Geoduck aquaculture investigations in Puget Sound: Digging deep for answers

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Objectives for the presentation:

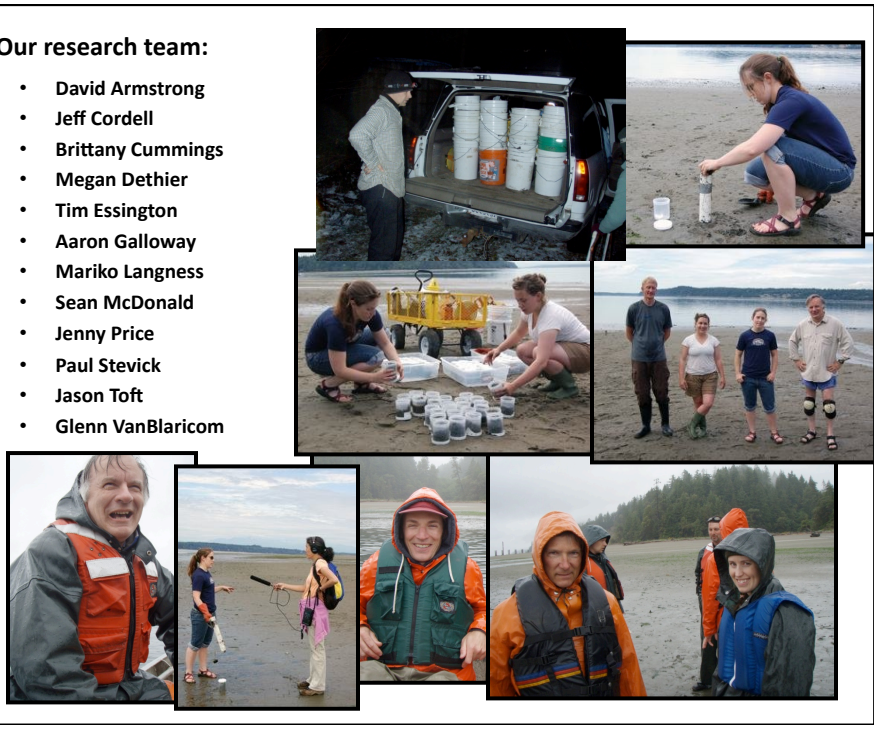

Comatarium

Update on our investigations of ecological disturbances and ecosystem response patterns associated with geoduck aquaculture operations on intertidal habitats of the Puget Sound region:

- **Overview of disturbance processes associated with aquaculture;**
- **Conceptual context of aquaculture activities associated with disturbance processes in nature;**
- **Summary of major goals and methods of our research;**
- **Review of progress on sample processing and performance metrics;**
- **First public presentation of preliminary data.**

Our research team:

- David Armstrong
- Jeff Cordell
- Brittany Cummings
- Megan Dethier
- Tim Essington
- Aaron Galloway
- Mariko Langness
- Sean McDonald
- Jenny Price
- Paul Stevick
- Jason Toft
- Glenn VanBlaricom



Initiation of culture cycle:
Outplanting and structural placement

Northern Case Inlet, 3 June 2008

Outplanted juvenile geoducks from hatcheries

Cycle initiation until about 1 year: Structural effects; At about 1 year: Disturbances associated with structural removal

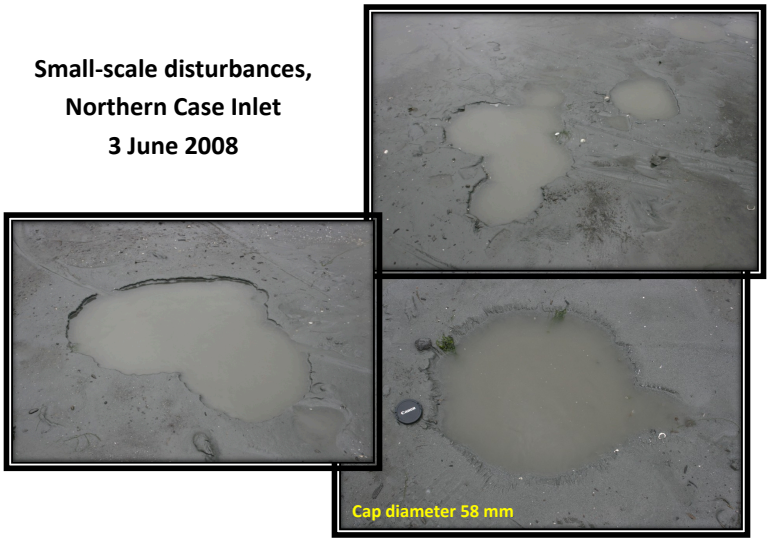
Northern Case Inlet,
3 June 2008

Harvest at ~5-7 years after planting:
Disturbances associated with harvest

Northern Case Inlet, 3 June 2008

Disturbances associated with harvest

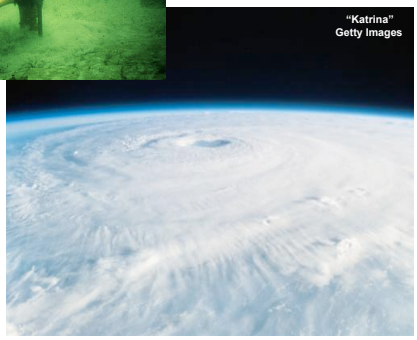
Small-scale disturbances,
Northern Case Inlet
3 June 2008



The product

A conceptual context for our study:

Disturbance ecology



Defining ecological disturbance:

A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substratum availability, or the physical environment

[Pickett, S.T.A., and P.S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, Orlando, Florida, USA.]

