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May 2nd, 10:30 AM - 12:00 PM

# Alexandrium cyst distribution and germination in Puget Sound

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Greengrove, Cheryl; Masura, Julie; Moore, Stephanie K.; Bill, Brian; Hay, Levi; Eldred, Kiara; Banas, Neil; Salathe, Eric; Mantua, Nat; Johnstone, James; Anderson, Donald; Trainer, Vera; and Stein, John, "Alexandrium cyst distribution and germination in Puget Sound" (2014). *Salish Sea Ecosystem Conference*. 51.
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## Speaker

Cheryl Greengrove, Julie Masura, Stephanie K. Moore, Brian Bill, Levi Hay, Kiara Eldred, Neil Banas, Eric Salathe, Nat Mantua, James Johnstone, Donald Anderson, Vera Trainer, and John Stein

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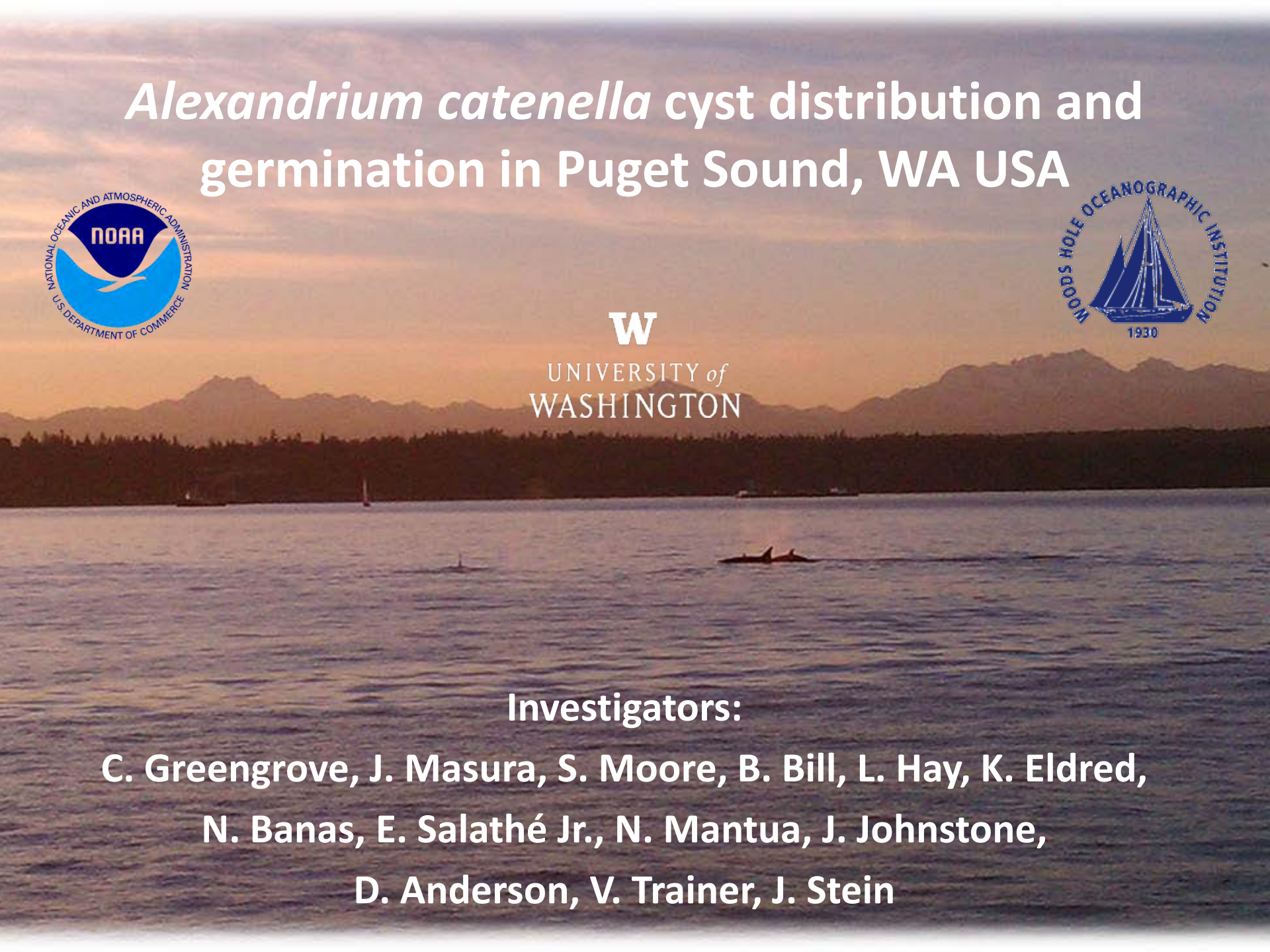
# *Alexandrium catenella* cyst distribution and germination in Puget Sound, WA USA




**Investigators:**

**C. Greengrove, J. Masura, S. Moore, B. Bill, L. Hay, K. Eldred, N. Banas, E. Salathé Jr., N. Mantua, J. Johnstone, D. Anderson, V. Trainer, J. Stein**

# *Alexandrium* outbreaks, shellfish toxicity, & human illnesses have plagued Puget Sound for decades

Coast Salish People

In North America, Indians of the Pacific Coast apparently were aware of the relationship between red tides and bioluminescence in ocean waters and toxicity in shellfish. They would not eat shellfish when these conditions appeared (Meyer et al. 1928). Illustrative of this, in 1928, Meyer et al. wrote:

> "From time immemorial it has been the custom among coast tribes of Indians, particularly the Poma, to place sentries on watch for Kal ko-o (mussel poison). Luminescence of the waves, which appeared rarely and then only during very hot weather, caused shellfishing to be forbidden for two days; those eating shellfish caught at such times suffered sickness and death. . . . According to a report a band of Indians died about fifty years ago from eating mussels gathered on the Mendocino coast during the month of August."

