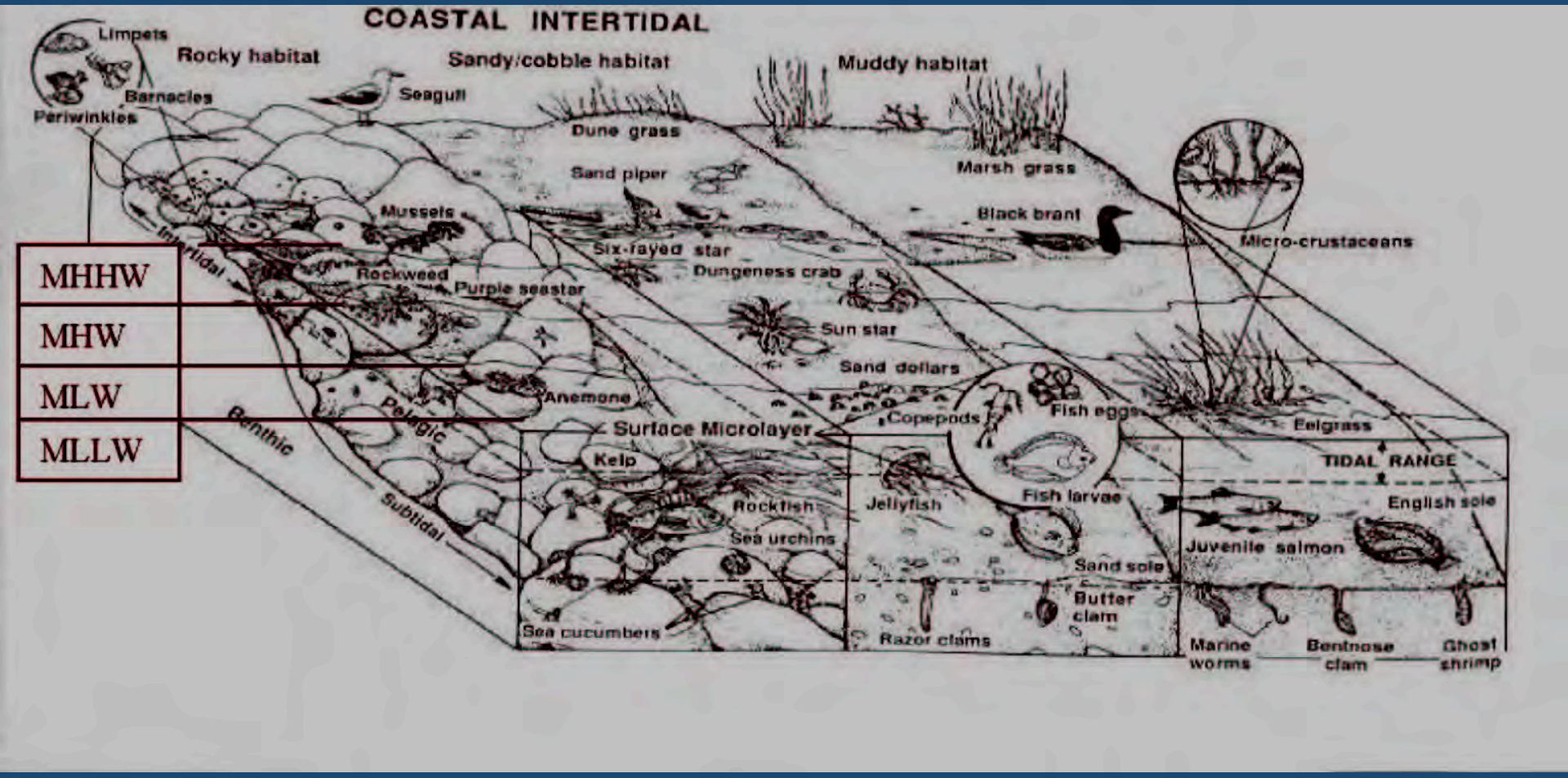
Over 200 spp. of fishes

100's of marine & terrestrial plants

>15 spp. of marine mammals

1000's of spp. of aquatic invertebrates

BEACH VARIABILITY

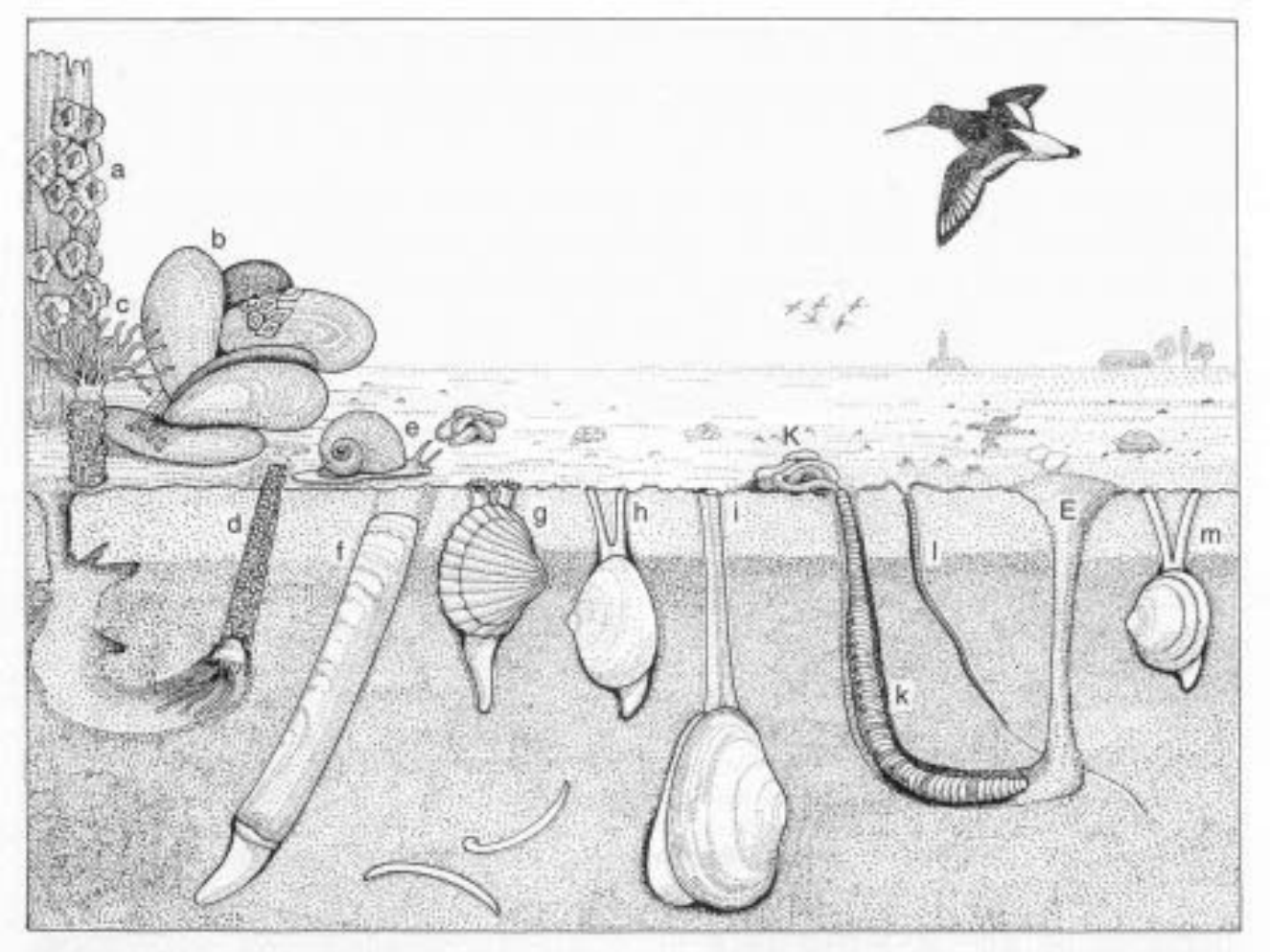


Composition of substrate, energy, exposure, salinity, tides, etc. determined by controlling factors

