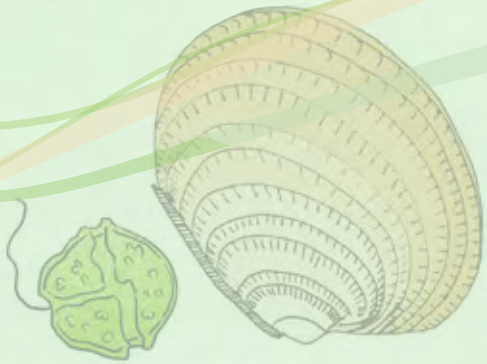
Harmful Algal Bloom Progress White Papers



Community-based monitoring programs

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Sea Grant Alaska

AOOS Alaska Ocean Observing System

Kachemak Bay National Estuarine Research Reserve

Harmful Algal Bloom Program

The main goal of the Harmful Algal Bloom monitoring program is to look for specific groups of phytoplankton that have the potential to be toxic and can result in shellfish poisoning. Once these cells are identified in the samples, other tests are preformed that can ultimately advise the safety of shellfish consumption in the area. Monitoring phytoplankton also provides us with valuable baseline information on the bloom cycles in Kachemak Bay.

How do we do this? Over the summer, approximately 200 phytoplankton samples are collected from 12 sites around Kachemak Bay by community members and KBNERR staff. The samples are examined under microscopes. When potentially harmful algae cells are seen, we report our findings to state agencies, mariculture farmers and many other stakeholders.

This program is funded by a State Wildlife Grant through ADF&G and USFWS. We are also supported by the national NOAA Plankton Monitoring Network and we depend on training, expertise and toxin testing from both the Charleston and Beaufort NOAA labs.

Thanks to our volunteers for sending in water samples. Their work is valuable to detecting toxic blooms.

KBNERR HAB program has coordinated regional toxin testing efforts through collaboration with multiple labs since 2006.

We hold regional HAB workshops and conferences to refine goals and products needed in this field.

We provide information to Alaska Dept. of Health and Social Services so they can determine the safety of recreational harvest of shellfish.

http://dhss.alaska.gov/dph/Epi/id/Pages/dod/psp/default.aspx

In our seven year old program we have:

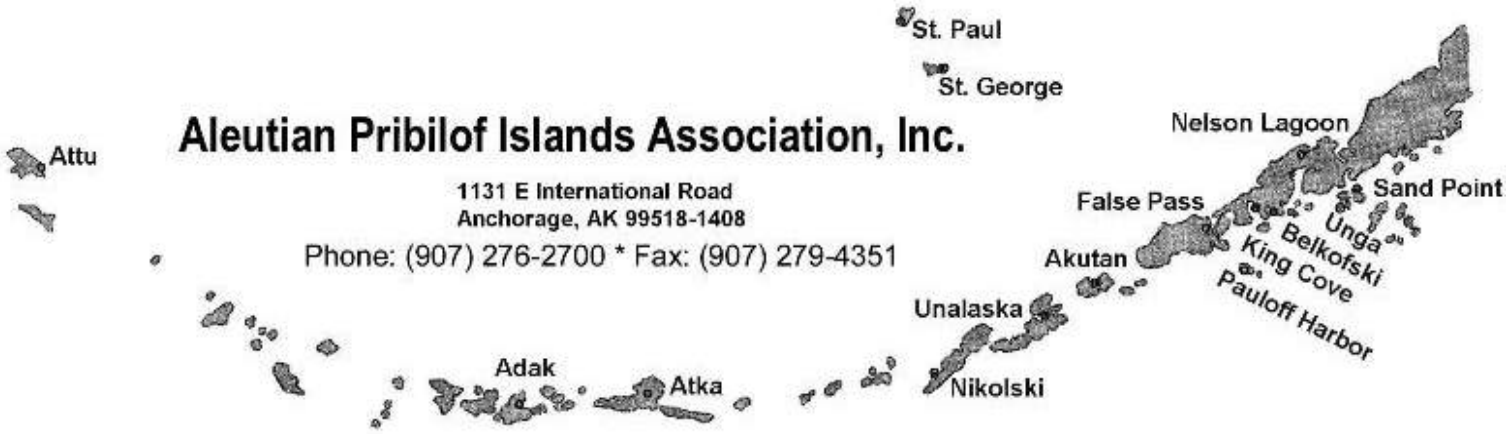
- Examined 1000s of phytoplankton samples;
- Trained over 100 community monitors;
- Documented blooms never seen before in Alaska;
- Developed a robust phytoplankton guide for Kachemak Bay.

What we do:

- Coordinate a group of community monitors including training and providing equipment;
- Read water samples monitors send in and identify present, abundant, and blooming phytoplankton species. If harmful species are seen, water samples are sent in for toxicity testing;
- If water sample shows toxins, then shellfish are sampled and sent for toxicity report. If results come back showing that the shellfish contained toxins, we contact DEC & HSS;
- All our data is reported on a weekly basis via e-mail updates as well as archived online;
- KBNERR organizes regional HAB workshops bringing together stakeholders, managers, and scientists;
- Regularly outreach about phytoplankton to the public and employees through local brown bag lectures, newspaper and radio media, and by presenting at scientific conferences;
- Provide information to state regulators and managers about the condition of the primary production in Kachemak Bay;
- Archive local data and summaries regional reports by multiple partners in a useable format.

Partners we coordinate with :

- South East Alaska Tribal Toxins
- Aleutian Pribilof Islands Association
- NOAA, NOS, Plankton Monitoring Network
- NOAA CCFHR lab in Beautort, NC
- NOAA Kasitsna Bay Lab
- State of Alaska Dept. of Environmental Conservation
- State of Alaska Dept. of Health and Social Services (HSS)
- State of Alaska Dept. of Fish & Game
- Dept. of Environmental Conservation



Aleutian Pribilof Islands Association
1131 E. International Airport Road
Anchorage, AK 99518
http://www.apiai.org/services/community-services/environmental-programs/paralytic-shellfish-poisoning-psp/

The Aleutian Pribilof Islands Association, Inc. (APIA) is a tribal consortium serving Alaska's thirteen Aleut Tribes. APIA's purpose is to promote the overall economic, social, and cultural development of the Aleutian and Pribilof Islands Region; to help Tribes to protect public health and the environment; and to encourage sustainable management of the natural resources upon which the Aleut people depend. Environmental programs are located within APIA's Health Department. The specific mission of this department is achieving safe, healthy and sustainable communities.

The APIA harmful algal bloom program goals and objectives meet evolving needs by the Tribes to understand the risks of illness and death and the associated shifts in the marine ecosystems from harmful algal blooms. *Bruce Wright*, the Senior Scientist with the Aleutian Pribilof Island Association, is located in Anchorage and works with a number of communities in Alaska on topics including climate change, harmful algal blooms, contaminants, environmental remediation and energy. Wright has been involved in a number of harmful algal bloom studies including initiating and maintaining paralytic shellfish poisoning (PSP) monitoring programs in a number of communities through varied funding and research on domoic acid detection through the North Pacific Research Board (NPRB).

In 2005 Wright and former University of Alaska Fairbanks professor, Ray RaLonde, were funded by NPRB to establish a baseline for PSP distribution and toxicity levels along the Gulf of Alaska with monthly sampling from 20 stations from near Ketchikan north and west along the Gulf Coast, including Kodiak Island, the Aleutian Islands, Pribilof Islands and Commander Islands. The data from the monthly samplings revealed the entire region was under threat from PSP. Beginning in 2009, the Environmental Protection Agency (EPA) funded PSP projects in the Aleut region and APIA completed demonstration project/baseline assessments intended to build the capacity in Aleutian

Islands communities. The multi-agency collaboration was designed to develop methods for communities to test for occurrence and distribution of PSP toxins to increase the communities' capacities in devising a mechanism to better respond to the threat and minimize the risks of poisoning.