The first seemingly documented case of PSP in North America occurred in 1793, when five members of Captain George Vancouver's crew became ill after eating mussels collected near Fitzhugh Sound in what is now British Columbia (Quayle 1969). One of the five died. Vancouver's account of this event appears to be the first detailed written description of the symptoms and progression of paralytic shellfish poisoning (Vancouver 1801).

Price, D., K. Kizer, K. Hansgen, (1991)
"California's paralytic shellfish poisoning prevention program, 1927-89"
Journal of Shellfish Research 10 (1):119-145

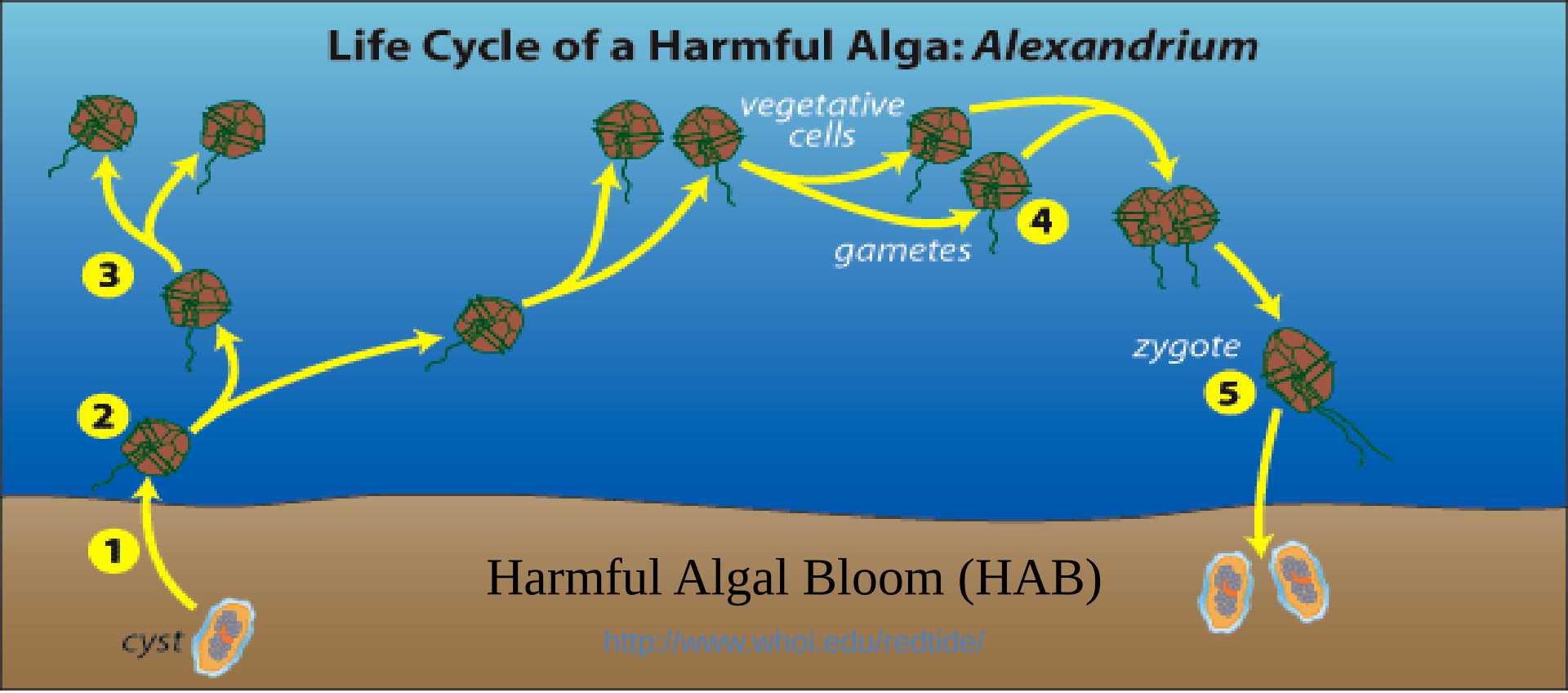
1793

HMS Discovery

Captain George Vancouver
http://www.vancouvermaritimemuseum.com

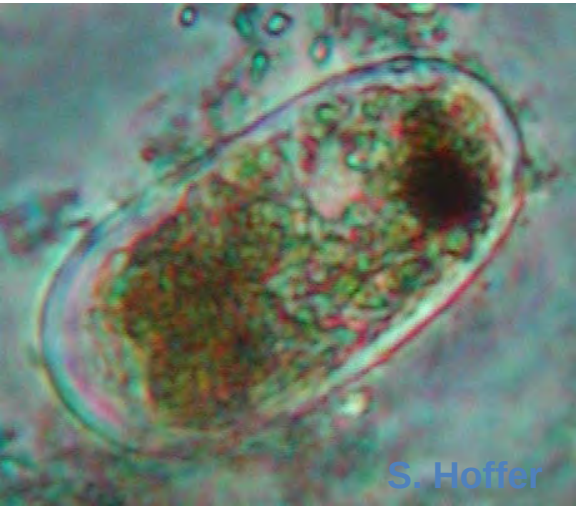
More Recently:

