Bering Strait: Algal Toxin Workshop

Abstract
A two-day Bering Strait Algal Toxin Workshop was held in Nome, Alaska on July 16 and 17. The workshop was co-sponsored by Alaska Sea Grant, the Alaska Ocean Observing System, the US Arctic Research Commission and NOAA. The first day of the workshop aimed at educating the general public and community of the Bering Strait Region, and around 30 people participated. Nine presenters covered the following topics: introduction to algal toxins; an overview of changing environmental conditions in the Bering Strait; algal toxins and their effects on marine resources such as shellfish, seabirds, and marine mammals; algal toxins and their effects on humans; Bering Strait & Western Alaska response and results focusing on seawater, seabirds, and marine mammals. There were also two group discussions focusing on public health response and harmful algal bloom response and communication.

The second day of the workshop aimed to educate healthcare professionals in the region and 18 healthcare professionals and other people attended. Presentations provided were trainings that focused on symptoms and response to to Paralytic Shellfish Poisoning (PSP), and Botulism.

Healthcare professionals attend training about symptoms and responses to botulism and Paralytic Shellfish Poisoning in Bering Strait Region. Photo by Beverly Bradley

Background

Algal toxins are produced during Harmful algal blooms, known as “HABs”, occur when microscopic algae (phytoplankton) grow rapidly to large numbers in the water. The “bloom” results in toxic or harmful effects on people, fish, shellfish, marine mammals, and birds. Certain environmental conditions may contribute to excessive growth of these organisms. Phytoplankton grow more slowly at colder temperatures and have faster growth rates at warmer temperatures. Compared to the southeast and southcentral regions of Alaska, little research has been done in the Bering Strait region concerning HABs; however, with air and sea surface temperatures reaching unprecedented highs in the Bering Strait over the last few years, there is potential for a harmful bloom event in the region.

Alaska Sea Grant, the Alaska Ocean Observing System, the US Arctic Research Commission and NOAA believed it was important to introduce the topic of algal toxins and their potential effects to the Bering Strait region and health professionals in the region. This two-day workshop in Nome covered identification of algal species that produce algal toxins, monitoring techniques, impacts to the ecosystem, and current algal toxin research results from marine wildlife samples collected from the region. The workshop also included presentations on changing environmental conditions in the Bering Strait region and the State’s role in public health responses to algal toxin poisoning. The first day of the workshop was targeted for local entities and the public. The second day was designed to inform local health care professionals in the region on the topic of algal toxins and provide training as to the proper medical response to algal toxin poisoning in people.

Gay Sheffield from ASG provides an introduction to the Algal Toxins Workshop. Photo by Beverly Bradley.

Presentations

Introduction to Algal Toxins: Vera Trainer, NOAA - NWFSC Marine Biotoxin Group

Vera Trainer from NOAA's Northwest Fisheries Science Center (NWFSC) Marine Biotoxins Group provided an introduction and background of algal toxins. HABs occur when phytoplankton grow rapidly to large numbers in the water (a "bloom"). There are many marine phytoplankton in the ocean. In fact, every second breath you take is due to marine phytoplankton as they produce over one-half of the world's oxygen. Less than one percent of these phytoplankton produce toxins that are harmful to humans and animals. However, the phytoplankton that are considered harmful produce biotoxins that can accumulate in filter-feeding shellfish and fish during blooms. The consumption of these shellfish by humans or animals can cause poisoning.

Trainer described one algal species, *Alexandrium catenella,* a dinoflagellate that produces a toxin called saxitoxin. *Saxitoxin* is responsible for what is commonly known as a "red tide" and if humans consume shellfish with high concentrations, they can experience Paralytic Shellfish Poisoning (PSP). Symptoms of PSP include numbness and tingling of the lips, mouth, face and neck, nausea, and vomiting. Severe cases result in paralysis of the muscles of the chest and abdomen which can lead to death. A limit of 80 micrograms of toxin per 1,000 micrograms of tissue is globally considered safe.

Alaska has a history of high concentrations of saxitoxins compared to the rest of the world. Saxitoxin acts like a cork on a bottle by blocking the flow of sodium into nerves. This paralyzes the nerves which in turn affects breathing and heart rate, creating the symptoms of PSP. These symptoms may sometimes be confused with botulism or the stomach flu, however tell-tale symptoms of PSP include tingling of the mouth, lips and extremities. There is no antidote for PSP; if the case is serious, survival will depend on the ability to receive CPR or other artificial respiration to support breathing.