Beginning in 2013, the PSP program began using the Village Protection Safety Officers (VPSOs) as technicians in Akutan, Atka, False Pass, Nelson Lagoon and St. George. APIA felt this expansion of the program was necessary after Atka had its first hits for PSP ever measured (August and September 2013). IGAP (an EPA program) staffers are responsible for the PSP collections in King Cove and Sand Point, the Alaska Sea Grant Marine Advisory agent provides program support in Unalaska, and a US Fish and Wildlife Service employees makes the collections in Adak during the summer. An important partner in the program has been the Alaska Department of Environmental Conservation's Environmental Health Lab, which provides certified analytics and acceptable protocols to insure the data are of the highest standards.

Information from these monitoring studies has led to further investigations on the fate and effect of PSP in the region. Results have documented PSP toxins moving through the marine food web via zooplankton and forage fish (sand lance, herring, etc.) ultimately toxifying Dungeness crab, shrimp, seabirds and marine mammals. The 2014-15 project funded by the EPA investigated the risk of toxin transfer to people and the marine ecosystem, and focused on investigating PSP contaminated forage fish, particularly sand lance. The findings from that effort have stunned many in Alaska with reports of PSP contaminated sand lance from many Gulf of Alaska communities and as far north as Deering, Kotzebue Sound. We have documented high PSP levels in collected sand lance, seabirds, sea otters and sea lions.

Aleut and Alutiiq elders readily share their observations; their traditional knowledge has guided much of APIA's harmful algal bloom (HAB) research effort. They are now asking for help in understanding the dramatic increase of pink salmon in the Aleutian Islands in 2015 and the near failure of pink salmon runs in Kodiak and the Aleutian Islands in 2016. Some suspect the 2015 HAB event in the Gulf of Alaska was at fault. Many believe the sea lion, fur seal and sea otter declines in the Aleut region are a consequence of increases in PSP levels and number of PSP events. They tell of windrows of dead and dying forage fish on beaches, some with many dead seabirds and some avoided entirely by seabirds. Commercial fishing is the primary economic driver in the Aleut region; many people are frightened their way of life and livelihoods are at risk of being lost.

Marine Advisory Program
College of Fisheries and Ocean Sciences
Kodiak Seafood and Marine Science Center
118 Trident Way • Kodiak, AK 99615
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Addressing Paralytic Shellfish Poisoning - Kodiak Archipelago

Paralytic shellfish poisoning (PSP) remains a serious health risk for Alaska residents practicing subsistence and personal shellfish harvest. Kodiak has recorded some of the highest toxins in the state and residents have been identified as high risk with illness and death reported from the area; 30% of the shellfish implicated in PSP illness statewide between 1993-2014 were from the Kodiak region

Paralytic Shellfish Toxins (PST) and the causative organism, the marine dinoflagellate of genus *Alexandrium,* have been monitored in the Kodiak region as project specific funding opportunities arise. The Alaska Sea Grant Marine Advisory Program, and faculty at the Kodiak Seafood and Marine Science Center (KSMSC, formerly FITC) have been involved in much of the PSP work conducted in the region, including PSP education and outreach; phytoplankton and toxin monitoring; and research toward utilization of low-cost, rapid field tests.

Recent paralytic shellfish toxin monitoring in the Kodiak archipelago was initiated in the villages of Old Harbor and Ouzinkie as part of the Alaska Department of Environmental Conservation (ADEC)-funded Recreational Pilot Program (2012-2015). The three-year local community monitoring program determined PSP levels in these communities remained above the FDA regulatory level and confirmed the ephemeral nature of PSP events, highlighting the need for beach-specific monitoring and a developed safe harvest program. Continued PST testing at these locations is ongoing through additional funding from the Alaska Native Tribal Health Consortium and the North Pacific Research Board. However the cost of testing is a barrier to long-term monitoring.

Julie Matweyou, Kodiak Marine Advisory Program Agent, is collecting additional information regarding toxin patterns in the region through collaborative educational activities with the Kodiak Island Borough School District, regional tribal organizations, and the UAA Kodiak Collage. The age-appropriate lessons have incorporated toxin testing using commercially available tests including the Scotia Rapid Test and the Abraxis Saxitoxin ELISA. While this data collected under these activities are inconsistent, the information adds to the growing body of data for the region and is pertinent to educating the community about the risk of PSP.

Communities in the Kodiak region seek solutions to safe harvest. The work conducted to date demonstrates high spatial and temporal variability and the presence of low level (background) toxins year round. Pre-harvest and beach specific testing is deemed essential for this region.

Toxin testing results from the described projects can be found through the Marine Advisory Program faculty website: https://seagrant.uaf.edu/map/staff/matweyou.php.

Marine Advisory Program
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References:

Lewis et al. 2012. *Harmful algal blooms along the North American west coast region: History, trends, causes, and impacts*. Harmful Algae 19:133–159.

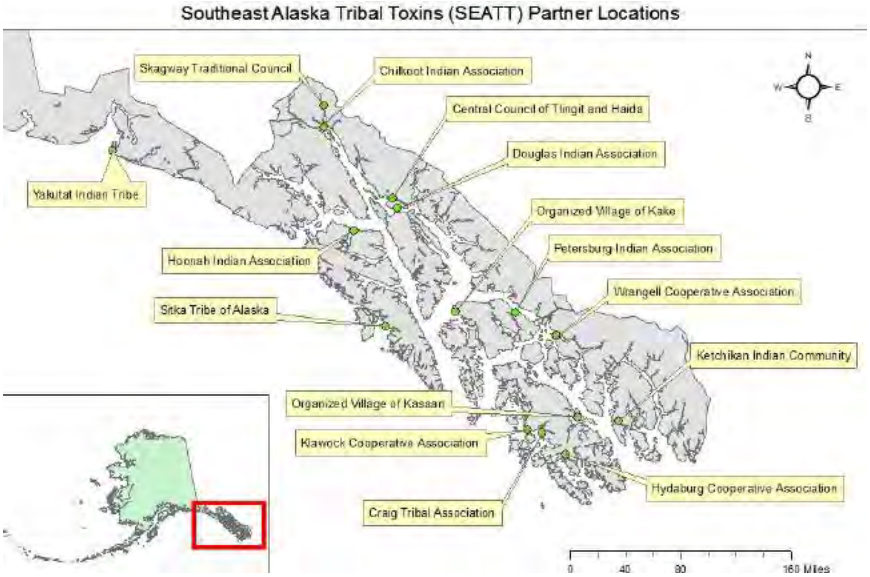
Matweyou, J.A. and Bartz, K. 2015. *Recreational Shellfish Project FINAL REPORT* (7.1.12-6.30.15); written and submitted to ADEC on behalf of KIBSD.

State of Alaska Epidemiology Bulletin No. 1 January 7, 2015. Editor: McLaughlin, J.

Southeast Alaska Tribal Toxins and the
Sitka Tribe of Alaska Environmental Research Laboratory

The Sitka Tribe of Alaska (STA), founder of Southeast Alaska Tribal Toxins (SEATT), has a vested interest in protecting traditional natural resources as well as the health of the local community. SEATT was formed in September 2013 to unify 15 southeast Alaska tribes in monitoring harmful algal bloom (HAB) events that pose a human health risk to subsistence and commercial shellfish harvesters. With "eyes on the water" actively monitoring sites within their communities, Tribes can establish subsistence management plans, and continue the cultural importance of shellfish harvesting. Each Tribal partner collects **weekly samples** at key community harvest sites including phytoplankton identification and quantification, salinity, sea and air temperature, whole water for cellular toxin analysis, and shellfish for biotoxins. The phytoplankton and environmental parameter data are uploaded to the SoundToxins database (soundtoxins.org) and are used as an "early warning" by researchers, managers, and community partners.

Shellfish and whole water samples are sent to the Sitka Tribe of Alaska Environmental Research Laboratory (STAERL) for toxin analysis. STAERL uses the receptor binding assay (AOAC Method 2011.27) for measuring saxitoxins and the enzyme-linked immunosorbent assay (AOAC Method 2006.02) for determining domoic acid concentrations. With new emerging toxins being detected in Alaska, STAERL is in the process of setting up a High-performance liquid chromatography mass spectrometer (HPLC MS) to add additional analytical capacity to the program.



All samples are processed and analyzed within a 48 hour period and results are posted to the Southeast Alaska Tribal Ocean Research webpage (seator.org/data). Results are also emailed out to all SEATT partners, local and state health officials, resource managers, and university staff. If detected toxin levels are above the regulatory limit of 80µg/100g or a SEATT partner site is observing HAB species in their phytoplankton sample, a shellfish harvest advisory is issued by the Tribe for the community.