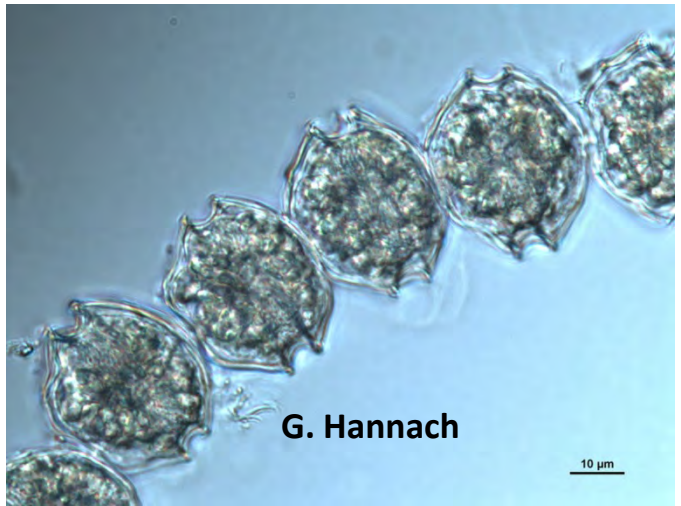
- 1942 – 3 deaths
- 2012 – 9 reported PSP illnesses
- Most years – shellfish bed closures

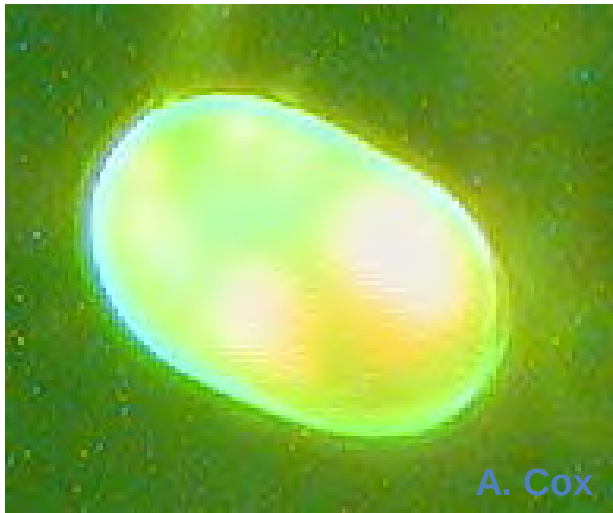



Dinoflagellate

Paralytic Shellfish Toxin (PST) Producer



# PS-AHAB

## Puget Sound – *Alexandrium* Harmful Algal Blooms



thou all-destroying but unconquering cell
from hell's heart I stab at thee
for hate's sake I spit my last breath at thee
Sink all coffins and all hearses to one common pool!
and since neither can be mine, let me then tow to pieces,
while still chasing thee, though tied to thee, thou damned cell!

PS-AHAB

All that most maddens and torments;
all that stirs up the lees of things;
all that cracks the sinews and cakes the brain;
all the subtle demonisms of life and thought;
all evil, to crazy Ahab, were visibly personified,
and made practically assailable in Alexandium.
He piled upon the cell's thecal plates
the sum of all the general rage and hate
felt by his whole race from Adam down;
and then, as if his chest had been a mortar,
he burst his hot heart's shell upon it.

# Modeling favorable habitat areas for *Alexandrium catenella* in Puget Sound and evaluating the effects of climate change

3-yr Project (2010-2013)
Funded by NOAA's Ecology and Oceanography of Harmful Algal Bloom Program (ECOHAB)

Web site:
www.tiny.cc/psahab

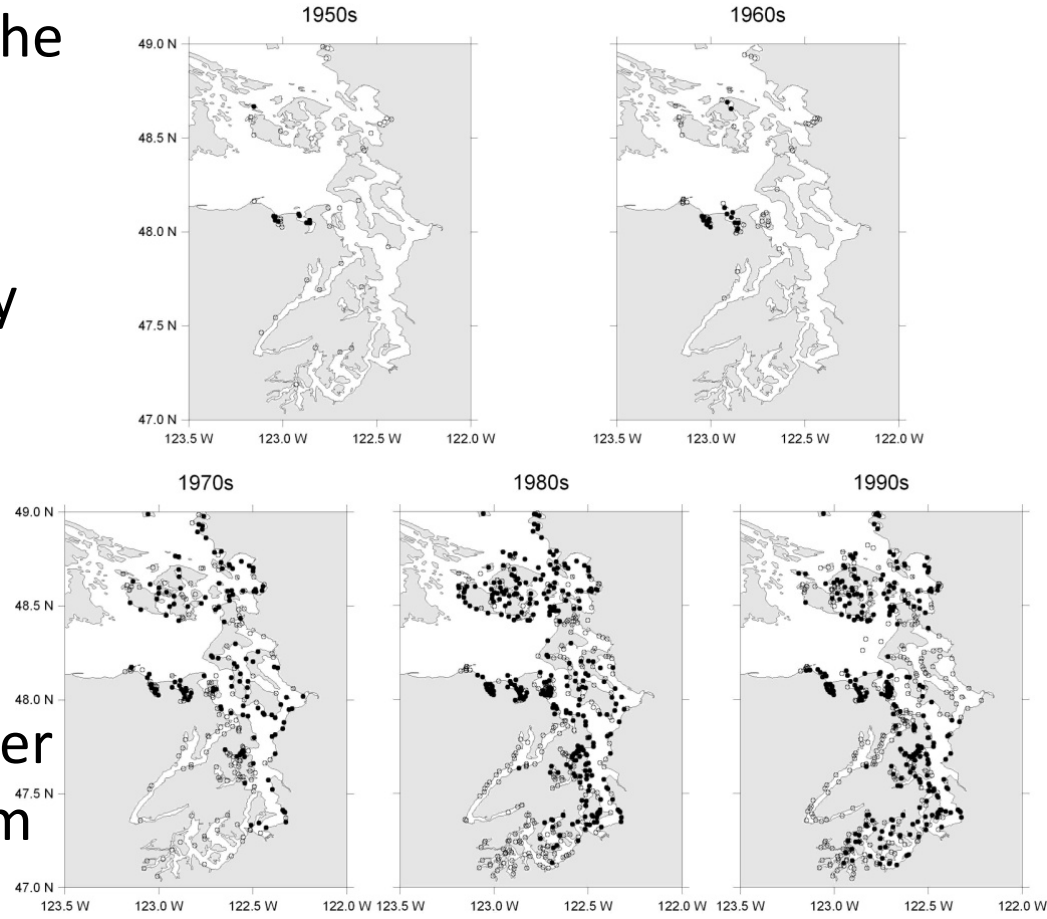
The team

# What we knew

(primarily from shellfish)