Metrics for characterizing disturbances, and for comparing disturbances of different types:

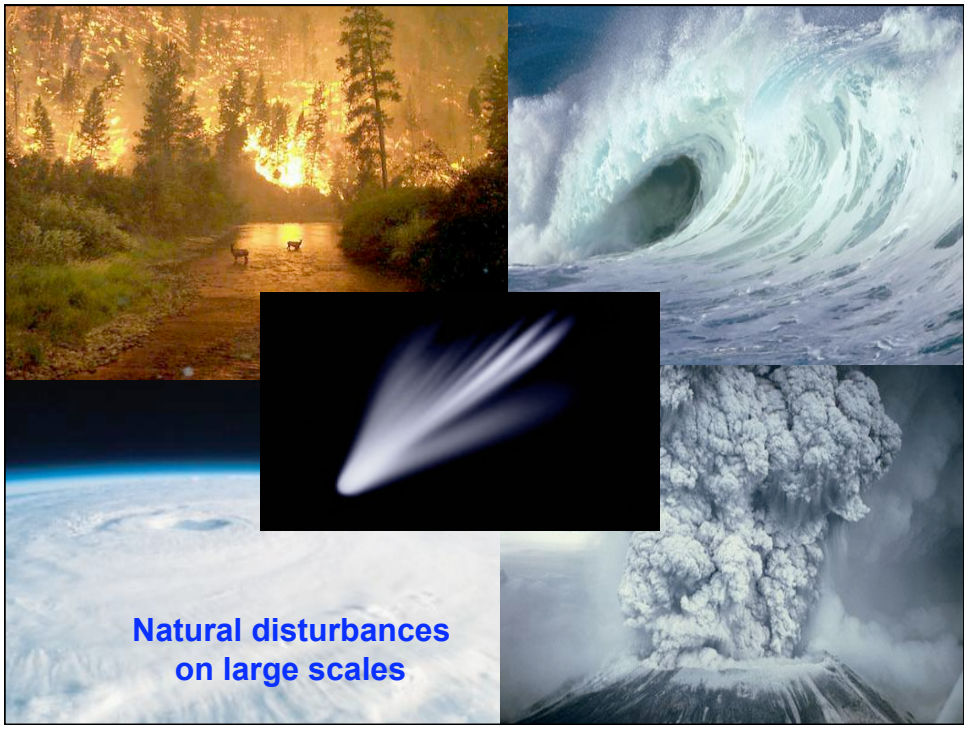
Frequency and duration:
How often and for how long?

Intensity:
How disruptive?

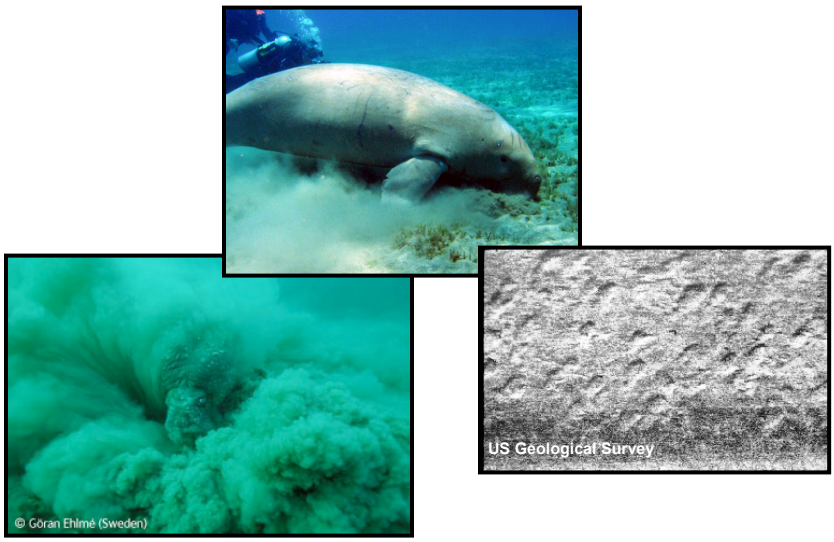
Size:
How big?

Chemical and Physical Attributes:
By what mechanisms does disruption occur?

Community resistance/resilience:
What are the spatial and temporal patterns of recovery of the disturbed community to the pre-disturbance configuration?