HABITAT FUNCTIONS

A FEW EXAMPLES

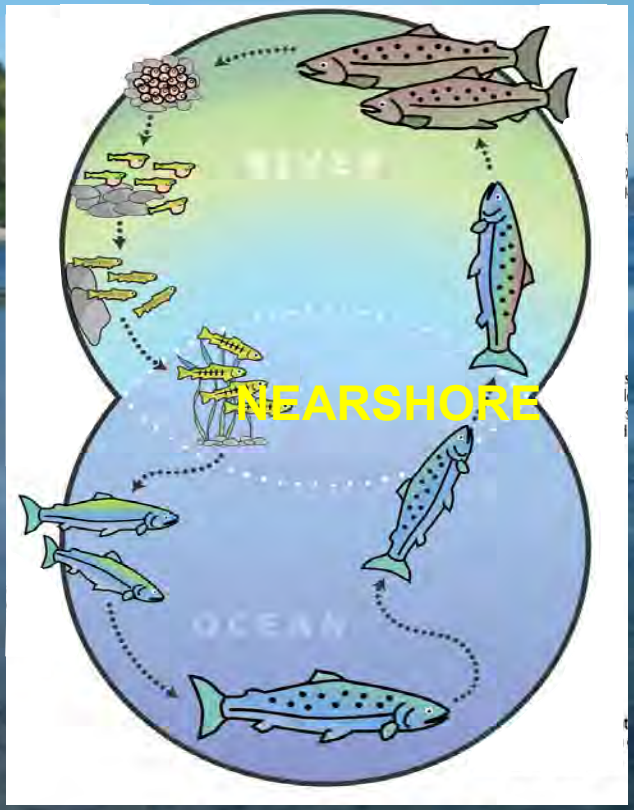
Benthos



Functions: Feeding, refuge, reproduction, productivity

Surf smelt spawn

Salmonid Nearshore Dependence

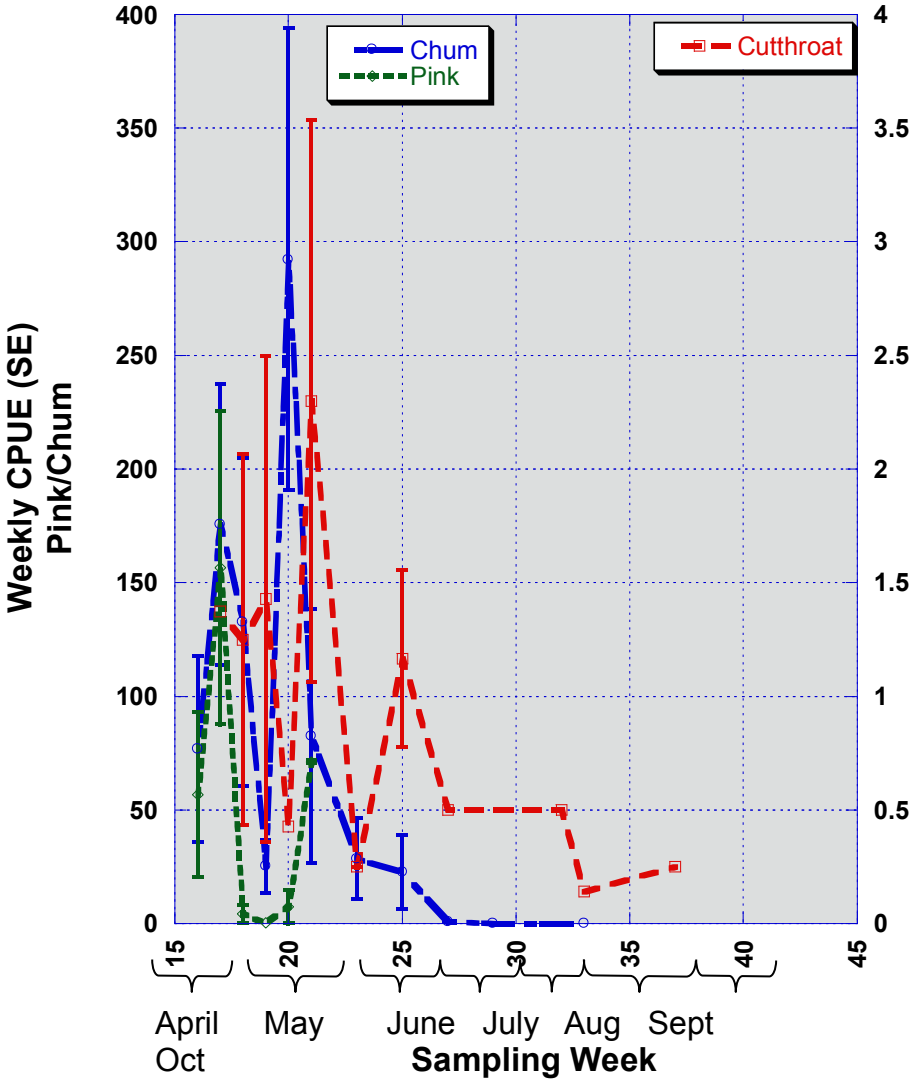


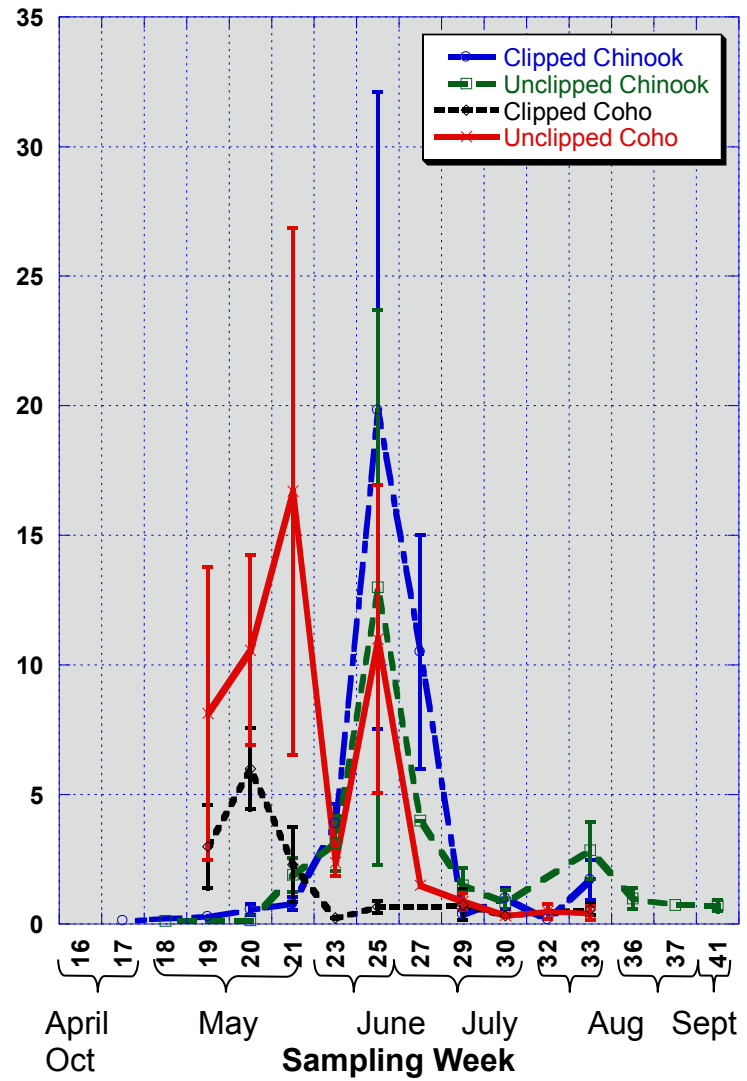
- **Rearing**
- **Feeding**
- **Refuge**
- **Migration**
- **Physiological transition**