- Blooms have increased since the 1950s
- Blooms usually occur from July through November
- Interannual variability is high
- Blooms are sensitive to weather and climate – like warm & calm
- Water temperatures > 13°C appear to enhance growth

Nishitani & Chew (1984)

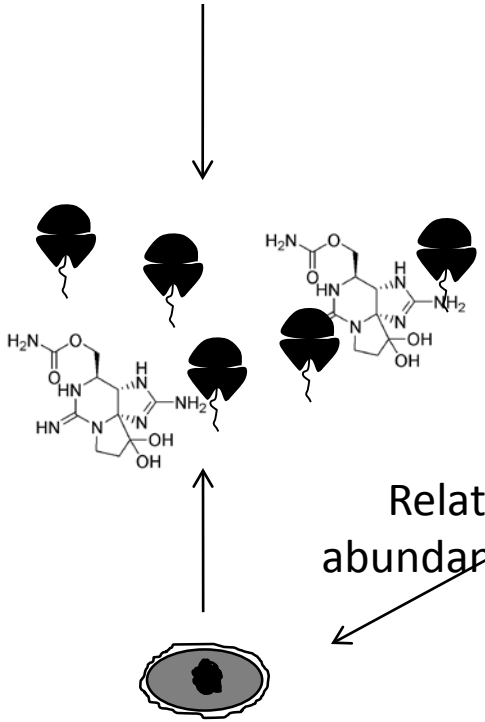


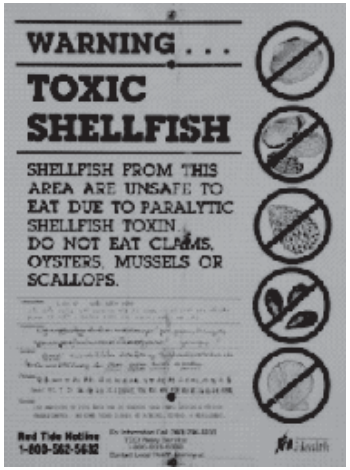

Shellfish harvesting closures due to PST by decade in Puget Sound based on Washington State Department of Health (WDOH) monitoring data. Trainer *et al.* (2003)

# What we didn't know…

## Where is Alex and what does it like?

How does temperature and salinity affect growth and toxicity?






Relationship between cyst abundances and shellfish toxicity

**Need to answer these questions in order to provide early warning of toxic events!**

Factors controlling the germination of cysts?
Interannual variability in cyst abundances?
Relationship between cyst abundance and bloom magnitude?

# Objectives of PS-AHAB

- **How much "seed" is available to initiate blooms and where is it located?**
  - Determine interannual variations in *A. catenella* cyst distribution in Puget Sound
- **When/where could this seed germinate and grow?**
  - Quantify rates of cyst germination and vegetative growth for a range of temperature, salinity, and light conditions
  - Determine the presence/absence of an endogenous clock that regulates cyst germination
  - Model favorable habitat areas for cyst germination and vegetative growth
- **How could these factors be altered by future climate change?**
  - Evaluate climate change impacts on favorable habitat areas
  - Establish a time series with sufficient depth to provide seasonal forecasts of toxic blooms

