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Alaska Harmful Algal Bloom Workshop: Community needs for HAB monitoring, research, and forecasts

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United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
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In-person and virtual attendees on day 3 of the workshop. Some attendees may not be pictured here. Photo credit: Thomas Farrugia

List of Abbreviations

ADEC - ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

ADEC EHL - ADEC'S ENVIRONMENTAL HEALTH LABORATORY

ADF&G - ALASKA DEPARTMENT OF FISH AND GAME

ADOH - ALASKA DEPARTMENT OF HEALTH

AOAN - ALASKA OCEAN ACIDIFICATION NETWORK

AOOS - ALASKA OCEAN OBSERVING SYSTEM

AHAB - ALASKA HARMFUL ALGAL BLOOM NETWORK

APMI - ALUTIIQ PRIDE MARINE INSTITUTE

ASG - ALASKA SEA GRANT

ASP - AMNESIC SHELLFISH POISONING

BSNA - BERING STRAIT NATIVE ASSOCIATION

BIA - BUREAU OF INDIAN AFFAIRS

CDC - CENTER FOR DISEASE CONTROL AND PREVENTION

CRP - NOAA NCCOS COMPETITIVE RESEARCH PROGRAM

DA - DOMOIC ACID

DEC - DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DOC - DISSOLVED ORGANIC CARBON

DSP - DIARRHETIC SHELLFISH POISONING

ECOHAB - NOAA NCCOS CRP ECOLOGY AND OCEANOGRAPHY OF HARMFUL ALGAL BLOOMS (ONE OF FOUR, NATIONAL COMPETITIVE NOAA HAB FUNDING PROGRAMS)

ELISA - ENZYME-LINKED IMMUNOSORBENT ASSAY

EPA - ENVIRONMENTAL PROTECTION AGENCY

EDNA - ENVIRONMENTAL DEOXYRIBONUCLEIC ACID

GAP - INDIAN ENVIRONMENTAL GENERAL ASSISTANCE PROGRAM FROM THE EPA

GTXS - GONYAUTOXINS

HAB - HARMFUL ALGAL BLOOM

HABHRCA - HARMFUL ALGAL BLOOM AND HYPOXIA RESEARCH AND CONTROL ACT

IFCB - IMAGING FLOWCYTOBOT

IOOS - U.S. INTEGRATED OCEAN OBSERVING SYSTEM

IOOS RA - U.S. INTEGRATED OCEAN OBSERVING SYSTEM REGIONAL ASSOCIATION

KANA - KODIAK AREA NATIVE ASSOCIATION

NCCOS - NOAA NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NERRS - NOAA NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

NMS - NOAA NATIONAL MARINE SANCTUARIES

NMFS - NATIONAL MARINE FISHERIES SERVICE WITHIN NOAA

NOS - NATIONAL OCEAN SERVICE WITHIN NOAA

NOAA - NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NSF - (NATIONAL SCIENCE FOUNDATION
NSHC - NORTON SOUND HEALTH CORPORATION
OCADS - OCEAN CARBON DATA SYSTEM
OA - OCEAN ACIDIFICATION; ALSO, THE HAB TOXIN OKADAIC ACID
OAP - OCEAN ACIDIFICATION PROGRAM
ODFW - OREGON DEPARTMENT OF FISH AND WILDLIFE
PMN - PHYTOPLANKTON MONITORING PROGRAM OF NOAA
PNW - PACIFIC NORTHWEST
PSA - PUBLIC SERVICE ANNOUNCEMENT
PWS - PRINCE WILLIAM SOUND
QPCR - QUANTITATIVE POLYMERASE CHAIN REACTION
RBA - RECEPTOR BINDING ASSAY
SEATOR - SOUTHEAST ALASKA TRIBAL OCEAN RESEARCH
SPATT (BAGS) - SOLID PHASE ADSORPTION TOXIN TRACKING
STA-ERL - SITKA TRIBE OF ALASKA ENVIRONMENTAL RESEARCH LAB
STXS - SAXITOXINS
UAF - UNIVERSITY OF ALASKA FAIRBANKS
USDA - UNITED STATES DEPARTMENT OF AGRICULTURE
USFS - UNITED STATES FOREST SERVICE
USGS - UNITED STATES GEOLOGICAL SURVEY
WHOI - WOODS HOLE OCEANOGRAPHIC INSTITUTION

Executive Summary

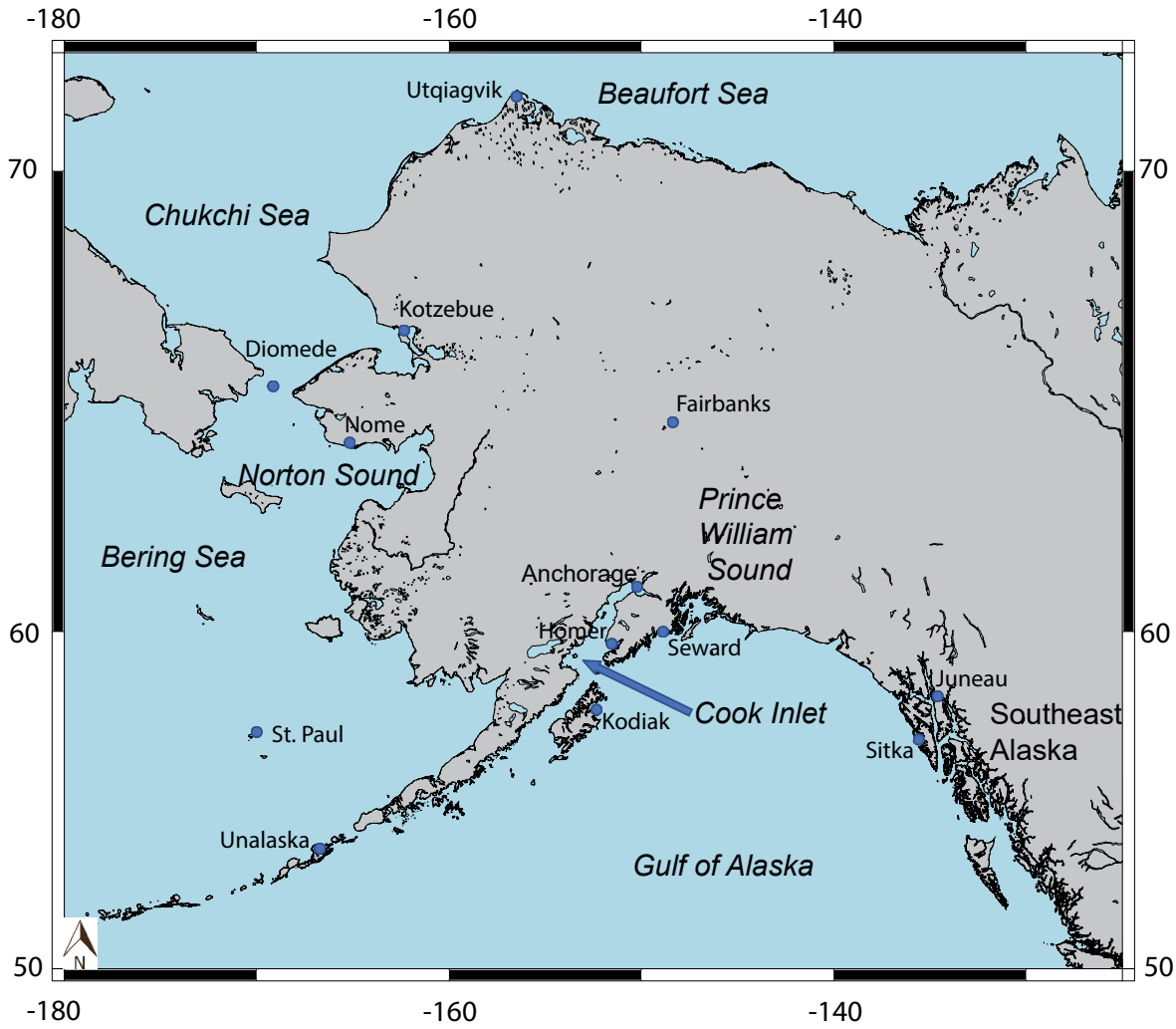
The Alaska Ocean Observing System (AOOS) works to support the Alaska Harmful Algal Bloom Network (AHAB) with assistance from NOAA's National Centers for Coastal Ocean Science (NCCOS) and a variety of other monitoring and research organizations working in Alaska. Together AOOS and NCCOS organized the 2023 Alaska HAB Workshop held at the Hotel Captain Cook in Anchorage, Alaska on March 27-29, 2023.

The goal of this workshop was to gather harmful algal bloom (HAB) samplers, monitors, researchers, and stakeholders living/working in Alaska to discuss community needs for HAB monitoring, research, and forecasting. Participants shared knowledge and current efforts on HABs around the state in order to better understand the distinct needs of communities across Alaska and to coordinate how these needs may be met. This workshop also provided the opportunity to consult experts about specific HAB-related questions and concerns, as well as foster relationships around the state and between agencies and institutions. The last Alaska statewide HAB meeting was conducted in Nome by UAF Alaska Sea Grant in 2019 (AHAB, 2020). The AHAB network, with the help of AOOS, plans to organize these HAB workshops more regularly moving forward.

Some of the topics discussed during the three-day 2023 workshop included:

- Overview of major HABs affecting coastal systems in Alaska.
- The role of the Alaska HAB Network, AOOS, and NOAA, and regional entities/leadership in supporting HAB mitigation.
- Listing of available methods for HAB monitoring and toxin quantification.
- Regional summaries of HAB monitoring impacts on Alaskan communities and ongoing response and mitigation efforts.
- Monitoring and research capabilities within the State.
- HAB monitoring and modeling approaches.
- NCCOS HAB forecasting efforts and potential forecast products.
- Methods for communication of HAB risks, community engagement and education.
- Major needs and challenges for HAB mitigation (i.e. mitigating harmful impacts to human health and the environment).
- Funding sources and approaches for long term HAB monitoring support.

During the months before the workshop, the AHAB Network was solicited for ideas on the best timing and location for the workshop, major topics that should be covered, in-person and virtual participants, and those in need of travel support from outlying parts of Alaska. A web questionnaire was distributed to AHAB members to gather this information. In addition, an Alaska HAB research discussion meeting was held on January 27, 2023 on the last day of the annual Alaska Marine Science Symposium (Anchorage, AK) to serve, in part, as a preliminary discussion about the upcoming workshop and to help formulate the subject matter and possible presenters. This gathered information was then incorporated into the workshop planning and agenda to ensure the needs of Alaskan communities were being served.



Map of Alaska with locations mentioned in this report denoted by blue dots.

Day 1 Current State of HAB work in Alaska

The following sections list major points of information about HABs and discussion. Where applicable, slides used for presentation purposes are shown.

Welcome and Opening Remarks

Thomas Farrugia (AOOS) made opening remarks to the attendees, including a summary of the workshop agenda (Appendix 1), an overview of the primary workshop objectives, and introduction of the speakers and organizational representatives present. A main driver of this workshop was to build community in a format where leaders are given an opportunity to make comments and express concerns. Also covered were the basics of IOOS and AOOS organizational structure. A discussion period followed this and every other presentation.

During an open discussion some dissatisfaction was expressed about whether the current Alaska Ocean Observing Systems (AOOS) format provides adequate representation for the various regions. Mr. Farrugia noted that an alternate suggestion would be to perhaps hold multiple different AOOS workshops in the state as there are four primary oceanic regions within Alaska: the Gulf of Alaska, the Aleutian Islands and southern Bering Sea, the northern Bering Sea/Bering Strait region, and the Chukchi and Beaufort Seas. The number of hosted workshops will be dependent on funding and participant interests. In response to participant questions, a summary of some of the common organizational acronyms was also provided (See List of Abbreviations on pages 5 and 6. The opening remarks concluded with an overview of HABs and toxins occurring in Alaska.

Figure 1. *Alexandrium* and *Pseudo-nitzschia* blooms are the two most common and impactful HABs in Alaska.

Review of Alaska HABs and Toxins

The dinoflagellate *Alexandrium catenella* is the primary HAB issue statewide. Alexandrium is able to produce 20+ toxins, with saxitoxin (STX) often as the primary toxin in Alaskan shellfish. Ingestion of toxic shellfish causes paralytic shellfish poisoning (PSP), a serious and potentially fatal illness. In July of 2020 there was an incidence of a PSP-related human fatality, which was the most recent HAB-related mortality nationwide (State of Alaska, 2020).

Pseudo-nitzschia is the secondary HAB of concern in Alaska. *Pseudo-nitzschia* is a genus of diatoms including a subset of species that can produce the neurotoxin domoic acid (DA). DA can accumulate in shellfish and other biota and causes

amnesic shellfish poisoning (ASP) upon ingestion. Because only low levels of DA have been observed in Alaskan shellfish so far, the current main concern from *Pseudo-nitzschia* blooms is detrimental impacts to wildlife (Lefebvre et al., 2016).

The tertiary HAB of concern in Alaska is Dinophysis, a genus of dinoflagellates which can produce okadaic acid (OA) and other toxins. Upon ingestion, OA causes diarrhetic shellfish poisoning (DSP), an illness that can cause severe gastrointestinal issues. Evidence suggests OA-producing *Dinophysis* blooms are occurring farther north into Alaska from the Pacific Northwest region as a potential result of climate change (Gobler et al., 2017).

Cyanobacteria are a fourth level HAB concern in Alaska. Cyanobacteria generally affect freshwater systems and can cause taste and odor issues in drinking water, or health effects from the cyanotoxins these cells produce. Some cyanobacteria can produce hepatotoxins, which can cause liver damage. No such effects to human or wildlife health have yet been reported in Alaska.