While saxitoxin is the most commonly found toxin in Alaska, domoic acid (DA) has been detected in Alaska shellfish and is also monitored in parts of the state. Domoic acid is produced by certain species of the diatom *Pseudo-nitzschia*. Domoic acid works as a nervous system exciter, leading to overstimulation of the nerves which causes Amnesic Shellfish Poisoning (ASP) in humans and marine animals. Symptoms include gastrointestinal distress, confusion, seizures, short-term memory loss, coma, and death.

Vera Trainer providing a background on HABs to the Western Alaska community. Photo by Beverly Bradley.

During her presentation, Trainer also discussed *Alexandrium* cysts which are hibernating *Alexandrium* cells that reside in the sediment. These cysts can rest dormant for decades until the right environmental conditions (warmer temperature, specific nutrients, and sunlight) allow them to bloom. It is thought that as the temperature and waters warm, the cysts may bloom more often, thus increasing the incidence of this type of HAB in western Alaska.

Trainor also addressed HABs monitoring, education, and outreach. One way to begin building an early warning system for HABs is to start a phytoplankton monitoring program, similar to what has been done in the State of Washington through the Olympic Region HAB (ORHAB; www.orhab.org) and SoundToxins (www.soundtoxins.org) partnerships. This could be as simple as collecting seawater once or twice a week to do harmful algae cell counts and test for toxins. This method is considered an early warning method because it can alert managers and harvesters that shellfish may be toxic and minimize costs to commercial shellfish growers by preventing the loss of product and recall.

Trainer finished off her presentation by providing an example of a local partnership that is successfully completing phytoplankton monitoring and utilizing the early warning method. Located in Sitka, the Southeast Alaska Tribal Ocean Research Partnership (SEATOR) partners with 15 local tribes to identify key harvest locations and collect samples. With the help of their partners on a weekly basis they collect phytoplankton,

seawater samples, salinity and sea surface temperature measurements, and shellfish for toxin analysis.

Overview of Changing Environmental Conditions in the Bering Strait: Rick Thoman, UAF - Alaska Center for Climate Assessment and Policy

Rick Thoman from the Alaska Center for Climate Assessment and Policy provided a powerful overview of the changing environmental conditions in the Bering Strait region. He started by painting a bigger picture of the entire state's conditions over the last few years, stating that temperatures have been mostly above normal in Alaska since June 2013. Three out of four of the warmest years in Nome over the past century have occurred since 2014. The average day in the last nine months in Nome is 6°F warmer than normal.

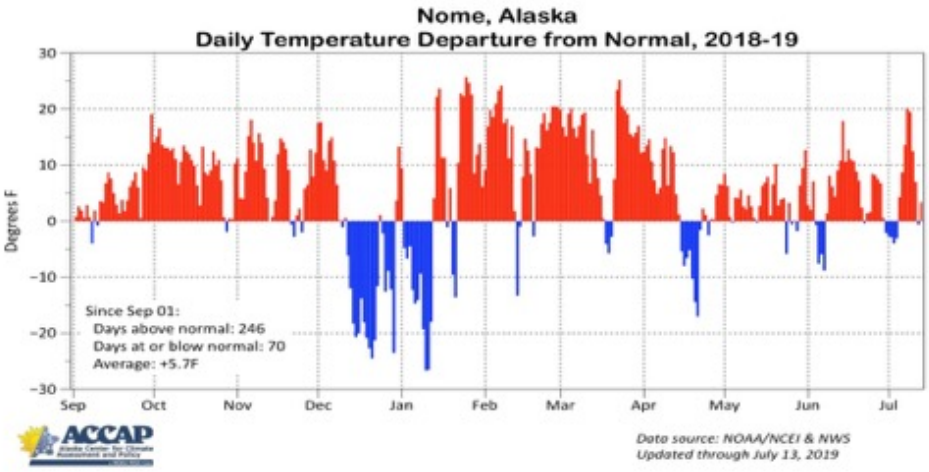


Figure 1. Daily Temp. Departure from Normal. Nome, 2018. Provided by Rick Thoman.