# The three components of PS-AHAB and who is doing what

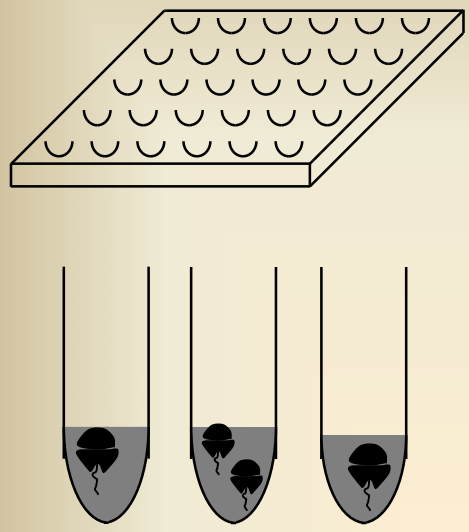
Steph/John

Brian/Steph/Vera/ Don/Students

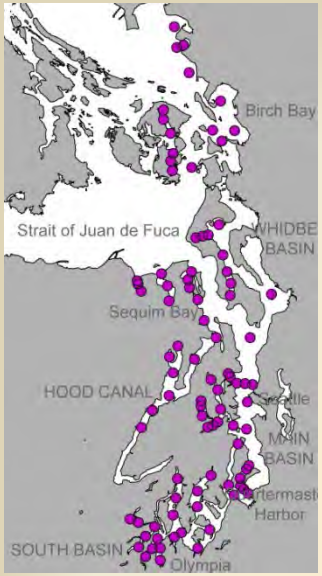
Cheryl/Julie/Steph /Students

Eric/Nate/Neil

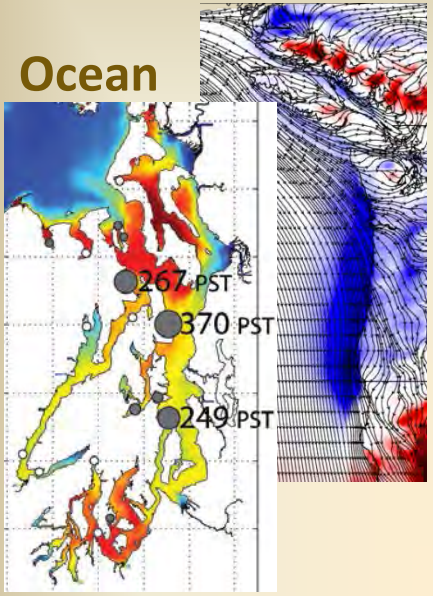
## Laboratory



## Field



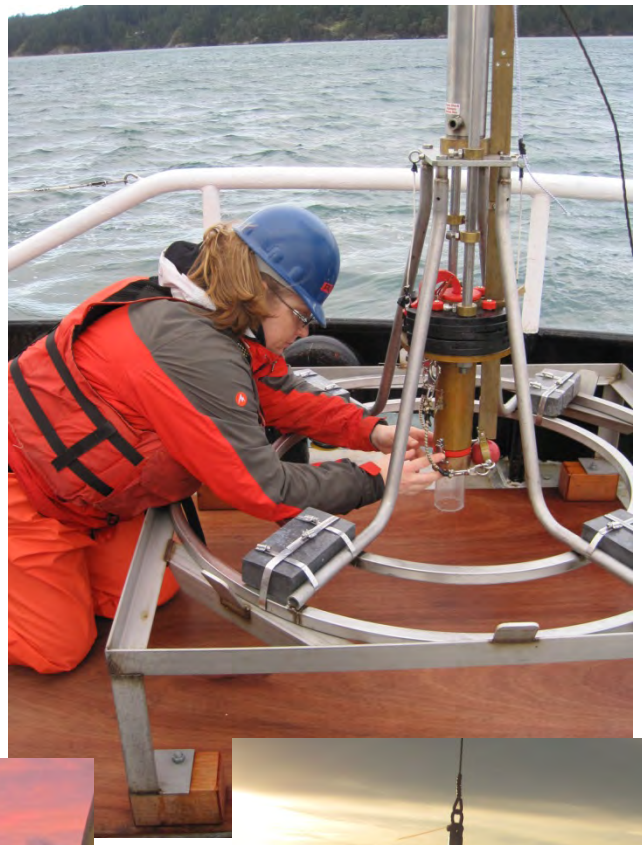

## Modeling



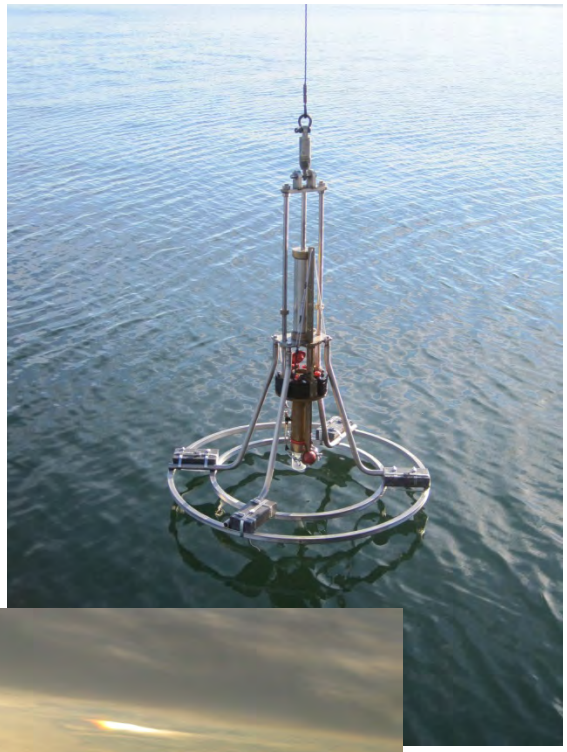
# 1. Factors controlling benthic and planktonic life stages

- Where are cysts located?
- When can they germinate and grow?

# Annual Field Surveys to Map the Abundance of *A. catenella* cysts

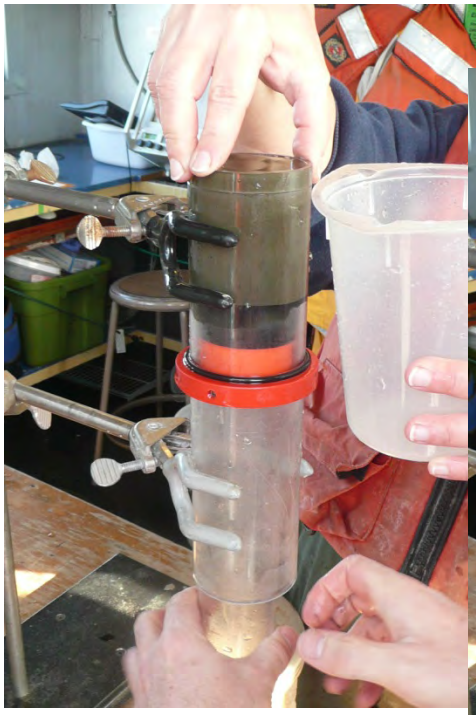


**Winter**
**2011, 2012, 1013**





RESEARCH
CLIFFORD A BARNES
SEATTLE SEAHAWKS
Brrrr!