Algal toxins can make their way throughout the food web and researchers are looking into how different elements of the ecosystem can accumulate these toxins. Much of this work in Alaska is being conducted by members of the AHAB network – the AHAB network was formed in 2017 to address the risk of HABs to human health and wildlife populations (Figure 2).

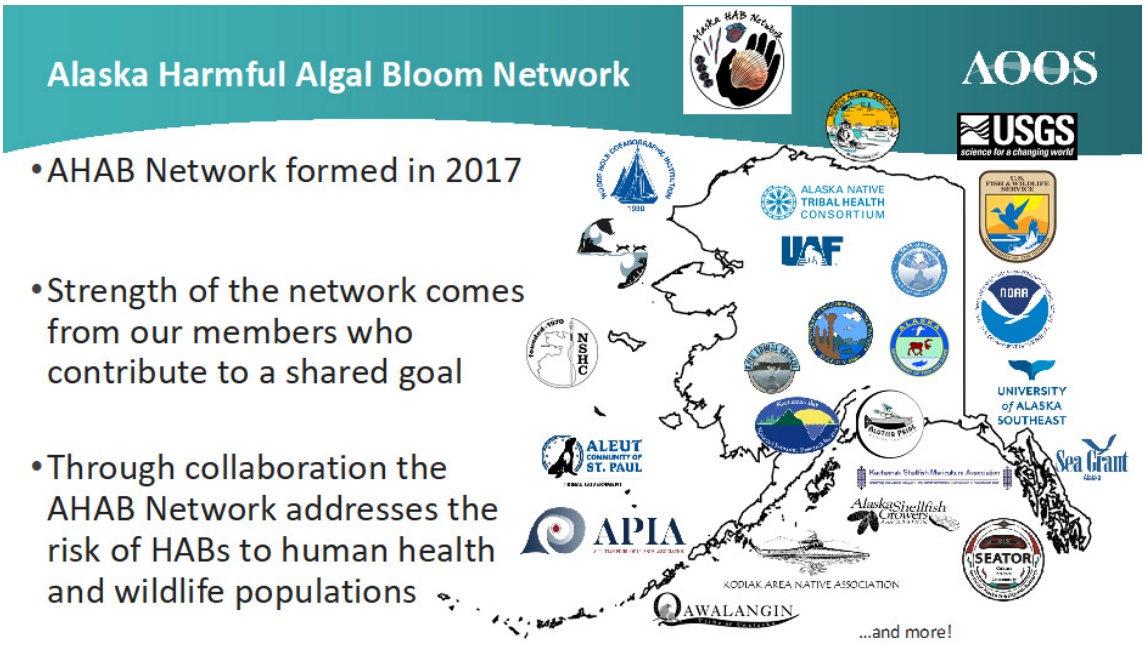


Figure 2. Summary of the Alaska Harmful Algal Bloom Network (AHAB).

Participating scientists pointed out new research in Alaska shows cyanobacterial blooms can also affect coastal environments, so toxins may occur along the length of an estuary as well as the surrounding marine waters.

Participant summaries on HABs in their region/organization

Representatives from participating organization provided summaries detailing which of the main regions of Alaska they work in (e.g., Bering Sea/Bering Strait, Arctic Ocean, the Gulf of Alaska), their specific locations, the institution(s) that they are affiliated with, and a brief synopsis of what HAB-related work that is being done. As was discussed in the opening remarks after each participant spoke, there was time allocated for ensuing questions and further discussion that are summarized here.

Kodiak Ocean Bounty: A shellfish farm located in Larsen Bay on Kodiak Island.

• Expressed support for more HAB research and its importance to shellfish farmers in Alaska.

Norton Sound Health Corporation: A non-profit tribal consortium headquartered in Nome, AK that includes the Norton Sound Regional Hospital in Nome as well as local clinics in the native villages around Norton Sound and the Bering Strait. The mission of the corporation is providing quality health services and promoting wellness among the local people and environment. The main goal of NSHC is to protect human health in the Bering Strait region located ~500 miles off the Alaska road system.

Participant Comments

- Cyanobacteria are an emerging health concern as a problem affecting drinking water resources.
- The Tribal health organizations are an important resource for residents of the Norton Sound-Bering Strait region.
- Staff are trying to start up sampling and monitoring for HABs and ocean acidification at a very basic level.
- Community concerns about HABs are growing in this region.
- There are efforts to coordinate with NOAA, ASG, AOOS, and AHAB on monitoring, messaging, and toxin testing.
- The main HAB-related concern in the region is to understand the severity of recent HABs and toxicity events, but there are no baseline data for HABs in many areas.
- In 2021, members began exploratory HAB sampling, with 2022 being the first year of systematic monitoring.
- The main challenges in the area are extreme resource limitations, including a lack of funding for HAB work and a high rate of staff turnover.
- Tribal environmental workers are trying to do HAB monitoring, but they already have other responsibilities including waste management, air quality monitoring, etc.
- In response to a question about organization, it was clarified that the area monitoring efforts are organized by individual Tribes using EPA GAP-funded staff.
- GAP funding has been flat for years while costs and needs have increased, so there is not enough long-term funding to keep staff supported.
- Even basic phone communication is an ongoing issue in the Bering Strait region. Many people do not have cell phone connectivity and communication can be challenging.
- In the past, the U.S. Coast Guard has been used for emergency marine event response.
- Communications are often taken for granted but this is a big issue in remote areas.

UAF Marine Advisory Program / Alaska Sea Grant (Nome): Bering Strait Agent. The Alaska Sea Grant Marine Advisory Program (MAP) is a university-based statewide program helping Alaskans with the practical use and conservation of the state's marine and freshwater resources. MAP is based at the University of Alaska Fairbanks, and offers technical assistance, marine education, applied research, and other expert advice on how Alaskans can sustain healthy coastal economies, communities and ecosystems.

Participant Comments

- UAF Alaska Sea Grant (UAF-ASG) is a stranding responder with the NOAA Fisheries Alaska Marine Mammal Stranding Network (NMFS).

- The current ECOHAB project led by Woods Hole Oceanographic Institution (WHOI) and NOAA Northwest Fisheries Science Center (NWFSC), of which the UAF-ASG Agent (Nome) is a Co-Investigator, has provided data showing extremely high *Alexandrium* cell abundances in the Bering Strait area during the summer of 2022. Located in the regional hub of Nome, UAF-ASG and NSHC Office of Environmental Health (NSHC-OEH), worked with ECOHAB shipboard researchers as they documented an extreme HAB event during summer 2022. This was an immediate and serious human health, food safety, and food security concern. Working collaboratively, the team was able to prepare

and deliver HAB advisories, as well as other outreach efforts, to provide needed information to coastal communities throughout the Bering Strait region.

- The Alaska Department of Health (ADOH), NSHC-OEH, and UAF-ASG continue to work together to support a response to the novel and concerning issue of HAB events. These efforts include data collection, sample collection, as well as production of educational materials and outreach activities with the regional public regarding HABs.
- During August 2022, results from a large surf clam collected for subsistence purposes three miles offshore of Savoonga, Alaska on St. Lawrence Island had a saxitoxin level that was five times above the FDA regulatory limit for the commercial sale of shellfish.
- Because of the lack of federal managers/researchers of marine resources in the Bering Strait region, it is the citizens, regional healthcare consortium, tribal governments, academic institutions, etc. are the first responders for HAB events. Responders are typically volunteers, with often little to no training, a lack of equipment and/or infrastructure for an adequate response.

Kawerak, Inc.: Bering Strait Native Association (BSNA) organized Kawerak as the regional non-profit corporation to provide services throughout the Bering Strait Region.

- Kawerak seeks to improve the Region's social, economic, educational, cultural, and political conditions.
- Works with NSHC and UAF Alaska Sea Grant (Nome), to support environmental and health concerns in the Bering Strait region.

Kodiak Area Native Association (KANA): Intertribal consortium supporting environmental and human health in Kodiak Tribal villages.

- KANA Is working with all 10 Tribes on Kodiak Island and is primarily a health care organization.
- Funded by EPA GAP funding since 2018, with a Bureau of Indian Affairs (BIA) grant for Tribal resilience.
- Pointed out HABs are a Tribal priority and Kodiak is 1st in the State for the number of PSP cases.
- Current funding for HABs is not a long-term solution as the GAP program may not continue and has been flat funded, so there is not enough to support HAB monitoring staff.
- KANA received a 1-time outlay of $50k from the State, but his does not amount to much.

Alaska Sea Grant Marine Advisory Program – Kodiak

- More State support is needed in Kodiak.
- Sustainability of funds for HAB response and monitoring is needed.
- In 2000, the State started a beach monitoring for shellfish toxicity with sites in Kodiak, but the project was discontinued.
- There is frustration that the State still cannot protect residents from PSP.
- There needs to be more prioritization of serving subsistence shellfish harvesters.
- In follow-up comments it was pointed out that there are labs in the state that can do testing of subsistence samples, such as the recent support by the Knik Tribe of Alaska.
- There is a lack of data interpretation in Kodiak communities, so raw data are not necessarily helpful without some additional information.

Southeast Alaska Tribal Ocean Research (SEATOR)

- SEATOR is organized through the Sitka Tribe of Alaska, but is becoming independent from the Tribe.
- SEATOR runs the Sitka Tribe of Alaska Environmental Research Lab (STA-ERL) in Sitka for shellfish testing and environmental monitoring.

Ocean & Earth Environmental Services: Ocean & Earth is a consulting firm that specializes in building environmental stewardship capacity through integrated partnerships, collaborations, and sound science.

- Ocean & Earth confirmed that SEATOR broke away from the Sitka Tribe.
- Their main function is to pursue funding for HAB support.
- It has been recognized that there are problems using GAP funding as it is a short-term source.

Qawalangin Tribe of Unalaska

- The Qawalangin Tribe is doing weekly HAB sampling for phytoplankton monitoring, *Alexandrium* and *Pseudo-nitzschia* monitoring as well as PSP toxin monitoring in shellfish.
- The main HAB issues in Unalaska involve subsistence harvesting.
- They are also doing some OA sampling with support from the Alutiiq Pride Lab.
- Capacity for shellfish testing is a big issue.
- There is a need to establish a baseline for HABs for ongoing changes.

Aleut Community of St Paul Island, Ecosystem Conservation Office

- Nixle (https://www.nixle.com/) is being used as a cell phone-based notification system for HABs in St Paul.
- Issues about capacity and sustained funding were echoed.
- There is a tradition of sending samples off island for testing.

Alutiiq Pride Marine Institute, Seward, AK.

- The Institute is operated by the tribal consortium Chugach Regional Resource Commission (CRRC).
- Their focus is on monitoring of biotoxins, phytoplankton, water chemistry, and environmental data.
- APMI sites include Southcentral locations in PWS and the Copper River.
- Support is primarily from EVOS with some from GAP funds.
- There are plans to incorporate dissolved nutrient monitoring, quantitative polymerase chain reaction (qPCR), and dissolved organic carbon (DOC).
- In summer, APMI does weekly monitoring of shellfish via ELISA and RBA.
- APMI underwent a rapid expansion from the hatchery, including a new research lab and a molecular lab.
- They share monitoring data on their website.

North Slope Borough, Department of Wildlife Management

- The department includes a wildlife veterinarian/research biologist, several wildlife biologists (management oriented) and subsistence research specialists (local hunters/ TEK holders).
- Focus is on monitoring of health of marine mammal subsistence species, supporting general research, and food safety aspects
- HABs are a number one issue.

Regarding the Seal Monitoring Program: In 2011, the State University of New York (SUNY) ran seal liver samples for cyanotoxins. Two of four samples had trace levels of toxins. This alerted people to a need to start monitoring for cyanotoxins. It is of greatest concern in freshwater lagoons.

Applied Research in Environmental Sciences Nonprofit, Inc.

- The organization is a non-profit through the Department of Energy Management.
- They use NOAA's Phytoplankton Monitoring Network (PMN) methods for monitoring HABs.

- So far, no HABs have been identified.
- They also work with WHOI on HAB cruises.
- Their focus is on education and outreach for community needs.

Woods Hole Oceanographic Institution (WHOI)

- WHOI works on HAB research cruises in N. Bering, Chukchi, and Beaufort Seas.
- Samples of opportunity are a primary collection method.
- Cruises this year have been completed on the R/V Norseman II.
- Methods include quantifying Alexandrium resting cysts, cells in the water column, toxins, and Imaging Flowcytobot (IFCB) monitoring of phytoplankton.
- WHOI also samples benthic invertebrates via an ongoing ECOHAB project.
- They will be putting an IFCB on the R/V Sikuliaq (NSF vessel) in 2023.

Columbia University

- One HAB researcher is currently in Kotzebue working on cyanobacterial blooms in Kotzebue Sound.
- Kotzebue Sound blooms were first noticed in 2009-2010.
- Cyanobacteria are good sentinels of global warming.
- Cyanotoxins are a human health concern.
- Blooms are detected via satellite, and are susceptible to wind-driven distribution.
- They are currently focused on Kobuk Lake, Kobuk River near Kotzebue, and Kotzebue Sound.
- Blooms last through September.
- There was a Pacific Herring fish kill in October 2021 that drew attentions as a possible HAB event.
- Some of the samples are examined using the Planktoscope.
- There are also suggestions that the Foldscope (paper microscope) may be a good tool as well.
- Comment from NCCOS CRP: Funding for cyanotoxin analysis is available through the AHAB.

Kachemak Bay National Estuarine Research Reserve (KBNERR)

- KBNERR started monitoring for HABs in 2006.
- They maintain a partnership with Alutiiq Pride Marine Institute.
- Weekly HAB sampling for phytoplankton cells is currently done.
- Most Kachemak Bay concerns are for HABs affecting shellfish mariculture.
- Historically, Kachemak Bay has not been a hotspot for HABs.