STAERL was developed to support subsistence harvest efforts but is also available to provide services to researchers and the commercial shellfish industry.

SEATT and STAERL collaborate with multiple agencies utilizing funding and technical resources including the Northwest Fisheries Science Center Marine Biotoxin Program (NOAA), National Centers for Coastal Ocean Science Charleston Laboratory (NOAA), Environmental Protection Agency, Bureau of Indian Affairs, Administration for Native Americans, Alaska State Department of Conservation Environmental Health Lab, University of Alaska Fairbanks College of Fisheries and Ocean Science, Southeast Alaska Regional Dive Fisheries Association, and Washington State Department of Health Public Health Laboratories.

For more information or to be added to our list-serve to receive the latest shellfish and HAB information, contact us at seator@sitkatribe-nsn.gov.

Current HAB Research in Alaska

2016 Alaska Harmful Algal Bloom Workshop
December 8 & 9, Anchorage, AK

This packet contains summaries of active research projects on harmful algal bloom (HABs) and algal biotoxins in the state of Alaska. These projects involve integration of citizen-based phytoplankton monitoring activities and local and traditional knowledge to better understand spatial and temporal patterns of HABs and shellfish toxicity; examination of the environmental mechanisms that regulate regional HAB dynamics; research to improve communication on HABs and their impacts; and field programs to test new technologies for the detection and monitoring of harmful algal species and biotoxins in seawater and shellfish. Research efforts are currently focused in the areas of Kachemak Bay, Kodiak Island, Aleutian Islands and Southeast Alaska. If you would like to know more about the progress and findings of these projects, the email address of the primary contact for each research team is provided.

Exploring short-term variation in ocean circulation patterns to better understand hydrographic factors relevant to harmful algal blooms in Kachemak Bay, Alaska

Project Team: Angela Doroff[1], Mark Johnson[2], and Georgina Gibson[3]

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Summary
Phytoplankton in Kachemak Bay are monitored throughout the year; by mid-May in 2016 the KBNERR monitoring program had documented thick phytoplankton blooms of *Psuedo-nitzschia* and *Chaetoceros* and had identified *Alexandrium* cells in the water. Paralytic shellfish poisoning (Saxitoxin) is produced by a species of *Alexandrium* and amnesic shellfish poisoning (domoic acid) is produced by *Psuedo-nitzschia.* Variation in the prevalence and severity of Saxitoxin events varies considerably throughout Alaska coastal waters likely due to the interplay between environmental and hydrographic factors and the biology of Saxitoxin-producing species. In Kachemak Bay, we explored short-term variation in circulation patterns with satellite drifters and a ROMS circulation model to better understand the prevalence and timing of Saxitoxin events in relation to local advection patterns and convergence and divergence patterns that may affect phytoplankton blooms. In 2016, preliminary data from deep (15 m drogued) and surface (1 m drogued) satellite drifter data suggest that the toxic forms of *Psuedo-nitzschia* and *Alexandrium* may have been resident and not transported into Kachemak Bay by intrusions of the Alaska Coastal Current during the time of this study. During 2012-2013, average drift days in the inner and outer Bay, respectively, were 19.4 and 8.2 days for deep and surface drifters combined. Model velocity fields suggest that on longer (monthly) timescales the inflow/outflow patterns in Kachemak Bay are relatively consistent. However, preliminary examination of water velocity at the surface and 15 m depth indicate daily to bi-weekly variability to this pattern and in the location of patches of convergence.

Communication and coordination on HAB risks in Kachemak Bay, Alaska

Project Team: Dominic Hondolero[1*], Steve Kibler[2], Kris Holderied[1], Stacey Buckelew[3]

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Partners
Department of Environmental Conservation
Sea Grant Marine Advisory Program
NOAA/NCCOS Phytoplankton Monitoring Network
Jakolof Bay Oyster Co.

Summary
Harmful algal blooms have been documented in coastal Alaska since the late 1700s, especially from phytoplankton species that cause paralytic shellfish poisoning (PSP). Alaska has an extensive coastline, with substantial recreational and subsistence harvesting of clams and mussels in coastal communities. While the state tests commercial shellfish product, there is no routine state testing of non-commercial harvests. Kachemak Bay, located in lower Cook Inlet, is a popular location for shellfish harvesters due to the proximity to Anchorage, a major population center in Alaska. In an effort to provide better information on HAB risks NOAA's Kasitsna Bay Laboratory (KBL), the Kachemak Bay National Estuarine Research Reserve (KBNERR), and their partners have collaborated to gather data on the phytoplankton in Kachemak Bay and provide information to shellfish harvesters and state agency managers about possible HAB toxins present in the system.

KBL researchers have been conducting intensive field research to determine environmental parameters that may be affecting HABs in Kachemak Bay (*e.g.* sea surface temperature, stratification of the water column, nutrients). KBL also participates in the citizen-based phytoplankton monitoring program run by KBNERR in Kachemak Bay, with funding from the NOAA Phytoplankton Monitoring Network. This monitoring program provides information on seasonal trends and interannual variations in phytoplankton populations with a special emphasis on those species known to cause HABs. In 2016, the Kasitsna Bay Laboratory created a new online HAB risk assessment tool that shows recent PSP toxin results from samples collected in Kachemak Bay, as well as real-time information on sea surface temperature, an environmental parameter that has been shown to be correlated with the risk of a bloom in *Alexandrium*, a dinoflagellate that is known to cause PSP. KBL is also working with our partners at the Department of Environmental Conservation, Alaska Ocean Observing System, Sea Grant Marine Advisory Program, oyster farmers, and Sitka Tribe of Alaska to improve availability of HAB information across the state. Our goals are to help shellfish harvesters make informed decisions about when to harvest and provide resource managers and oyster farmers with better science information and tools to guide their shellfish testing, resource management and farm operations.

Identification of Environmental Drivers Governing HABs in Kachemak Bay, Alaska.

Project Team: Dominic Hondolero[1*], Steve Kibler[2], Kris Holderied[1], Wayne Litaker[2]

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Partners
Kachemak Bay NERR
AOOS
Gulf Watch Alaska

Summary
Through an ongoing Kachemak Bay NERR-Gulf Watch Alaska project, oceanographic data have been collected at a series of transect lines and fixed monitoring stations to track environmental change across Kachemak Bay and Lower Cook Inlet. These data make it possible to track seasonal patterns in chlorophyll, dissolved nutrients, phytoplankton and zooplankton. To augment this monitoring dataset, a series of sub-bay locations have been sampled since 2013 to better characterize small scale spatial-temporal patterns and the role of nutrients in HAB development and decline. This intensive sampling has revealed that vertical stratification of the water column is a primary control on nutrient availability and the development of the spring diatom bloom in Kachemak Bay. There are indications that milder winters and higher surface water temperatures since late 2013 have promoted more intense blooms of *Alexandrium*, the toxic dinoflagellate that causes Paralytic Shellfish Poisoning (PSP) in Alaska. In the spring of 2016, we have conducted weekly/biweekly HAB monitoring to track the relationship between hydrodynamic forcing, nutrient concentrations, phytoplankton abundance, HAB development and shellfish toxicity among the outer sub-bays (Fig. 1). Results indicate springtime *Alexandrium* blooms initiating from overwintering resting cysts occur first in protected sub-bays like Tutka Bay, Kasitsna Bay and Sadie Cove. These local blooms then seed bay-wide events.