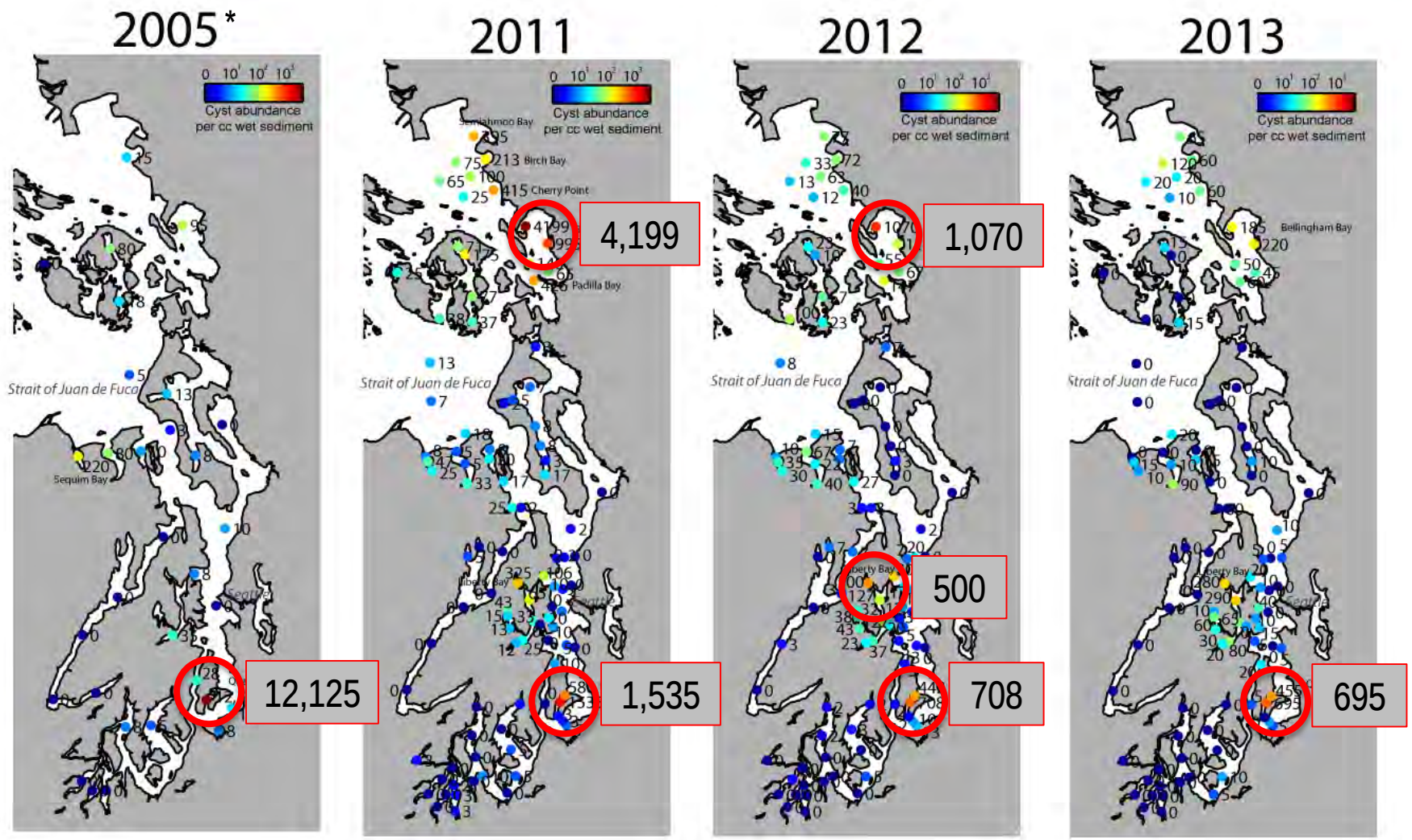
# Sediment Sample Processing

**CYSTS (Yamaguchi, Itakura and Ishida, 1995)**
- **Sonicated**
- **Sieved**
- **Preserved (formalin)**
- **Solubilized cell walls (methanol)**
- **Stained (primulin)**
- **Counted (in Sedgewick-Rafter slide using epifluorescence microscopy)**

**TOC**
**Loss on ignition**

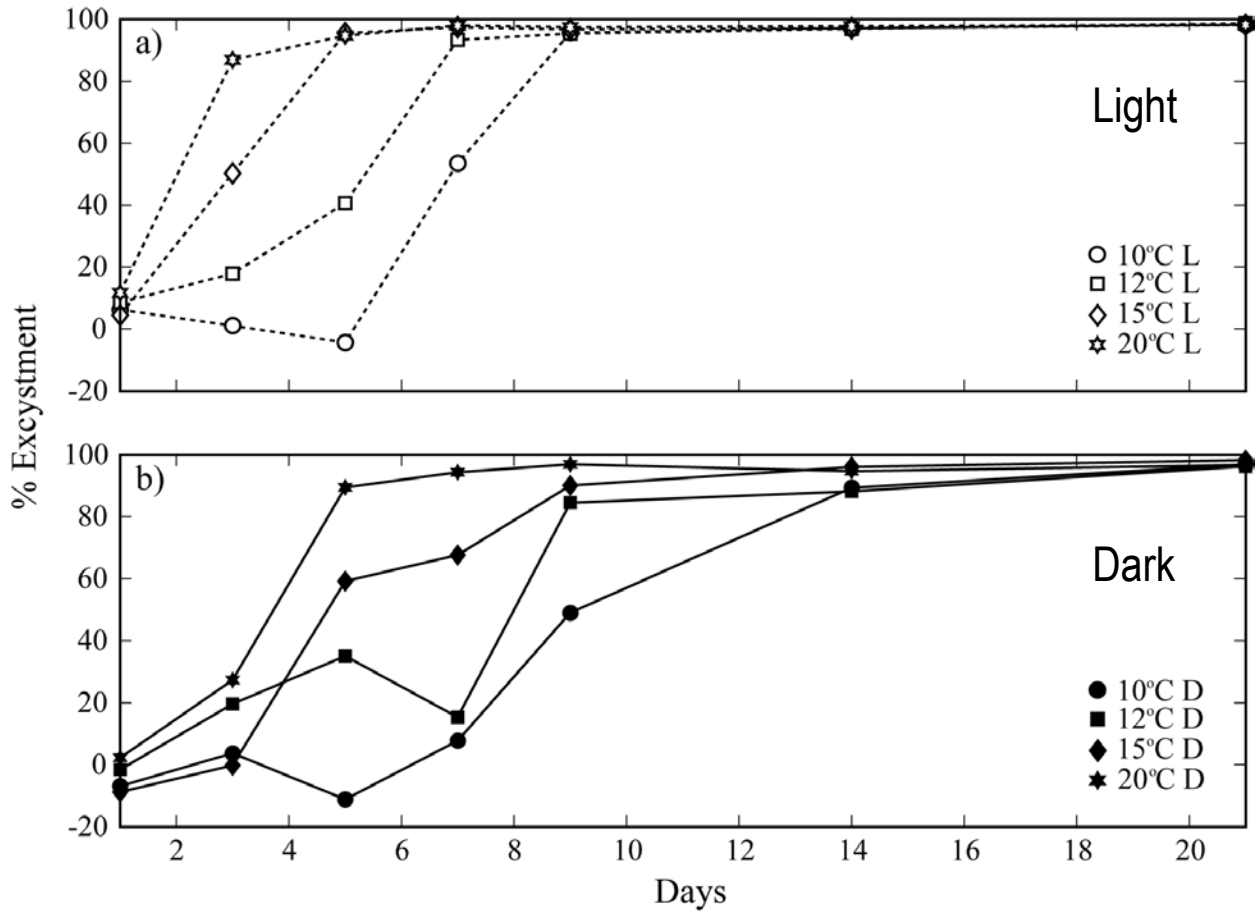
**GRAIN SIZE**
**Beckman-Coulter LS 200**
**Particle Size Analyzer**