Alaska Dept. Environmental Conservation (DEC), Environmental Health Lab (EHL)

- EHL is the only lab in Alaska certified for commercial shellfish testing.
- EHL also helps support subsistence testing through a Knik Tribe partnership.
- The state needs a better toxin analysis program that is able to do more monitoring.
- Field kits are needed to track toxins with more focus on GTXs.
- Regional toxin kits may be needed to focus on different toxin congeners.

USGS Alaska Science Center

- In 2016, following the large die-off of Common Murres, USGS started HAB toxin analysis of seabirds and forage fish with support from NOAA.

• USGS recently completed a PST dosing trial of seabirds with the Alaska SeaLife Center and the National Wildlife Health Center. This trial investigates the level at which saxitoxin effects the behavior of seabirds in order to assess the ecological relevance of HAB toxins.

• STX has been detected regularly in seabirds, forage fish, invertebrates, and shellfish across Alaska. The concentration of STX in seabirds, forage fish, and invertebrates have generally been low in comparison to human consumption limits.

• DA has been detected less commonly in seabirds, and more frequently in forage fish, invertebrates, and shellfish. The concentration of DA has also been low in comparison to human consumption limits.

NOAA Charleston Lab (Hollings Marine Lab)

• The lab is focused on capacity building for toxin analysis and method development.

• They develop RBA methods for PSP toxins and Ciguatoxins.

• They also support the FDA lab and state labs.

• The Charleston lab works heavily with SEATOR on establishing monitoring in southeast as well as with APMI.

NOAA Alaska Fisheries Science Center – Ecosystem Monitoring and Assessment Program, Auke Bay Lab in Juneau

• The focus is on mariculture, monitoring environmental conditions, phytoplankton community composition via both microscopy for all genera and qPCR on eDNA samples for *Alexandrium*, and PSP toxins in oyster tissue via ELISAs.

• They work to collect samples in the Gulf of Alaska, and IFCB data in the southeast Bering Sea.

• They also work to use satellite algorithms for phytoplankton community characterization.

• The Auke Bay Lab is currently developing an algorithm for dinoflagellates.

• They collect water samples for phytoplankton taxa and size fractionated chlorophyll in the Gulf of Alaska, Bering and Chukchi seas, and IFCB data in the Bering and Chukchi seas.

• Along with collaborators at Pacific Marine Enronmental Laboratory (PMEL), University of Washington(UW), and Bigelow Labs, they work to use satellite algorithms for phytoplankton community characterization. For example, they are currently developing a satellite algorithm for dinoflagellates to determine possible occurrences of *Alexandrium* spp. HABs.

• Mariculture research at AFSC includes monitoring of PSP toxins in Pacific oysters (*Crassostrea gigas*) and harmful algal blooms using eDNA, microscopy (net tows and discrete water samples), and enzyme-linked immunosorbent assays (ELISA).

Alaska Department Fish and Game (ADF&G), Veterinary Toxicology

• ADF&G works on mycopathogens.

• They work on HABs in southeast Alaska.

• They have looked at HAB toxins in wolf packs and sea otters; some of those samples were positive for DA.

USDA Forest Service

• USDA works with the PWS Stewardship Foundation.

• They maintain remote monitoring sites and do monthly sampling of ecotoxins.

• Samples are sent to Alutiiq Pride for analysis.

North Carolina State University (NCSU)

• The Plankton Ecology Lab analyses DA, STX, and cyanotoxins from summer 2018, 2019 and 2022 from varying environments on St. Paul Island.

• The lab works with the Village of Kotzebue on ad-hoc confirmation of cyanotoxins (e.g., microcystin confirmation in pacific herring during mortality event), on employing passive toxin trackers and assist with building on-site capacity for toxin analyses using ELISAs.

General Discussion Topics

A breakout session enabled participants from Alaska subregions to discuss their local HAB issues and then report back to the whole audience on their greatest priorities. But there was general agreement that discussion of some of these same topics would be more useful with all participants. Some of the salient topics of discussion follow.

A. HAB Funding Needs and Challenges

- SEATOR started with a meeting of 3-5 people in 2012-2013 for NOAA PMN training and some toxin testing. In 2015, the testing lab started doing shellfish analysis at small scale, expanded to 50-100 samples in 2015-2016, and now up to 1,500 samples per year. The lab currently has four lab staff just for toxin testing.
- It is a lot or work to sustain funding. SEATOR is are always chasing funding.
- A good funding champion and writer is needed to maintain the funding stream as it takes so much effort.
- There is no compensation for chasing funding either.
- Funding levels do not keep pace with costs of doing the monitoring.
- A 3-year project, for example, will not work. A longer funding period is needed.
- We are set up for long term failure even when we have short term success because the funding will end.
- Programmatic funding is needed that has long enough duration to be effective.
- AOOS gets HAB funding but it needs to be spread among too many people.
- A larger funding stream through IOOS to AOOS is needed to sustain HAB work.
- Regionally-led monitoring/response efforts need funding opportunities that flow directly to the regional entities.
- In the Arctic, the HAB research cruises are ending this year. Where will bloom warning information come from next year?
- Can the USCG collect monitoring samples for HABs?
- More sustained funding from GAP is also needed to support HAB mitigation in communities.
- Similar funding problems are happening to the Ocean Acidification monitoring program.
- The higher latitude areas such as the coastline of the Bering Sea/Bering Strait and Chukchi and Beaufort seas have the highest costs for everything in the region. Even the logistics of shipping are difficult. For instance, there are no docks along the Arctic Ocean to sample from, a boat is needed, and sometimes an ice auger to reach the seawater. It is more expensive for fuel, etc., so funding does not go as far.
- Less expensive monitoring approaches are needed in the Arctic.

B. Toxic Resource Messaging

- The focus should be on monitoring and mitigation for human health risk, not closure. Although subsistence resources are very unlikely to be restricted or closed by regulators due to HAB concerns, it is important to keep in mind that restrictions on subsistence activities incur a very high cost to coastal peoples.
- There is a great need for safety measures, but unified voices are needed for clear messaging.
- There is a fear of regulatory action in the crabbing industry. In Norton Sound, people do not want monitoring because they might have toxic crabs, which may close the commercial fishery. There also needs to be more testing for subsistence harvested crabs.
- Where subsistence harvesters are provided with shellfish toxin monitoring data, it is a real challenge getting them to understand when toxicity levels should be taken as an action level to stop harvesting.
- Regarding data robustness, things like replication are not very applicable for subsistence resource monitoring. Data replication is a western culture viewpoint, not very useful on the ground in communities where single measurements

are the only thing possible for practical and cost reasons.

- Research-based approaches to monitoring is not sustainable long term.
- There is a continual fear of having regulatory action over high toxin levels.
- It is a challenge even to find a suitable location for HAB monitoring. Do you use the best site to represent the data or a site that is more accessible?
- The emphasis should be on monitoring, not research, but monitoring alone is not enough.
- Harvest and hold approaches are the only proven solution for subsistence shellfish. But can that work for the Arctic where turnaround time for toxin analysis is much longer?
- Regarding monitoring and Public Service Announcements, even minimal warning is better than zero.
- Clear messaging from sustained monitoring with harvest & hold-style testing are the only proven solution for HAB mitigation.

Presentation: Human health aspects of PSP, Louisa Castrodale, Alaska Dept. Health, Division of Public Health.

The human health impacts of PSP were introduced.

PSP has caused human mortalities in Alaska.

While ecological, environmental, and conservation issues are important effects of HABs, the overwhelming consensus of the workshop is that protecting human health is the top priority.

Figure 3. Role of public health organizations in HAB mitigation.

Ensuing Discussion

- Surveillance Monitoring for HABs and congeners is a priority.
- Research on sodium channel binding and dissociation is needed.
- Training in HABs should be required for clinicians to recognize symptoms of toxicosis.
- There was general agreement about a HAB training requirement, especially in remote areas.
- At the 2019 HAB workshop in Nome, the Dept. of Public Health provided training to staff and clinicians for PSP and Botulism emergency response (AHAB, 2020). This approach might work if used more widely.

Synopsis from Day 1

1. Funding HAB Monitoring and Research in Alaska

The consensus of this workshop was that one of the biggest issues with HABs in Alaska was a lack of funding for monitoring and toxin testing, which has led to limited baseline HAB data over much of the state. Because HABs and their toxins effect so many locations in Alaska, there are multiple entities that compete for the same pool of money, resulting in very uneven distribution of support. It was suggested that grants be targeted to regions and not to specific researchers, as many locations may not have good grant writing support, and therefore will be underfunded. Another suggestion was to set up a funding program specifically for Alaska HAB research.

It was noted that HAB work in Alaska is often more challenging than other parts of the U.S., and that certain regions of Alaska (e.g., the Arctic Ocean coastline) will be inherently more challenging and costly than others due to more demanding physical environments, lack of infrastructure, and general remoteness. For example, there are no docks along most of the Arctic Ocean for use in collecting plankton samples or for docking boats. And beach sampling is often not possible due to shore ice or wave energy. There is a perception among some of the participants of the workshop that federal funding organizations tend to fund less taxing projects to serve larger population areas or to have a perceived bigger outcome versus cost and effort. This model does not work well for Alaska, where the population is sparse and even simple monitoring or transport costs are so much more expensive. For example, Karenia brevis (Florida red tide) research in the Gulf of Mexico has been better funded than HAB research in Alaska in part due to Florida having 30 times the population relative to Alaska.

Current funding sources are also insufficient to maintain HAB monitoring and testing in the face of continually increasing costs for personnel, fuel, and other items. Community consortia attempting to maintain monitoring and testing face unrelenting proposal writing to continue even minimal HAB monitoring efforts. Communities and organizations in Alaska contend with a continual turnover in both paid and volunteer staff due to a lack of consistent funding and may find it hard to cover annual increases in personnel costs. Currently, a significant portion of funding for HAB mitigation and monitoring comes from EPA's Indian Environmental General Assistance Program (GAP) grants. These are advantageous in that they are readily available to native communities, but come with limits in funds per tribe and GAP grant dollar amounts have not kept up with inflation.

It was also argued that there needs to be seed money, or at least quasi-guaranteed funding for start-up and maintenance of various HAB monitoring programs throughout the state that have annual needs. The grant funding system creates more problems for small communities. More applications for funding require more administrative support, which exacerbates the burden of HAB monitoring on community personnel and reduces equity of resources. Disadvantaged communities with no one to write and maintain grant funding have limited HAB monitoring funding, and so experience higher risks and potentially, greater incidence of HAB-related illnesses. It was suggested that USDA grants available for solid waste disposal (USDA, 2023) could be used as the framework to set up HAB monitoring as well. This topic concluded with the general consensus in the workshop being that the state needs to support shellfish toxin monitoring through the ADEC.

2. Impacts of HABs in Alaska

In terms of human health risks, Alaska has some of the worst HAB problems in the U.S. (AHAB, 2020). There is general recognition within the state that consistent and repeated messaging, outreach and educational efforts about HAB risks over the last 20+ years has made residents more aware of human health risks associated with HAB toxins in Alaska, but this communication effort needs to continue as people immigrate to Alaska, as new generations of young people participate in harvesting, and as the continually increasing tide of tourists comes to coastal areas where HAB toxins are common (AHAB, 2020). But many people (researchers, regulating agencies, commercial fishers, tribal communities, etc.) are still unaware of the severity of risks associated with HABs in Alaska.

With the information showing HABs occurring from the Aleutian Islands all the way into the Bering, Chukchi, and potentially Beaufort Seas, there are growing concerns about the risks associated with HAB toxins. While southern Alaska has dealt with PSP for centuries, residents north of the Aleutians are relatively new to these problems. So not only is there no existing infrastructure for monitoring and response to contend with HAB risks, but there are very few baseline data against which to measure the effects of these changes. It was also brought up that more prevalent climatic variability is leading to more gaps in long-term datasets as cruises and monitoring efforts are canceled due to extreme weather events. The changing climate is also causing more temperate organisms to move into polar ecosystems like in the Bering Sea.

There is a need for better and more available HAB detection and quantification methods. The ADEC Environmental Health Laboratory is the only place in Alaska that does HAB testing (PSP, ASP, DSP?) for commercial seafood products in Alaska. The Department is building capacity to help this need but the same logistical difficulties exist for shipping samples to Anchorage, and turnaround time for results may not come in an actionable timeframe.. There needs to be better use of existing field and field lab testing methods for monitoring of HAB toxins as toxicity events ramp up and down. Pairing use of these fast and inexpensive field methods for early warning and tracking of toxicity with added formal laboratory testing of seafood products would provide a two-tiered approach to monitoring and would provide more information to communities than seafood testing alone. New field kits providing better, more accurate toxin testing results are also needed to assess toxicity and reduce the amount of time, expense and expertise necessary for toxin analysis. These better field tools should be developed quickly!

There is also a need for better sharing of HAB data among researchers, monitors and communities. Data needs to be standardized and maintained in a central database, perhaps hosted by AOOS or a federal agency, that is accessible to all Alaskans. This database could be used to formulate baseline data for HABs on a statewide level. Such a baseline may become very useful as ecosystems continue to adapt to projected changes in climate. Both the raw data as well as interpreted data products are needed to increase accessibility. Disseminating data and information on a central website would be advantageous.

