SoundToxins Partnership -- Harmful Algal Blooms Monitoring in Puget Sound

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Teri King
Washington Sea Grant
University of Washington
P.O. Box 488
Shelton, WA 98584

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ABSTRACT

The SoundToxins Partnership was created in 2006 under NOAA's Oceans and Human Health directive to respond to an increasing threat of harmful algal blooms (HABs) in Puget Sound. It is a citizen- and industry-based monitoring program whose goal is to protect human health, fisheries, and shellfisheries from exposures to biotoxins. The monitoring is designed to provide phytoplankton data that may warn of HAB events. Sufficient warning enables early or selective seafood harvesting, thereby minimizing human health risks and reducing economic losses to important Puget Sound fisheries.

The Washington State Department of Health relies on the near real time phytoplankton monitoring data supplied by SoundToxins to prioritize expensive shellfish testing for diarrhetic shellfish poisoning (DSP), paralytic shellfish poisoning (PSP), and amnesic shellfish poisoning (ASP) toxins. In addition, fish and shellfish farmers rely on the phytoplankton data to manage their grow-out areas and harvest regimes.

Enhanced communications and annual trainings helped to develop a robust and well trained volunteer core for observing phytoplankton throughout Puget Sound. The use of an alert system enabled monitors to report 172 alerts to health officials about the presence of harmful algae species that warranted additional review of shellfish products for unsafe biotoxin levels. One alert for Dabob Bay in April of 2015 is noted as a prime example of how SoundToxins monitoring is effective in protecting human health.

Collection of water temperature and salinity data along provided no insights into harmful algae modeling at the various sampling locations. *Pseudo-nitzschia* species, *Alexandrium* species, *Dinophysis* species, and *Heterosigma akashiwo* blooms were sparse throughout the study period. Two locations, Sequim Bay and Quartermaster Harbor, are well documented for harmful algae issues and had samples run for nutrient analyses with no insights into harmful algae modeling. All of these data sets are preserved for long term forecasting and use by natural resource managers and researchers as harmful algae modeling advances.

INTRODUCTON

Shellfish are critical to the culture, economy and ecology of Puget Sound. They are habitat forming, provide food for humans and other species, and perform water filtering functions important to all organisms that live in or near the Sound. Native American Tribes have a long history of incorporating shellfish into their daily lives through ceremony and art, as well as food. Today Washington State is a national leader in farmed bivalve shellfish, an industry that employs more than 3,200 people in family wage jobs and contributes an estimated $270 million to the economy (Washington Shellfish Initiative 2011). The majority of shellfish farming and recreational harvest opportunities are in rural communities. Recreation and tourism associated with shellfish harvesting on state owned beaches annually accounts for more than $1 million in revenue for license sales and an estimated economic value of $5.4 million (Washington Shellfish Initiative 2011).

Ensuring safe and wholesome shellfish for consumption relies on water free of terrestrial and legacy pollutants and toxins from harmful algal blooms (HABs). A phytoplankton bloom can be harmful in several ways. Some blooms can produce anoxic (without oxygen) or hypoxic (little oxygen) conditions in the water column. This occurs when one or two species is the dominant organism in a bloom and blocks the sunlight from other organisms in the lower water column. Other plankton begin to die and decompose. Through the process of decomposition, oxygen is used up. Fish die due to lack of oxygen and decomposition continues. Eventually, the massive bloom dies as well, removing any additional oxygen from the water column. This entire process can lead up to a fish and/or shellfish die-off, leading to a negative impact on our economy.

During harmful algal bloom events, there are closures of shellfish beds, lost production in fisheries, and reduction in tourism and associated service industries. Public illness, medical treatment, and advisories cost money. Fisheries-related business close and insurance and unemployment rates increase and public resources are redirected to monitoring programs.

Human health can also be impacted from harmful algal blooms. There are about 50 known species of phytoplankton that produce a toxin. As the toxin moves through the food web, it bioaccumulates in the tissue of large fish and marine mammals. Humans can contract illnesses from eating contaminated shellfish and fish.