# Where are cysts located?




*2005 data from Horner et al. (2011): Harmful Algae

# Factors controlling cyst germination

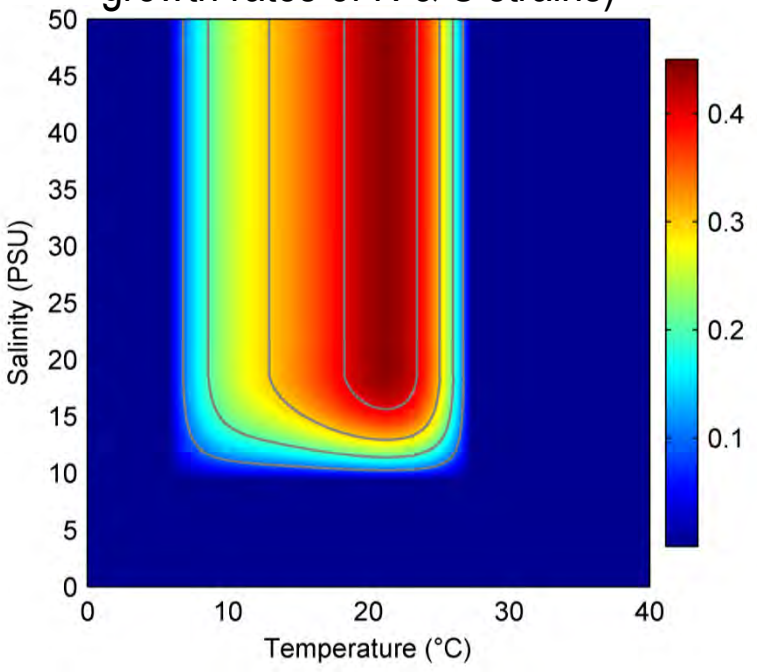


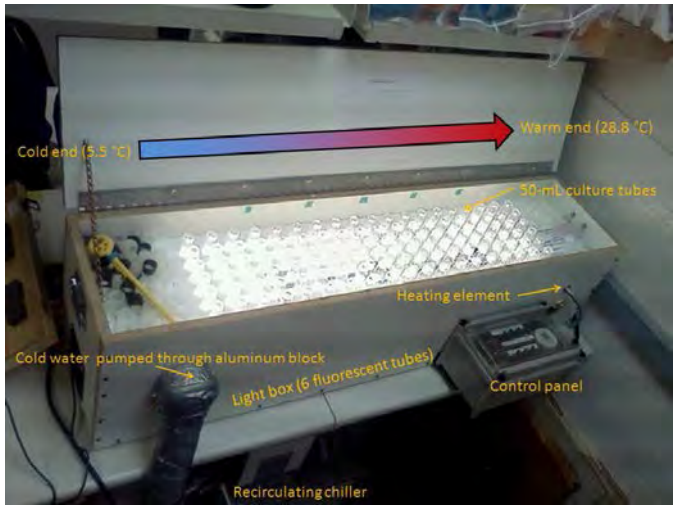

Prefers light and warmer conditions

# Puget Sound *Alexandrium* growth

- Puget Sound *Alexandrium* are euryhaline (20-35 psu) with a broad optimal temperature range (14-24°C)
- Maximal growth rates ~0.3-0.5 $\mu$ $d^{-1}$

Modeled growth response (based on specific growth rates of N & S strains)