Ocean temperatures are following a similar pattern. For example, Nome's sea surface temperature (SST) departure from normal was greater than 9°C this summer.

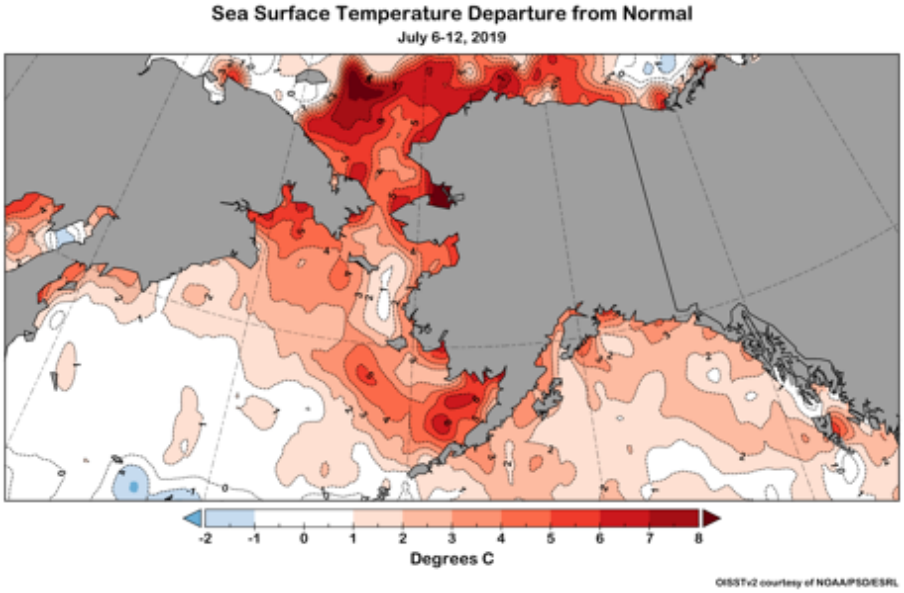


Figure 2. SST departure from normal July 6-12, 2019 in Nome. Figure provided by Rick Thoman.

With the increase in SST there has been a dramatic decrease in sea ice, and the last two years in the Bering Strait are unlike any from the previous 40 years of satellite data. The last of the season's sea ice used to melt out of the Bering Sea around summer solstice but it has been occurring earlier since the 2000's. Without the sea ice to reflect the sun's rays, the heat from the sun gets absorbed by the water, resulting in elevated temperatures.

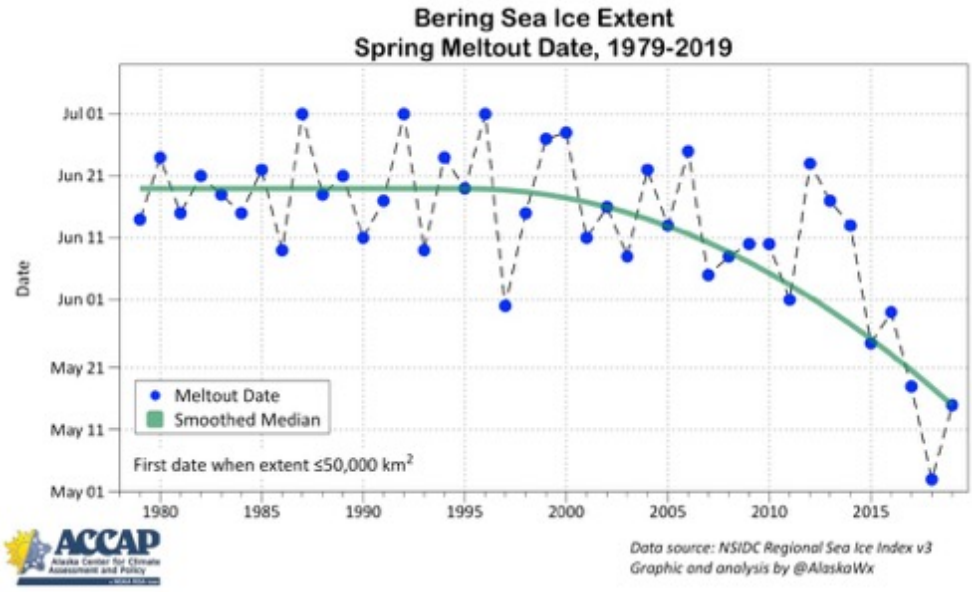


Figure 3. Bering Sea ice extent from 1979-2019. Figure provided by Rick Thoman.