Benthic – Pelagic Coupling

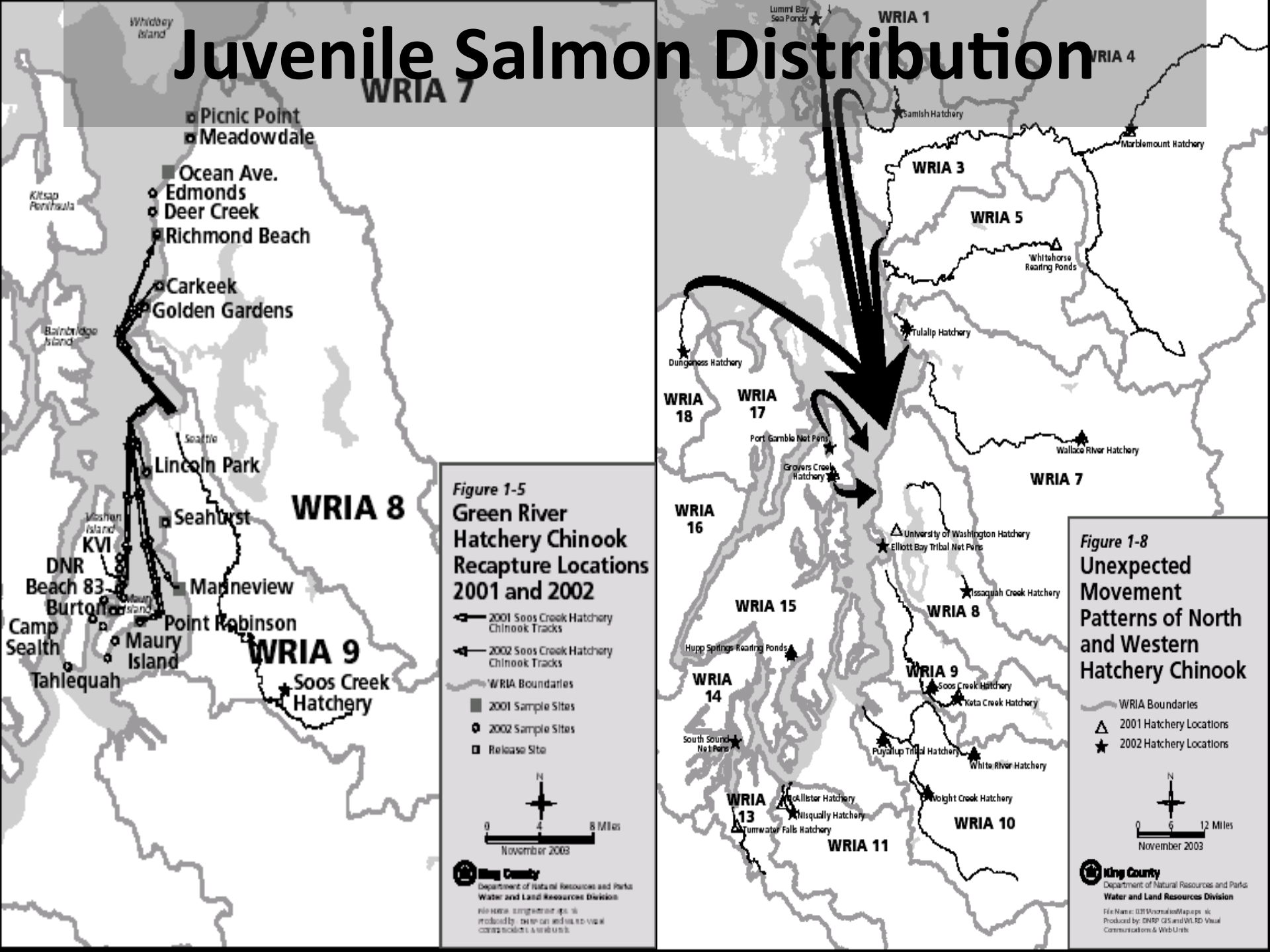
4. 25. 2001

Timing of Salmonid use in Shallow Marine Nearshore Waters

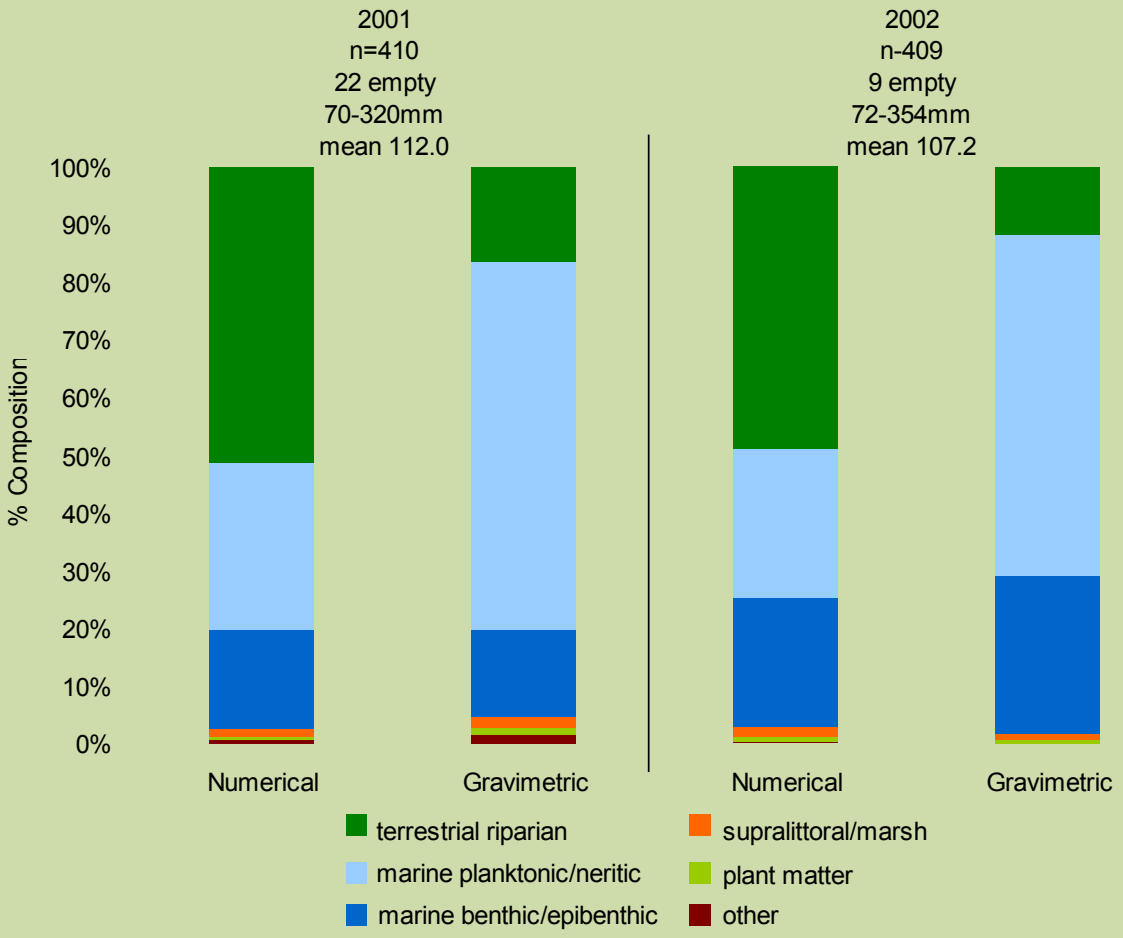




Juvenile Salmon Distribution



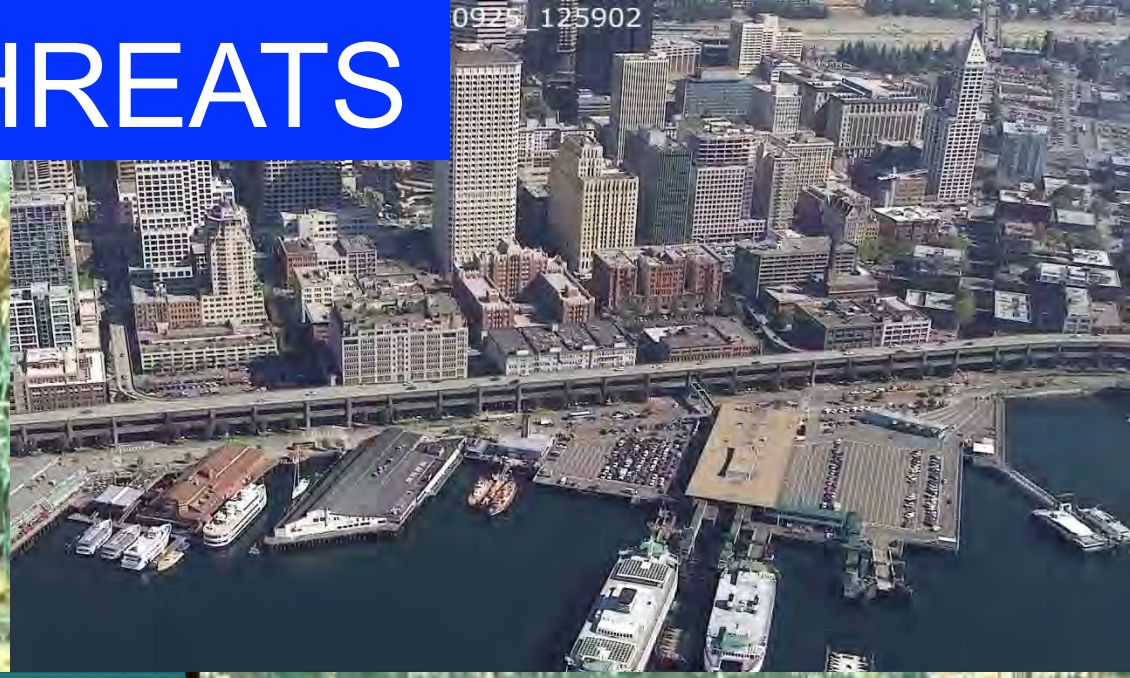
Overall diet composition based on prey ecology for juvenile Puget Sound chinook