3. Successes in HABs in Alaska

There have been some successful community science approaches to HAB monitoring and mitigation in Alaska but more could be done to better leverage collective resources, and better leverage starts with better communication. SEATOR was brought up as an excellent example on how to build up a monitoring system/program that could be emulated throughout the state. While SEATOR is a successful partnership between several tribes and non-tribal entities, funding is always an issue and they must actively pursue funding. Participants also indicated that community science approaches are not free. There is a feeling that scientists, monitors, organizers, and communications people maintaining such efforts need to be compensated for the work that they do outside of the urban-based hub communities. Available jobs are in very short supply and goods are more expensive. So, community based HAB monitoring can provide needed income to samplers to incentivize them and help support their families while the data are collected. There needs to be better approaches to monitoring for toxins, involving data collection, local expertise, travel, packaging/shipping, communication and/or outreach, etc. It is felt that participants in such monitoring efforts should be fairly compensated. Working in remote parts of Alaska is not analogous to working along the continental US coastline. For example, monitoring programs may rely on individuals using their own vehicle and their own fuel, and fuel costs in Alaska are typically far more expensive than in the continental US. Furthermore, a small influx of cash to people living in coastal communities would very much help grow any

monitoring networks. It should also be noted that the number of people living along the Alaskan coastline is a very small fraction of the rest of the continental US, meaning there is a much smaller pool of potential monitors.

In support of HAB information sharing and public service announcements (PSAs) about developing outbreaks, It was suggested that Nixle has been very effective in parts of Alaska. Nixle (www.nixle.com) is a community information service which enables two-way communication through email, text, social media, or voice messages. It has been used in the Pribilof Islands successfully and shows some promise in spreading the word in remote communities when there are outbreaks of PSP, ASP, or DSP. Monitoring and information sharing can also be supported by better use of inexpensive technology. HAB monitoring can probably be more effectively and widely used statewide. Planktoscope (www.planktoscope.org), an open-source hardware/software platform that allows for quantitative imaging of plankton samples, is being successfully used in Kotzebue Sound. This technology seems underused and could be effectively deployed elsewhere in the state. More expensive scientific technology can also be better used. An Imaging Flow Cytobot (IFCB) was deployed on Bering Sea & Chukchi Sea monitoring cruises the last two years. The instrument was able to detect what was maybe the largest ever *Alexandrium* bloom ever recorded (Anderson et al., 2021). IFCBs have also been successfully deployed to find blooms elsewhere in the state, so this technology may be useful if better deployed. There have been some successes throughout the state by partnering with NOAA's Phytoplankton Monitoring Network (PMN) for early warning of developing bloom events. Wider implementation of these approaches would be beneficial. Many entities have formed partnerships, including mutually beneficial partnerships between federal, state, academic, tribal, and non-profit communities. These partnerships have built capacity to monitor systems and well as to validate and develop new methods.

HAB training is also needed more widely in Alaska. During 2019, UAF Alaska Sea Grant held a HAB Workshop in Nome, Alaska. The first day was a public HAB workshop and the second day was used to provide the regional tribal healthcare medical staff (NSHC) with training from the Alaska Dept. of Public Health, State Epidemiologist in Paralytic Shellfish Poisoning and Botulism. Training included causes, symptoms, and treatments. Regional village clinicians were able to voluntarily join in (AHAB, 2020). This approach needs to be used more widely for HABs to reach a wide geographic range and a larger audience, and to better disseminate the information. This training should be implemented statewide. There is a high turnover in medical professionals as many are working temporary assignments. Because botulism, and to a lesser extent, HAB toxins, are not such a pervasive problem in many regions, the medical professionals may not be familiar with them. Alternatively, there is an online training being developed for all new/temporary medical staff to familiarize them with these localized issues.

4. Subsistence Issues

Participants felt that the most effective approach to safeguard shellfish harvesters from HAB toxins is monitoring and mitigation, and not regulations prohibiting harvesting. This reasoning is due to the importance of subsistence harvesting to coastal residents, many of which rely on marine resources for survival. In Alaska, HABs have a larger impact on basic food security statewide. The narrative on Alaskan seafood harvesting needs to change so the marine resources utilized for subsistence purposes are given similar weight in testing/monitoring as commercial marine resources. North of the Diomede Islands, subsistence fishing is much more common than commercial fishing as there are no federally-regulated commercial fisheries (NPFMC, 2009), though there is a limited State managed commercial season salmon fishery in the Chukchi Sea.

Testing for HAB toxins in coastal communities needs to be standardized with more uniform monitoring approaches. Even monitoring data collected with imprecise field methods can be useful for risk management. Harvest & hold is an important concept and could be implemented during times when toxins are more of a threat. Some organisms accumulate HAB toxins in their organs (e.g., hepatopancreas in crabs) and harvesters should be encouraged to discard these tissues during suspected HAB outbreaks. This type of messaging needs to be better utilized in communities. Notably, the FDA/ADEC regulatory limit of 80 µg /100 g of saxitoxin equivalents in shellfish is often an ineffective deterrent to harvesters as many native villagers continue to consume fish, shellfish, and invertebrates at toxin levels exceeding this limit (Kibler, et al., 2022). Even harvest and hold can be ineffective because of the minimum 2–3-day turnaround time before toxicity data are provided to harvesters. Turnaround time is even greater in more remote communities. As a result, residents rely more

on traditional knowledge than testing to mitigate toxicity outbreaks. Minor toxicity symptoms are often accepted and resulting illnesses are rarely reported. In more remote Alaska coastal communities, a 24-hour response system should be developed, potentially with assistance from the Coast Guard. One toxic walrus harvested for subsistence can make over 30 people sick. Samples of the animal in question should be tested and consumption postponed pending the results of the toxin analysis. But turnaround time has to be shortened. This proactive approach is done in Nunavut, Canada for Trichinella mitigation (parasitic nematodes). Such safeguards were not necessary just a few years ago, but became necessary as the incidence of the illness has increased. A similar approach should be used for HAB toxins.

Synopsis from Day 2 HAB monitoring methods and tools

HAB cell monitoring benefits and methods: Information about the monitoring system used by the Kachemak Bay National Estuarine Research Reserve (KBNERR) was presented.

KBNERR monitors collect phytoplankton samples once a week during April – October using the protocol developed by NOAA's PMN. Before the pandemic, a network of approximately 40 monitors in Kachemak Bay and the Kenai region were involved in monitoring. But much fewer now. The samples are sent to Homer for analysis, and a weekly update detailing the weekly phytoplankton assemblage is then distributed. The program is funded through a NOAA operations grant that is part of the National Estuarine Research Reserve Ssystem (NERRS). Generally, the program is just looking at presence/absence of HAB cells and the data are not used to close down any shellfishing. If there are any toxic or potentially toxic genera of phytoplankton found to be present at high concentrations, shellfish samples will also be collected and shipped for analysis. Because of the large number of mariculture farms in Kachemak Bay (mainly oysters), there is a delicate balance between informing residents of toxicity risks and halting harvest and sale of shellfish unnecessarily. The language in PSAs and community information products needs to be appropriate. The KBNERR has a good relationship with the local hospital built on collaborative public health workshops and other efforts. The CDC does a lot of cross-cutting work on public health messaging, and should be leveraged for reporting systems on how, where, and when HABs are occurring in the state.

Question: How is the program funded?

Answer: KBNERR's phytoplankton monitoring was funded previously by annual funds from ADF&G, but funding was withdrawn three years ago. Now monitoring is supported by the NOAA operational grant for NERRS.

Question: Is KBNERR working with any health care organizations for HAB response?

Answer: KBNERR maintains several such relationships locally, and at a higher level with ADEC and ADOH. All messaging regarding HABs or toxic shellfish are channeled through the State. The Reserve also distributes informational products about HABs and toxins. In the past we monitored shellfish toxicity as well, but not at present because of a lack of funding to support it.

Comment: In Kachemak Bay there are a variety of docks to facilitate plankton sample collection in contrast to many locations where they do not exist.

Question: Is public information provided by local health care organizations? Is it based on toxicity or cell abundance?

Answer: KBNERR focuses only on relative abundance of HAB cells, and any alerts are stipulated as relating only to the cells themselves. But during obvious blooms we will work to collect shellfish samples for toxin analysis from AHAB members.

Comment: Regarding HAB communication, KBNERR has been really great in sharing information with Kodiak. KANA uses a similar alert format with hard copy postings in kiosks at shellfish sites, flyers, and email lists.

The KBNERR presentation led to a general discussion about messaging for HABs.

Discussion about HAB messaging:

The overall goal is to help educate communities about phytoplankton as well as HABs. But there is a fine line between sharing HAB information and scaring people. During the last PSP shellfish toxicity outbreak in Kachemak Bay in 2015-2016, KBNERR and partners met to establish a communication plan including DOH, NOAA, local environmental agents,

and regional mariculture representatives. The goal was to provide information but avoid damage to commercial shellfish farmers in the area. The communication plan provided a protocol for what should and should not be said. This type of planning was great because it included connections with public health in local communities and was very helpful.

Sharing information about HABs in this way can be extremely valuable. This type of planning was done in Kodiak before KANA's shellfish monitoring project started. There is very specific language that can be used for messaging to the public, and also to public health representatives. A risk communication workshop was held in Homer a few years ago to discuss these issues. The same style of communication has been used at SEATOR as well. CDC held a workshop some years ago to cover the same type of communications. It was very useful. PSP and DA were top ranking issues.

The above lead to a general discussion about sampling and monitoring for HABs in the Arctic.

Discussion Topic: HAB Monitoring:

Phytoplankton monitoring was started in the Bering Strait region in April of 2021 (NOAA, 2021). Although ice algae are very important for community production, they are not monitored. WHOI researchers have looked at the ice algae for HAB cells and found that *Alexandrium* cells and cysts can be included with the ice algae community (Anderson et al., 2022). *Pseudo-nitzschia* cells were also found in the ice of the Beaufort Sea. A photo was shown for ice sampling four miles offshore. There is great risk involved in this type of offshore work on sea ice, and safety is a priority for samplers. Recognizing that high latitude HAB work is presents some unique challenges, there is an effort to standardize the sampling protocols with other methods across the U.S.

Discussion Topic: HAB toxin detection and monitoring methods:

Effective monitoring programs rely heavily on proper tools for HAB cell and toxin detection. Here various HAB monitoring tools were discussed and are detailed below.

HABscope is a cell monitoring tool developed based on dinoflagellate swimming behavior (Hardison et al., 2019). The technology uses a microscope with an attached smartphone camera to detect the swimming patterns of HAB species and quantify their abundance. HABscope was first developed for the Florida red tide, Karenia brevis, but other motile HABs have since been added. Presently, HABscope data collected by a network of volunteers is used to inform the HAB forecast for Florida.

BloomOptix uses a packable microscope and takes pictures to upload to an online database to look at various HAB species.

qPCR uses PCR targeting a specific gene sequence on the target cell and measures how long it takes to reach a target number of copies. A linear equation is then used with a standard curve to estimate number of gene copies and the number of cells present in a sample. qPCR generally requires an expensive qPCR machine and a full molecular lab to run samples in 96-well plates. But small handheld qPCR units are available that use short strips of tubes instead of a plate. They are now manufactured by various companies and show promise in routine monitoring for presence and abundance of HAB species. But these smaller units not field methods by any means and the portable machines can only run a few tubes at a time. So the smaller systems may not be practical for monitoring.

Continuous Plankton Recorder (CPR) is another product that could help in monitoring HABs in Alaska. The CPR is a torpedo-shaped device a long spool of fine mesh that is towed behind vessels. These devices are mounted on ships such as the ocean-going ferries and the program one of the longest running marine biological datasets in the world with decades of data. As the ship transits, surface seawater is directed through the slowly spooling roll of silk mesh, capturing a long record of the major plankton species encountered along the transit. The CPR is run on ships of opportunity and records the species of plankton that are encountered by the vessel (Reid et al., 2003).

Environmental Sample Processor (ESP) provides autonomous in situ collection and analysis of water samples. The ESP is a robotic biological sampling system that collects and analyses filtered water samples to quantify toxins as well as estimate the abundance of HAB cells present in a sample.

Imaging Flow Cytobot (IFCB) is an in situ automated machine that uses a combination of flow cytometry and video technology to capture high resolution images of suspended particles. These images can be used to identify the presence and abundance of HAB species.

Satellite Remote Sensing uses sunlight as the light source and is cost effective for collecting data, but has limitations in Alaska due to pervasive cloud cover. There are some algorithms which may detect certain HAB species from the background plankton assemblages. These techniques are still being evaluated.

Discernment and local knowledge are needed to determine which of these tools or techniques are best suited for different regions, HAB species, and community needs. Further discussion is needed on this topic. The IFCB had the most support among the technologies discussed. However, the general consensus was that this instrument would be difficult to host on a mooring, which was a suggested mode of deployment during the workshop. An alternative to the mooring could be to mount the IFCB on a boat-drone or a glider. However, this would be challenging in the Bering Sea due to strong currents and the potential for crossing into the Russian Federation. Another drawback to the IFCB is the high cost, and need for training and maintenance, which could draw money away from community monitoring projects.

How to implement different methods in different regions

There were questions from participants about other HAB monitoring methods currently in use across Alaska, such as mooring data, community monitoring, nearshore sampling, etc. Environmental data collected from buoys is overseen by IOOS, including wave monitoring buoys. The data are publicly accessible as a resource (AOOS, 2024). The North Slope Borough is very interested in mooring-based monitoring solutions because it is so difficult to do shore-based work. Is there a capacity building effort within AOOS to meet current and future needs? There is also the ability to leverage current moorings. There were questions about how such moorings were sited.