Multiple algal toxin classes are present in Puget Sound that necessitate vigilant monitoring to ensure safe human consumption of shellfish. Water loving or hydrophilic toxins such as domoic acid caused by *Pseudo-nitzschia spp*. and paralytic shellfish toxins caused by *Alexandrium catenella* are currently monitored and regulated by the Washington State Department of Health (WDOH), but recently there has been an explosion in the presence of various fat loving or lipophilic algal toxins, including dinophysistoxins caused by Dinophysis spp., that have led to various human illnesses and a complete ban on the export of Washington shellfish to the European Union. Of greatest immediate concern is the presence of algal toxins associated with diarrhetic shellfish poisoning (DSP) that led to a beach closure and a recall of commercial product from Sequim Bay in August of 2011.

In response to the threat of HABs to human health and shellfish harvest in Puget Sound, the SoundToxins program was started in 2006 as a part of NOAA's Oceans and Human Health Initiative (OHHI) directive. Sound Toxins was created as a citizen and industry based monitoring program to provide sufficient warning of HAB events to enable early or selective harvesting of seafood, thereby minimizing risks to human health and reducing the economic loses to Puget Sound fisheries. The goal of the cooperative SoundToxins partnership is to establish a cost-effective monitoring program to:

- Provide an early warning of HAB events to WDOH using phytoplankton data. Rapid relative abundance determinations of the key HAB species, and in particular *Dinophysis*, will help the WDOH pinpoint shellfish growing areas where regulatory testing is needed.

- Determine those key variables that are conducive to the initiation and thriving of HAB species by monitoring environmental parameters (temperature, salinity, macronutrients, toxins, chlorophyll). These variables may be useful in providing early warning of harmful events.

Seawater samples are collected weekly by participants at sites throughout Puget Sound and are analyzed for salinity, temperature, and phytoplankton species. Phytoplankton species diversity is described and the four target species specifically identified and enumerated are *Pseudo-nitzschia* species (causes amnesic shellfish poisoning; ASP), *Alexandrium* species (causes paralytic shellfish poisoning; PSP), *Dinophysis* species (causes diarrhetic shellfish poisoning; DSP), and *Heterosigma akashiwo* (causes fish kills). In addition, some key monitoring locations also process samples for nutrients, chlorophyll, and toxins.

With nine years of monitoring, the program has been able to demonstrate effectiveness of providing an early warning system. This was clearly shown during the Sequim Bay DSP incident in August 2011 when SoundToxins volunteers from the Jamestown S'Klallam Tribe were able to alert WDOH of elevated levels of *Dinophysis* spp.

The WDOH has an early warning monitoring network of mussel cages throughout Puget Sound for toxin monitoring, however, these mussels currently are tested only for PSP toxins and domoic acid. Additional monitoring for DSP and other toxins that threaten Puget Sound stresses the already stretched State budget. SoundToxins monitoring targets high-risk sites that have an immediate need for testing for "new toxins" in shellfish. The use of SoundToxins phytoplankton data, entered into the new database in near real-time allow WDOH to prioritize expensive shellfish testing for DSP toxins only when *Dinophysis* species are present. The WDOH has emphasized the importance of SoundToxins as an early warning system. In fact, the WDOH acquired a modest amount of funding in early 2012 to create a new, improved, easy to use database for data entry by participants and support data management. Jerry Borchert, shellfish specialist for WDOH stated, "there is an urgent need for us to use SoundToxins data in real-time to pinpoint those shellfish growing areas where monitoring for DSP toxins is essential. This will help us to focus our resources to high risk areas" (Borchert pers. comm.)

While SoundToxins was originally supported through the NOAA OHHI with funding from the Northwest Fisheries Science Center's West Coast Center for Oceans and Human Health, the OHHI budget was zeroed out in the Congressional budget in 2012 leaving a significant funding gap for continuation of the program. Despite these cuts, NWFSC staff are committed to support SoundToxins through in-kind staff salary funding. In addition, Washington Sea Grant (WSG) has joined as a program partner and is assuming the role of volunteer coordination, data management and communication. WSG has been successful in receiving grants to support the SoundToxins program from the National Estuary Program: Toxics and Nutrients Ambient Monitoring Program through the Washington State Department of Ecology and the NOAA Sea Grant Aquaculture Extension and Technology Transfer Program.