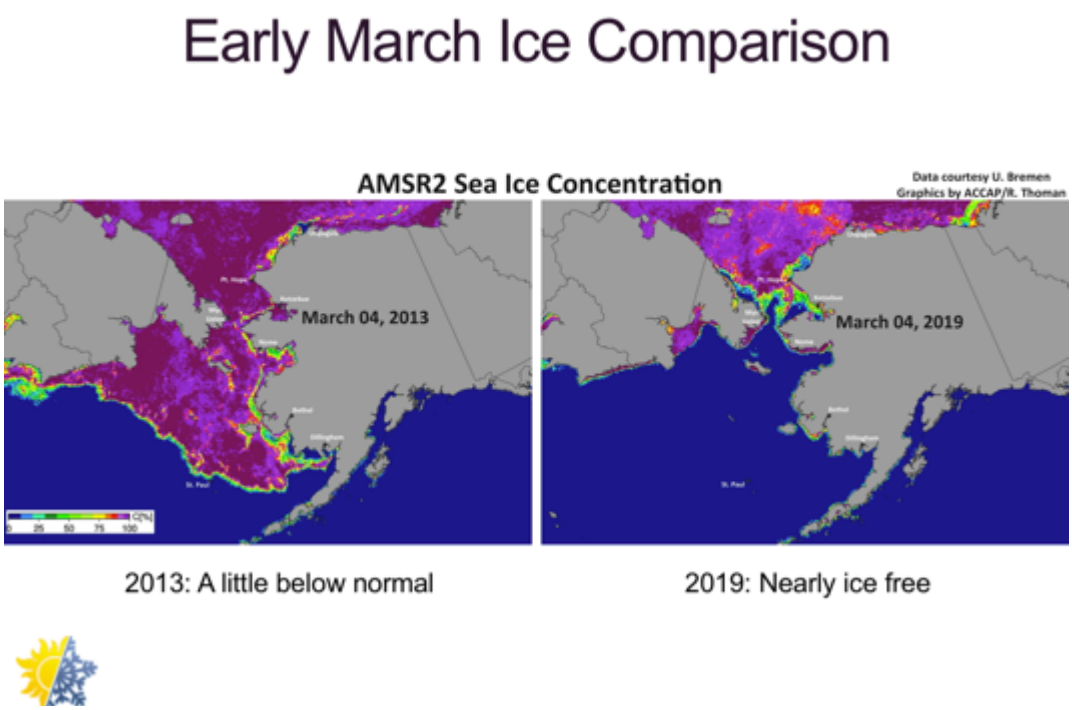


Figure 4. Western Alaska early March ice comparison between 2013 and 2019. Figure provided by Rick Thoman.

Thoman emphasized that for the Bering Strait every year since 2010 has been in the top ten warmest years and that there hasn't been a coldest year since the 1950's. He also explained that monthly changes in SST has not been uniform over space or time.