There is also interest in more IFCB-based monitoring for HABs. Three places were identified as highest priority for IFCB HAB monitoring: Kachemak Bay, Kodiak, and the Bering Strait. Some questions then arose about support for such IFCB setups, the cost and amount of personnel hours required to maintain them. The IFCBs require a lot of upkeep and attention to keep them operating. Much like gliders, which also provide good data, there are concerns over the cost vs. benefit for Alaska. Different regions have different issues. It is important to note that each region's issues are not static, what is an issue one year in SE Alaska may be an issue in the Bering Sea the next. However, there are some fundamental differences between the regions. Sample collection methods will also vary based on regions that have seasonal sea ice vs regions without seasonal sea ice. It is important to consider how the benefits of a particular method be maximized without increasing the costs. An IFCB, for instance, has a very high startup cost and significant personnel time and expertise are needed to operate the instrument routinely.

Discussion Topic: HAB forecasting

NOAA's National Centers for Coastal Ocean Science (NCCOS) includes a HAB Forecasting Branch, and two presentations were given to foster forecasting discussions. Within this branch there are several HAB forecast products covering the Laurentian Great Lakes (Wynne et al., 2013), the Gulf of Maine (NOAA, 2023), and the Gulf of Mexico (Stumpf et al., 2003). NCCOS also helps facilitate forecast product development by its partners in the Puget Sound region (NANOOS, 2024) and California (SCCOOS, 2024), and is working to develop forecasts for Lake Okeechobee, Florida and the Chesapeake Bay. Alaska is the next region of interest, with an immediate focus on the Kodiak Archipelago (hereafter Kodiak).

HAB forecasting was defined as using models to project blooms and their effects based on relationships with environmental factors. Model development tends to be iterative and can be operated in forecast mode, hindcast mode, or as a nowcast

of near real time. NCCOS presented general plans on a two-fold forecasting approach for Kodiak. The first will be based on the approach utilized for the Gulf of Maine HAB forecast system (NOAA, 2023), where *Alexandrium* resting cyst abundance data are coupled with a cell growth and migration model and a hydrodynamic model to create 1) a seasonal forecast of bloom severity and 2) a weekly nowcast projecting *Alexandrium* cell concentrations across the Gulf. The particular products of the forecast were developed using user feedback over time depending on the stakeholder needs. For instance, one of the products from the Gulf of Maine forecast is a map of average *Alexandrium* projected cell concentration over the region with the surface current field, average wind direction during the last 3.5 days, and observed mussel toxicity at fixed shore monitoring stations. This graphic and others are distributed with a summary interpretation each week to an email list of regional stakeholders in state and local governments, shellfish monitoring and environmental agencies, mariculture representatives, and individual shellfish farmers. The products are refined based on feedback received and after a stakeholder meeting held every two years. The goal is to make the forecast useable to the greatest number of people in the region.

The Gulf of Maine forecast is based on 20+ years of previous work by WHOI, NOAA, and other partners. Unfortunately, this type of background information is absent in Alaska, and the area where blooms occur is much larger with many differences in particular environmental drivers. As a result, the focus will be on one area first, in Kodiak. Data collection to map cysts in Kodiak is scheduled for winter 2023-2024, where cyst abundance will be used to project spring *Alexandrium* cell distribution in the Chiniak Bay area of eastern Kodiak. A hydrographic and bloom survey was completed in July to get an idea what cell distribution looks like, and we plan to compare cyst distribution this winter with summer cell abundances to see what kind of general patterns emerge. A simultaneous regional approach will use environmental factors governing *Alexandrium* growth and abundance (i.e., salinity, temperature, chlorophyll, etc.), with a decision tree to forecast where blooms may be the most severe.

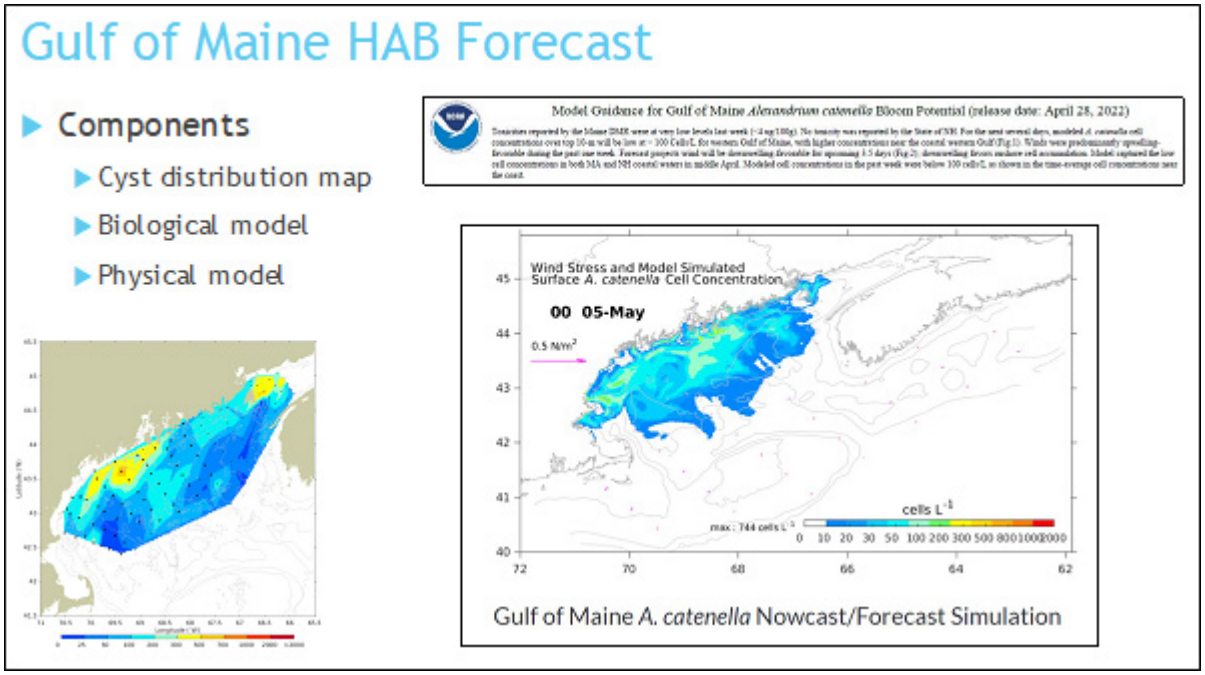


Figure 4. Forecast products from the Gulf of Maine HAB forecast.

Presentation about HAB Detection. By Tod Leighfield

A presentation was given about toxins and used as a starting point to discuss toxin detection and effects. At the NCCOS Lab in Charleston, SC is the HAB Monitoring and Reference Branch, a group that focuses on detecting, monitoring, and

mitigating HAB impacts through HAB and toxin measurement method development and validation (laboratory and field). The Branch also focuses on citizen science, the Phytoplankton Monitoring Network (PMN), and methods for HAB prevention and control. The toxic effects of STX are comparable to that of biological weapons and should not be taken lightly.

Some of the challenges about HAB toxins is that there are multiple chemical congeners present with different toxic potencies. The particular congeners present in HAB cells can vary regionally. In addition, the uptake of each congener into shellfish tissue varies among congeners and among shellfish species. For analysis, there are multiple and complex sample matrices that can affect toxin quantification. Biological, biochemical and chemical methods are available for analysis (Fig. 5). Mass spectrometry could be used to determine the type of toxins and the congeners present in a sample; however, a reference standard needs to be developed to validate for food safety. A bioassay is used for rapid but non-specific analysis and mass spectrometry should be used for detailed results. The ADEC Environmental Health Lab (EHL) runs mouse bioassays on all subsistence testing samples because of rapid turnaround (1-2 days). HPLC is used for research projects or when time is not critical as the samples are usually run in batches every few months. The results of these analyses are also compared with results from newer methods, such as mass spectrometry. More work is needed to develop a baseline for each toxin. The toxin profile from samples needs to be determined but a larger dataset is needed.

Discussion Topic: HAB Toxin

There were some questions about recent antibody test development and field tests. It was pointed out that most antibody tests are designed to detect STX, and may not work as well when other congeners are dominant. It was reported that many times Alaska shellfish samples have a large relative fraction of GTXs present in addition to other congeners like STX and neoSTX. So, it is important to know how a particular test performs for these congeners. The deficiencies of these tests are recognized but development of new and better ones takes a very long time, screening of existing products might be useful. With the new testing capacity in Kodiak this may be feasible.

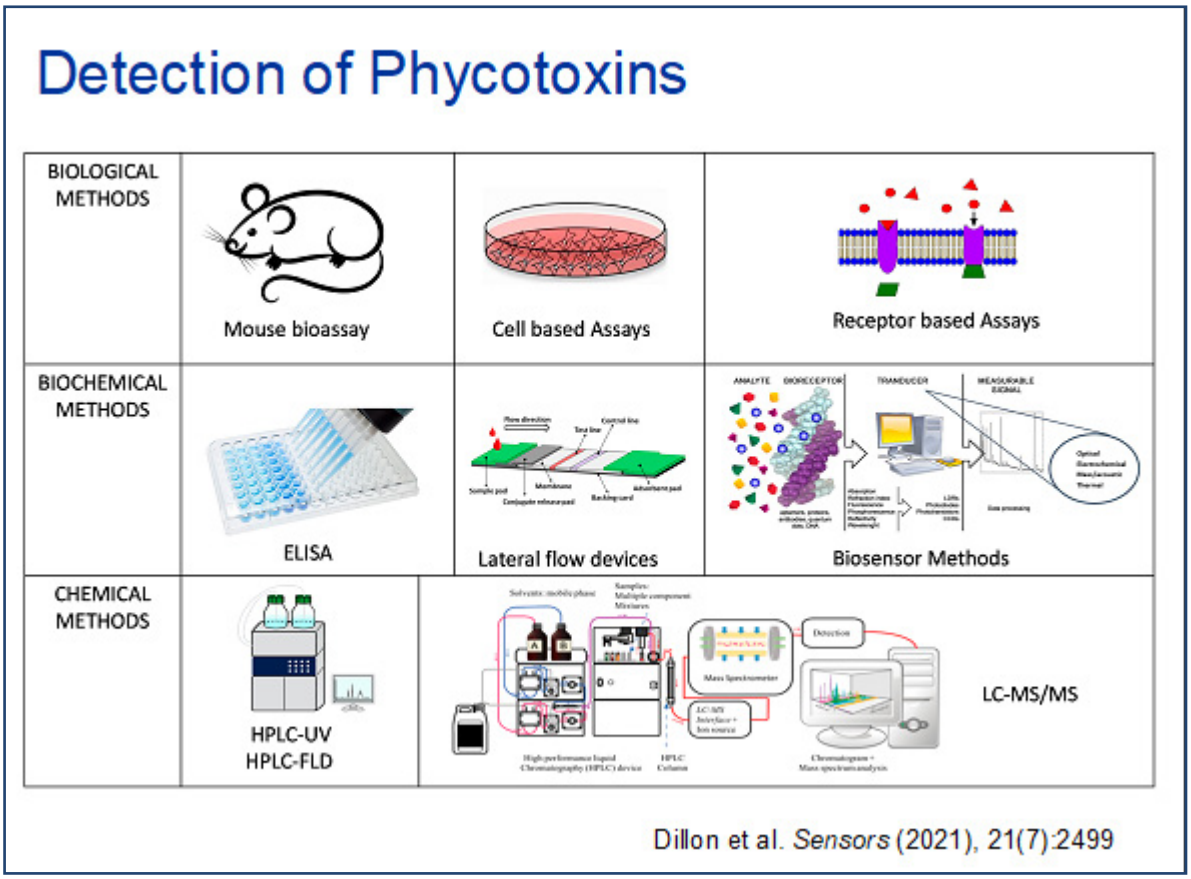


Figure 5. Three main methods of HAB toxin analysis.

Discussion Topic: Bering Sea Cruise

Preliminary results from a summer 2022 research cruise in the northern Bering Sea as well as the Chukchi Sea were discussed. The cruise found a massive *Alexandrium* bloom which produced a number of different toxins. This suggests that different strains of *Alexandrium* were present, as different strains can produce different toxins. It is not known why this is the case as there does not appear to be a straightforward link between toxin production and environmental conditions.

Presentation: HAB Dynamics in the Northern Bering Sea, Bering Strait, Chukchi Shelf, and Western Beaufort – Evie Fachon, WHOI

A presentation was given summarizing the sampling cruises and major findings. Information on *Alexandrium* cell abundance, cyst distribution, Pseudo- nitzschia species, toxins in plankton and invertebrates, and IFCB data are collected on each cruise.

Figure 6. Arctic sampling cruises for blooms.

Presentation: Environmental and Climatological Methods – Tim Wynne, NOAA NCCOS

A presentation was given about using climatological methods for prediction of *Alexandrium* blooms in the GOA. SST imagery from the VIIRS sensors were compiled from 2012-forward and climatological mean temperatures were calculated. Also compiled were ocean color images (working on this now) using 10-day anomalies from the long term mean. We are also testing if *Alexandrium* blooms occur where other phytoplankton blooms occur (Fig. 7). This is a similar approach to a previous algorithm study in the Chesapeake Bay, where field-collected chlorophyll was correlated with satellite chlorophyll.