Critical to the success of SoundToxins is the coordination and support of monitors throughout the Puget Sound region. Having a technical support team, coordinator and routine communication is the key to continued success of the program in terms of volunteer retention and advancement of observations and sample processing. The funding from the NEP grant has been critical to establishing and reinforcing these citizen science best management practices.

METHODS AND MATERIALS

Detailed sampling and analytical methods for this work followed standard operating procedures described in the Quality Assurance Project Plan (King 2015) and are summarized below.

Communications and Training

Each year volunteers are offered training via a 1.5 day event. The first day is spent providing phytoplankton and sampling procedures to primarily new volunteers and veteran volunteers interested in refresher training. The second day is spent recapping the previous years harmful algae observations, research and fishery implications and discussing new and emerging issues. The trainings are popular with SoundToxins volunteers and natural resource staff, and higher education students.

SoundToxins offers a one-stop pathway to transmit information to partners about harmful algal bloom events. A 24 hour, 7 day email account is monitored by Washington Sea Grant staff to handle volunteer questions and alerts. Information about harmful algae are transmitted directly to WDOH, NOAA and researchers. This process insures that all parties are receiving the information as soon as it is available and there is no confusion by the volunteers as to whom to contact. It also allows WDOH and NOAA staff to monitor emails from the central account for action. We maintain lists of researchers from around Puget Sound working on various plankton species and are able to review SoundToxins data real time to help them find their species of interest to enhance their research activities.

Weekly and Monthly bulletins summarizing observations are compiled and distributed to SoundToxins monitors, WDOH and NOAA staff. The bulletins are a good way to communicate back to volunteers about the value of their data and how it fits into the Puget Sound ecosystem.

Study Location

SoundToxins monitoring is conducted by citizen volunteers in strategic and opportunistic sites throughout Puget Sound from the San Juan Islands south to Totten Inlet (Figure 1). The sampling locations: North Bay - Allyn, Budd Inlet – Port Plaza, County Dock – East Sound, Discovery Bay, Fort Worden State Park, Manchester – Clam Bay, Mystery Bay, Penn Cove, Port Susan – Kayak Point, Port Townsend, Quartermaster Harbor – Dockton, Quilcene Bay, Sequim Bay, Spencer Cove – Hartstine Island, Totten Inlet.