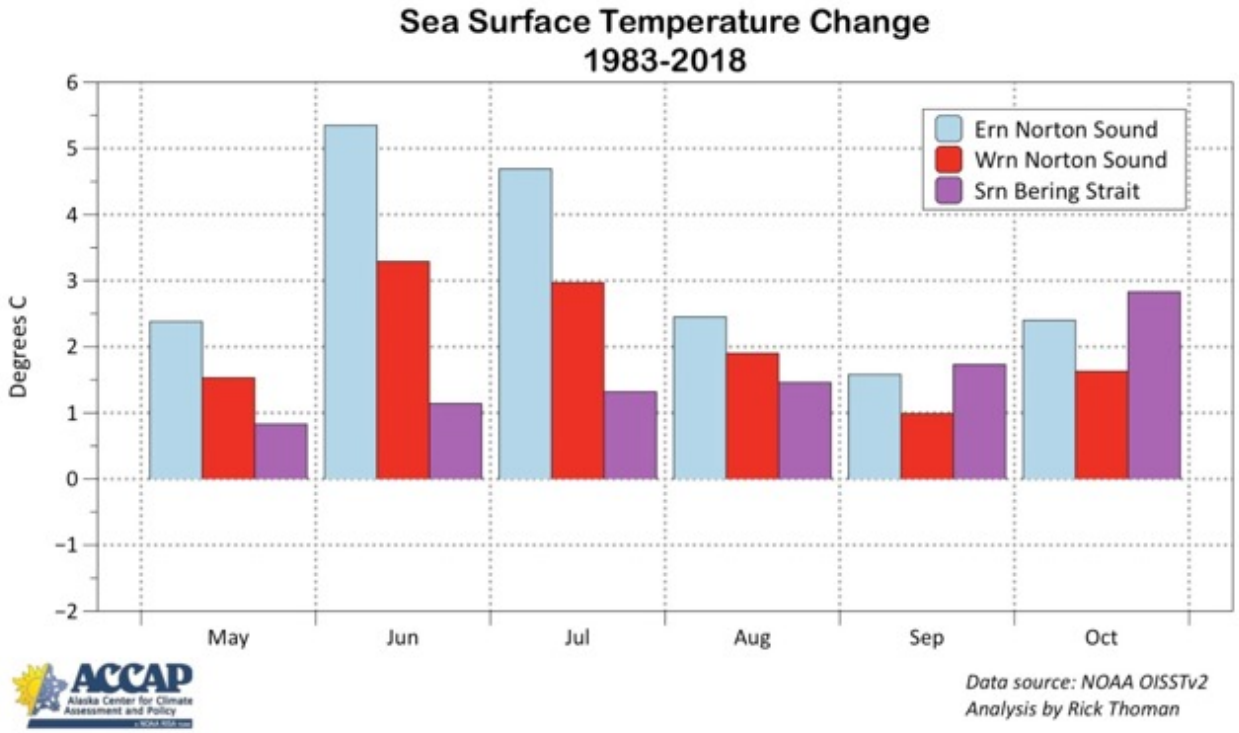


Figure 5. Bering Strait SST change. Graph provided by Rick Thoman.

Looking into the future, Thoman has a paper in review that suggests Bering Sea ice is extremely sensitive to ongoing warming, and the last few years of unprecedented temperatures could become the normal in 20 years. In 40 years, the same temperatures could become the optimistic outlook. SST is closely tied to ice melt and loss, meaning sea surface temperatures would also likely rise. Thoman stated that these warmer summer temperatures are expected to increase in the future. This most likely means that the Bering Sea will also experience an increase in HABs, since warmer waters promote blooms.

Panel 1: Algal Toxins and Effects on Marine Resources

Panel 1 presenters prepare to speak on Algal Toxins and Effects on Marine Resources. Pictured above from left to right: Julie Matweyou, Kathi Lefebvre, Matt Smith, and Caroline Van Hemert. Photo by Beverly Bradley

Shellfish: Julie Matweyou, Alaska Sea Grant

Alaska Sea Grant's Julie Matweyou explained algal toxins and their effect on shellfish. She began by providing a background on how the State of Alaska monitors and regulates shellfish. All commercially harvested Alaskan shellfish are regularly tested by the State before sale and consumption. This means that all store-bought Alaska shellfish are safe to eat. However, Matweyou noted that HABs affect the commercial shellfish industry from a logistical and revenue perspective. Because commercial shellfish are subject to PSP testing and processing, there is increased cost, ex-vessel value loss, and potential economic loss. For example, you can't sell crab whole in Kodiak because they have to be pulled apart to be tested.

No routine testing is done by the state for recreational, personal use, or subsistence shellfish harvest. The State of Alaska has put out a blanket statement that all shellfish within the state are unsafe to harvest. Since Alaskans in parts of the state harvest and consume shellfish anyway, this has led to the creation of regional monitoring efforts.

Matweyou explained there is a need for beach-specific testing due to spatial and seasonal variability. (A beach with high levels of toxins could be in close proximity to a beach with normal levels.) A comprehensive approach to HABs should also include both

phytoplankton and shellfish monitoring. To accomplish this there needs to be strong community partners and educational partnerships.

Seabirds: Caroline Van Hemert & Matt Smith, USGS

Caroline Van Hemert and Matt Smith from the USGS Alaska Science Center provided information on algal toxins in Alaska seabirds. Seabirds are exposed to toxins through marine resources such as fish, shellfish, and invertebrates. Not a lot of research has been conducted about the direct effects of algal toxins on birds. However, historically there have been some bird die offs linked to HABs. Van Hemert spoke to the fact that direct causation can be difficult to establish between HABs and bird mortality.

