SOUNDTOXINS

A diverse partnership of Washington state shellfish and finfish growers, environmental learning centers, Native tribes, and Puget Sound volunteers, SoundToxins is a monitoring program designed to provide early warning of harmful algal blooms and *Vibrio parahaemolyticus* events in order to minimize both human health risks and economic losses to Puget Sound fisheries.

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Moorings in Puget Sound, Washington

Harmful Algal Blooms (HABs) of some species appear to be increasing in frequency and extent in the Puget Sound region, thereby possibly escalating threats to human health, food web dynamics and fishery economies. In addition, disease outbreak and closures of shellfish harvesting have resulted from high concentrations of the bacterium *Vibrio parahaemolyticus*. Due to the apparent increase of HAB and *V. parahaemolyticus* events, the Partnership for Enhanced Monitoring and Emergency Response to HABs and "Vibrio events" (SoundToxins) was formed.

SoundToxins features weekly monitoring for HAB toxins and cells at 11 sites in Puget Sound. Water quality data from moorings can also contribute greatly to the understanding of the plankton and bloom dynamics.

Moorings can provide early warning of toxic events

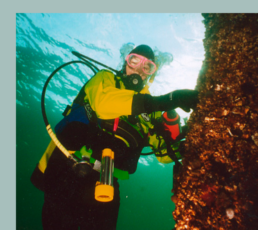
Many HAB organisms such as *Alexandrium catenella* and *Dinophysis* species are flagellates that possess whip-like tails (flagella) that they use for swimming. Under certain conditions, this ability can give these species a competitive advantage over other non-swimming phytoplankton groups. For example, warming of surface waters or the input of freshwater from river inflows can result in stratification. Stratification is a condition where the water column forms distinct surface and bottom layers and mixing of these water masses is limited. Sometimes nutrients in the surface layer can become depleted and therefore limit the growth of phytoplankton. Phytoplankton need to remain close to the surface where they can use sunlight for photosynthesis. The swimming ability of flagellates allows them to swim down into the bottom layer to use nutrients (plant food) that other non-swimming phytoplankton (like diatoms) that are trapped in the surface layer cannot access. In these stratified conditions, the flagellates (including the flagellated HABs) can flourish.

The detection of the onset of stratification could provide early warning of HAB risks. Stratification of temperature or salinity can be measured using specific sensors on moorings. Cheryl Greengrove of the University of Washington Tacoma first began using moorings to detect stratification and examine relationships with *A. catenella* abundance in Quartermaster Harbor in 2006 *(see interview with Cheryl Greengrove on Moorings, next page)*.

Sea lions relax on a mooring
Photo by ECOHAB-PNW, 2006

SoundToxins Participant Spotlight:
Karlista Rickerson
(Quartermaster Harbor)

What is your interest is SoundToxins?
I've collected mussels for the Washington State Department of Health for a few years, so the chance to actually "look at" the phytoplankton that cause the paralytic shellfish poisoning and amnesic shellfish poisoning was exciting. I'm curious and like to ask questions, such as: when scuba diving, what was in that mouth full of water I just swallowed; or, why do mussel die offs occur about the same time each year?



Karlista scuba diving near "The Barges" in 2002. Photo by J.D. Rowe

Why is SoundToxins important to you?
I want to be part of a long-term monitoring program because I have often asked myself questions like, "What if there are other phytoplankton that cause problems? What if the shellfish are toxic at a lower level than determined to be "safe?"

What is your environmental background?
I have been taking underwater photographs in Puget Sound for 24 years and have watched the dive sites change over the years.

What do you do for fun when you're not busy monitoring?
Scuba dive! And work in my garden.

The Northwest Fisheries Science Center has recently been collaborating with the Washington State Department of Ecology, King County Department of Natural Resources, and the University of Washington to increase the number of sites in Puget Sound with moorings that can detect stratification and other environmental parameters. Detection of stratification requires sensors at both the surface and at depth. In August 2008, a surface mooring was deployed at Squaxin Passage by scientists of the Department of Ecology and Northwest Fisheries Science Center. This compliments the existing bottom mooring maintained by the Department of Ecology. In 2009, the Northwest Fisheries Science Center will deploy another mooring in Sequim Bay – a known “hot spot” for HABs of *A. catenella* and paralytic shellfish toxins in Puget Sound.