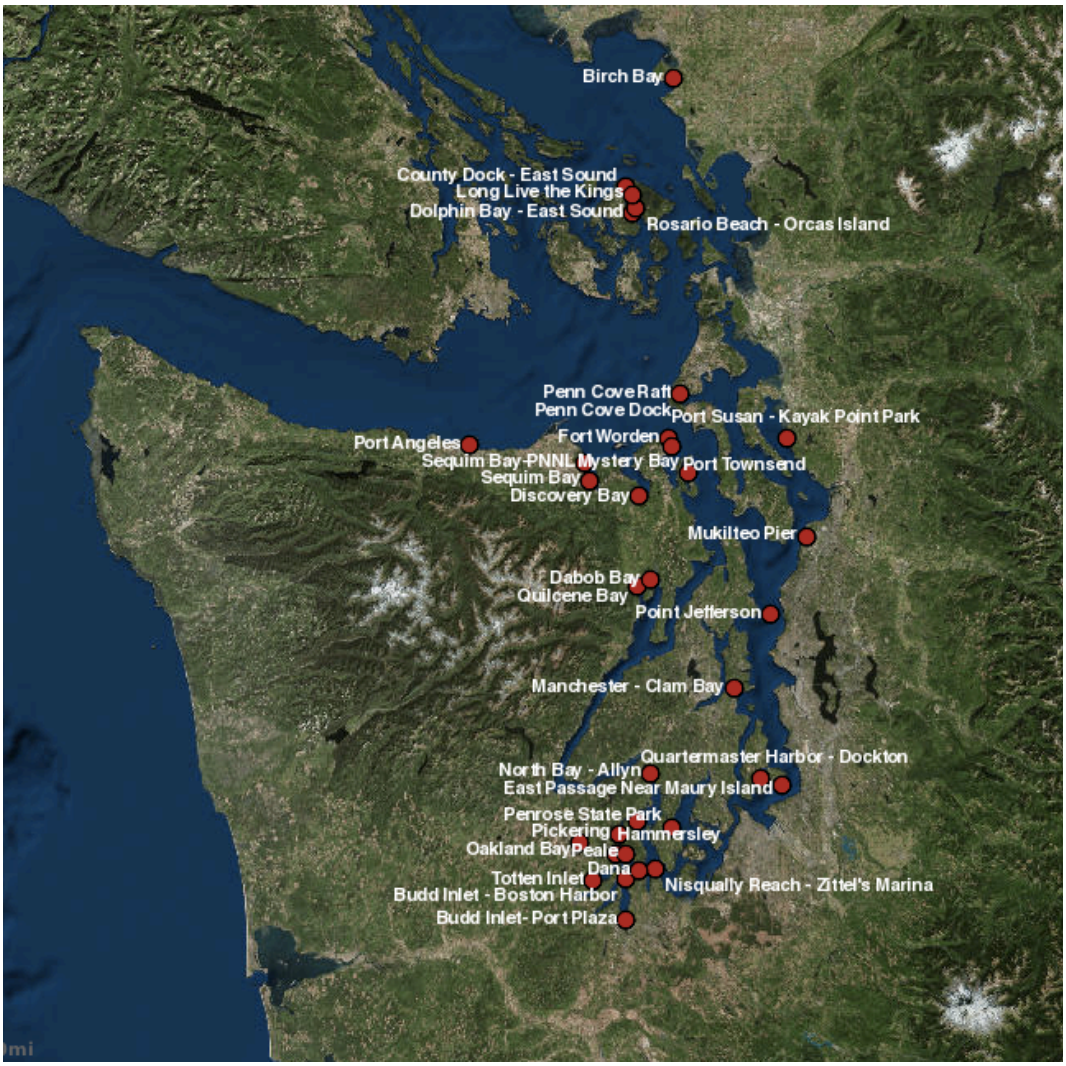

Figure 1. SoundToxins sampling locations.

Sample Collection

Seawater sample collection was conducted weekly from March through October and monthly (or every other week) from November through February (weather and safety permitting). Data were collected on salinity, temperature, and phytoplankton species diversity including *Pseudo-nitzschia* species, *Alexandrium* species, *Dinophysis* species, and *Heterosigma akashiwo* . In addition, some key monitoring locations also processed samples for nutrients, chlorophyll, and toxins to be held for future analysis if warranted.

Sample Processing

Seawater for Environmental Parameters

All seawater samples were monitored for salinity and temperature using the using the Standing Operating Procedures documented in the SoundToxins Quality Assurance and Project Plan (King 2015) and reported into the SoundToxins database.

Seawater for Plankton Species Diversity

All plankton analysis were conducted by trained SoundToxins monitors using the Standing Operating Procedures documented in the SoundToxins Quality Assurance and Project Plan (King 2015) and reported into the SoundToxins database.

Seawater for Nutrient Analyses

All nutrient analyses were conducted at the Marine Chemistry Lab, School of Oceanography at the University of Washington. The method blank and surrogate recovery quality control samples, matrix spikes, and internal standards all met established laboratory criteria.

Data Quality

There were no analytical issues that compromised data quality or the ability to analyze data. Minor deviations from the study plan (see Deviations from the QAPP, below) were due to a lack of samples warranting analysis at locations other than Sequim Bay and Quartermaster Harbor and an unprecedented bloom of *Pseudo-nitzschia* species along the outer coast that required reprioritization of resources, both human and laboratory.

Deviations from the QAPP

Analyses of chlorophyll and toxins were not completed under this contract as other resources were identified for running these analyses at a later time due to laboratory constraints subsequent to the unprecedented West Coast HAB event in 2015.