“…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

THREATS



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

Studies/Results

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

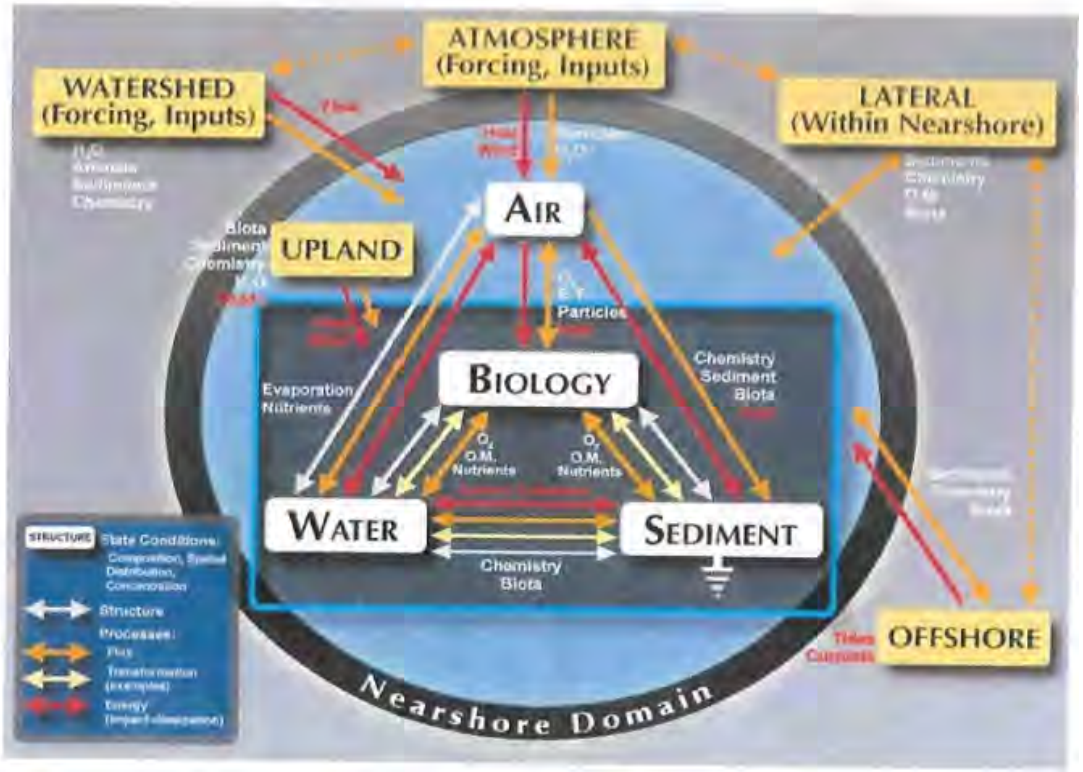
- LITERATURE REVIEW
- NATURAL RESOURCE MANAGEMENT EXPERIENCE
- FAMILIARITY WITH MARICULTURE PRACTICES
- PROFESSIONAL NEARSHORE EXPERIENCE & EXPERTISE
- PUGET SOUND NEARSHORE CONCEPTUAL MODEL

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

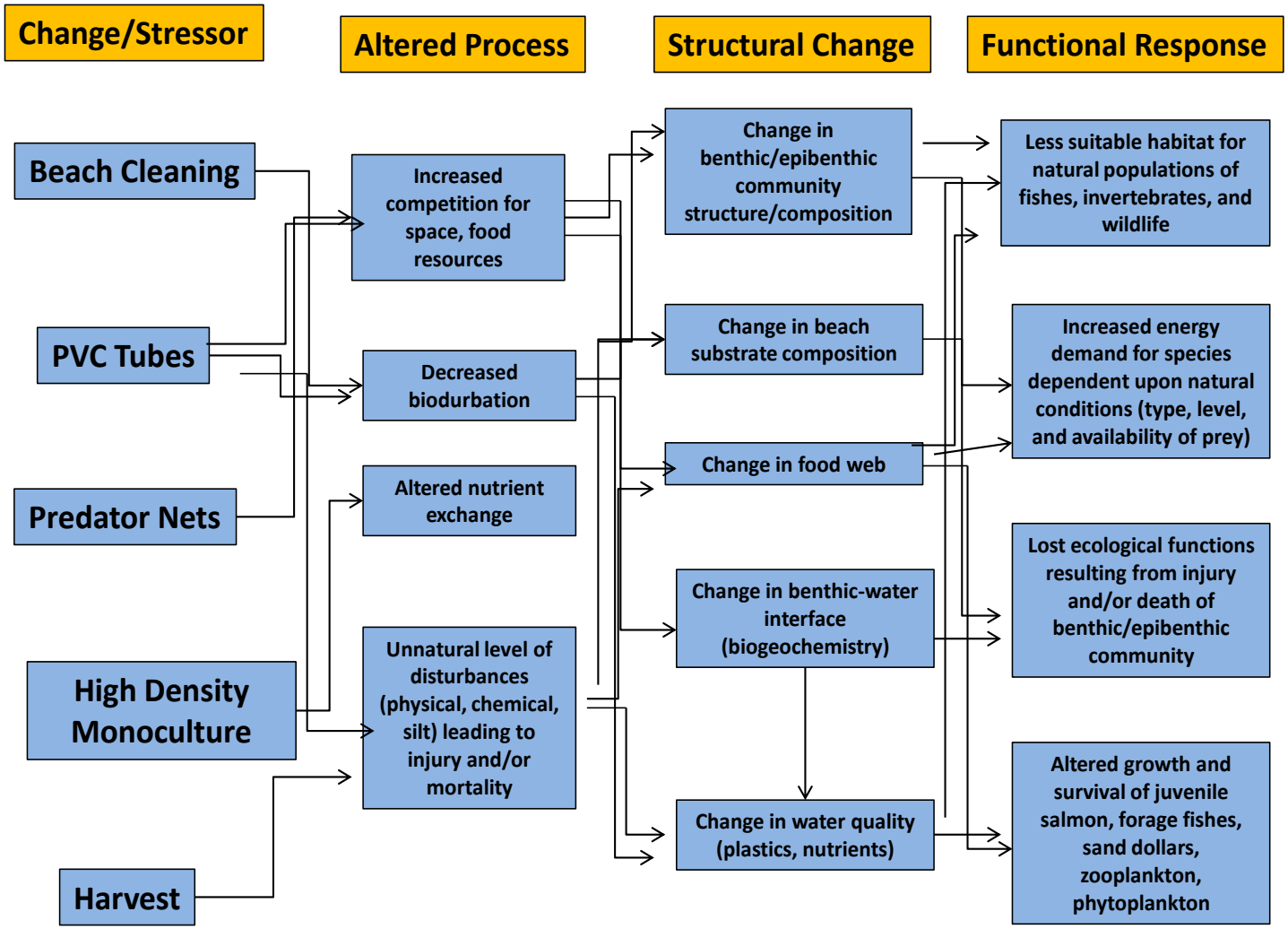
A synthesis tool for understanding and nearshore systems and their response to stressors



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

Source: Simenstad et al. 2006.