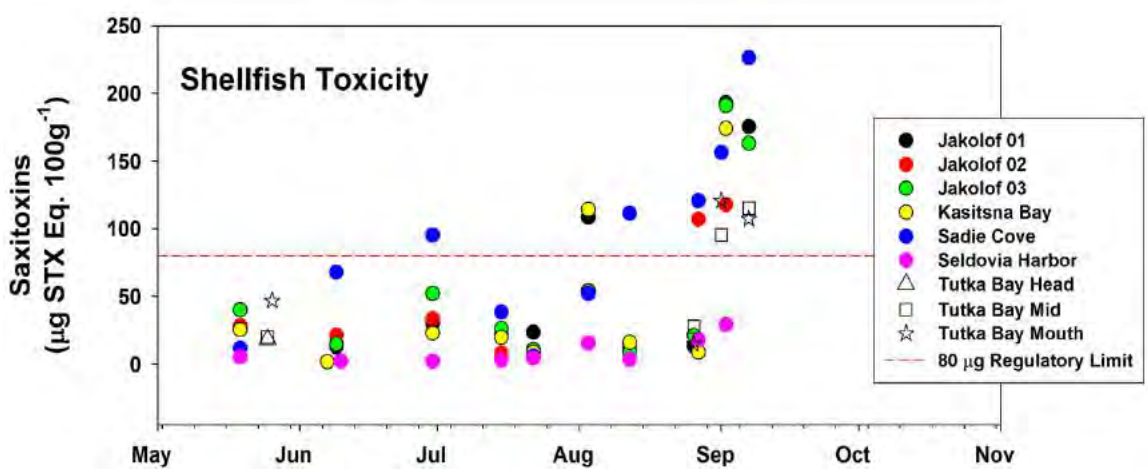

Fig. 1. Shellfish toxicity in Kachemak sub-bays during summer 2016.

Improved Tools for HAB Detection and Monitoring in Alaska.

Project Team: Steve Kibler[1*], Dominic Hondolero[2], Mark Vandersea[1], Kris Holderied[2], Wayne Litaker[1]

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Partners
North Carolina State University, Toxicology Dept.
Kachemak Bay NERR
NOAA Center for Coastal Environmental health & Biomolecular Research
Jakolof Bay Oyster Co.

Summary
Until recently, HAB monitoring and mitigation efforts have relied on shellfish toxicity testing combined with more limited plankton sampling with HAB cell abundance determined via microscopy. Because microscopy-based cell counting methods are unable to adequately quantify low cell concentrations in the period before blooms occur, and shellfish toxicity is not always indicative of HAB cell abundance, sensitive quantitative PCR assays for *Alexandrium* species were developed for routine determination of *Alexandrium* abundance (Fig. 1). Another tool that has been effective for HAB monitoring is the *HABwatch* cage, a low cost mesh cage with Pacific Oysters (Fig. 2) that was moored at sites in Kachemak Bay. *HABwatch* cages allowed monitoring where shellfish were sparse or too small to be effective. Previous testing has showed Pacific Oysters were as effective as mussels for toxin monitoring. Other tools under development for HAB monitoring are sold phase absorption toxin tracking (SPATT) materials. Working with partners at North Carolina State University's Toxicology Dept., we are testing three types of SPATT materials in tandem with the *HABwatch* shellfish cages (Fig. 2). The advantages of the SPATT method include no dependency on shellfish availability, very low material cost, reduced processing time, and elimination of matrix effects during toxin analysis.

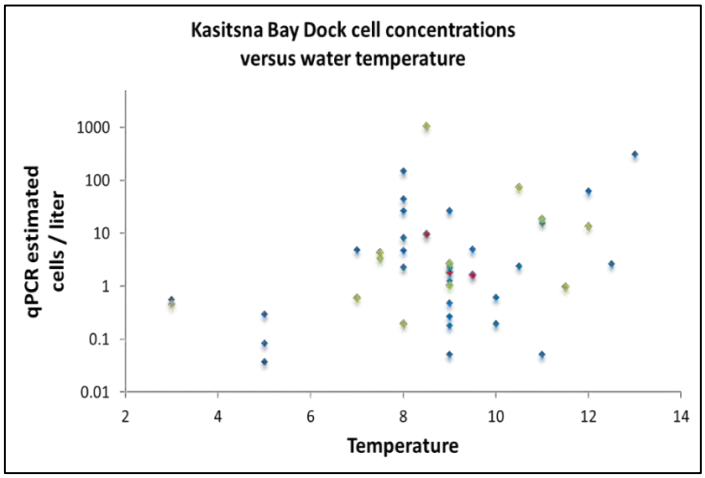

Fig. 1. qPCR data showing *Alexandrium* abundance Kasitsna Bay, Alaska 2013-2014.

Fig. 2. *HABwatch* (lower) and SPATT monitoring cages for HAB toxin monitoring.

Implementation of Community Based PSP Testing for Subsistence and Recreational Shellfish Harvesting In Southwestern Alaska – A Project Description

Project Team: Julie A. Matweyou[1*], R. Wayne Litaker[2], Steven R. Kibler[2], Bruce A. Wright[3], Donnie R. Hardison and Patricia A. Tester[2]

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Summary
Subsistence shellfish harvesters in southwest Alaska are exposed to high paralytic shellfish poisoning (PSP) risks due to their strong cultural traditions, dependency on shellfish resources, and limited accessibility to medical care. The state has a toxin-monitoring program in place for the commercial shellfish industry and samples are submitted to the Alaska Department of Environmental Conservation (ADEC) for analysis ($125/sample + shipping). **Resource limitations, though, have restricted routine testing of recreational/subsistence-harvested shellfish.** A recent ADEC pilot program (2012-2015) demonstrated community-based monitoring is an effective strategy to reduce PSP risks, but the project ended after three years. This study will leverage community networks from the ADEC monitoring program and the Aleutian Pribilof Islands Association (APIA) with NPRB-funded technologies (#1118) to implement subsistence shellfish testing. A new electrochemical PSP test (ECtest) is expected to offer rapid shellfish screening in remote locations. The test features a numerical readout at a cost of <$20/sample. The project will include re-testing of shellfish analyzed previously via ADEC and APIA programs and analysis of new samples collected at the Kodiak and Aleutian Island sites to validate the ECtest. The project objectives are to test commonly harvested bivalve species and implement on-site community PSP testing when the ECtest is internally validated. Shellfish collected by community samplers in the Kodiak Islands (Kodiak, Old Harbor, Ouzinkie) and Aleutian Islands (King Cove, Sand Point) will be screened with the ECtest and the results validated via HPLC analysis (a regulatory method). Outreach will include workshops to gather local knowledge about shellfish resources and cleaning methods, as well as training volunteers in on-site testing methods with the ECtest. Study results will be incorporated into a project web page and fact sheets for public dissemination. Community-based PSP screening and monitoring capacity should ease the burden on ADEC for PSP testing and improve community awareness and information on PSP toxicity trends. The ECtest will also offer the scientific community a tool to monitor the environment for PSP toxins, which may be increasing in Alaska due to climate change.

Exploring primary productivity processes during 2012-2016 through continuous time-series data on water quality in Kachemak Bay.

Project Team: James Schloemer, Angela Doroff*, Catie Bursch, Steve Baird, Rosie Robinson

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Summary
Kachemak Bay is a complex estuary with multiple fresh water inputs including glacial melt water (late summer/fall) and a tidal range of up to 9 m. Beginning in 2001, continuous monitoring of water quality variables provided high-resolution information on seasonal fluctuations and monthly variability of abiotic conditions in the Kachemak Bay estuary. Beginning in 2012, our community-based phytoplankton monitoring program collected and summarized weekly data on surface phytoplankton throughout the year. Water temperatures during the study period included an anomalous cold-water year, a transition year, followed by three anomalous warm-water years. Warmer temperatures may facilitate the onset of HABs and in 2015-2016 our monitoring programs identified toxic events and informed regional closures for shellfish harvest in the Bay. We examine the onset and duration of phytoplankton proliferation relative to water temperature, salinity, photosynthetically active radiation, dissolved oxygen, as well as chlorophyll fluorescence. The diversity of phytoplankton occurring in Kachemak Bay consists of diatoms (32 genera/ 11 common) and dinoflagellates (12 genera/ 5 common), providing additional complexity given genera-specific bloom conditions, however, the annual onset of phytoplankton production and depletion are evident in these data. Diatoms generally become abundant in early spring; during 2012, 2014, and 2015 (phytoplankton became abundant April 01 ± 1 week); 2013 (March 23 ± 1 week); 2016 (May 01 ± 1 week). Dinoflagellates became abundant for periods in mid-late fall; 2013 (August 01 - 14 and September 15 – November 14); 2014 (September 01 – 07); 2015 (October 8 – 31); 2016 (August 23 – September 7); 2012 (no dominance observed). By November 14 of all years there were low levels of phytoplankton in the system until the following spring. Despite favorable growth conditions there were isolated periods of low presence during 2013, 2014, and 2015. These data suggest influence by other system factors and the need for more thorough inspection of its components.