Natural disturbances on smaller scales



Anthropogenic disturbances

Large scale

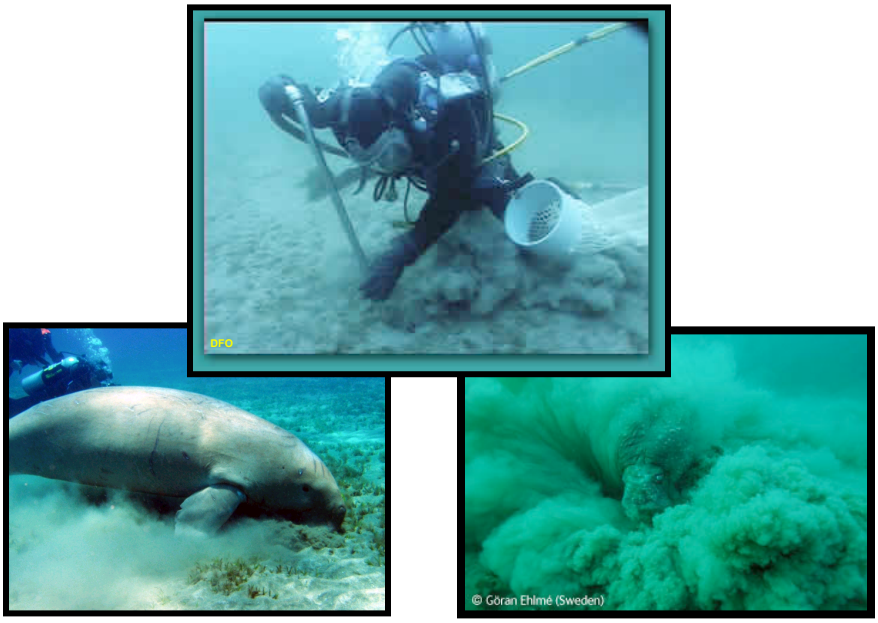
Small scale

Disturbance-dependent species

Fireweed

Wild Blackberry

Avalanche Lilly



Project objectives and foci:

Measurement of effects of five categories of disturbance, all associated with geoduck aquaculture activities, on the benthic infauna of intertidal sand habitats in the Puget Sound region:

1) **Predator exclusion structure & juvenile;**
2) **Predator exclusion structure presence;**
3) **Predator exclusion structure removal;**
4) **Enhanced geoduck densities in cultured areas;**
5) **Harvest of geoducks from cultured areas.**

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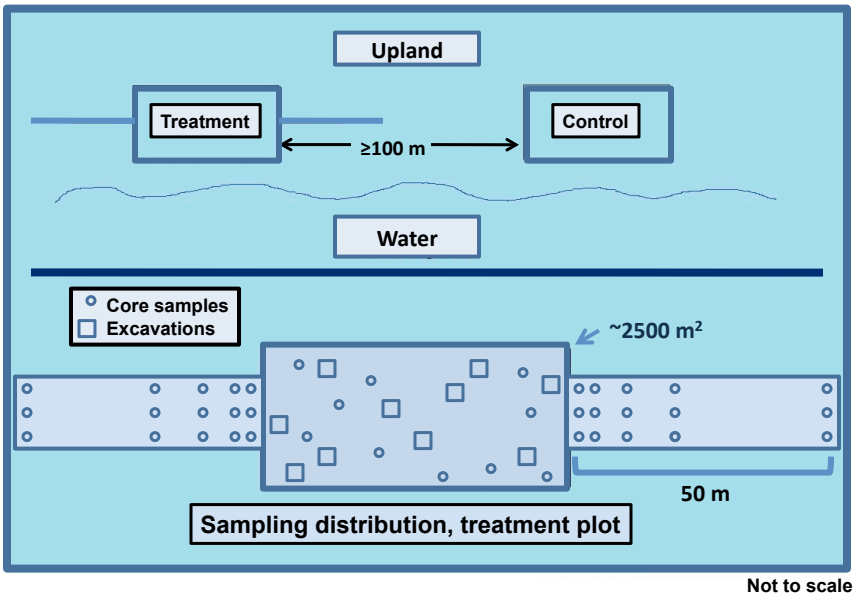
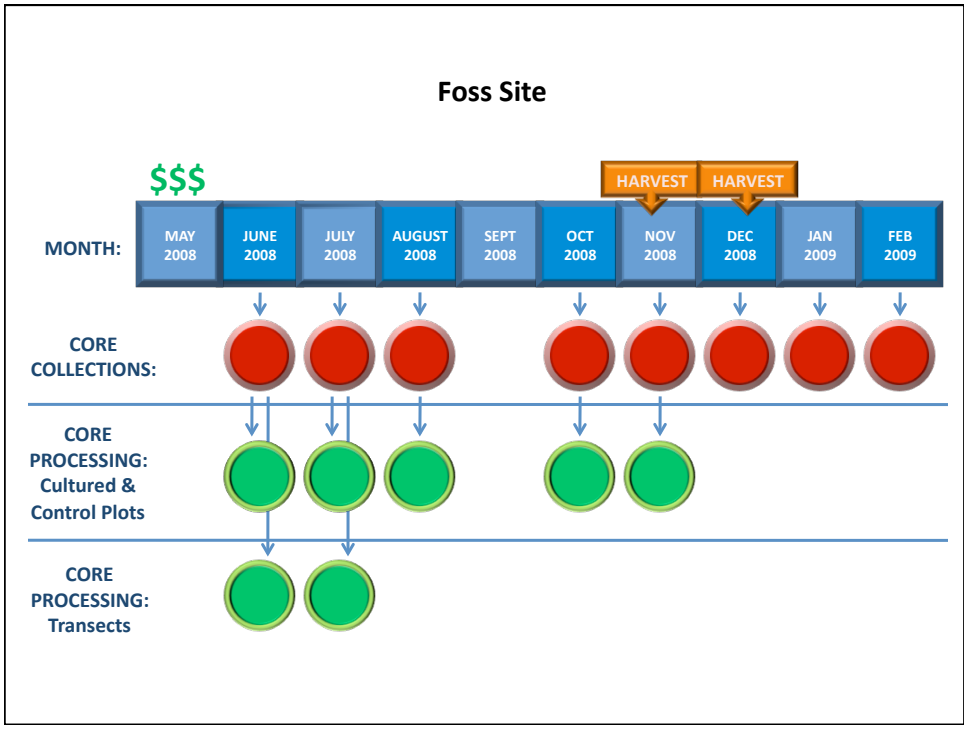
What are benthic infauna?