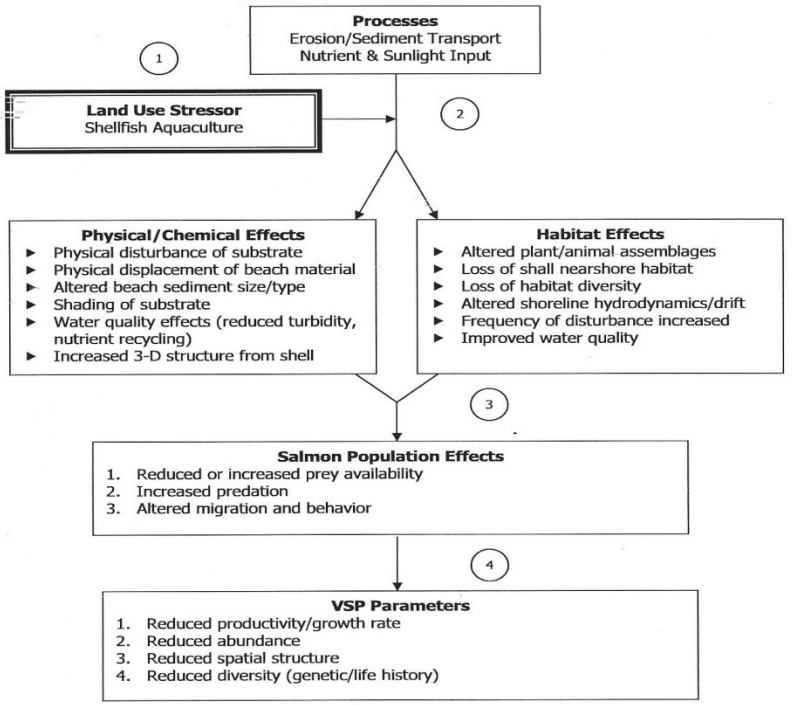
Conceptual Sub-model Geoduck Mariculture



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



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.**

Burley Lagoon 5/15/13

Burley Lagoon 8/20/13

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?**

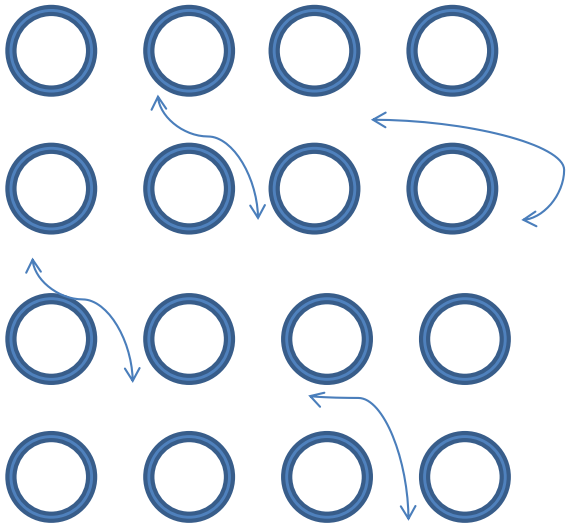
PVC TUBE IMPACTS

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; Goulletquer et al. 1999; Bendell-Young 2006; Dumbauld et al. 2009; Straus et al. 2011).

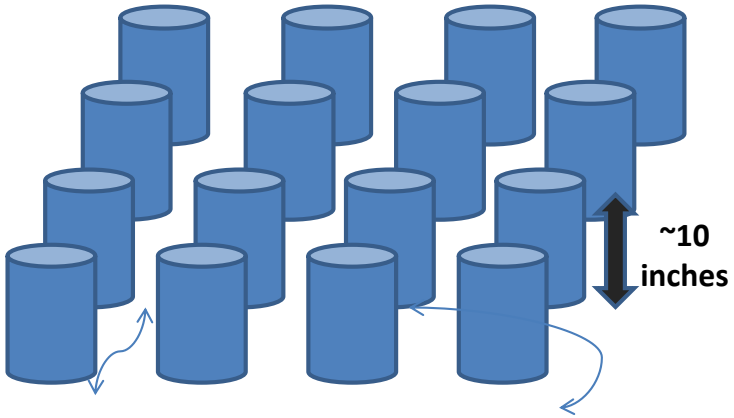
PVC TUBE IMPACTS

- 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



Plan view of tubes in beach



Cross section view of tubes in beach

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

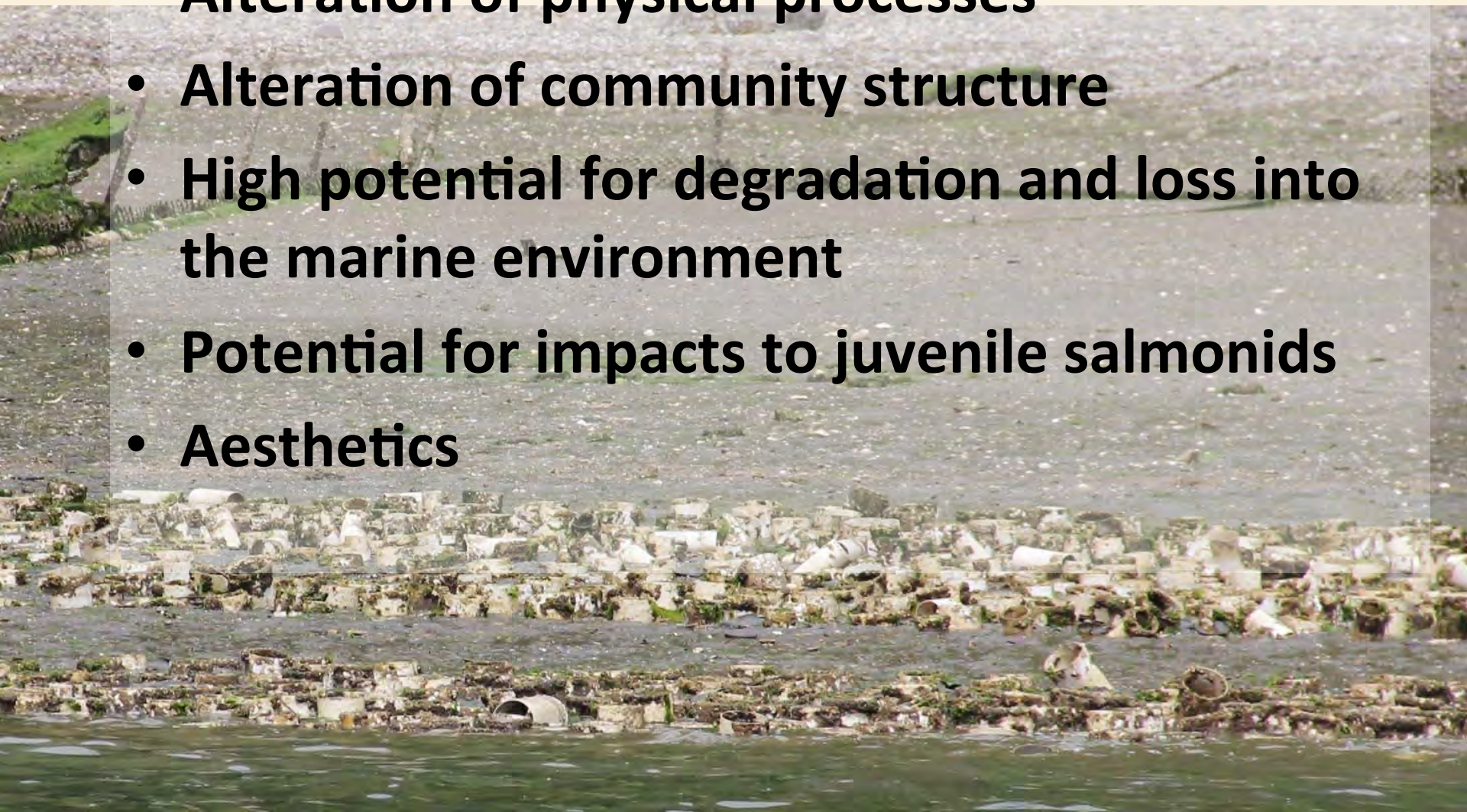
36,300 ft of tube/acre X 11 acres = 399,300 ft of PVC pipe

75.63 miles of PVC pipe

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.