The ultimate vision for this collaborative project is to have data from all of the Puget Sound moorings telemetered via satellite to experts on land to determine, in real-time, which waters are becoming stratified and are the most likely sites for toxic blooms.

Types of Sensors

Sensors are attached to moorings to measure continuous water quality parameters such as temperature, salinity, density, chlorophyll, turbidity, pH, nutrients, light, and dissolved oxygen. Some Puget Sound moorings have sensors near the water surface only; others have sensors near the surface and at depth or have profiling sensors that move up and down in the water column to provide information on stratification. Data from the sensors can be stored for later retrieval or telemetered for real-time access.

Cheryl Greengrove on Moorings

What is a mooring?

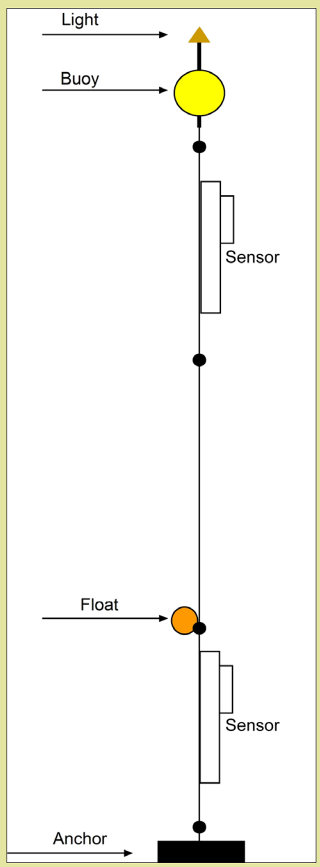
Moorings are held in place using anchors or chains or attached to existing structures such as wharves. They have sensors attached to monitor properties in the water.

What parameters do they monitor?

Puget Sound’s moorings primarily monitor oceanographic properties, including temperature, salinity, density, dissolved oxygen, chlorophyll, nutrients and light. Sensors at the surface and at the bottom can detect differences in these properties associated with stratification of the water column. The moorings can be set to monitor properties at different timescales, but in general, the more frequent the observations the more often the moorings need to be pulled out of the water and serviced to replace their batteries and/or download their data. Moorings in Puget Sound need to be “serviced” or cleaned frequently due to biofouling. The mooring in Quartermaster Harbor currently records temperature and salinity every 15 minutes. Profiling moorings have sensors that move vertically through the water column at set times. Several profiling moorings are currently found in Hood Canal.

How do you access the data?

Data from the Quartermaster Harbor mooring are currently downloaded when it is serviced to remove marine fouling organisms, such as macroalgae and barnacles. Batteries are also replaced and sensors are calibrated as part of the regular mooring service. Other moorings, such as those in Hood Canal, have their data telemetered in real-time back to shore. The Quartermaster Harbor mooring is telemetry capable, and it is envisioned that data will be accessed from this mooring in real-time in the near future.



What makes a good mooring site?

A survey of *A. catenella* cysts found that Quartermaster Harbor had cyst concentrations in sediments that were 2 orders of magnitude greater than any other site in Puget Sound (the second highest concentration was found in Sequim Bay) (Horner et al 2008). Quartermaster Harbor is a good site for a mooring because it is a shallow “incubator bay” for *A. catenella*. Our hypothesis is that tidal currents form a front at the southward facing entrance to the bay, and so blooms within Quartermaster Harbor cannot readily escape. At the University of Washington in Tacoma (UWT), we are currently working with the Department of Ecology to build a circulation model of Quartermaster Harbor to test our hypothesis. Our mooring, along with moorings from King County, will help groundtruth this circulation model and understand more about the flow of water in Quartermaster Harbor and how this might affect blooms of *A. catenella*.

Why is it important to expand the network of moorings?