Identifying Environmental Drivers of *Alexandrium* Harmful Algal Blooms in Southeast Alaska

Project Team: Elizabeth Tobin[1*], Ginny Eckert[1], Cody Crumpton[2] and Chelsea Wallace[2]

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Partners
Southeast Alaska Tribal Toxins (SEATT)
Sitka Tribe of Alaska Environmental Research Laboratory (STAERL)

Summary
Paralytic shellfish toxins (PSTs) that cause paralytic shellfish poisoning (PSP) in Alaska threaten public health, impact important traditional foods and diminish valuable shellfish resources. Despite the long recognized impacts of PSP to coastal communities, very little information exists regarding the ecological mechanisms that support bloom formation of the causative marine alga, *Alexandrium* sp., in Southeast Alaska. Researchers at the UAF Juneau Center conducted an intensive regional survey to identify source locations (cyst "seedbeds") of toxic *Alexandrium* blooms in areas of Northern Southeast Alaska with historically high concentrations of toxic shellfish. Survey data indicates that Porpoise Islands (Icy Strait), Game Creek Point (Port Frederick), Auke Bay and Bridget Cove (Favorite Channel) are likely bloom initiation sites for the Juneau and Icy Strait areas. Weekly to monthly phytoplankton and water quality monitoring data collected from 2008-2016 in Auke Bay were analyzed to identify environmental conditions associated with toxic *Alexandrium* blooms. A robust correlation between *Alexandrium* cell abundance and particulate (intercellular) saxitoxin concentrations provides evidence that local *Alexandrium* populations consistently produce paralytic shellfish toxins even at low abundances. Initial results indicate that toxic *Alexandrium* cells begin to proliferate in near-surface waters when sea surface temperature (SST) reaches 7°C. While *Alexandrium* was present across a range of SSTs (7-15°C) and surface salinities (7-30 psu), the highest cell densities were observed during intermediate SSTs (11-13°C) and salinities (21-23 psu). These initial findings suggest an optimum temperature/salinity window for accelerated growth of *Alexandrium* in Southeast Alaska. Continued work to examine additional environmental variables, such as nutrients, river discharge, precipitation, stratification and wind, that support rapid growth of toxin-producing *Alexandruim* will help build predictive capacity in the timing, distribution and impacts of paralytic shellfish toxins in Southeast Alaska.

Linking traditional knowledge and ecological studies to improve understanding of paralytic shellfish poisoning and enhance sustainability of shellfish harvest in Southeast Alaska.

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Partners
Hoonah Indian Association

Summary
Shellfish are an important traditional food for many Alaskans, but regular outbreaks of paralytic shellfish poisoning (PSP) caused by the saxitoxin-producing marine alga, *Alexandrium sp.*, make recreational and subsistence harvest unsafe. Within the last 5 years, there have been more than 30 reported cases of PSP in Alaska, including 2 fatalities. This study aims to enhance sustainability of shellfish harvest in Southeast Alaska by examining both the natural and human dimensions of the PSP problem. We conducted interviews and mapping exercises with recreational and subsistence harvesters in the northern Southeast Alaska communities of Juneau and Hoonah to document local and traditional knowledge (LTK) about how people experience and respond to PSP and to inform ecological research efforts. Because PSP in Alaska is centuries old, knowledge about the timing and locations of safe and unsafe shellfish harvest have been passed on orally through generations. Distinct spatial patterns of shellfish toxicity in the Icy Strait region of Southeast Alaska were revealed from interviews. Longtime (>30 years) harvesters did not report any noticeable changes in shellfish toxicity attributed to PSP over time. This LTK was used to investigate benthic populations of *Alexandrium* cysts in an intensive regional-scale effort to identify potential sources of toxic blooms. The expansive coastline and routine shellfish harvest in rural communities impose significant challenges for biotoxin management and research in Alaska. Integration of LTK and ecological inquiry is one approach to overcome these challenges and can provide insight on long-term toxicity patterns, identify community adaptation strategies, and determine the social and ecological features that support sustainable shellfish harvest.

AHAB

Alaska Harmful Algal Bloom Monitoring Partnership

What is AHAB?

In Alaska there are several types of algae that can cause harm when populations reach high enough numbers. During these harmful algal blooms (HABs), the algal species and their toxins can accumulate in shellfish and can also be transferred up the food chain to humans. In addition, high concentrations of some algal species can cause fish mortality. The first recorded death due to paralytic shellfish toxins in Alaska was in 1799 when a party of Aleut hunters under the command of a Russian fur trading company ingested mussels. Within minutes, half the party experienced nausea and dry mouth, and two hours later, 100 hunters had died. Alaska has one of the highest incidences of reported paralytic shellfish toxins in the world. Paralytic shellfish poisoning (PSP) can cause paralysis, gastrointestinal problems, and respiratory arrest and can be fatal if prompt medical care and respiratory support is not available. The illness of 24 people and death of 2 people in Southeast Alaska due to PSP in 2010 and 2011 illustrate the urgent need for change in the way paralytic shellfish toxins are monitored and managed in Alaska. The AHAB partnership has created new capabilities for HAB monitoring which, together with regulatory testing of shellfish by the Alaska Department of Environmental Conservation, results in safer shellfish harvesting in Alaska.

The goal of AHAB is to provide sufficient warning of harmful algal bloom events to enable safe shellfish harvesting in Alaska.

Partnership Goals

The goal of AHAB program is to provide sufficient warning of HAB events to enable early or selective harvesting of shellfish, thereby minimizing risks to human health and reducing economic loss to Alaska shellfisheries. To best accomplish this goal, the program objectives are: 1) to use monitoring of phytoplankton with net tows and microscopes as an early warning of shellfish toxicity; 2) to rapidly screen for HAB toxins in shellfish; 3) to determine which locations have the highest risk of HABs to allow for safe expansion of the shellfish industry, and 4) to determine which combination of environmental factors can be used for early warning of HABs in Alaska.

The Partners

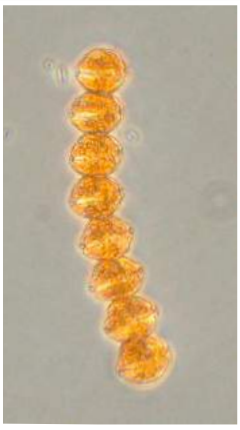
AHAB is a diverse partnership of shellfish farmers, science centers, national research reserves, high schools, universities, State agencies, and Alaska Natives. AHAB collaborates with State Department of Epidemiology, the Alaska Department of Environmental Conservation, and the Department of Health and Human Services. Only through collaboration can our efforts to mitigate the massive effects of PSP be achieved.

The Monitoring Program

AHAB participants currently sample at important recreational, commercial and subsistence shellfish harvest sites in Alaska. Seawater is collected and tested for salinity, temperature, and toxins. The abundance of harmful species *Pseudo-nitzschia, Alexandrium,* and *Dinophysis* is determined. This information is used to gain an understanding of bloom dynamics, to assess which environmental factors are conducive to HAB formation, and which predictive factors may be used to forecast outbreaks.

What We Do

AHAB is a dynamic, expanding program. AHAB leads training classes on microscope methods and rapid screening tests for toxins in shellfish and seawater. Monitoring for HABs can be a part of real-world science in your community -- for schools, AHAB is science project that is achievable by students -- for shellfish farmers, rapid testing for toxins will help reduce economic impacts – for science centers, phytoplankton identification provides relevance to community outreach.



The Harmful Species

Alexandrium, a dinoflagellate, as its name implies, has two flagella and can therefore move up and down through the water column. It is known for the suite of toxins that it produces (saxitoxin and gonyautoxin derivatives) referred to as paralytic shellfish toxins (PSTs). PSTs are responsible for the human illness called paralytic shellfish poisoning which can cause tingling of the lips, tongue, short term paralysis and even death. PSTs have been responsible for frequent shellfish closures in Alaska for centuries with an increase in closure locations and frequency in recent years. Some of the highest PST concentrations in the world have been measured in Alaska.