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

NETTING IMPACTS CONT'

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**

HARVEST IMPACTS CONT'

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)**

HARVEST IMPACTS CONT'

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

http://upload.wikimedia.org/wikipedia/commons/4/43/Calidris_alpina_juv.jpg

http://upload.wikimedia.org/wikipedia/commons/1/10/Melanitta_perspicillata.jpg

- 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

http://thumbs.dreamstime.com/x/great-blue-heron-24089576.jpg

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

Dentraster excentricus

- 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

Sample #	Collection point	Tidal Elevation	Sand Dollar Count
1	South	0.0	96
2	South	-2.0	64
3	North	+2.0	11
4	North	0.0	74
5	North	-2.0	62

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.**

Summary
WATER QUALITY IMPACTS CONT'

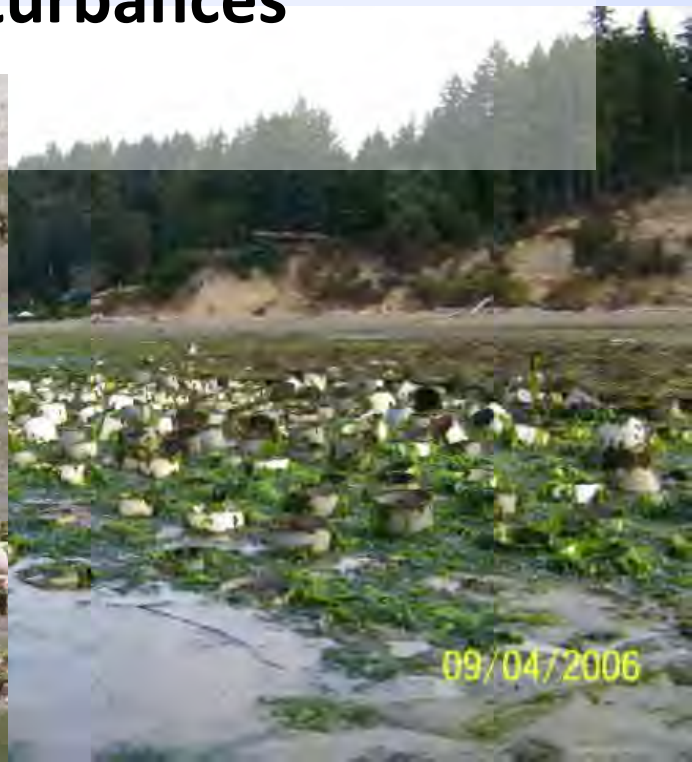
- Cultivated geoduck clams may contribute (via biodeposition of feces and pseudofeces) to altered sediment conditions (chemistry, habitat quality for other organisms), including higher sediment ammonia concentrations, increased organic carbon, sediment oxygen demand, anoxia, increased dissolved nutrients 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

SMA

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

SEPA DETERMINATION

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

ACTION/IMPACT	IMPACT INTENSITY/ DURATION	SIGNIFICANT	COMMENTS
Beach Preparation	Moderate-High/Short-term activity, latent effects	Yes	Permanent alteration of habitat and species composition
PVC Tubes	High/2-3 yrs, latent effects	Yes	Individual and cumulative, cyclical
Predator Nets	High/2-3 yrs, latent effects	Yes	Individual and cumulative, cyclical
Maintenance	Moderate/Periodic during 3-yr period	Possibly	Individual and cumulative, cyclical. Direct mortality could lead to determination of significance
Harvest	High/Duration of harvest, latent effects	Yes	Individual and cumulative, cyclical
ASSOCIATED RISKS			
Clam Density	High/5-7yrs	Yes	cumulative, cyclical
Disease and Parasites	High/5-7yrs	Yes	cumulative, cyclical
Genetic Risks	High/5-7yrs	Yes	cumulative, cyclical

Summary Impact and Significance Table Cont'

ASSOCIATED IMPACTS			
Birds	Moderate-High/Duration of project, latent effects	Possibly	Declining populations; Sensitive to disturbance; Reduced access/food supply; cumulative, cyclical
Fishes	Moderate-High/Duration of project, latent effects	Yes	Alteration of habitat, food supply; cumulative, cyclical
Benthic Communities	High/Duration of project, latent effects	Yes	Permanent alteration of habitat, community dynamics, ecological processes, structure, and functions; direct mortality; cumulative, cyclical
Marine Mammals	Low to Moderate/Duration of project	Not likely	
Water Quality	High/Duration of project, latent effects	Yes	Altered benthos, plastic pollution, silt, release of toxins, cysts, eggs
Aesthetics	High/3-4 yrs	Yes	Mariculture structures
Public Access	High	Yes	Exclusion

References

100. Willner, G. The Potential Impacts of the Commercial Geoduck Hydralic 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, Kamermans 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
168. Anderson, D.M. 1971. Spawning, growth and spatial distribution of the geoduck clam, Panope generosa
Gould, in Hood Canal, Washington. Ph.D. Thesis, University of Washington, Seattle.
171. Bendell, L.I. 2014. Evidence for decliness in the Native Leukoma staminea as a Result of the Intentional Introduction of the Non-native Venerupis philippinarum in Coastal British Columbia, Canada Estuaries and Coasts 37:369-380.
172. Bradbury, A. 1999. The relative abundance of benthic animals and plants on subtidal geoduck tracks before and after commercial geoduck fishing. Appendix 6, Final SEIS for the Puget Sound Commercial Geoduck Fishery. Washington State Department of Natural Resources and Washington State Department of Fish and Wildlife, 2001.
173. Borde, A.B., R.M.Thom, S. Rumrill, and L.M. Miller. Geospatial habitat change analysis in Pacific Northwest coastal estuaries. 2003. Estuaries Vol. 26, No. 4B.
174. Brennan, J.S., K.F. Higgins, J, J.R. Cordell, V. Stamatiou. 2004. Juvenile salmonid composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. King County Department of Natural Resources and Parks, Seattle, Washington.
175. Brennan, J.S. and K.F. Higgins. 2003. Fish species composition, timing, and distribution in nearshore marine waters: A synopsis of 2001-2002 beach seining surveys in King County, WA. In Proceedings of the 2003 Puget Sound Research Conference, March 31-April 3, 2003, Vancouver, British Columbia, Canada. Puget Sound Action Team, Olympia, Washington.
176. Buchanan, J.B. 2006. Nearshore birds in Puget Sound. Puget Sound Nearshore Partnership Report number 2006-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, WA.
177. Cerco, C.F. and M.R. Noel. 2007. Can oyster restoration reverse cultural eutrophication in Chesapeake Bay? Estuaries and Coasts. Vol. 30, No. 2, p. 331-343.

178. Dachs, J. and L. Mejanelle. 2010. Organic pollutants in coastal waters, sediment, and biota: A relevant driver for ecosystems during the anthropocene? Estuaries and coasts 33: 1-14.
179. DeFur, P. and D.N. Rader. 1995. Aquaculture in estuaries: Feast or famine? Estuaries Vol. 18, No. 1A.
180. Dernie, K.M., M.J. Kaiser, E.A. Richardson, R.M. Warwick. 2003. Recovery of soft sediment communities and habitats following physical disturbance. Journal of Experimental Marine Biology and Ecology, Vols. 285-286.
181. Diana, J.S., H. S. Egna, T. Chopin, M.S. Peterson, L. Cao, R. Pomeroy, M. Verdegem, W.T. Slack, M.G.Bondad-Reantaso, and F. Cabello. 2013. Responsible Aquaculture in 2050: Valuing Local Conditions and Human Innovations Will Be Key to Success. Bioscience, Vol. 63(4).
182. Dethier, M. 2006. Native shellfish in nearshore ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2006-04. Published by Seattle District, U.s. Army Corps of Engineers, Seattle, Washington.
184. Drake, P. 1997. The effect of aquaculture practices on the benthic macroinvertebrate community of a lagoon system in the Bay of Cadiz (Southwestern Spain). Estuaries Vol. 20, No. 4.
186. Duffy, E., D.A. Bauchamp, R.M. Sweeting, R.J. Beamish, and J.S. Brennan. 2010. Ontogenetic Diet shifts of juvenile Chinook salmon in nearshore and offshore habitats of Puget Sound. Transactions of the American Fisheries Society 139: 803-823.
187. Dumbauld, B.R., J.L. Ruesink, and S.S. Rumrill. 2009. The ecological role of bivalve shellfish aquaculture in the estuarine environment: A review with application to oyster and clam culture in West Coast (USA) estuaries. Aquaculture, Vol. 290, Nos. 3-4.
188. Eissinger, A. 2007. Great blue herons in Puget Sound. . Puget Sound Nearshore Partnership Report No. 2007-06. Published by Seattle District, U.s. Army Corps of Engineers, Seattle, Washington.
190. Feldman, K.L., D.A. Armstrong, B.R. Dumbauld, T.H. DeWitt, and D.C. Doty. 2000. Oysters, crabs, and burrowing shrimp: review of an environmental conflict over aquatic resources and pesticide use in Washington State's (USA) coastal estuaries. Estuaries, Vol. 23, No. 2.
191. Fresh, K.L. Juvenile Pacific salmon in Puget Sound. Puget Sound Nearshore Partnership Report 2006-06. Published by Seattle District, U.s. Army Corps of Engineers, Seattle, Washington.
192. Fresh, K., C. Simenstad, J. Brennan, M. Dethier, G. Gelfenbaum, F. Goetz, M. Logsdon, D. Myers, T. Mumford, J. Newton, H. Shipman, C. Tanner. 2004. Guidance for protection and restoration of the nearshore ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2004-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at http://pugetsoundnearshore.org.
194. Gelfenbaum, G., T. Mumford, J. Brennan, H. Case, M. Dethier, K. Fresh, F. Goetz, M. van Heeswijk, T.M. Leschine, M. Logsdon, D. Myers, J. Newton, H. Shipman, C.A. Simenstad, C. Tanner, and D. Woodson. 2006. . Puget Sound Nearshore Partnership Report No. 2006-01. Published by Seattle District, U.s. Army Corps of Engineers, Seattle, Washington.
195. Gerritsen, J., A.F. Holland, and D.E. Irvine. 1994. Suspension-feeding bivalves and the fate of primary production: an estuarine model applied to Chesapeake Bay. Estuaries 17(2): 403-416.