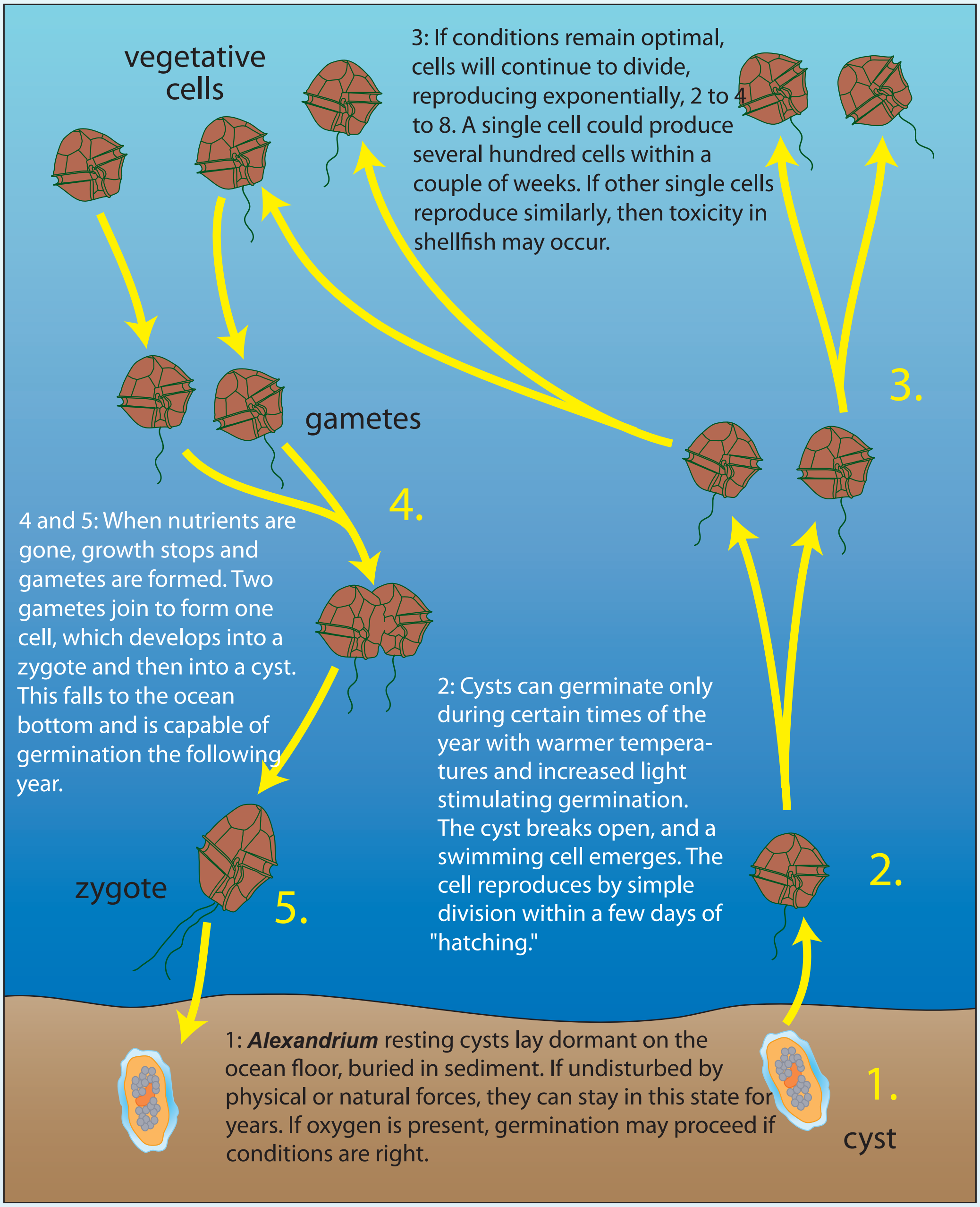
Expanding the network of moorings in Puget Sound and having the data telemetered to shore will allow oceanographic conditions that promote the growth of certain harmful algae to be monitored in real-time. This will allow the onset of stratification to be detected and will provide advanced warning of the increased risk of HABs. Monitoring the physical oceanographic conditions gives us vital information about the biology of Puget Sound that can impact human health.

REFERENCE: Horner, R.A., C.L. Greengrove, J.R. Postel, J.E. Gawel, K.S. Davies-Vollum, A. Cox, S. Hoffer, K. Sorensen, J. Hubert, J. Neville, and B.W. Frost. Accepted. Alexandrium cysts in Puget Sound, Washington, USA. In: Ø. Moestrup et al. (Eds.) Proceedings of the XII International Conference on Harmful Algae, Copenhagen, DK, 4-8 September 2008. International Society for the Study of Harmful Algae and Intergovernmental Oceanographic Commission of UNESCO.