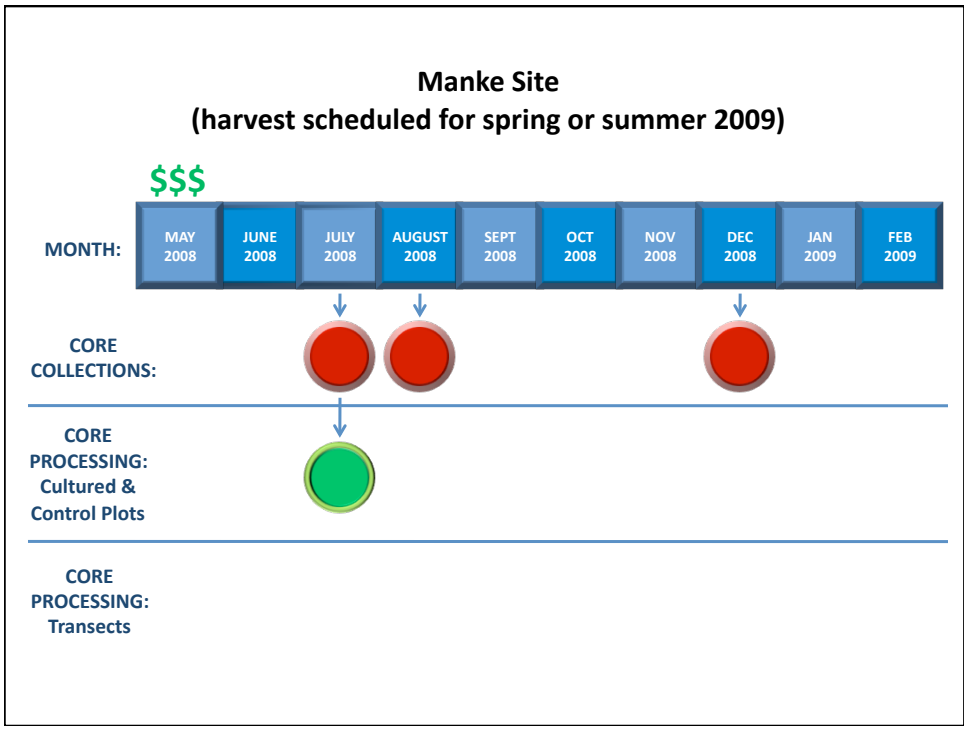
1) Live on or in the sediments;
2) Mostly invertebrates, but may include vertebrates;
3) Highly diverse;
4) Dominant groups are usually crustaceans, polychaete worms, and small bivalves;
5) Often abundant (commonly > 10,000 individuals per m^2);
6) Generally quite small (body lengths < 1 cm);
7) Retained on a 0.5 mm seive.

Study site locations for evaluation of harvest effects

Study Site Layout




Foss Site
$$$
HARVEST
HARVEST
MONTH:
MAY 2008
JUNE 2008
JULY 2008
AUGUST 2008
SEPT 2008
OCT 2008
NOV 2008
DEC 2008
JAN 2009
FEB 2009
CORE COLLECTIONS:
CORE PROCESSING: Cultured & Control Plots
CORE PROCESSING: Transects


Manke Site
(harvest scheduled for spring or summer 2009)
$$$
MONTH:
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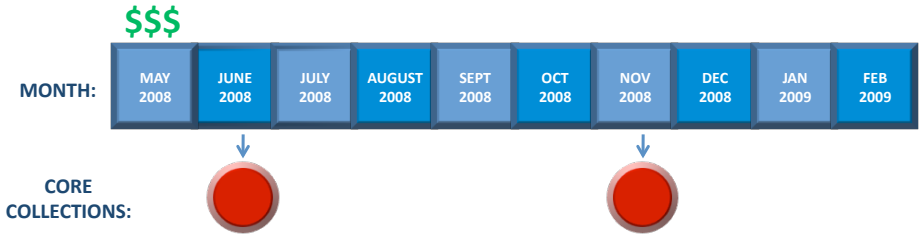
NOV 2008
DEC 2008
JAN 2009
FEB 2009
CORE COLLECTIONS:
CORE PROCESSING: Cultured & Control Plots
CORE PROCESSING: Transects

Chelsea/Wang Site
(harvest scheduled for summer or fall 2009)



Timeline for core sample processing

- Collection rate: ~150 cores per month;
- Processing time:
  1) Separate animals from sediment and debris: ~1 hour;
  2) Identify and count animals: ~1 hour;
  3) Quality assurance/quality control: ~15-30 minutes;
  4) Data entry: ~5 minutes.