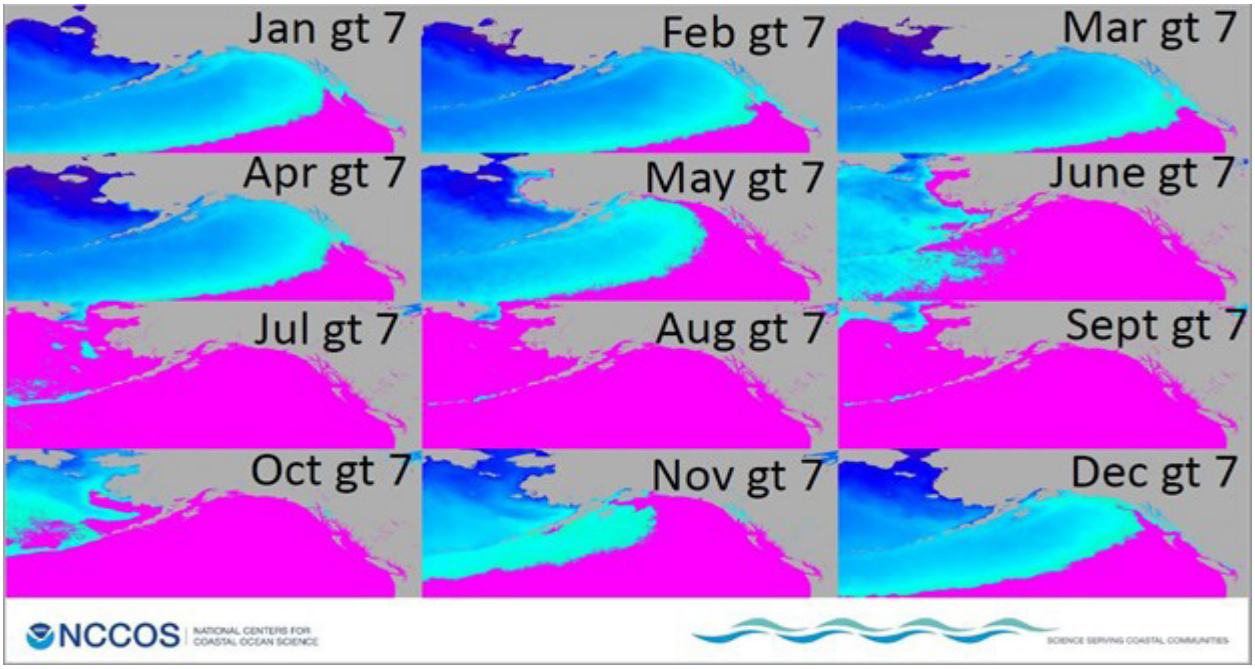


Figure 7. Satellite climatology data and relationship with HABs in Alaska. Here are long term (~20 year) monthly Sea Surface Temperature trends. The pink areas denote where long term monthly water temperatures are greater than 7oC.

Presentation: Environmental Modeling of HABs in Southeast Alaska – John Harley, Univ. Alaska Southeast (UAS) Coastal Rainforest Center

A presentation was given about efforts to model PSP potential using mussel toxicity data collected at SEATOR since 2016. The ADOH data show PSP events include more than 40 cases during 2010-2016, and the Sitka Tribe of Alaska's Environmental Research Lab (STA-ERL) started operating in 2015. Mussels make the best monitoring shellfish because they take up and eliminate PSP toxins very rapidly, and previous data show *Alexandrium* blooms in SE tend to peak in the spring and then again in the late summer-early fall. The objective is to use environmental monitoring data and what we know about *Alexandrium* growth and toxicity to predict toxic vs. non-toxic shellfish. We want to know if environmental conditions are conducive for a bloom, if an intense bloom occurs with toxic cells, and if toxins accumulate at high levels in shellfish. Shellfish toxicity data have to be lagged behind *Alexandrium* blooms, which themselves have to be lagged behind environmental drivers. Multivariate analysis shows the primary drivers of blooms are SST, air temperature, season, salinity, freshwater discharge, wind speed and PAR, while tidal exchange, upwelling, and precipitation are less important. So far, the model was bad at predicting actual shellfish toxicity (i.e., nonlinear), but showed promise for predicting the timing of spring blooms.

For an operational forecast, we would need an in situ network of SST and salinity data, better toxicological information about toxin uptake in shellfish species, and a circulation model to incorporate transport of toxic cells.

Group Trip: Tour of ADEC EHL

The participants loaded into a bus and drove to the nearby DEC lab for a tour of the state-of-the-art facility. Workshop participants were shown the equipment used by DEC to analyze food safety and environmental health samples. DEC staff explained how different testing techniques work, the time and supplies needed to run different techniques, and what capacity was available to increase testing of HAB samples.

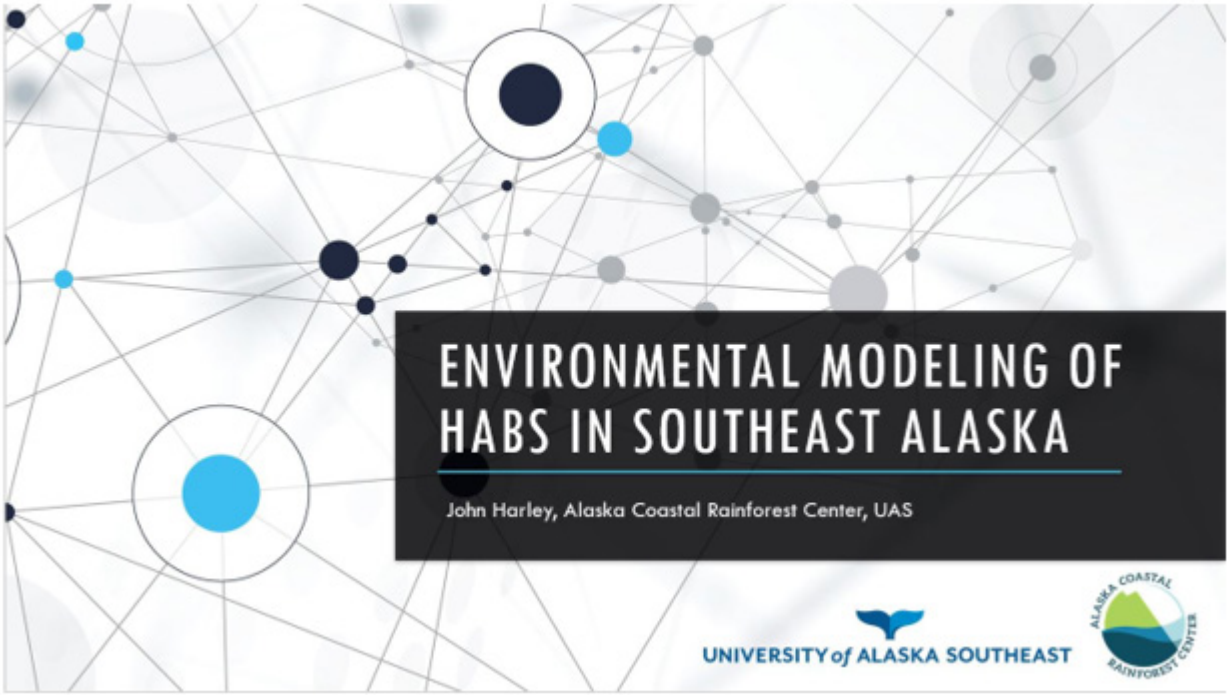


Figure 8. Modeling of *Alexandrium* blooms and shellfish toxicity.

Day 3 Synopsis: Community Needs and How They Can Be Met

In regards to community needs the main concern is that sufficient monitoring is needed to prevent illnesses. This applies to recreational, commercial, and subsistence fishing. The state sometimes considers subsistence fishing the same as commercial fishing which can be viewed as inappropriate by some Native Alaskan tribes. Human health is the primary concern for monitoring.

Discussion Topic: Setting up tribal HAB monitoring like SEATOR.

A long-term HAB monitoring program is needed to establish a baseline and observe trends over time as a result of natural, anthropogenic, or climatic factors. How this will be funded is a major question. Funding for HABs is relatively low and highly competitive, including competition among the attendees at this workshop. Chris Whitehead spoke about the monitoring program at SEATOR and how that may be used as a model. One of SEATOR's main successes was the ability to tap into and leverage traditional tribal knowledge and resources. Many of the tribes know when and where certain species will have high STX concentrations and when and where there is a low risk of STX. This is knowledge that is not easily measured or modeled. In 2013 there was no long-term subsistence monitoring program in Southeast Alaska. In 2014 NOAA and EPA started a phytoplankton monitoring network in Southeast Alaska. In 2015 they built a lab in Sitka, and by 2016 there were 12 tribes participating in the program. By 2019, there were 15 communities included, spanning all of southeast Alaska. The tribal organization started taking the lead on STX monitoring. Three program elements were deemed to be important: 1.) phytoplankton observations/early warning, 2.) tissue testing/toxin testing, and 3.) communicating results.

There are significant costs to keep this network operating. For instance, a database is maintained to house the monitoring data. It was started with NOAA PMN and was included in the SoundToxins monitoring and research network that Vera Trainer started. But now SEATOR has their own database hosted by AOOS. It was pointed out that data sovereignty is a big deal and that AOOS helps keep the data publicly accessible via a partnership with Axiom Data Science, who is building a data portal. Funding for the SEATOR network is always a challenge to maintain, but starting from the ground up is the best way. Many communities do not want outsiders involved in the project, and maintaining sovereign communications

Figure 9. Alaska DEC's Environmental health Laboratory.

is important. One of the hardest steps is to just get started, as it is easy to get caught up in the minutia of planning. It was pointed out that one of the strengths of the SEATOR approach is that it is a place-based connection where community needs and traditional knowledge is important.

Discussion Topic: Incorporating emerging cyanohabs into HAB monitoring.

The SEATOR discussion led to questions about emerging cyanobacterial blooms and what approaches were adopted to test for these.

There is continual discussion at SEATOR about emerging HABs, such as cyanobacteria, alongside continuing threats like PSP and DA. A question was raised whether SEATOR has started doing any cyanotoxin testing or deployed SPATT bags for monitoring. SEATOR has talked about this approach, and there has been some limited toxin testing for microcystins in Juneau and Kodiak. There is also a proposal to look at cyanotoxins in SE AK down to British Columbia. At present things are limited by cost and personnel. SPATT collections have also been used in Kotzebue Sound and St. Paul.

The USFS is interested in HABs in the Chugach Forest region, which encompasses the Kenai area near Seward, the whole PWS area, and the Copper River area east of PWS. They have been doing phytoplankton tows and mussel sampling through a PWS nonprofit group, but have very limited resources. They want to connect with area partners to understand what aspects of HABs they should focus on, and what directions they should be heading for the most value. Some monitoring sites have been visited but no regular monitoring work yet. The Chugach Regional Resource Commission (CRRC) is also interested in these conversations. CRRC now hosts the Alutiiq Pride Marine Institute in Seward.

It was pointed out that planning for data collection is very important for HAB monitoring, and that lacking any federal funding, researchers should go to the communities to determine their major concerns about HABs. This is how you begin building capacity. In person visits and adequate follow-up will build trust over time and encourage community involvement.

There were more questions about how SEATOR is structured and how it maintains funding support. There is a continual effort to secure more funding, and that additional support is always needed. Staff are quickly overtaxed if the HAB operations outstrip the funding stream without more staff support.

Some questions came up proposing that AOOS hosts a list of funding sources for HABs, with template proposals and a recipe to follow for funding from GAP, NOAA, etc. There is a need for AOOS to help support this for AHAB members. Groups with no funding want to access the same resources as others, but competition among different groups in Alaska needing funding does not help. It was pointed out that the power of an organization like AHAB comes from the participants, not the organization.

Better data-sharing could also be facilitated through AOOS. A database could be set up through Axiom (https://www.axiomdatascience.com/). The primary function of the proposed database would be to house baseline data.

Presentation: Setting up a long-term HAB monitoring program. – Chris Whitehead, Ocean & Earth Environmental Services

Obtaining funding support for a HAB monitoring program in Alaska is a difficult process that requires sustained effort and strategic planning. In a manner similar to SEATOR, a three-phase process is recommended, including 1. Establishing phytoplankton monitoring for early warning of HABs, 2. Adding tissue testing for HAB toxins, and 3. Building a network to communicate the results. For step one, weekly plankton tows are done at a series of monitoring sites that should be local harvest locations. Environmental parameters (temperature, salinity) should also be collected, and possibly whole water sampling for other parameters, along with data entry and communicating the results. This provides early warning capacity and gets communities involved in monitoring environmental changes. Shellfish toxin monitoring is the next step, where samples of commonly harvested shellfish and/or another biota are collected and sent for toxin testing. This serves as a screening system for toxins in subsistence foods and also for tracking of toxicity event development and decline. The data should be housed at a central database with a public facing or network-facing web page with the latest results. Email sharing, PSAs, flyers and other communication items can also be included. It's best to start simple and then build capacity and members over time. But the communication support also has to grow to support it. In the graphic (Fig. 10), a suggested starting point is to use community GAP funds (~$125k) to get started with a few personnel and emphasis on turnaround and communication of the monitoring results. Additional funds (~$150 - $300k) can then be pursued through a variety of possible sources including BIA, Sea Grant, NOAA, EPA, and other sources to widen the network and build more capacity. The next steps are then to chase more funding ($1 - $5M) to build scientific capacity, such as toxin analysis, a database, and more lab staff and communication support.

In response to this presentation were many comments. Participants pointed out that chasing funding is a major challenge, and the more grants to manage, the harder it is. A strong communications team is needed to share results, advocate for support, widen the network and chase funding. Government relations and comms groups will likely be needed to deal with all the agencies. It should be kept in mind that all governing bodies have inertia to overcome, so time and sustained effort is needed for success. Advocacy for change is very hard in the face of government regulatory agencies that have oversight of resources. A regional network of support is also needed to advocate with more voices, to share communications, and to support sampling. It never works when outsiders come in and try to shortcut the communication system. And short-term projects do not really work. A lot of time and resources can be wasted if the regional network is not involved. Everyone needs to be on the same page.

Presentation: Federal Funding for HAB Science and Management – Marc Suddleson, NOAA CRP.