Pseudo-nitzschia, a needleshaped pennate diatom. Some species of *Pseudo-nitzschia* are known to produce the toxin, domoic acid, which when concentrated in shellfish and transferred up the food chain, can cause neurological damage and in severe cases, death in marine birds, marine mammals, and humans. Domoic acid poisoning in humans, also known as amnesic shellfish poisoning (ASP), can cause temporary and in more severe cases, permanent short-term memory loss. Low levels of domoic acid have been measured in Alaskan shellfish since at least 2004.

Dinophysis, a dinoflagellate, includes some species that are known to produce toxins such as okadaic acid, dinophysis toxins and pectenotoxins, which are responsible for the human syndrome called diarrheic shellfish poisoning (DSP). Diarrheic shellfish poisoning includes gastrointestinal symptoms such as diarrhea, nausea, vomiting and abdominal cramping. Several species of Dinophysis are present in Southeast Alaska and these cells have been observed in high numbers. Shellfish closures have occurred in the adjacent waters of British Columbia. Currently, there is no formal testing program in Alaska for toxins associated with DSP.

Who We Are

Kate Sullivan from University of Alaska Southeast and Ginny Eckert from University of Alaska Fairbanks lead training courses, site visits, and overall project management including information management, outreach, and project sampling design. Steve Morton and Jeff Paternoster from NOAA Charleston provides phytoplankton species identification and database administration. Vera Trainer and Bich-Thuy Eberhart from NOAA's Northwest Fisheries Science Center provide analysis of seawater and shellfish samples for HAB toxins.

AHAB

Alaska Harmful Algal Bloom Monitoring Partnership

Funding Provided By

The University of Alaska, United States Department of Agriculture, National Oceanic and Atmospheric Administration's (NOAA) National Center for Coastal Ocean Science Monitoring and Event Response to Harmful Algal Blooms Program, NOAA Northwest Fisheries Science Center, NOAA National Ocean Service, Alaska Sea Grant, the US Centers for Disease Control and Prevention, and the North Pacific Research Board.

Contact Information

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NOAA — National Oceanic and Atmospheric Administration, U.S. Department of Commerce

UAS University of Alaska Southeast — learn · engage · change

UAF University of Alaska Fairbanks

Summary of Domoic Acid and Saxitoxin in Walruses and Ice Seals

Lori Quakenbush and Anna Bryan

The Alaska Department of Fish and Game (working with the U.S. Fish and Wildlife Service and the North Slope Borough) contributed stomach and intestinal contents from walruses and ice seals collected between 2006 and 2013 to an overview study of toxic algae exposure (domoic acid and saxitoxin) for multiple species of marine mammals in northern Alaska; the results were published in Lefebvre et al. (2016) with walruses having the highest concentrations of 13 species tested. Additional testing of walruses (2014 and 2016), and ringed and bearded seals (2015) was conducted and results are presented below.

Walruses

Table 1. Domoic acid and saxitoxin concentrations (maximum) in walruses (2012–2013) reported in Lefebvre et al. (2016) and in 2014 and 2016 from walruses harvested in the Bering Sea, Alaska. Highest concentrations are bolded.

Walrus	Domoic acid Max ng/g	Saxitoxin Max ng/g
Lefebvre	**6,457**	240
2014	2,538	**1,162**
2016	49	81

In 2014, we compared toxin concentrations in stomach vs. intestinal contents of the same individuals and found that intestinal content had higher concentrations for both domoic acid and saxitoxin in 5 of 9 (55.6%) walruses tested (Table 2).

Table 2. Domoic acid and saxitoxin concentrations in stomach and intestinal contents from the same individual walruses harvested near St. Lawrence Island, Alaska, 2014.

	Domoic acid		Saxitoxin	
Walrus ID	Stomach content (ng/g)	Intestinal content (ng/g)	Stomach content (ng/g)	Intestinal content (ng/g)
G14-0061	3.78	2,537.37	BDL	23.56
G14-0064	BDL	2.49	BDL	13.76
G14-0070	BDL	245.78	BDL	1,161.80
G14-0072	19.95	BDL	BDL	BDL
G14-0085	BDL	BDL	BDL	BDL
G14-0090	3.51	16.56	BDL	7.8
S14-0051	9.79	488.9	BDL	499.04
S14-0056	49.95	12.3	97.49	8.76
S14-0062	BDL	BDL	BDL	BDL

In 2016, we compared toxin concentrations in stomach contents vs. urine and found that domoic acid concentrations were higher in urine for 6 of 9 (66.7%) walruses, but for saxitoxin only 4 of 9 (44.4%) were higher (Table 3). Domoic acid in urine was above detection limits for all walruses tested (n = 9), even when stomach contents were below detection (5 of 9). Saxitoxin in urine was more variable and was above detection limits for 5 of 9 tested but only matched concentrations found in stomach contents for two of them. In one animal both were below detection and in the other both had detectible concentrations with stomach contents at a higher concentration (Table 3). Therefore it appears that urine may be the best matrix to detect domoic acid, and intestinal content may be best for saxitoxin. Unfortunately, we were not able to test all three matrices in the same individuals, doing so is necessary to determine if urine is better than intestinal content for either toxin.

Table 3. Domoic acid and saxitoxin concentrations in stomach contents and urine from the same individual walruses harvested near St. Lawrence Island, Alaska, 2016.

	Domoic acid		Saxitoxin	
Walrus ID	Stomach content (ng/g)	Urine (ng/ml)	Stomach content (ng/g)	Urine (ng/ml)
S16-010	3.5	3.4	28.9	BDL
S16-011	4.3	0.6	7.5	BDL
S16-014	BDL	3.3	27.2	6.2
S16-016	BDL	1	BDL	BDL
S16-028	10.1	2.3	28.8	BDL
S16-032	BDL	1.1	BDL	14.1
S16-037	BDL	49	BDL	4.2
S16-038	0.0	2.0	BDL	3.8
S16-039	BDL	19.6	BDL	4

In an effort to determine the source of the toxins found, we analyzed feet and siphons of several species of clams found in five walrus stomachs that tested positive for toxins. All clam parts from all stomachs had measurable concentrations of domoic acid (range 2.8–29.0 ng/g) and saxitoxin (12.4–60 ng/g) (Table 4). All concentrations of domoic acid and saxitoxin measured in these clams were below the regulatory limits for human consumption. However, additional testing of walrus stomach contents, intestinal contents, urine, milk, amniotic fluid, and prey items in stomachs and intestines should be conducted to better understand and monitor HABs in walruses. Because these toxins depurate rapidly it is likely that any detection in any matrix indicates that higher concentrations likely occurred prior to sampling, therefore low concentrations should not be assumed to indicate low exposure.

Table 4. Domoic acid and saxitoxin concentrations in three genera of clams removed from the stomachs of walruses harvested near St. Lawrence Island, Alaska in 2016.

			Domoic acid		Saxitoxin	
Walrus ID *Bivalve from stomach*	# of bivalves analyzed	Bivalve part analyzed	Stomach content (ng/g)	Urine (ng/ml)	Stomach content (ng/g)	Urine (ng/ml)
S16-007			**7.6**	**-**	**30**	**-**
Serripes spp.	2	Feet	21.0		17.6	
Mactromeris polynyma	1	Foot	29.0		12.4	
S16-010			**3.5**	**3.4**	**28.9**	**BDL**
Serripes spp.	3	Feet	3.6		33.2	
Mya spp.	~6	Feet and siphons	4		24.4	
S16-014			**BDL**	**3.3**	**27.2**	**6.2**
Mya spp.	1	Foot and siphon	2.8		20.4	
S16-028			**10.1**	**2.3**	**28.8**	**BDL**
Serripes spp.	4	Feet	26.7		14.3	
Mactromeris polynyma	2	Feet and siphons	20.9		20.0	
S16-031			**4.8**	**-**	**81.1**	**-**
Unidentified bivalve	~20	Feet and tissue	19.2		60	

Ice seals

In 2015, stomach contents were tested from 52 ringed seals and 48 bearded seals. Most were below detection limits for both domoic acid and saxitoxin. Domoic acid was detected in 5 (9.62%) ringed seals and 4 (8.3%) bearded seals (Table 5). Saxitoxin was detected in one ringed seal and two bearded seals. All detected levels of both domoic acid and saxitoxin were low and not likely to cause harmful effect to seals.