Hastings, R.W. and D.R. Heinle. 1995. The effects of aquaculture in estuarine environments:
Introduction to the dedicated issue. Estuaries Vol. 18, No. 1A.
198. Goodwin, C.L. and B.C. Pease. 1987. The distribution of geoduck (Panope abrupta) size, density and quality in relation to habitat characteristics such as geographic area, water depth, sediment type, and associated flora and fauna in Puget Sound, Washington. Washington Department of Fisheries Technical Report No. 102.
200. Hastings, R.W. and D.R. Heinle. 1995. The effects of aquaculture in estuarine environments:
Introduction to the dedicated issue. Estuaries Vol. 18, No. 1A.
201. Hall, S.J. 1994. Physical disturbance and marine benthic communities: Life in unconsolidated sediments. Oceanography and Marine Bology: An Annual Review, 32.
202. Hall, S.J. and M.J.C Harding. 1997. Physical disturbance and marine benthic communities: the effects of mechanical harvesting of cockles on non0target benthic infauna. The Journal of Applied Ecology, Vol. 34, No. 2.
205. Hosack, G.R., B.R. Dumbauld, J.I. Ruesink, and D.A. Armstrong. 2006. Habitat associations of estuarine species: comparisons of intertidal mudflat, seagrass (Zostera marina), and oyster (Crassostrea gigas) habitats. Estuaries and Coasts, Vol. 29, No. 6B.
206. Huppert, D.D., R.L. Johnson, J. Leahy and K. Bell. 2003. Interactions between human communities and estuaries in the Pacific Northwest: Trends and implications for management. Estuaries Vol. 26, No.
48.http://www.centerforfoodsafety.org/issues/312/aquaculture/threats-to-environment-and-wildlife#
208. Keafer, B.A., K.O. Buessler and D.M Anderson. 1992. Burial of living dinoflagellate cysts in estuarine and nearshore sediments. Marine Micro Paleontology, Vol. 20.
209. Kennish, M., M.J. Brush and K.A Moore. 2014. Drivers of change in shallow coastal photic systems: A special issue. Estuaries and Coasts Vol. 37.
210. Kozloff, E.N. 1996. Seashore life of the Northern Pacific coast. An illustrated guide to Northern California, Oregon, Washington, and British Columbia. University of Washington Press, Seattle. 370pp.
211. Kruckenberg, A.R. 1995. The natural history of Puget Sound country. University of Washington Press,
Seattle. 468pp.
212. Leschine, T.M. and A.W. Petersen. 2007. Valuing Puget Sound's Valued Ecosystem Components. Puget Sound Nearshore Partnership Report 2007-07. Published by Seattle District U.S. Army Corps of Engineers, Seattle, WA.
213. Lohrer, A.M., S.F. Thrush, and M.M. Gibbs. 2004. Bioturbators enhance ecosystem function through complex biogeochemical interactions. Nature, Vol. 431 (7012).
215. Lu, L., J. Grant, and J. Barrell. 2008. Macrofaunal spatial patterns in relationship to environmental variables in the Richibucto estuary, New Brunswick, Canada. Estuaries and Coasts 31: 994-1005.
216. Magnuson-Stevens Fishery Conservation and Management Act. 2007. U.S. Department of Commerce, NOAA, NMFS.
218. Michael J. Kennish & Mark J. Brush & Kenneth A. Moore. 2014. Drivers of Change in Shallow Coastal Photic Systems: An Introduction to a Special Issue. Estuaries and Coasts (2014) 37 (Suppl 1):S3–S19See table and section on anthropogenic stressors (p. 9-10)

221. Probert, P.K. 1984. Disturbance, sediment stability, and trophic structure of soft-bottom communities. Journal of Marine Research, 42.
222. Rhoads, D.C. 1974. Organism-sediment relations on the muddy sea floor. Oceanography and Marine Biology, An Annual Review, 12.
224. Ruesink, J.L, H. S. Lenihan, A. C. Trimble, K.W. Heiman, F. Micheli, J. E. Byers, and M.C. Kay. 2005. Introduction of non-native oysters: ecosystem effects and restoration implications. Annu. Rev. Ecol. Evol. Syst., 36:643-89.
225. Richardson, N.F., J.L. Ruesink, S.Naeem, S.D. Hacker, H.M. Tallis, B.R. Dumbauld, L.M. Wisehart. 2007. Bacterial abundance and aerobic microbial activity across natural and oyster aquaculture habitats during summer conditions in a northeastern Pacific estuary. Hydrobiologia Vol. 596 (1).
226. Rickets, E.F., J. Calvin and J. Hedgpeth. 1968. Between Pacific Tides (4th edition). Stanford University Press.
228. Simenstad, C.A. and K. Fresh. 1995. Influence of intertidal aquaculture on benthic communities in Pacific Northwest estuaries: Scales of disturbance. Estuaries Vol. 18. No. 1A
230. Snelgrove, P.V.R. 1999. Getting to the bottom of marine biodiversity: Sedimentary habitats. Bioscience, Vol. 49 (2).
231. Snelgrove, P.V.R., M.C. Austen, G. Boucher, C. Help, P.A. Hutchings, G.M. King, K. Isao ,J.D.P. Lambshead, and C.R. Smith. 2000. Linking biodiversity above and below the marine sediment-water interface. Bioscience, Vol. 50 (12).
interface. Bioscience, Vol. 50 (12).
232. Straus, K.J., L.M. Crosson, and B. Vadapalas. Various Updates. Effects of geoduck aquaculture on the environment: A synthesis of knowledge.
233. Thom, R. M. G. D Williams and A. B. Borde. Conceptual models as a tool for assessing, restoring, and managing Puget Sound habitats and resources.
234. Wagoner, E., B.R. Dubauld, S. D. Hacker, A. C. Trimble, L. M. Wisehart, J.L. Ruesink,.2012. Density-dependent effects of an introduced oyster, Crassostrea gigas on a native intertidal seagrass
235. Williams, D. D. R. M. Thom, J.E. Starkes, J.S. Brennan, J.P. Houghton, D. Woodruff, P.L. Striplin, M. Miller, M. Pedersen, A. Skillman, R. Kropp, A. Borde, C. Freeland, K. McArthur, V. Fagerness, S. Blanton, and L. Blackmore, 2001.Reconnnaissance Assessment of the State of the Nearshore Ecosystem
236. Wall, C.C., B.J. Peterson, and C.J. Gobler. 2011. The growth of estuarine resources (Z.marina, M. mercenaria, C. virginica, A. irradians,, C. variegatus) in response to nutrient loading and enhanced suspension feeding by adult shellfish. Estuaries and Coasts 34:1262-1277.

James S. Brennan
15365 Sunrise Drive NE
Bainbridge Island, WA 98110
(206) 855-8670
(206) 661-5567 (cell)
jsbrennan360@gmail.com

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
Independent Consultant to commercial and non-commercial fisheries entities, marine research and education programs, and private clients. July 1993-May 1994.

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

Project Lead for the development and implementation of the Columbia River commercial salmon gillnet fishery/marine mammal observer program. National Marine Fisheries Service. December 1990-November 1999.

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

Staff Research Biologist for Consortium of California State Universities. Designed and conducted marine research and education programs. Geographic areas of research and teaching included Alaska, Washington, Oregon, California, Mexico, Jamaica, and Antarctica. Contract clients for personal research included U.S. Fish and Wildlife Service, NOAA, National Marine Fisheries Service, Washington Department of Fisheries, Alaska Department of Fish and Game, U.S. Army Corps of Engineers, California Department of Fish and Game, U.S. Department of Interior National Parks Service, and Sea Grant. January 1986-October 1989.

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

Ichthyology, **Moss Landing Marine Laboratories**, 1986.
Fish Biology, **University of California**, Santa Cruz, 1986.
Marine Vertebrates, **Moss Landing Marine Laboratories**, 1985.
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.