NOAA and a several federal agencies provide funding that supports HAB research around the U.S. The NOAA NCCOS Competitive Research Program is a national leader in Harmful Algal Bloom research and implements four competitive research programs and the HAB Event Response program, authorized under the Harmful Algal Bloom and Hypoxia Research and Control Act. CRP also supports regional ecosystem research to facilitate adaptation to sea-level rise and sound ecosystem-based management decisions. The four NOAA NCCOS Competitive Research Programs that support HAB research are:

Ecology and Oceanography of Harmful Algal Blooms (ECOHAB)

Monitoring and Event Response for Harmful Algal Blooms (MERHAB)

HAB Prevention, Control and Mitigation (PCMHAB)

Social, Cultural and Economic Impacts of Harmful Algal Blooms (SEAHAB)

Other sources of federal funding for marine and freshwater HAB research include NIH/NIEHS-NSF Oceans and Human Health Program; the U.S. Army Corps of Engineers (USACE); the USGS Cooperative Matching Funds, Water Resources Research Act Program, and the Youth and Education in Science Program.

The ensuing discussion indicated there are so many research funding sources but very few if any sources of long-term sustainable or operational funding. This is a challenge for many reasons. For example, the Tribal Health Consortiums always ask how a new monitoring program will be supported. It is a very long process to secure funding, all have project start and end dates, but few personnel to do everything. Volunteers are often needed but this is hard to maintain, as it takes so much time and effort. Another source of funding support is through NERR's education programs, such as Project Grad. Another might be the Alaska Native Science Education Program. UAF has the Fire and Ice Program, which can support HAB work, through an education program. AOOS AHAB offered to compile a list of funding sources and participants discussed the critical need for a grant writing workshop, Seek funding is continuous effort requiring dedicated and trained personnel. It was also noted that managing the resulting grants also requires staff time.

Discussion Topic: Information Sharing and Communications – Presented by Thomas Farrugia, AOOS.

What is HAB communication? Communication may cover the following:

1. What are HABs? Identify them and their effects, risks, etc. Build awareness.
2. Targeted Outreach and information sharing to specific groups. Using 1-pagers, flyers, etc.
3. Provide HAB updates, including PSAs, toxin results, progress reports used for ongoing efforts to the stakeholders.
4. Focus on specific HAB research projects. It may involve engaging specific stakeholders, or keeping them engaged in the project.
5. Communications about events or times of higher risk. Toxicity outbreaks, PSAs, time sensitive information about risks, developing threats. Includes need-to-know information for human health and safety.
6. Sharing of large-scale data, such as regional maps, time series, data, reports, etc. to large audiences.

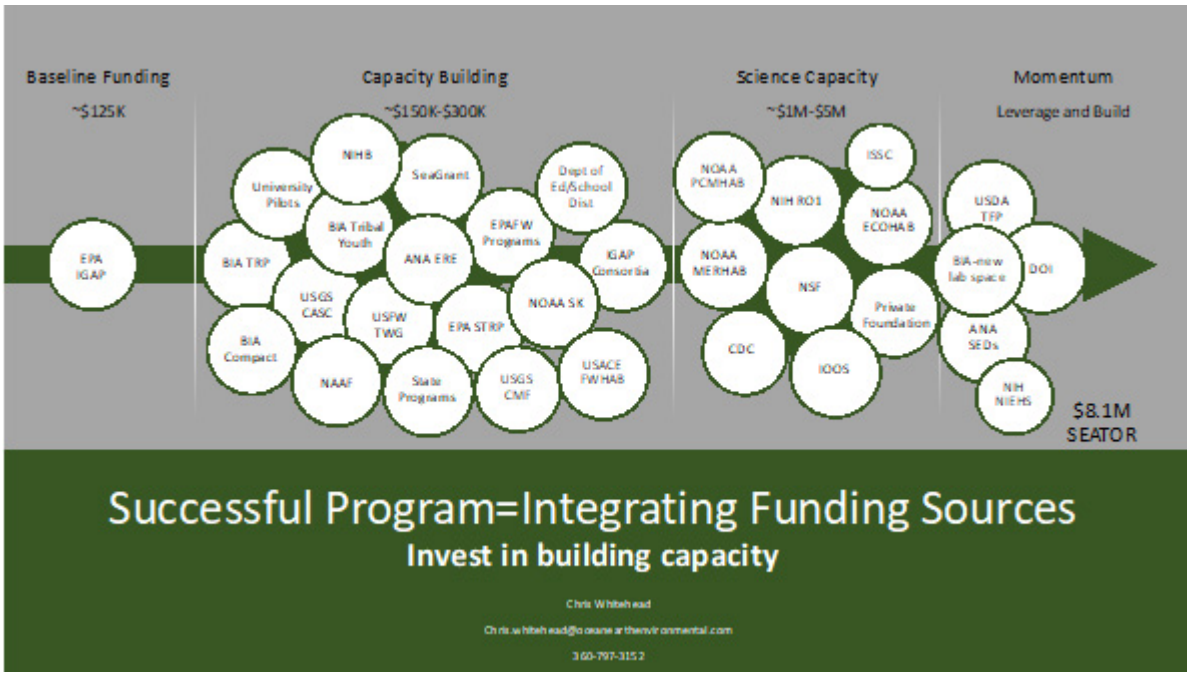


Figure 10. Integrating funding sources to support development of a HAB monitoring program.

In response to a question, it was pointed out that the AHAB Network and its coordinator try to facilitate communications, but do not need to be involved in everything. AHAB can help strengthen a region's ability to mitigate HAB effects. AHAB is simply the coordinating body for HABs in Alaska, which is spelled out in its mission statement: "The Alaska Harmful Algal Bloom Network (AHAB) was formed in 2017 to provide a statewide approach to HAB awareness, research, monitoring, and response in Alaska. AHAB coordinates a diverse group of coastal stakeholders to address human and wildlife health risks from toxic algal blooms" (AHAB, 2024). The focus is on informing without alarming, and the list of objectives of the organization is a living body that adapts to needs. This is an important function in the face of environmental change.

Summary, conclusions, and next steps

A variety of topics concerning HABs in Alaska were discussed over the three-day workshop, which concluded with the broad goal of raising awareness of the need for greater federal and state investment in research to better understand HABs in Alaska and to develop effective strategies to sustain programs that help mitigate HAB impacts on Alaskan people, communities and business. The bulleted list below summarizes the priorities that were discussed:

- A baseline for HABs in all regions of Alaska (i.e. The Gulf of Alaska, The Bering Sea and Bering Strait region, and areas adjacent to the Arctic Ocean) must be established. This is important as Alaska is the fastest warming state in the U.S. due to a changing climate. For example, 10-15 years ago very few HABs were reported in the areas adjacent to the Arctic Ocean and Bering Sea, but now there are enormous blooms of *Alexandrium*, (Anderson et al., 2021), and potentially other species as well, such as *Pseudo-nitzschia* (Hubbard et al., 2023). Monitoring of HABs and their toxins is critical to assess the extent of HAB risks in these new areas and to track how problems are changing.

- Co-production of knowledge about the local ecosystems should be incorporated into the modern understanding of HABs and marine ecology. Executive Order 13175 states that the federal government must interact with sovereign Indian tribal governments (Whitehouse, 2022). But in a larger sense, engagement with tribal governments, Alaska Natives, and all residents of the state is critical to develop monitoring approaches, and to improve understanding about linkages among Alaskan coastal systems.

• A central clearing house of Alaska HAB monitoring, testing and related environmental and oceanographic data should be developed. Presently, data are collected by researchers, agencies and tribal groups but are often not unified or accessible to others that may need the information. Data are needed for baseline establishment, to track changes, to assess environmental effects, assess risks, test models, and validate forecasting products. One such place to house a HAB data repository could be AOOS and the AHAB network.

• The HAB community (i.e., researchers and monitors in Alaska) should be seen as a helpful resource Statewide. Some tribes have been reluctant to work with state or federal HAB monitoring efforts for fears of being "shut down" (i.e., having certain harvesting opportunities limited due to regulations). Several workshop attendees asserted that the regulatory limit of 80 µg/100 g is a firm guidance for human consumption of seafood meant to ensure human health, and that this guidance should not be dismissed. However, it was also pointed out that some subsistence fishing communities may to object to regulatory agencies attempting to cut off their subsistence lifestyle, particularly if there are instances of severe illness or death that the subsistence community itself has not experienced.

• Better outreach and communication are needed to secure additional (appropriated) funding. One idea suggested videos could be made explaining HAB issues regionally, and these videos could be made available through the AHAB network and/or aggregated into a single outreach product (e.g., a Story Map).

• Regional hubs are essential to monitor and study HABs in different regions across Alaska. The AHAB network acts as the cohesion across regions, and provides a high-level communication platform to lift up regional concerns and aggregate information for state and national level decision-makers and funding sources.

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Pictured are two members of the Qawalangin Tribe of Unalaska looking at a water sample.
Photo credit: Shayla Shaishnikoff

Appendix 1: Workshop Agenda

ALASKA HAB WORKSHOP
Community needs for HAB monitoring, research, and forecasts

March 27-29, 2023 | Aft Deck, Captain Cook Hotel - Anchorage, AK (and via Zoom)

Alaska Harmful Algal Bloom Network, Alaska Ocean Observing System
National Centers for Coastal and Ocean Science

Purpose: The goal of this workshop is to gather HAB samplers, monitors, and researchers working in Alaska and discuss community needs for HAB monitoring, research, and forecasts. Participants will share knowledge and current efforts on HABs around the state, better understand the distinct needs of communities across Alaska, and coordinate how to meet those needs.

This workshop will also provide a space to ask questions to HAB experts, and it will be a chance to form and nurture relationships around the state, since the last statewide HABs meeting in Alaska took place in 2019.

Time	Presenter/Contributor	Mon. March 27 – Current state of HAB work in Alaska
8:30 – 9:00		Morning Coffee
9:00 – 9:30	Thomas Farrugia, Steve Kibler	**Welcome and general introductions**
9:30 – 10:30	Thomas Farrugia	**Review of Alaska HABs & Toxins** *Brief overview of HABs with time for general questions*
10:30 – 11:00		Break
11:00 – 12:30	All participants	**Participant summaries on HABs in their region/organization** *3-5 min per participant/organization (slides optional)*
12:30 – 1:30		Lunch (provided)
1:30 – 3:00	All participants	**Regional breakout discussions and report out** *Small regional groups discuss importance of HABs work*
3:00 – 3:30		Break
3:30 – 4:30	Louisa Castrodale (DOH), Katherine Newell (CDC)	**Human health aspects of PSP** *Symptoms, response, and role of health care providers*

Time	Presenter/Contributor	Tue. March 28 – HAB monitoring methods and tools
8:30 – 9:00		Morning Coffee
9:00 – 10:00	Jasmine Maurer, Thomas Farrugia	**HAB cell monitoring benefits and methods** *How HAB cells are sampled and what can be learned*
10:00 – 10:30	Steve Kibler, Tim Wynne	**Discussion: NCCOS HAB forecasts discussion and feedback** *Examples of what HAB forecasting can do and discussion*
10:30 – 11:00		Break
11:00 – 12:00	Tod Leighfield	**HAB toxin detection and monitoring benefits and methods** *How algal toxins are detected and what can be learned*
12:00 – 1:00		Lunch (provided)
1:00 – 1:30	Steve Kibler, Tim Wynne	**Environmental changes and HABs** *Presentation on how HABs may change in the future*
1:30 – 2:00	Steve Kibler	**Discussion: How to implement methods in different regions?** *Discuss how the methods presented can meet regional needs*
2:00 – 2:30	John Harley	**Using modeling as an early warning tool** *What modeling can tell you, what data are needed for models*
2:30 – 3:00		Break and prepare for field trip to DEC
3:00	Thomas Farrugia	Meet outside the Captain Cook to load shuttles to DEC lab
3:30 – 4:30	Patryce McKinney	**DEC lab tour** *See how samples are tested for PSP toxins at the state lab*
5:00		Return to Captain Cook Hotel (shuttle provided)
5:30 – 7:30		Happy hour (49th State Brewery) – appetizers and cash bar

Time	Presenter/Contributor	Wed. March 29 – Community needs and how to meet them
8:30 – 9:00		Morning Coffee
9:00 – 9:30	Chris Whitehead	**Setting up a long-term HAB monitoring program** *Learn how SEATOR started and developed their HAB program*
9:30 – 10:00	Steve Kibler, Chris Whitehead	**Discussion: The role of funding/support entities** *How funding entities can help, what is still lacking?*
10:00 – 10:30		Break
10:30 – 12:00	Steve Kibler, Tod Leighfield, Thomas Farrugia	**Discussion: Regional needs for HAB cell and toxin monitoring** *What are the barriers to more HAB monitoring?*
12:00 – 1:00		Lunch (provided)
1:00 – 2:30	Thomas Farrugia	**Discussion: HAB information sharing all levels** *How to better communicate before/during/after a HAB event?*
2:30– 3:00		Break
3:00 – 4:30	Thomas Farrugia, Steve Kibler, Tim Wynne	**Summary, conclusions, and next steps** *How best to move forward? Future regular workshops?*
4:30		Adjourn