Data Analysis

Analyses of salinity and temperature data include basic descriptive analyses that use a table to represent summary statistics of mean and data range. Algal observations, and cell densities for *Pseudo-nitzschia* species *Alexandrium* species, *Dinophysis* species, and *Heterosigma akashiwo* include basic descriptive analyses that use a table to represent summary statistics of mean and data range.

A comparison between Sequim Bay and Quartermaster Harbor site data was conducted using the t-test as appropriate for homogeneous variance assumption. For cell density data, the non-parametric Mann-Whitney test was used to compare sites and the Pearson's correlation coefficient (r) and its statistical significance used to initially examine relationships among the different measured parameters. Finally, linear regression analysis and logistic regression analysis was used to examine whether there is a parameter, or a set of parameters, that could be used to develop a predictive model for the density of cells for each species of concern. Ordinary least squares linear regression used to examine whether there is a relationship between cell density and the environmental and water chemistry parameters. Stepwise linear regression analysis used to screen those variables with significant ($P \leq 0.05$) Pearson's r with the response variable (both contemporaneous and lagged).

RESULTS

Annual trainings were held for veteran and new SoundToxins volunteers in 2012, 2013, 2014, and 2015 that covered SoundToxins protocols, SoundToxins data results, and emerging harmful algal issues and species. On site training was provided to all new sites and for veteran sites where volunteer turnover occurred. New SoundToxins sites during the project period were: Port Gamble Bay monitored by the Port Gamble S'Klallam Tribe, Sequim Bay Channel monitored by the Pacific Northwest National Laboratory, Glen Ayr/Annas Bay monitored by the Skokomish Tribe, Port Susan monitored by the Stillaguamish Tribe, and Burley Lagoon monitored by Taylor Shellfish. Reinvigorated sites as a result of enhanced communications are: Dabob Bay monitored by Taylor Shellfish, Quilcene Bay monitored by Pacific Seafoods and Totten Inlet monitored by Big Cove Shellfish.

Steering committee meetings held regularly by core team members and scientists, natural resource managers and policy officials have lead to increased collaboration and recognition of SoundToxins program strengths and opportunities for advancement. As a result some SoundToxins volunteers were engaged in an exploratory survey by NOAA to identify the distribution of *Azadinium* species in Puget Sound. This information has been used to develop a robust research program for both Puget Sound and the outer coast that has been recently funded by NOAA.

The email communication system resulted in 172 alerts to WDOH and NOAA.
One observation of note was made on April 19, 2015 where the SoundToxins volunteer in Dabob Bay observed *Alexandrium catenella* cells. She alerted the SoundToxins email that triggered WDOH going out to Dabob Bay and collecting a mussel sample for toxin analysis. The presence of *Alexandrium* was out of the norm for this area at this time. The mussel sample reading was 183 micrograms of PSP toxins/100 g of tissue thus immediately closing the shellfish growing area. Mussels harvested by a commercial company were on a truck for distribution and WDOH was able to make notification and prevent the delivery of the toxic product into the food supply.

Weekly and monthly summaries of observations were distributed to SoundToxins volunteers and interested parties. SoundToxins data was summarized and presented as part of the Puget Sound Environmental Monitoring Program's Marine Water Quality Working Group annual reports.

Water samples were collected and analyzed for salinity, temperature, and phytoplankton species diversity of four harmful genera, *Pseudo-nitzschia* species, *Alexandrium* species, *Dinophysis* species, and *Heterosigma akashiwo*.

Salinity and temperature readings for routinely monitored SoundToxins sites is summarized in Table 1. Other sites reported data, but did not have a robust data set for analyses.

Table 1. Salinity and temperature data from SoundToxins sites from September 2012 to August 2015.