Total per core: ~2.5 hrs.

Total processing time required per month to keep pace: ~450 hrs, or full-time work for 2-3 people.

Projected activities

Year 1	Year 2	Year 3	Year 4	Year 5
Pilot study				Data modeling & analysis
Power analysis				Final reporting
Harvest disturb infauna study	Harvest disturb infauna (cont.)	Harvest disturb infauna (cont.)		
Structure disturb infauna study	Structure disturb infauna (cont.)	Structure disturb infauna (cont.)	Structure disturb infauna (cont.)	
	Structure disturb epifauna study	Structure disturb epifauna (cont.)	Structure disturb epifauna (cont.)	
	Structure disturb mobile study	Structure disturb mobile (cont.)	Structure disturb mobile (cont.)	
Alpha sites (planting)	Alpha sites (structure)	Alpha sites (struct removal)	Alpha sites (growout)	Alpha sites (harvest)

Projected activities: Impact of potential loss of funding

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Some data – but first, some reminders!

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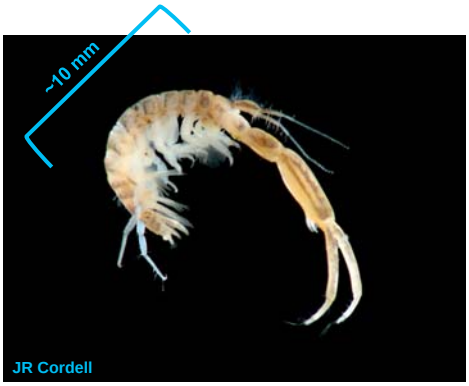
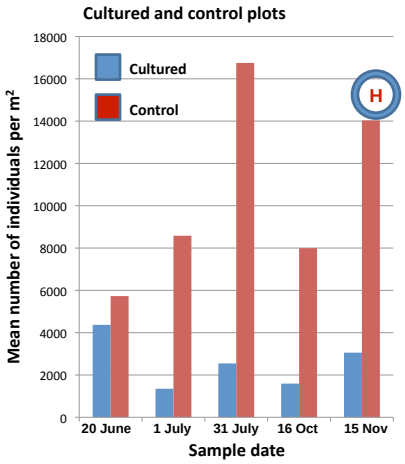
- **So . . . . when you see the data . . . .**

Don't get too excited.

Abundant species at Foss site: "*Corophium*" group:

Americorophium salmonis
Monocorophium acherusicum*
Monocorophium insidiosum*

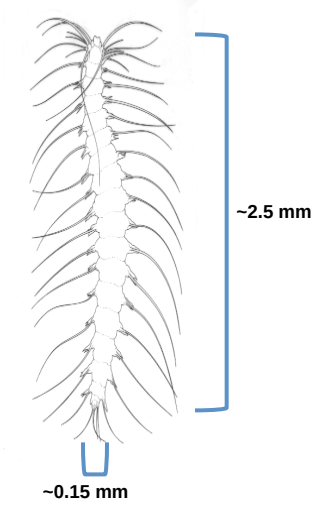


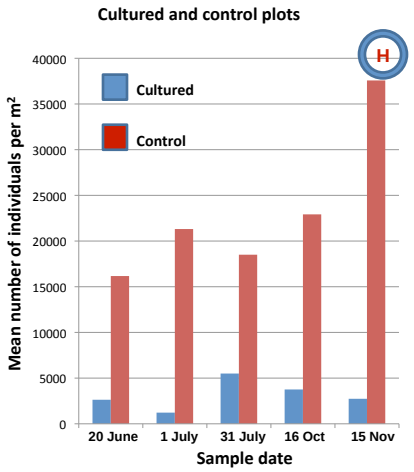


PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

*introduced species

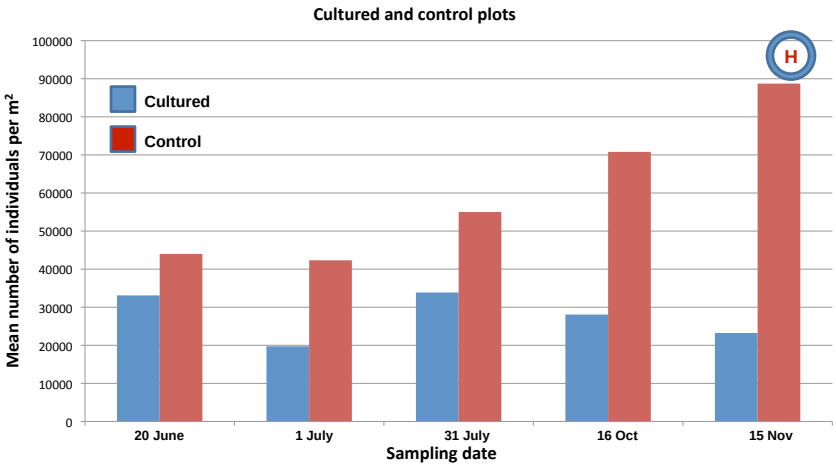
Abundant species at Foss site:
Microphthalmus hystrix





PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Infaunal densities, all species combined, at Foss site



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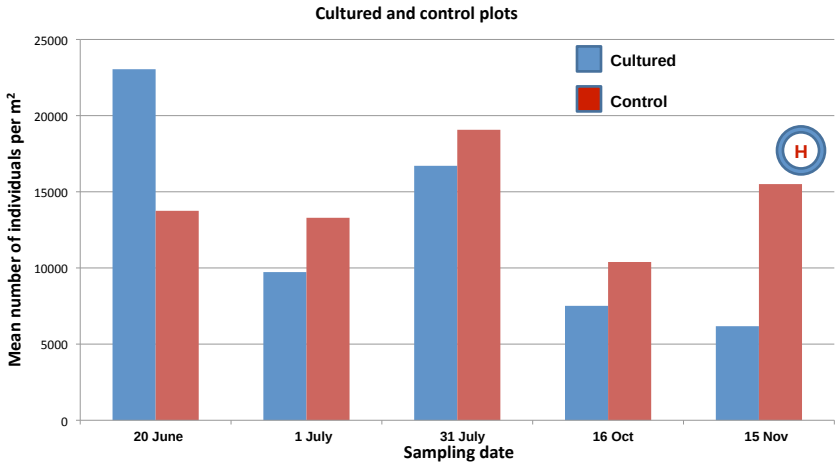
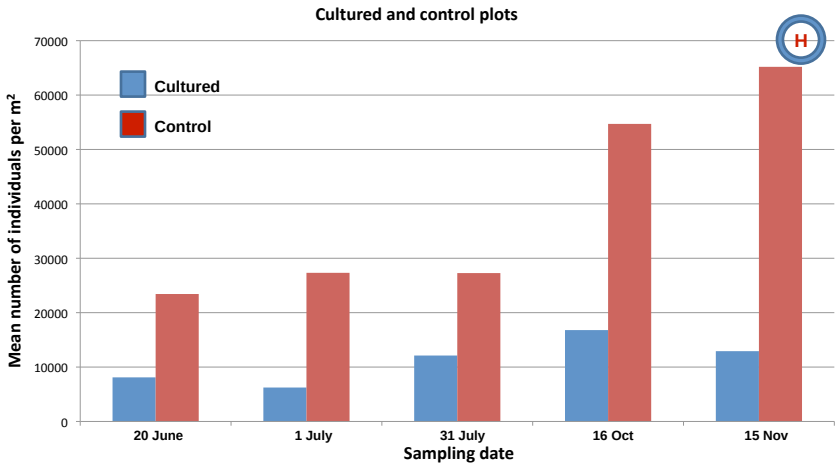
Densities of major taxonomic groups at Foss site: Crustaceans



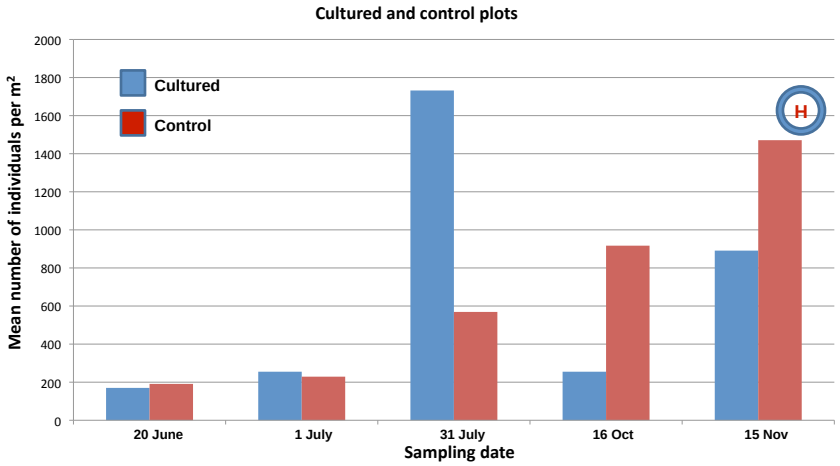
PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Densities of major taxonomic groups at Foss site: Polychaetes



PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Densities of major taxonomic groups at Foss site: Bivalves