Appendix 2: Participant list

Name	Name of organization, tribe, or agency
Bargmann, Naomi	U.S. Geological Survey Alaska Science Center
Brady, Carol	Alaska Dept. of Environmental Conservation
Branson, Maile	Alutiiq Pride Marine Institute
Carl, Allison	Chugach Regional Resources Commission
Carl, Dustin	Chugach Regional Resources Commission
Castrodale, Louisa	Alaska Department of Health
Chiskok, Darlene	Native Village of Saint Michael
Cornett, Juliana	Alaska Sea Grant/NOAA Alaska Fisheries Science Center
Divine, Lauren	Aleut Community of St. Paul Island Tribal Government
Eisner, Lisa	NOAA Alaska Fisheries Science Center
Fachon, Evie	Woods Hole Oceanographic Institution
Farrugia, Thomas	Alaska Ocean Observing System
Filipek, Nicole	Sitka Tribe of Alaska
Gann, Jeanette	NOAA/NMFS/ABL
Gannon, Megan	Nome Nugget
Garland, Anne	Applied Research in Environmental Sciences Nonprofit, Inc.
Gustafson, Jonathan	Qawalangin tribe of Unalaska
Harley, John	University of Alaska Southeast
Hart, Miranda	North Carolina State University
Holderied, Kris	NOAA NCCOS
Kibler, Steve	NOAA/NOS Beaufort Lab
Lange, Priscila	NOAA JPSS project
Leighfield, Tod	NOAA National Ocean Service
Lieske, Camilla	Alaska Department of Fish and Game
Lydon, Tim	U.S. Forest Service
MacArthur, Anna Rose	Kawerak Inc
Matweyou, Julie	Alaska Sea Grant
Maurer, Jasmine	Kachemak Bay National Estuarine Research Reserve
McKinney, Patryce	Alaska State Environmental Health Lab
Menadelook, Chuck	Kawerak Inc
OBrien, Erik	Farmer, Federal
Pate, Emma	Norton Sound Health Corporation
Poe, Aaron	Northern Latitudes Partnerships
Ravelo, Alexandra	University of Alaska Fairbanks - International Arctic Research Center
Ray, Ellen	U.S. Forest Service
Schnetzer, Astrid	NC State University

Schoen, Sarah	U.S. Geological Survey Alaska Science Center
Shaishnikoff, Shayla	Qawalangin Tribe of Unalaska
Sheffield, Gay	University of Alaska Fairbanks / Alaska Sea Grant
Smith, Matthew	U.S. Geological Survey
Snowball, Michelle	Native Village of Saint Michael
Stimmelmayr, Raphaela	North Slope Borough Department of Wildlife Management
Subramaniam, Ajit	LDEO/Columbia University
Suddleson, Marc	NOAA NCCOS
Sutton, Lauren	Kachemak Bay National Estuarine Research Reserve
Trifari, Michelle	NOAA Protected Resources Division; Alaska Sea Grant
Van Hemert, Caroline	U.S. Geological Survey Alaska Science Center
Wall, Andie	Kodiak Area Native Association
Whitehead, Chris	Ocean and Earth Environmental
Wynne, Tim	NOAA/NOS Beaufort Lab

Appendix 3: Post-workshop Survey

Dear Alaska HAB Workshop participants, we are working with partners at UAF & UW Tacoma to use wintertime surveys of Alexandrium cysts as a forecast tool for particularly severe blooms and PSP risk in southwest and southcentral Alaska. We are developing an action plan for advancing HAB forecast modeling over the next 5-10 years and would like to gauge potential interest in Alexandrium cyst monitoring as a supplement to bloom/toxicity monitoring in your area.

Please answer the following questions. We'll use your responses to help guide project planning in Alaska.

1. Would your organization be interested in Alexandrium cell/cyst monitoring to supplement shellfish PSP toxicity information as an early warning tool for PSP risk?

2. Would your organization be interested in helping with winter sampling for Alexandrium cysts?

3. Would your organization be interested in participating in routine qPCR-based monitoring for Alexandrium cells or resting cysts?

Thanks so much for the input. We will provide periodic updates through the Alaska HAB Network as forecast work moves forward.

Steve Kibler & Tim Wynne, NOAA National Centers for Coastal Ocean Science

Thomas Farrugia, AOOS Alaska HAB Network

Thank you for participating in the 2023 Alaska HAB Workshop!

Great turnout, 50 participants
Topics covered
Anonymous survey

1. How did you attend the workshop? (In-person, virtually, both)
2. Which days did you attend? (M, T, W)
3. What did you think about the length of the workshop? (Was three days too short? Too long? Just right?)
4. Was the workshop helpful?
5. Will you be able to implement any of the methods or activities in your region?
6. Did you feel like you were able to share your perspective?
7. What could have been done better?
8. Was the DEC lab tour useful/interesting?
9. What topics would you want to cover (maybe for next time)?
10. How often should these workshops take place?
11. Should future workshops be in other locations (than Anchorage)?
12. Did you like the location/room/catering?
13. Any other comments?

Dear Alaska HAB workshop participant,

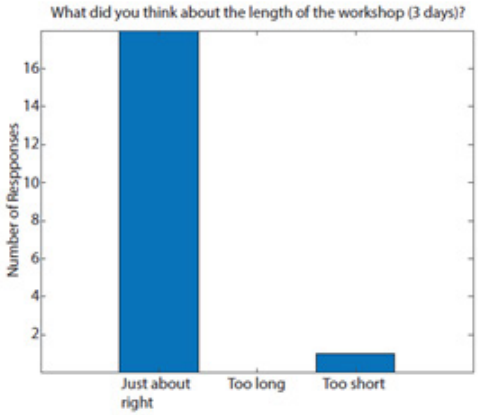
Thank you for participating in the 2023 Alaska HAB Workshop!

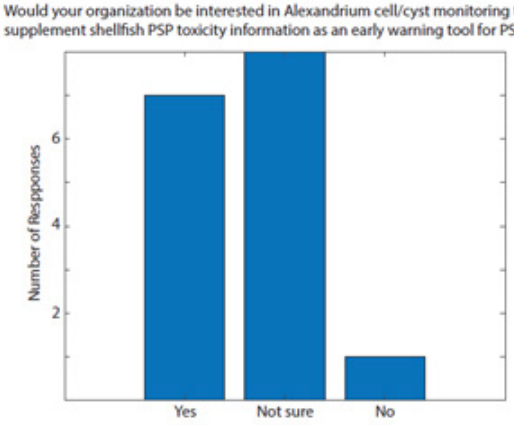
I was very pleased by the discussion and turnout at the workshop. We had a total of 50 participants (both in person and virtually), which generated some informative and insightful discussions.

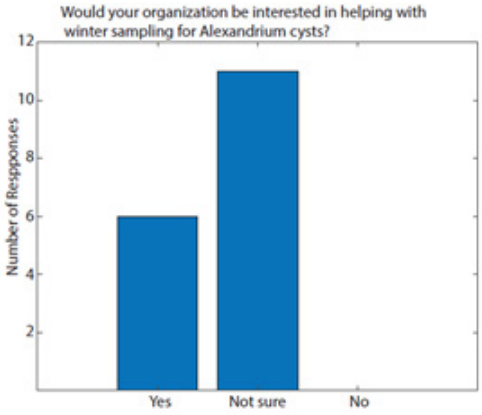
As a quick reminder, throughout the 3 days, we touched on:
- current HABs work in different regions of Alaska and future needs
- human health aspects of PSP
- methods and benefits for monitoring for HAB cells and toxins
- HAB forecasting benefits, challenges and ongoing work
- setting up long-term HAB monitoring programs
- funding and support for HAB work in Alaska
- communications and data sharing about HABs
- important next steps and future meetings for HAB work in Alaska
- AND we got to take a tour of the DEC lab where samples are tested for toxins!

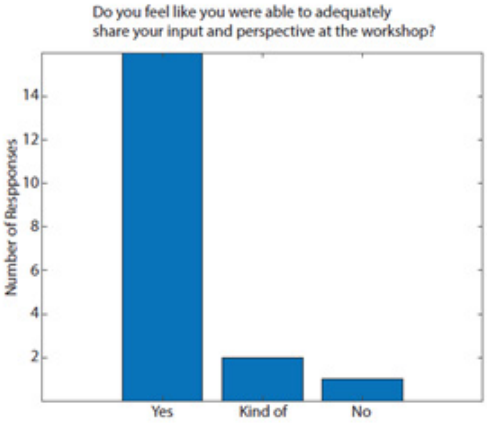
It would be really helpful if you could all take a few minutes to fill out this post-workshop survey. It will help us evaluate how this workshop went and what we can do better for next time. We also ask a couple questions about potential interest in Alexandrium cyst monitoring as a supplement to bloom/toxicity monitoring in your area.

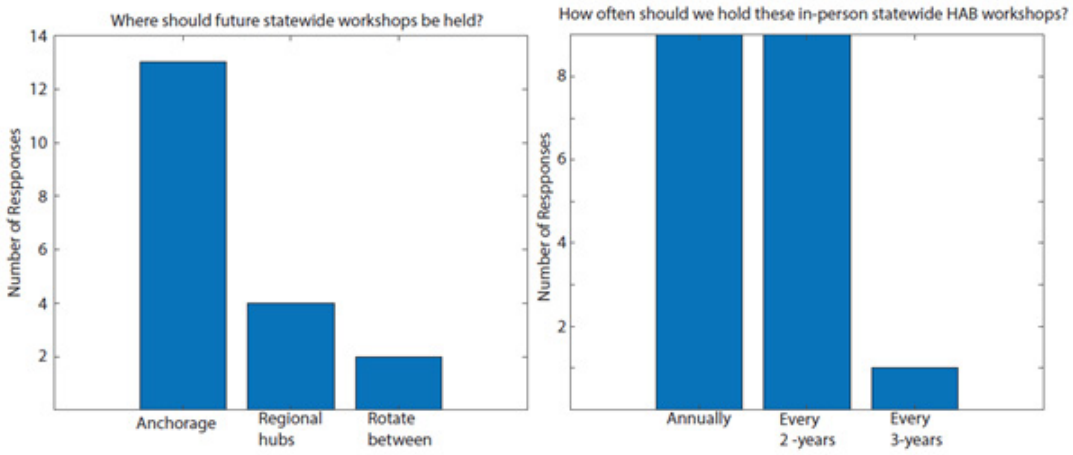
Appendix 4: Post-workshop Survey Results

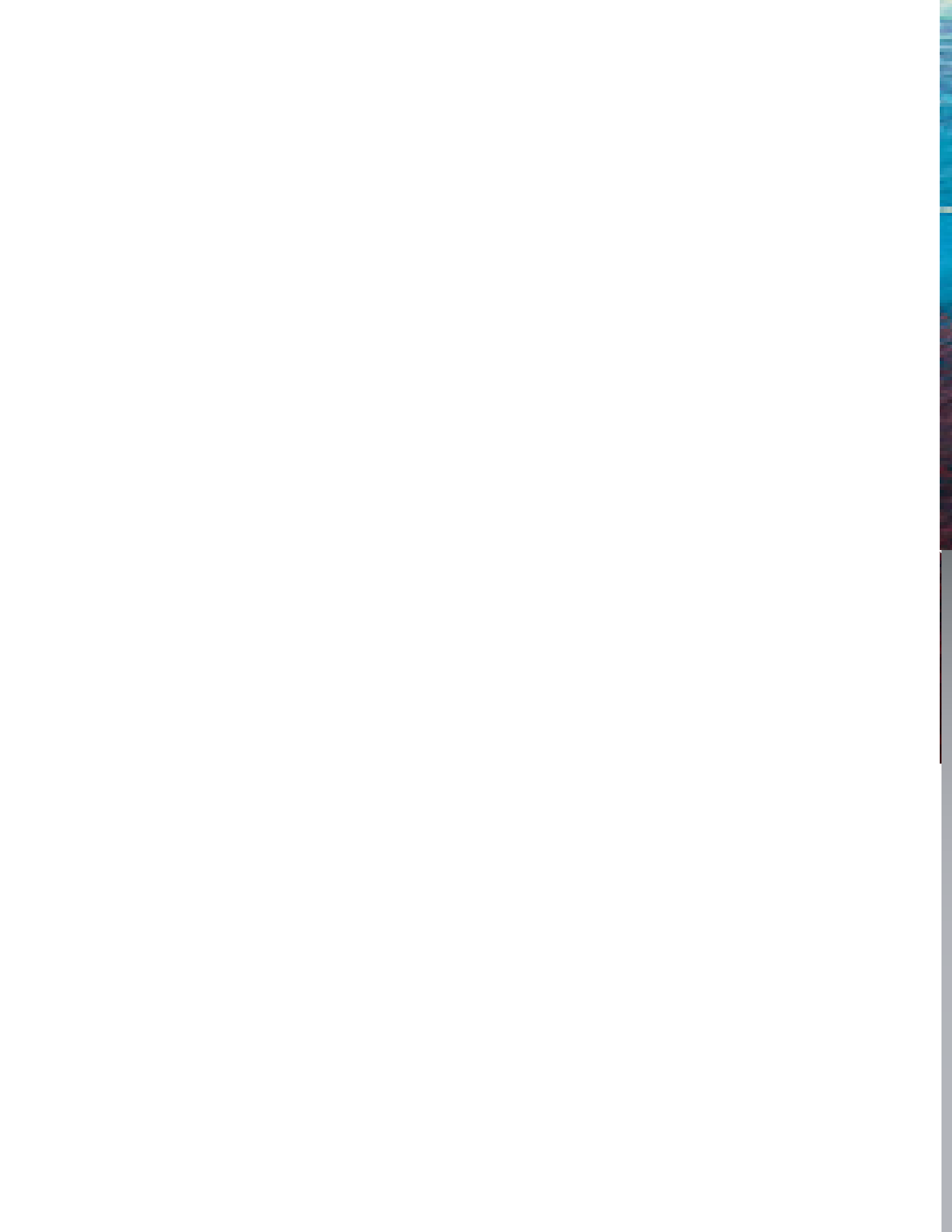









Where should future statewide workshops be held?
Number of Resppponses
14
12
10
8
6
4
2
Anchorage
Regional hubs
Rotate between
How often should we hold these in-person statewide HAB workshops?
Number of Resppponses
8
6
4
2
Annually
Every 2 -years
Every 3-years



U.S. Department of Commerce

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National Oceanic and Atmospheric Administration

Richard W. Spinrad, *Under Secretary for Oceans and Atmosphere*

National Ocean Service

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