	Temperature			**Salinity**		
Site	**Min Temp C**	**Max Temp C**	**Mean Temp C**	**Min Salinity ppt**	**Max Salinity ppt**	**Mean Salinity ppt**
Allyn – North Bay	7.5	21.5	15.1	7	31	26.25
Budd Inlet - Boston Harbor	9.6	20.0	14.2	15	29	25.8
Clam Bay	7	17	11.3	25	36	33.1
County Dock – East Sound	5	22	13.3	30	35	33.9
Discovery Bay	6	21	12	9	36	31.3
Fort Warden	5	19.5	11.3	29	39	32
Long Live the Kings – Orcas	6.5	19.6	12.5	30	32	31
Mystery Bay	5	21	12.5	29	35	35.5
Penn Cove	5	22	13.1	10	33	25.3*
Port Susan	4.6	19.8	13.7	0	27	19.1
Port Townsend	6	14	10.4	14	35	31.8
Quartermaster Harbor	8	20	13.6	1	32	27.1
Quilcene Bay	10	23.1	15.3	21	30	27.5
Sequim Bay	3.5	19.2	10.8	29	35	31.7
Spencer Cove	3	20	12.9	27	32	29.3
Totten Inlet	8	20	15.1	21	35	28.3

Phytoplankton observations of four harmful genera, *Pseudo-nitzschia* species, *Alexandrium* species, *Dinophysis* species, and *Heterosigma akashiwo* are summarized in Table 2.

Table 2. *Alexandrium* species, *Dinophysis* species, data from SoundToxins sites from September 2012 to August 2015.

	***Alexandrium* specie**				***Dinophysis* species**			
Site	**No of Obs**	**Min Cells/L**	**Max Cells/L**	**Mean Cells/L**	**No of Obs**	**Min Cells /L**	**Max Cells/L**	**Mean Cells/L**
Allyn – North Bay	1	439	439	439	17	3	438	81.3
Budd Inlet - Boston Harbor	0	0	0	0	18	1	68	24
Clam Bay	7	-	-	-	53	-	-	-
County Dock – East Sound	27	-	-	-	49	-	-	-
Discovery Bay	12	10	131,538	11,617	70	2	180,000	4,299
Fort Warden	8	1	4,000	530	6	1	20,000	4,005
Long Live the Kings – Orcas	14	-	-	-	22	-	-	-
Mystery Bay	10	6	195	58	43	3	10,000	929
Penn Cove	2	1	2	1.5	7	1	10,000	1,435
Port Susan	0	0	0	0	5	4	27	13
Port Townsend	5	18	24,000	5,376	25	1	10,000	879
Quartermaster Harbor	25	4	20,000	1,498	83	2	10,000	336
Quilcene Bay	3	-	-	-	18	-	-	-
Sequim Bay	18	1,000	15,000	2,911	65	28	33,000	3,369
Spencer Cove	4	13	48	31	50	8	1,371	59
Totten Inlet	2	16	51	33	5	1	40	17

- = data entered as relative abundance and not cell counts

Table 3. *Heterosigma akashiwo* and *Pseudo-nitzschia* species, data from SoundToxins sites from September 2012 to August 2015.

	Heterosigma akashiwo				***Pseudo-nitzschia spp.***			
Site	**No of Obs**	**Min Cells/L**	**Max Cells/L**	**Mean Cells/L**	**No of Obs**	**Min Cells/ L**	**Max Cells/L**	**Mean Cells/L**
Allyn – North Bay	1	1,280,000	1,280,000	1,280,000	11	1	110,000	10,340
Budd Inlet - Boston Harbor	0	0	0	0	12	1	8200	995
Clam Bay	11	-	-	-	70	-	-	-
County Dock – East Sound	9	-	-	-	44	-	-	-
Discovery Bay	4	60000	2,400,000	944,000	57	7	1,246,000	80,907
Fort Warden	0	0	0	0	61	6	674,000	18,684
Long Live the Kings - Orcas	6	-	-	-	28	-	-	-
Mystery Bay	3	2	15	8	54	7	334,5000	24,638
Penn Cove	2	1	3	2	41	1	3,200,000	398,928
Port Susan	1	18	18	18	35	2	1,690,000	117,383
Port Townsend	8	7	80,000	32,541	70	7	278,000	17,107
Quartermaster Harbor	2	46	485	265	62	5	178,000	8,912
Quilcene Bay	0	-	-	-	12	-	-	-
Sequim Bay	7	1,000	3,090,000	593,714	64	183	3,610,000	265,713
Spencer Cove	8	7	93	30	53	3	95,510	3,878
Totten Inlet	0	0	0	0	17	30	56,500	34,594