Table 5. Domoic acid and saxitoxin concentrations (maximum) in ringed (2006–2012) and bearded seals (2007–2013) reported in Lefebvre et al. (2016) and in 2015 from seals harvested in the Bering and Chukchi seas, Alaska. Highest concentrations are bolded.

Species	Domoic Acid Max ng/g	Saxitoxin Max ng/g	Source
Ringed seal	**127**	**172**	Lefebvre
	32	33	2015
Bearded seal	48	**15**	Lefebvre
	73	11	2015

Overall Summary

It is unknown at what concentrations these algal toxins are harmful to these pinnipeds. In addition to stomach and intestine contents and urine, they are found in amniotic fluid and milk and thus could be harmful to neonates. Fortunately, domoic acid and saxitoxin do not reside in muscle, blubber, or other tissues commonly eaten by humans. However, the toxins are found in the clams in walrus stomachs; clams are highly favored as food by hunters and their families. These clams are the likely source of the algal toxins in the walrus stomachs.

Reference

Lefebvre K. A., L. Quakenbush, E. Frame, K. B. Huntington, G. Sheffield, R. Stimmelmayr, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gill. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae 55:13–24.

Alaska Ocean Observing System
1007 W. Third Avenue, Suite 100
Anchorage, AK 99501
907.644.6703 www.aoos.org

"SUSTAINED" COASTAL AND OCEAN OBSERVING INITIATIVES AROUND ALASKA

In order to maximize our investment in harmful algal bloom research and monitoring activities in Alaska, we encourage any new HABs initiatives be coordinated with and leveraged by existing coastal and ocean observing activities around the state. The following highlights the primary sustained efforts we're aware of, but may not be completely exhaustive. Please let Carol Janzen at the Alaska Ocean Observing System know if you are aware of other efforts that should be included here. janzen@aoos.org.

Alaska Ocean Observing System (AOOS): www.aoos.org
AOOS is the Alaska regional component of the national Integrated Ocean Observing System (IOOS- https://ioos.noaa.gov/). AOOS collaborates with other entities with funding support for the following long-term observing activities around Alaska:

- Ecosystem Moored Observatories:
  - Complete: Chukchi Sea (near Hanna Shoal)
  - Planned: Bering Sea, Beaufort Sea, and Gulf of Alaska
- Real-time Wave Buoys:
  - Year-Round, Lower Cook Inlet, CDIP Buoy (since 2011)
  - Seasonal, Bering Strait, AXYS ™ Watchmate Buoy (2013, 2014, 2015, ?)
- Water level:
  - Real-time acoustic iGage water level observations from 9 remote villages
  - Pilot water level projects for new observing technologies /implementations
- Gliders: Summer, open water glider surveys along Bering Sea Coast, 2013-present
- Ocean acidification:
  - OA Research Center
  - OA moorings (Gulf of Alaska, Seward and Bering Sea) (2011 - *)
  - OA sampling along the Seward Line biannually (2008 - *)
  - Burk-O-Lator at Seward Alutiiq Pride Hatchery (2014-*)
  - 2017, Underway OA and other parameters made on AK Ferry M/V Columbia traveling weekly from Bellingham, WA to Skagway, AK, round-trip

AOOS also supports a regional Data Assembly Center that houses the largest collection of Alaska coastal and ocean data, and facilitates several collaborative efforts including the Alaska Ocean Acidification Network (http://www.aoos.org/alaska-ocean-acidification-network/) and the Alaska Integrated Water Levels Observing Network.

NOAA Pacific Marine Environmental Laboratory (PMEL), Seattle, WA: http://www.pmel.noaa.gov/

- EcoFOCI – Ecosystems and Fisheries Oceanography Coordinate Investigations: http://www.ecofoci.noaa.gov/

Purpose – To study the ecosystems of the North Pacific Ocean, Bering Sea and U.S. Arctic to improve understanding of ecosystem dynamics and apply that understanding to the management of living marine resources. EcoFOCI scientists integrate field, laboratory and

modeling studies to determine how varying biological and physical factors influence large marine ecosystems within Alaskan waters. M2 is a long term mooring in the Bering Sea; http://www.pmel.noaa.gov/foci/foci_moorings/mooring_info/mooring_location_info.html

- Ocean Climate Stations: http://www.pmel.noaa.gov/ocs/ ;
- Ocean Station Papa http://www.pmel.noaa.gov/ocs/ (1949 discontinuous - *)

Papa Ocean Station Papa (50°N, 145°W) is an important site for continued monitoring of ocean climate, because it has one of the oldest oceanic time series data records.

- PMEL Arctic Zone: http://www.pmel.noaa.gov/arctic/
- Distributed Biological Observatory: http://www.pmel.noaa.gov/dbo/
- RUSALCA – Russian-American Long-term Census of the Arctic: http://www.pmel.noaa.gov/rusalca/

NOAA Carbon Program: http://www.pmel.noaa.gov/co2/

This program focuses on observations of key physical, chemical, and biological parameters to support NOAA's overall efforts to predict how marine ecosystems will respond and to develop management strategies for adapting to the consequences of ocean acidification. Alaska (AK) efforts include:

- Long term moorings: There were four OA specific moorings in AK from 2011- 2016. Two remain: one in Resurrection Bay (GAKOA) and the other in the lower Bering Sea (M2). (http://www.pmel.noaa.gov/co2/story/Coastal+Moorings)
- Research cruises: To date, shipboard surveys covered open ocean conditions (i.e. World Ocean Circulation Experiment - WOCE). NOAA is now working on a coordinated interdisciplinary ship-based hydrography along the US coasts and in large estuaries. An Alaska-wide onshore intensive cruise took place in 2013-14 that sampled over 1200 stations. Cruise return plans to repeat surveys every four years.
- Underway platforms: 2014, two Liquid Robotics wave-gliders were deployed during the summer and monitored surface OA and CTD parameters in the Gulf of Alaska. In 2016 the OA wave-gliders were deployed in the Arctic. Trial deployments of two SailDrones (another form of autonomous glider) in the Arctic in 2016 measure surface CTD parameters.

University of Alaska Fairbanks College of Fisheries and Oceanography (UAF-CFOS): http://www.uaf.edu/cfos/

- The Seward Line (1998 – present): (https://www.sfos.uaf.edu/sewardline/)
    - Purpose - To develop an understanding of the response of this marine ecosystem to climate variability
- Long-term GAK1 mooring in Resurrection Bay (1998 – present): (http://www.ims.uaf.edu/gak1/) and (http://www.gulfwatchalaska.org/monitoring/environmental-drivers/gulf-of-alaska-mooring-gak1-monitoring/)
    - Long term measurements (not all from the mooring) date back to 1970.

University of Washington-Applied Physics Laboratory (UW-APL) http://www.apl.washington.edu/

- International Arctic Buoy Programme (http://iabp.apl.washington.edu/) (early 1990s)

Purpose - To maintain a network of drifting buoys in the Arctic Ocean to provide meteorological and oceanographic data for real-time operational requirements and research purposes including support to the World Climate Research Programme (WCRP) and the World Weather Watch (WWW) Programme.

- Bering Strait Moorings: Pacific Gateway to the Arctic (1990-*)

Purpose – To maintain moorings that measure temperature, salinity, water velocity, and sometimes nutrients, fluorescence, transmissivity to monitor flow through the western and eastern channels of the Bering Strait. There are currently 3 moorings in on this project that are regularly serviced annually.
(http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html)

Pribilof Islands - Bering Watch (St. Paul Island, King Cove, and St, George Island)
Purpose: to provide data collection tools to enable and empower local environmental and community-based monitoring and to facilitate communication of relevant ecological and biological information with all stakeholders. These data are not currently shared.
(http://www.beringwatch.net/site/)

- Includes wide ranging descriptive data (e.g., environmental anomalies) and more focused, detailed observations on specific, or focal, species (e.g., this program participates in the USFWS Izembek Wildlife Refuge monitoring activities).
- Maintain the local "Citizen Sentinel" network to record observations from community members (e.g. hunters and fishermen).