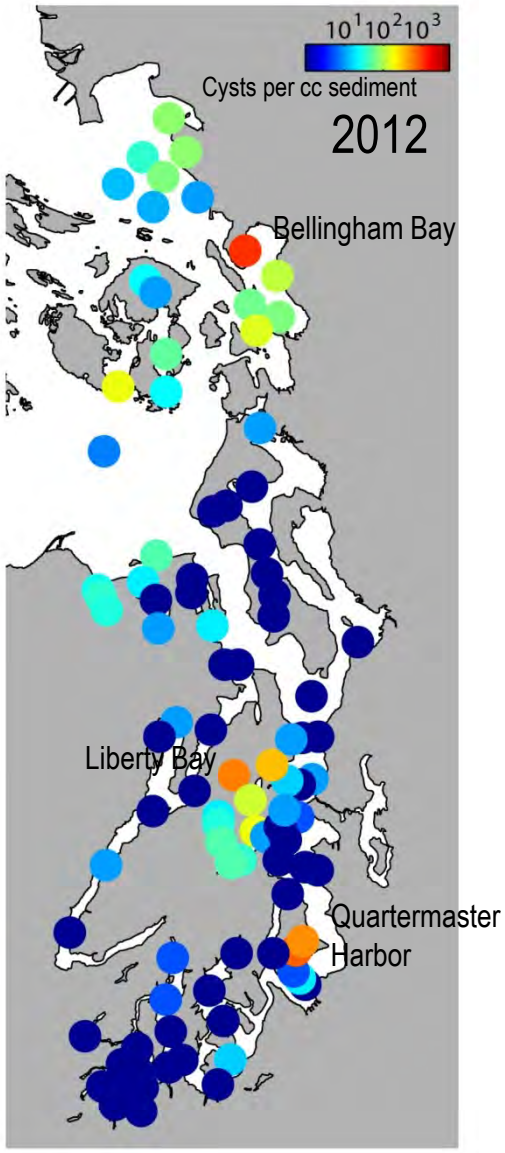




Temperature Gradient Bar (Watras et al. 1982)

- Chilling/heating elements
- 12L:12D
- 6 salinities × 19 temps × 2 strains (*n*=2)

See Brian Bill's Poster

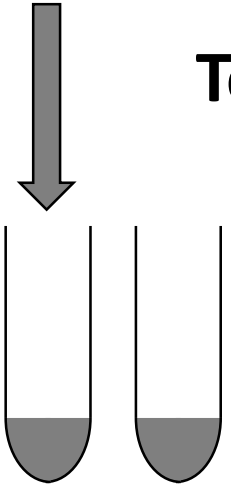
# Cyst viability (14L:10D, 14°C)



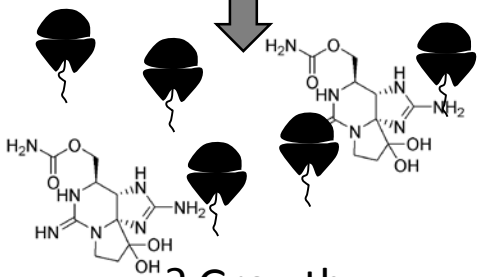

| Site # | Site name | Depth (m) | Cysts/cc | % Viability[**] |
|---|---|---|---|---|
| 1 | Semiahmoo Bay | 16 | 77 | 37[30] |
| 4 | Birch Bay | 9 | 72 | 34 |
| 5 | Georgia Strait - SE | 50 | 63 | 24 |
| 8 (0-1 cm) | Bellingham Bay - North | 9 | 1070 | 48 |
| 8 (0-1 cm) | Bellingham Bay - North | 9 | 1070 | 54 |
| 8 (1-3 cm) | Bellingham Bay - North | 9 | 1070 | 44 |
| 9 | Bellingham Bay - East | 24 | 117 | 52 |
| 10 | Bellingham Bay - South | 18 | 67 | 44 |
| 11 | Bellingham Bay - West | 55 | 55 | 48 |
| 12 | Padilla Bay | 26 | 147 | 30 |
| 15 | Lopez Sound - Outer | 22 | 52 | 20 |
| 17 | Cattle Point | 26 | 160 | 32 |
| 22 | Seqium Bay - Center | 27 | 35 | 34 |
| 58 | Port Madison | 36 | 320 | 42 |
| 59 | Liberty Bay | 4 | 545 | 36 |
| 60 | Port Orchard - North | 21 | 130 | 46 |
| 61 | Port Orchard - South | 25 | 175 | 54 |
| 78 (0-1 cm) | Quartermaster Harbor - Center | 13 | 708 | 16 |
| 78 (0-1 cm) | Quartermaster Harbor - Center | 13 | 708 | 38 |
| 78 (1-3 cm) | Quartermaster Harbor - Center | 13 | 708 | 66 |
| 79 | Quartermaster Harbor - Inner | 7 | 500 | 42 |

# Laboratory Experiments to Determine Factors Controlling **Growth and Toxicity of Vegetative Cells**, and Germination of Cysts

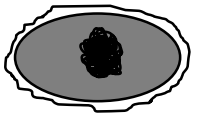
Vegetative cell



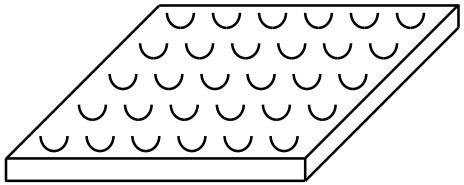
Δ Temperature
Δ Salinity

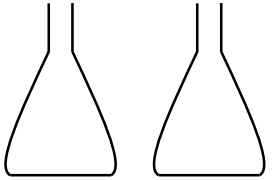


? Growth
? Toxicity

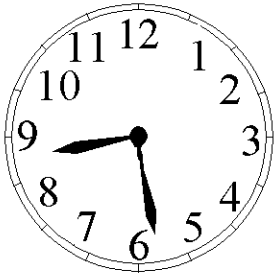


Cyst

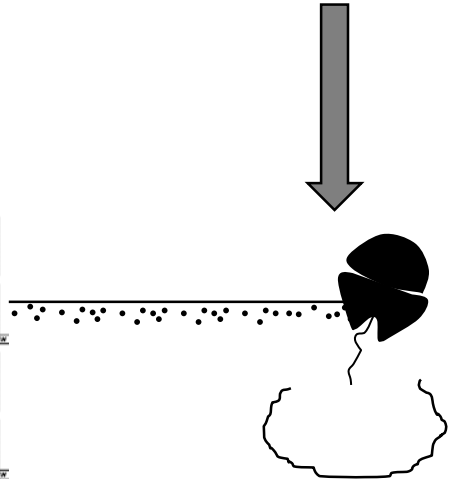




Δ Temperature
Δ Light



? Endogenous clock



? Germination


Questions?