- = data entered as relative abundance and not cell counts

In addition, two locations, Sequim Bay and Quartermaster Harbor where compared for harmful species, salinity and temperature and nutrients. As often the case, species presence was a limiting factor for analysis.

Mann-Whitney U Tests were used between the two sites, Sequim Bay and Quartermaster Harbor for each species. There was a significant difference between the two sites for *Dinophysis* species (p=0.00005) and *Pseudo-nitzschia* species. (p=0.001). No significant difference between the two sites for *Alexandrium* species (p=0.246) and *Heterosigma akashiwo* (p=0.218). It's important to note that for Quartermaster Harbor, only two *Heterosigma akashiwo* values in the data set. All Mann Whitney U values were high for *Alexandrium* species (U= 379), *Dinophysis* species (U= 4,973), *Heterosigma akashiwo* (U= 14), and *Pseudo-nitzschia* species (U= 3,384).

Pearson's correlation coefficient (*r*) and its statistical significance were used to initially examine relationships among the different measured parameters. All correlations had low r-values and the results are as follows:

Quartermaster Harbor

Alexandrium species: Water temperature (r= 0.154), salinity (r=-0.153), PO_4 (r= 0.771), $Si(OH)_4$ (r= 0.016), NO_3 (r=0.730), NO_2 (r= 0.872), NH_4 (r= 0.867). Though higher r-

values were given to the nutrient categories, only four values were used to calculate the correlations.

Dinophysis species: Water temperature (r= -0.057), salinity (r=-0.074), PO_4 (r= -0.139), $Si(OH)_4$ (r= -0.451), NO_3 (r= -0.160), NO_2 (r= -0.128), NH_4 (r= -0.245).

Heterosigma akashiwo: Water temperature (r= -1) and salinity (r= -1). None of the nutrient data matched up to the Heterosigma data.

Pseudo-nitzschia species: Water temperature (r= 0.088), salinity (r= 0.158), PO_4 (r= -0.197), $Si(OH)_4$ (r= -0.365), NO_3 (r= -0.411), NO_2 (r= -0.464), NH_4 (r= -0.306).

Sequim Bay
Alexandrium species: Water temperature (r= 0.113), salinity (r= -0.050). Only one data point was provided for nutrients and was therefore insufficient in calculating the correlation.

Dinophysis species: Water temperature (r= 0.293), salinity (r= 0.053), PO_4 (r= -0.227), $Si(OH)_4$ (r= -0.124), NO_3 (r= -0.327), NO_2 (r=-0.354), NH_4 (r=-0.484).

Heterosigma akashiwo: Water temperature (r= 0.807) and salinity (r= -0.530). None of the nutrient data matched up to the *Heterosigma* data. Though the r- value for *Heterosigma* is at 0.807, it is important to note that this is taken from seven values.

Pseudo-nitzschia species: Water temperature (r= 0.434) and salinity (r= -0.128).

Regression analysis was used to examine whether there is a parameter, or a set of parameters, that could be used to develop a predictive model for the density of cells for each species of concern. Ordinary least squares linear regression was used to examine whether there is a relationship between cell density and the environmental and water chemistry parameters. Stepwise linear regression analysis was used to screen those variables with significant ($P \leq 0.05$) Pearson's *r* with the response variable (both contemporaneous and lagged). All regressions had low R^2 values and the results are as follows:

Quartermaster Harbor
Alexandrium species: : Water temperature (R^2= 0.024), salinity (R^2= 0.023), PO_4 (R^2= 0.326), $Si(OH)_4$ (R^2= 0.0002), NO_3 (R^2= 0.532), NO_2 (R^2= 0.760), NH_4 (R^2= 0.752). Though values for the nutrients are higher to 1 than water temperature and salinity, only four values were measured for these regressions.