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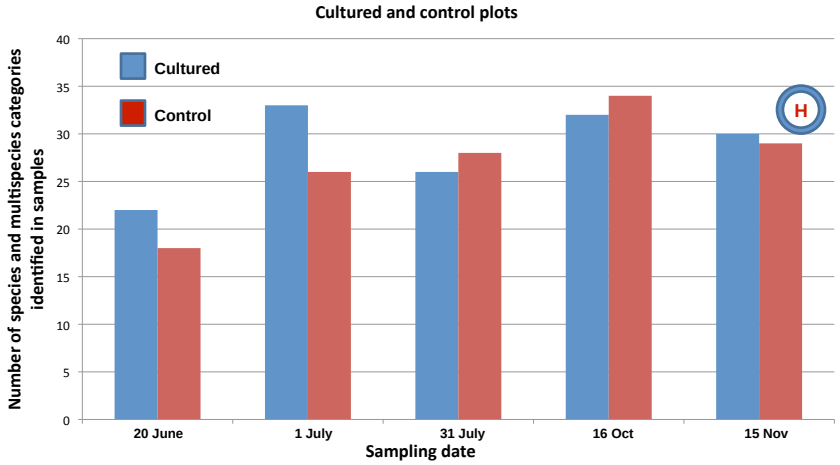
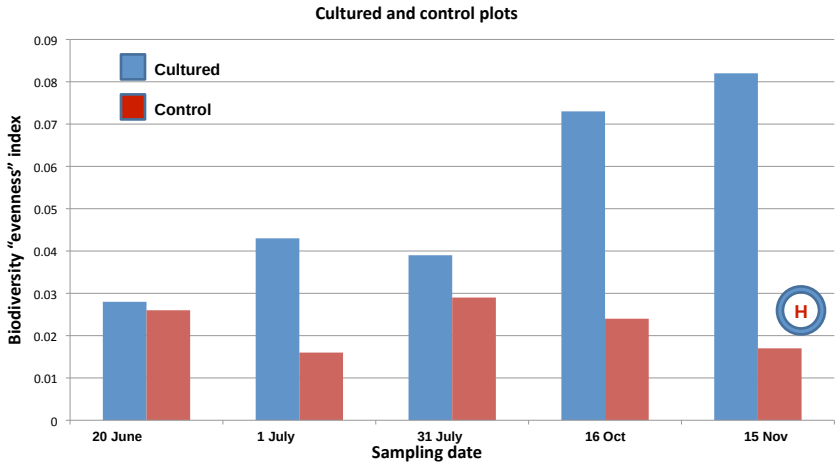
Diversity Indices I: Numbers of species and multispecies categories in samples



PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Diversity Indices II:
"Evenness" of species & multispecies categories in samples



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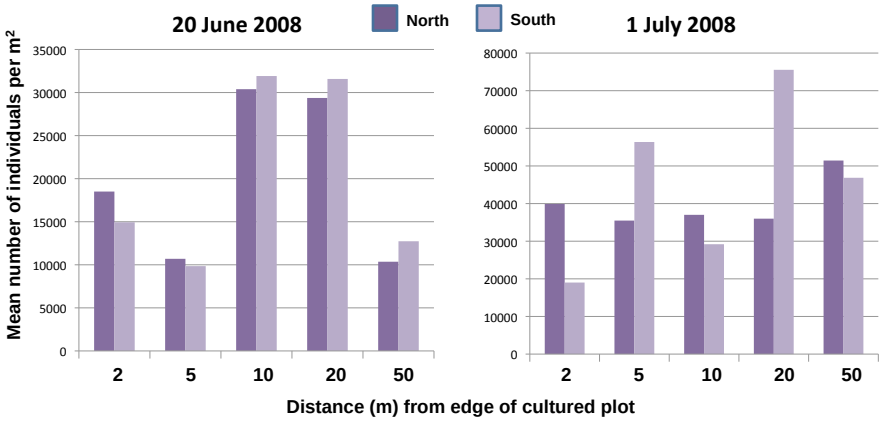
Data from transects extending away from edges of cultured plot at Foss site: All infauna combined

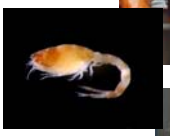


PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Quality assurance/quality control for small infauna

Evaluation of accuracy of species identification: Some examples with crustaceans, with thanks to Jeff Cordell

- "*Corophium*" group: 97% correct (n=139)
- *Cumella vulgaris*: 100% correct (n=70)
- *Huntemmania jadensis*: 95% (n=284)
- Other harpacticoid copepods: 93% (n=291)
- Crustaceans overall: 95% (n=784)
- Polychaetes: Just getting started – stay in touch!



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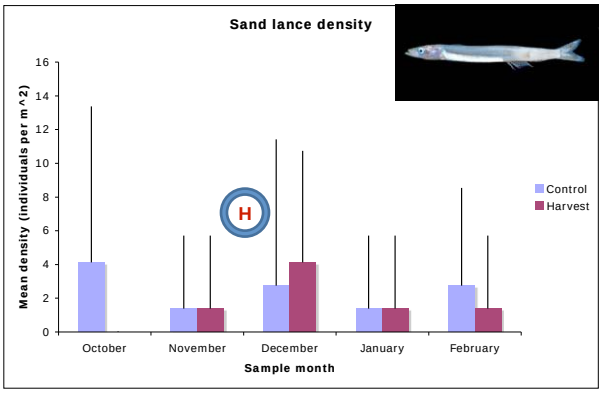
Larger species: Foss site



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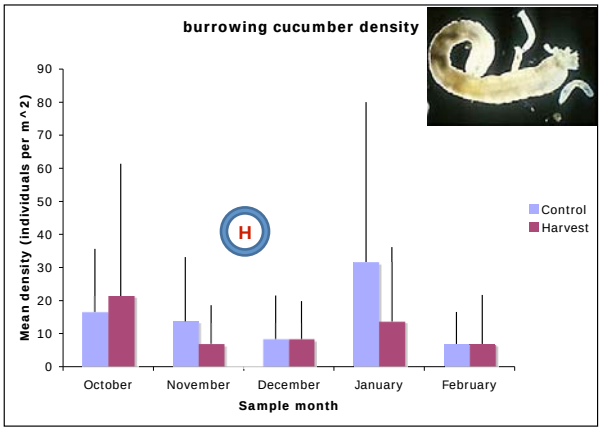