The Life Stages of *Alexandrium*

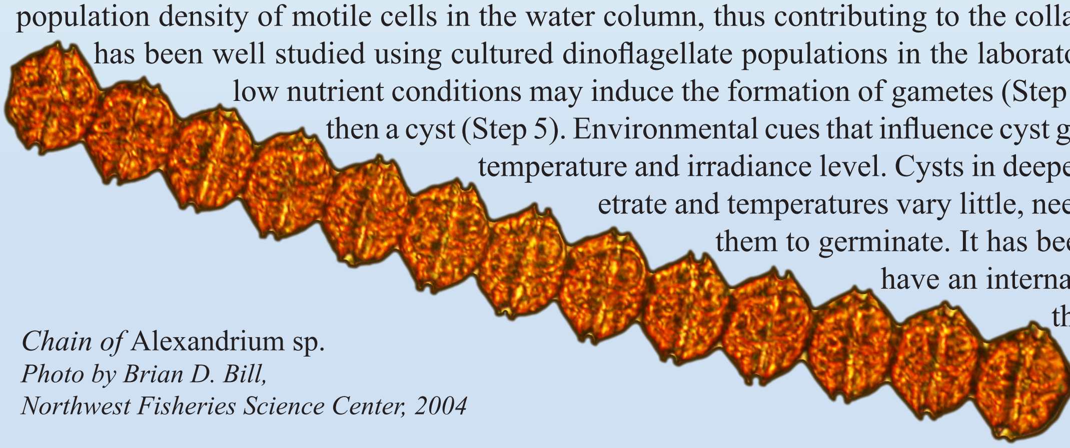
Alexandrium catenella is a known toxin-producing dinoflagellate species; it is one of the first species ever linked to paralytic shellfish poisoning (PSP). These toxins can affect humans, other mammals, fish and birds. This species is responsible for numerous human illnesses and several deaths after consumption of contaminated shellfish. Toxic blooms and PSP toxins in shellfish have been reported in Chile, Japan, most of the Pacific coast of the U.S.A., and many other places in the world.

A. catenella produces a colorless resting cyst as part of its life cycle (see Fig). The cyst is roughly ellipsoidal with rounded ends; it is covered by a smooth wall and a mucilaginous substance. Cysts have a size range of: 38-56 µm in length and 23-32 µm in width.



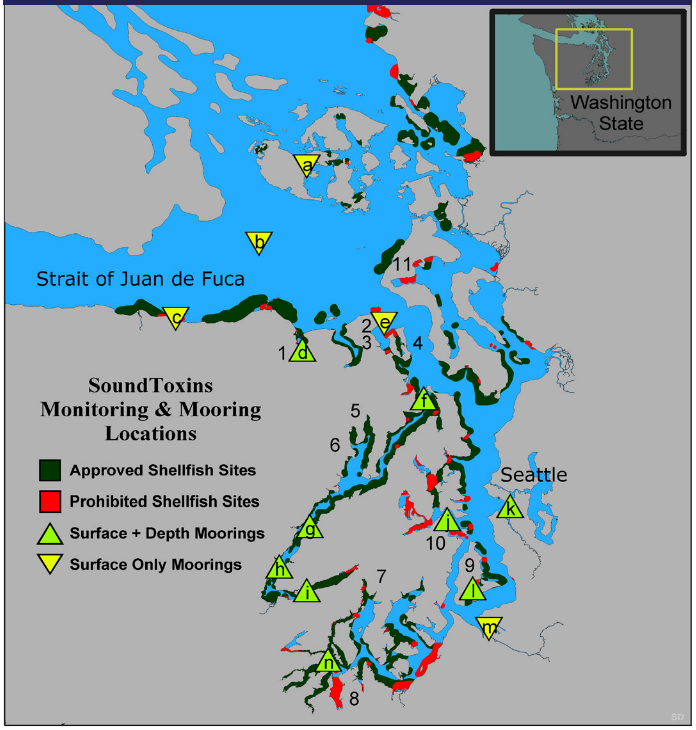
HOW A TOXIC BLOOM OCCURS
The Life Cycle of One Cell
Image courtesy of Don Anderson, Woods Hole Oceanographic Institute