Dinophysis species: Water temperature (R^2= 0.003), salinity (R^2= 0.005), PO_4 (R^2= 0.045), $Si(OH)_4$ (R^2= 0.209), NO_3 (R^2= 0.018), NO_2 (R^2= 0.012), NH_4 (R^2= 0.053).

Heterosigma akashiwo: Water temperature (R^2= 1), salinity (R^2= 1). Though perfect regression results, this is due to only two data points being available for this regression. No nutrient data was available.

Pseudo-nitzschia species: Water temperature (R^2= 0.009), salinity (R^2= 0.023), PO_4 (R^2= 0.039), $Si(OH)_4$ (R^2= 0.133), NO_3 (R^2= 0.169), NO_2 (R^2= 0.215), NH_4 (R^2= 0.094).

Sequim Bay

Alexandrium species: Water temperature (R^2= 0.013) and salinity (R^2= 0.002). Only one data point was provided for nutrients and was therefore insufficient in calculating the regression.

Dinophysis species: Water temperature (R^2= 0.086), salinity (R^2= 0.003), PO_4 (R^2= 0.052), $Si(OH)_4$ (R^2= 0.301), NO_3 (R^2= 0.290), NO_2 (R^2=0.126), NH_4 (R^2= 0.234).

Heterosigma akashiwo: Water temperature (R^2= 0.651), salinity (R^2= 0.281). No nutrient data was available. There were only seven data points available for calculations.

Pseudo-nitzschia species: Water temperature (R^2= 0.188) and salinity (R^2= 0.073). Very minimal nutrient data was available.

DISCUSSION

Communication and training is vital to the retention of volunteers and the reliability of the data for subsequent use by natural resource managers and researchers. Volunteers that see their data presented as part of a Puget Sound view on a weekly and monthly basis are more committed to long term monitoring. The annual training has helped with retention as well as having dedicated assistance for plankton identification questions and processing assistance.

SoundToxins has on numerous occasions protected public health by alerting health managers to the presence of harmful algae and the need for shellfish tissue testing. We know that shellfish samples collected by WDOH for toxin analyses are screened using SoundToxins cell data to prioritize sample locations for processing in the laboratory.

Although interesting, the environmental and algal data collected within this time period does not pinpoint parameters for phytoplankton modeling to predict harmful algal blooms. The observations of harmful algae at SoundToxins monitoring sites, will be helpful in developing a longer term data set, but on its own are insufficient to perform model experiments given the lack of harmful algal events. Phytoplankton come and go throughout Puget Sound from year to year and season to season. Over the course of this project period we demonstrate this quite well.

CONCLUSION

SoundToxins plays a critical role in the management of Puget Sound shellfisheries by helping to identify water bodies with toxic algae and alert resource managers to direct additional monitoring efforts to the area. SoundToxins data is also used to help prioritize laboratory analysis of shellfish tissues, which is extremely important during peak analysis periods – those traditionally known to have harmful algal blooms in the summer months. Volunteer monitors are capable and qualified with sufficient training, resources and long-term guidance to provide critical data to help understand harmful algal blooms. The data collected by the SoundToxins program is archived and preserved so that it can be used as a long term dataset for future analysis as well as for incident review. Long term funding for the SoundToxins Program that includes communications, training, volunteer resource needs and data management is critical for maintaining and expanding the diverse sampling locations so that monitors can continue to collect data needed to identify new species of concern entering Puget Sound and to document environmental factors that might be used in modeling scenarios. The funding provided by the United State Environmental Protection Agency through its National Estuary Program via contract with the Washington State Department of Ecology serving as Lead Organization for Toxics and Nutrients Prevention Reduction and Control Projects has been invaluable to sustain the SoundToxins program during a transitional period. The standardization of the communication tools and resource materials will aid the SoundToxins program in establishing a long term, dedicated funding source as well as provide certainty and commitment to our incredible volunteers and partners.

LITERATURE CITED

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