Kodiak Laboratory, Alaska Fisheries Science Center, NOAA – Kodiak, AK:
http://www.afsc.noaa.gov/kodiak/kodiakLab_HOME.php

- Shellfish Assessment Program: Includes Ocean Acidification and Climate Research Activities, primarily in laboratory impact experiments.
(http://www.afsc.noaa.gov/RACE/shellfish/shellfish_HOME.php)
- Groundfish Assessment Program: Conducts field and laboratory research on the abundance and distribution of marine invertebrate and fish populations, their life history, population dynamics, habitats, ecological interactions, and impacts of human activities such as bycatch, discard mortality, and habitat alteration.

Kasitsna Bay Lab, NOAA, Seldovia, AK:
http://www.nurp.noaa.gov/Spotlight/KasitsnaBay.htm

- Partnerships between NOAA's National Ocean Service (NOS) and Office of Oceanic and Atmospheric Research (OAR), through the National Undersea Research Program (NURP)
- Serves as an Alaska field station of the Center for Coastal Fisheries and Habitat Research
- Marine research and teaching laboratory for UAF and Cold Water Diving Program
- Collaborates regularly with KBNERR Kachemak Bay monitoring activities (described next).

Kachemak Bay National Estuarine Research Reserve, NOAA/UAA, Homer, AK:
http://accs.uaa.alaska.edu/kbnerr/

Purpose - KBNERR is a state-federal-local partnership managed by the Alaska Center for Conservation Science at the University of Alaska, Anchorage (UAA), in partnership with the NOAA. Main functions include research and monitoring to support successful coastal management strategies. Coastal topics include ecosystem dynamics, coastal currents, salmon biology, **harmful algal blooms**, ocean acidification, bivalve populations, and socio-ecological issues.

- HABS at KBNERR: (http://accs.uaa.alaska.edu/kbnerr/harmful-algal-bloom-monitoring/)
Includes monitoring for specific groups of phytoplankton known to carry toxins that can result in shellfish poisoning; monitoring phytoplankton to provide valuable baseline information on the bloom cycles; collecting~200 phytoplankton samples from 12 sites using community members and KBNERR staff.

- Surface and near-bottom samples and CTD casts are collected along four transects in Lower Cook Inlet and Kachemak Bay (12 stations) and sampled quarterly.
- One transect in Kachemak Bay (10 stations) are sampled monthly.

Prince William Sound Science Center, Cordova, AK: http://pwssc.org/

- (Zoo)Plankton Monitoring Program: 2007 - present

Supports Herring recovery research by a grant from the **Exxon Valdez Oil Spill Trustee Council**. Surveys plankton populations in the spring (as herring juveniles recover from the winter and also when herring larvae start feeding) and autumn (prior to over-wintering) to monitor populations. Copepods of the genus Neocalanus, the most common medium-sized zooplankton in the Gulf of Alaska, are a very important prey item for herring.
(http://pwssc.org/plankton-monitoring/

- Oceanography: programs aimed at understanding integrated ecosystem functions;
- Moored profiling moorings, plankton and oceanic observations;
- Monthly surveys of zooplankton and oceanographic conditions at 12 locations in Prince William Sound. At each station, zooplankton species sample (concentration and abundance), water temperature, salinity, chlorophyll, turbidity; and nitrate. http://pwssc.org/plankton-and-oceanic-observations-in-prince-william-sound/

Auke Bay Laboratories, NOAA, Juneau, AK: http://www.afsc.noaa.gov/ABL/default.php
The Alaska Fisheries Science Center's Auke Bay Laboratories (ABL) conducts scientific research throughout Alaska on commercially marketable fish species and on all aspects of marine ecosystems (ocean physics and chemistry essential to fish habitats, and the structure and functioning of marine food webs). Many observations are made opportunistically with the fishing fleet.
(http://www.afsc.noaa.gov/ABL/EMA/EMA_default.php)
Four main programs:

1. Marine ecology and stock assessment
2. Recruitment energetics and coastal assessment
3. **Ecosystem monitoring and assessment**

Oceanographic observations include conductivity-temperature with depth (CTD), nutrient levels, and estimates of the composition and biomass of **phytoplankton** and zooplankton (includes jellyfish) species. Observations are used to connect climate change and variability in large marine ecosystems to early marine survival of commercially important fish species in the Gulf of Alaska, Bering Sea, and Arctic.

4. Genetics

Glacier Bay National Park, AK: https://www.nps.gov/glba/index.htm
Purpose - The Southeast Alaska Network (SEAN) implements long-term ecological monitoring and provides scientifically sound natural resource information to park managers. Scientists in the field at Glacier Bay National Park and Preserve make observations of temperature-conductivity with depth (CTD), salinity, turbidity, dissolved oxygen, **phytoplankton abundance**, and acidity at 24 stations across a 100-km range. Continuous vertical profiles are made as deep as 400 m below the surface. The same stations are measured 9 times each year.
(https://www.nps.gov/glba/learn/nature/ocean.htm)

Alaska SeaLife Center, Seward, AK: http://www.alaskasealife.org/
Projects focus on Alaska marine life and environments. The Center's marine cold water research facilities, live animal collections, and specialized staff allows us to use a combination of experimental and field research to:

- Investigate physiological and ecological processes affecting marine animal population dynamics.
- Conduct controlled experiments to understand factors affecting reproductive success and fitness in marine species.
- Monitor marine animal responses to environmental variability and stressors.
- Evaluate human impacts on our marine environment and animal populations.\
- Develop tools to support recovery and restoration of marine resources.

Example Program: Bioindicators for coastal monitoring developed methods to use bay mussels in coastal monitoring programs in arctic and subarctic environments. The results from this study will provide methods to assess environmental stress in bay mussels, a potential indicator of coastal environmental conditions and change.

Sitka Sound Science Center, Sitka, AK: http://www.sitkascience.org/

- The Chum Project is aimed at addressing concerns about escapement of hatchery fish and interactions with wild stocks; Sperm whale avoidance and Killer Whale projects; marine debris.
- SSSC is planning (with Sitka Tribe) to deploy a mooring that will included CTD, DO, OA sensors and possibly other variables in 2017. (contact PI: Esther Kennedy)

SEATOR – Southeast Alaska Tribal Ocean Research: Sitka, AK; http://www.seator.org/

Two main programs:

- STAERL (Sitka Tribe of Alaska Environmental Research Lab): Purpose - to give shellfish harvesters a way to test subsistence shellfish. Both commercial and subsistence toxin testing are focused on increasing SEATT partnerships and local citizen's access to local shellfish. http://www.seator.org/Lab
- The Southeast Alaska Tribal Toxins (SEATT) network coordinates 15 souteast Alaska Tribal responses to the threat of toxic shellfish and HABS. Purpose - to inform communities about the current risks of harvesting subsistence shellfish and assess total vulnerability to toxic shellfish. This program is collaborating and supported in part by the NOAA NW Fisheries Science Center Marine Biotoxin Program. http://www.seator.org/seatt
    - Each SEATT partner monitors phytoplankton weekly at one or more key community harvest sites.
    - Parameters include water samples for cellular toxin analysis, air and water temperature, salinity, and shellfish for biotoxins analysis, such as PSP and domoic acid.

North Pacific Research Board, Anchorage, AK: www.nprb.org

Purpose - To support research on or relating to the fisheries or marine ecosystems in the North Pacific Ocean, Bering Sea, and Arctic Ocean. The core program addresses pressing fishery management issues and important ecosystem information needs. Projects are geographically centered in the Gulf of Alaska, Bering Sea & Aleutian Islands, and Arctic Ocean ecosystems.

Alutiiq Pride Shellfish Hatchery, Seward, AK – 2014: http://alutiiqpridehatchery.com/

Conducts shore-based continuous OA Monitoring as part of the IOOS Pacific Region Ocean Acidification Network (**IPACOA**). Using a Burk-O-Lator, this program measures pCO2/TCO2, temperature, salinity, and dissolved oxygen continuously from a flow-through seawater stream and also from discrete samples. They also process water samples for other OA sample collection efforts in the region. http://alutiiqpridehatchery.com/ocean-acidification-monitoring/