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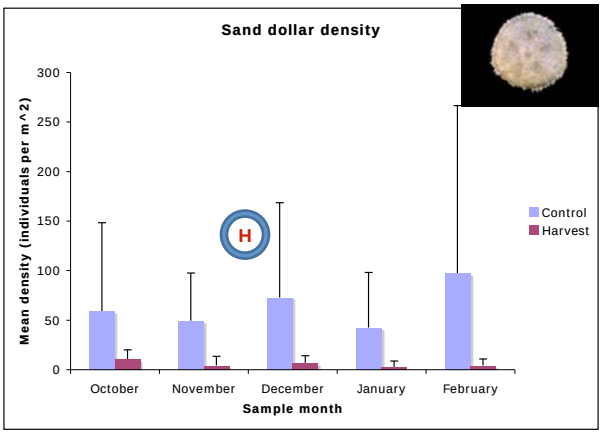

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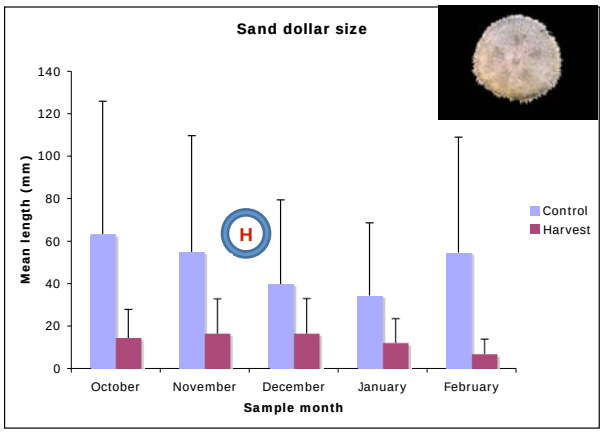


PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Nutrient Pools in Geoduck Habitat: High Enough to Present Eutrophication Problems?

Jeffrey Cornwell
Roger Newell
Michael Owens
George Waldbusser

Center for Environmental Science
Horn Point Environmental Laboratory
University of Maryland

Project Goals

- Determine the maximum amount of nutrient release (mass of nitrogen and phosphorus) possible during geoduck harvest
- Determine the immediate release of nitrogen and phosporus during harvest
- Compare/contrast release rates to other Puget Sound nutrient inputs
- Examine how in-place geoducks affect the near shore nutrient balance

Project Approach

- Assessment of sedimentary N and P pools before harvest and after harvest.
- Rapid assessment N and P releases via analysis of water flowing off the mudflats during harvest.
- Sediment-water exchange of oxygen, nitrate, ammonium, phosphate and dinitrogen (N_2-N from denitrification) using core fluxes .

Sampling Pore Water

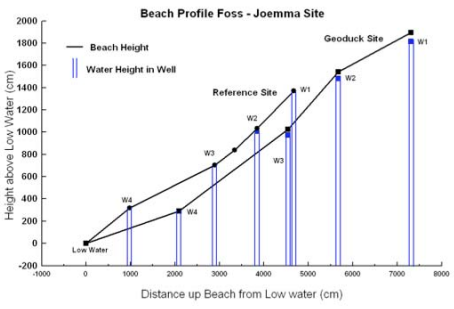
Three approaches for sampling the pore water in the beaches: 1) pore water equulibrators (right), 2) sediment sippers (right below) and 3) pvc wells (below). The sippers allow the greatest spatial sampling resolution an appear to be the best way to assess pore water chemistry. The wells provided excellent data on how much of the water exited the beach profile during low tide.

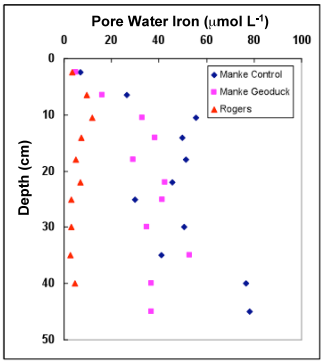
Pore Water Data

Two surprising results:

1)Most of the water is retained in the beach profile during low tide, suggesting that water at the depth of the geoducks didn't exchange quickly with the overlying water, and

2)2) pore water reduced iron indicates that the water within the beach was devoid of oxygen and was likely the site of substantial nutrient regeneration. No sulfide was detected.





PRELIMINARY DATA: DO NOT DUPLICATE OR CIRCULATE

Micah's presentation here

Special thanks!

- **Washington Sea Grant Program staff, with particular thanks to Penny Dalton, Raechel Waters, and Teri King!**

Puget Sound Action Team

Special thanks (2)!

- Collaborating growers, homeowners, tribal biologists, and other key colleagues: Steve Bloomfield, Tom Bloomfield, Dan Cheney, Peter Downey, Aleta Erickson, Jeff Fisher, Kent Kingman, John Lenz, Brian Phipps, Andy Suhrbier, Kelly Toy

Puget Sound Action Team

Questions?

Puget Sound Action Team