Technical representative/guest speaker for Washington Department of Fish and Wildlife at public meetings and regional forums, presenting marine resource information, interpretation of environmental regulations, technical guidance for protection, enhancement, and restoration projects. 1995-1999.

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.

Outdoor Writer for Gamefishing Quarterly and The Fish Sniffer. 1985-1987.

Volunteer for the Monterey Bay Aquarium. 1987-1988.

Volunteer/Guest Lecturer, Elkhorn Slough National Estuarine Research Reserve. 1984-1989.

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 Fish and Wildlife White Paper Technical Review Panel; 2007
- Washington State Department of Fish and Wildlife HCP Science Review Panel; 2007, 2008
- 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, Pacific Estuarine Research Society Conference, 2002, 2003, 2004, 2005, 2006, 2007, 2009
- 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

Duffy, E., D.A. Bauchamp, R.M. Sweeting, R.J. Beamish, and J.S. **Brennan**. 2010. Ontogenetic Diet shifts of juvenile Chinook salmon in nearshore and offshore habitats of Puget Sound. Transactions of the American Fisheries Society 139: 803-823.

Brennan, J.S., H. Culverwell, R. Gregg, P. Granger. 2009. Protection of marine riparian functions in Puget Sound, Washington. Prepared for Washington Department of Fish and Wildlife (WDFW Agreement 08-1185), Olympia, WA.

Brennan, J.S. 2010. Ecology and management of marine riparian areas in Puget Sound: Phase Ib – Riparian buffer summary. Prepared for Washington Department of Fish and Wildlife, Olympia, WA.

Brennan, J.S., H. Culverwell, R.M. Gregg, J. Kershner, D.M. Tonnes, and D. Norman. 2008. Ecology and management of marine riparian areas in Puget Sound: Phase I – Marine Riparian Guidance Document (**draft**). Prepared for Washington Department of Fish and Wildlife, Olympia, WA.

Brennan, J.S. 2007. Marine riparian vegetation communities of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-02. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Carlisle, A., A. King, G.M. Cailliet, and J.S. **Brennan**. 2007. Long-term trends in catch composition from elasmobranch derbies in Elkhorn Slough, California. Marine Fisheries Review, 69: (1-4).

Gelfenbaum, G., T. Mumford, J. **Brennan**, H. Case, M. Dethier, K. Fresh, F. Goetz, M. van Heeswijk, T.M., Leschine, M. Logsdon, D. Myers, J. Newton, H. Shipman, C.A. Simenstad, C. Tanner, and D. Woodson, 2006. Coastal Habitats in Puget Sound: A research plan in support of the Puget Sound Nearshore Partnership. Puget Sound Nearshore Partnership Report No. 2006-1. Published by the U.S. Geological Survey, Seattle, Washington. Available at *http://pugetsoundnearshore.org*.

Fresh, K., C. Simenstad, J. **Brennan**, M. Dethier, G. Gelfenbaum, F. Goetz, M. Logsdon, D. Myers, T. Mumford, J. Newton, H. Shipman, C. Tanner. 2004. Guidance for protection and restoration of the nearshore ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2004-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at *http://pugetsoundnearshore.org*.

Brennan, J.S., and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program. Copyright 2005, UW Board of Regents, Seattle, WA. 34 p.

Brennan, J.S. and K.F. Higgins. In prep. Distribution patterns of marked juvenile Chinook and coho salmon in central Puget Sound nearshore waters.

Cordell, J.R., J.S. **Brennan**, K.F. Higgins, and V.A. Stamatiou. In prep. Dietary analysis of salmonids collected from central Puget Sound beaches.

Brennan, J.S. 2004. Riparian functions and the development of management actions in marine nearshore ecosystems. In: Lemieux, J.P., Brennan, J.S., Farrell, M., Levings, C.D., and D. Myers (eds.), Proceedings of the DFO/PSAT sponsored Marine Riparian Experts Workshop, Tsawwassen, B.C., February 17-18, 2004. Can. Man. Rep. Fish. Aquat. Sci. No. 2680. Viii + 84pp.

Lemieux, J.P., J.S. **Brennan**, M. Farrell, C.D. Levings, and D. Myers (Editors). 2004. Proceedings of the DFO/PSAT sponsored Marine Riparian Experts Workshop, Tsawwassen, B.C., February 17-18, 2004. Can. Man. Rep. Fish. Aquat. Sci. No. 2680. Viii + 84pp.

Brennan, J.S., K.F. Higgins, J, J.R. Cordell, V. Stamatiou. 2004. Juvenile salmonid composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. King County Department of Natural Resources and Parks, Seattle, Washington.

Brennan, J.S. and K.F. Higgins. 2003. Fish species composition, timing, and distribution in nearshore marine waters: A synopsis of 2001-2002 beach seining surveys in King County, WA. *In* Proceedings of the 2003 Puget Sound Research Conference, March 31-April 3, 2003, Vancouver, British Columbia, Canada. Puget Sound Action Team, Olympia, Washington.

Sobocinski, K.L., J.R. Cordell, C.A. Simenstad, and J.S. **Brennan**. 2003. Results from a paired sampling regime. *In* Proceedings of the 2003 Puget Sound Research Conference, March 31-April 3, 2003, Vancouver, British Columbia, Canada. Puget Sound Action Team, Olympia, Washington.

Culverwell, H. and J.S. **Brennan**. 2003. Marine riparian areas: Protection and preservation in Puget Sound and the Georgia Basin. *In* Proceedings of the 2003 Puget Sound Research Conference, March 31-April 3, 2003, Vancouver, British Columbia, Canada. Puget Sound Action Team, Olympia, Washington.

Mavros, W. and J.S. **Brennan**. 2001. Nearshore beach seining for juvenile chinook (Onchorhynchus tshawytscha) and other salmonids in King County intertidal and shallow subtidal zones. *In* Proceedings of the 2001 Puget Sound Research Conference. T. Droscher, editor. Puget Sound Action Team. Olympia, Washington.

Brennan, J.S. and H. Culverwell. 2001. Marine riparian: An assessment of riparian functions in marine ecosystems. *In* Proceedings of the 2001 Puget Sound Research Conference. T. Droscher, editor. Puget Sound Action Team. Olympia, Washington.

Williams, G.D., J.S. **Brennan**, R.M. Thom, M. Miller, D. Woodruff, A. Borde, S. Blanton, and J. Southard. 2001. A comprehensive assessment of the central Puget Sound (King County) nearshore ecosystem: Historic changes, data gaps, and pending threats. *In* Proceedings of the 2001 Puget Sound Research Conference. T. Droscher, editor. Puget Sound Action Team. Olympia, Washington.

Williams, G.D., R,M. Thom, J.E. Starkes, J.S. **Brennan**, J.P. Houghton, D. Woodruff, P.L. Striplin, M. Miller, M. Pedersen, A. Skillman, R. Kropp, A. Borde, C. Freeland, K. McArthur, V. Fagerness, S. Blanton, and L. Blackmore. 2001. Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8

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

Zelo, I., H. Shipman, and J.S. **Brennan**. 2000. Alternative bank protection methods for Puget Sound shorelines. Shorelands and Environmental Assistance Program, Washington Department of Ecology, Olympia, Washington. 130pp.

Brennan, J.S. and G.M. Cailliet. 1991. Age determination and validation studies of white sturgeon, Acipenser transmontanus, in California. In: The Proceedings of the 1st International Symposium on the Sturgeon, P.Williot (ed). pp. 209-234.

Kohlhorst, D.W., L. Botsford, J.S. **Brennan**, and G.M. Cailliet. 1991. Aspects of the structure and dynamics of an exploited central California population of white sturgeon (Acipenser transmontanus). In: The Proceedings of the 1st International Symposium on the Sturgeon, P.Williot (ed). pp. 277-293.

Brennan, J.S. and G.M. Cailliet. 1989. Comparative age determination techniques for white sturgeon in California. Transactions of the American Fisheries Society. Vol. 118 (3): 296-310.

Brennan, J.S. and D. Shafer. 1989. Antarctic otolith collections for age and growth studies. In: R.P. Hewitt (ed), U.S. Antarctic Marine Living Resources (AMLR) 1988-1989 Field Season Cruise Report, Cruises AMLR 8901 and AMLR 8902 (National Ocean Cruise SU-88-02).

Brennan, J.S. 1988. Age determination and verification of California white sturgeon (Acipenser transmontanus): A comparative analysis. MS Thesis, Moss Landing Marine Laboratories, 70pp.

Brennan, J.S. 1984. Techniques for ageing sturgeon: A comparative analysis. American Zoologist 24(3): A26.

References available upon request