Cyst formation allows *Alexandrium* to over-winter when water temperatures become too cold to support growth. The cysts rest in the sediment (Step 1) until certain environmental and/or endogenous cues trigger them to germinate (Step 2). Cyst germination provides the inoculum for a new planktonic population when conditions become favorable again for growth of motile cells in the water column (Step 3). The importance of a resting stage in bloom dynamics has been demonstrated by many dinoflagellate species. For example, massive cyst formation events decrease the population density of motile cells in the water column, thus contributing to the collapse of the blooms. Cyst formation has been well studied using cultured dinoflagellate populations in the laboratory. These studies have shown that low nutrient conditions may induce the formation of gametes (Step 4) which join to form a zygote and then a cyst (Step 5). Environmental cues that influence cyst germination, to some extent, include temperature and irradiance level. Cysts in deeper waters, where light does not penetrate and temperatures vary little, need other endogenous cues to trigger them to germinate. It has been shown that some dinoflagellates have an internal circannual rhythm that tells them the time of year to germinate regardless of whether the environmental conditions are favorable.



Chain of Alexandrium sp.
Photo by Brian D. Bill,
Northwest Fisheries Science Center, 2004

SoundToxins Map
Puget Sound, Washington



Monitoring Locations	Agency
1. Sequim Bay	Jamestown S'Klallam tribe
2. Fort Worden	Port Townsend Marine Science Ctr. (PTMSC)
3. Port Townsend	PTMSC
4. Mystery Bay	PTMSC
5. Dabob Bay	Taylor Shellfish
6. Quilcene Bay	Coast Seafoods Company
7. Allyn	Washington Sea Grant
8. Budd Inlet	Evergreen State College
9. Quartermaster Harbor	Vashon Island Resident
10. Manchester	NWFSC
11. Penn Cove	Penn Cove Mussels LLC.
Fish Farms	American Gold Seafood / Others

Mooring Locations	Agency	Parameters Measured
a. Friday Harbor	NOAA	T
b. Strait of Juan de Fuca	NOAA	T
c. Port Angeles	NOAA	T
d. Sequim Bay	NOAA/NWFSC	T, S
e. Port Townsend	NOAA	T
f. North Buoy	UW	T, S, O, PAR*
g. Duckabush	UW	T, S, O, Chl, N*
h. Hoodsport	UW	T, S, O, Chl, N, PAR*
i. Twanoh	UW	T, S, O, Chl, N, V*
j. Manchester	DOE	T, S, O, Chl
k. Seattle	King County DNR	T, S, O, Chl, Turb, pH, PAR
	NOAA	T
l. Quartermaster Harbor	King County DNR	T, S, O, Chl, Turb, pH, PAR
	UW Tacoma	T, S
m. Tacoma	NOAA	T
n. Squaxin	DOE	T, S, O, Chl

T=temperature, S=salinity, O=dissolved oxygen, PAR=light, N=nitrate, Chl=chlorophyll, Turb=turbidity, pH=water acidity, V=horizontal velocity
**profiling mooring=sensors move up and down through the water column*

About SoundToxins

The overall goal of this cooperative partnership is to establish a cost-effective monitoring program that will be led by state managers, tribal harvesters, and commercial fish and shellfish farmers. The SoundToxins program aims to provide sufficient warning of HAB and vibrio events to enable early or selective harvesting of seafood, thereby minimizing risks to human health and reducing economic losses to Puget Sound fisheries. The objectives of the program are to determine which environmental conditions promote the onset and flourishing of HABs and increased concentrations of *V. parahaemolyticus* and to determine which combination of environmental factors can be used for early warning of these events. To accomplish this, seawater samples are collected weekly by the participants at 11 different sites throughout Puget Sound and are analyzed for salinity, temperature, nutrients, chlorophyll, (paralytic shellfish toxins and domoic acid) phytoplankton species, and *V. parahaemolyticus*. Phytoplankton species diversity is described and the four target species specifically identified and enumerated are *Pseudo-nitzschia* species, *Alexandrium catenella*, *Dinophysis* species, and *Heterosigma akashiwo*.

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SoundToxins Participants
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Websites
SoundToxins - www.SoundToxins.org
NWFSC HAB Prog. - www.nwfsc.noaa.gov/hab
ORHAB - www.orhab.org
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