USGS slide explaining HABs and seabirds. Slide provided by Caroline Van Hemert (USGS).

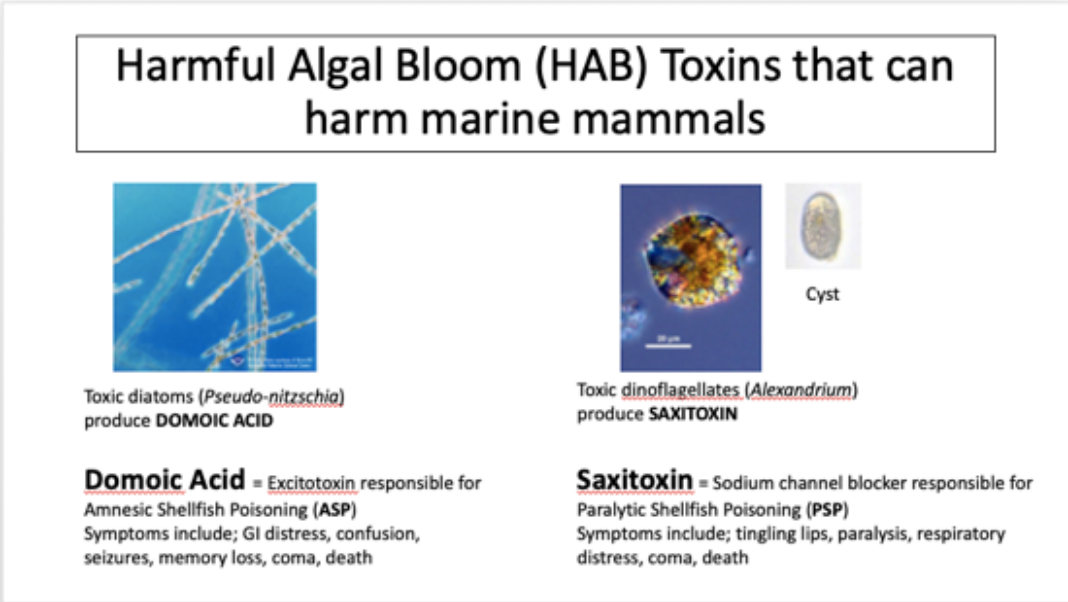
There have been a number of bird die offs in Alaska over the last few years. From 2015 to 2018 there was a Common Murre die-off in the Gulf of Alaska, a Tufted Puffin die-off in the Pribilof Islands, and a multispecies (Northern Fulmar and others) die-off in Chukchi and Bering seas. Preliminary findings in seabirds showed that saxitoxins are common in birds and forage fish across Alaska. Domoic Acid was rare in birds but present in forage fish at trace concentrations. Van Hemert emphasized there is no direct evidence suggesting recent bird die-offs in Alaska were caused by HAB toxins but there are still many unanswered questions.

Smith and Van Hemert (USGS) discuss PSP in seabirds. Photo by Beverly Bradley.

Collaborative research to understand the effects of saxitoxin ingested by birds is underway through the USGS National Wildlife Health Center. In 2018 a captive mallard study took place, looking at lethal dose and tissue toxicity. Dosed birds took 15 minutes to an hour to die. Toxin analysis showed that most saxitoxin was detected in gastro intestinal tissue but no saxitoxin was detected in the heart, blood or brain. Behavioral signs of saxitoxin toxicity appear in the form of convulsions, head drooping, and lame wings. For the mallards that survived, blood and fecal samples were collected. In feces, there was a large spike in toxins followed by a decline with no quantifiable toxin after 48 hours. No toxin was detectable in tissues at all after one week. This indicated that even though toxins may not be detectable in birds, that does not rule out that they came into contact with them.

Marine Mammals: Kathi Lefebvre, NOAA WARRN-West Lab & Raphaela Stimmelmayr, NSB Department of Wildlife Management

Kathi Lefebvre from the NOAA Wildlife Algal Toxins Research and Response Network (WARRN-West) Lab provided an overview on algal toxins and marine mammals. She began by giving a recap of the algal toxins that can be harmful to marine mammals and humans.



HAB toxins that can harm marine mammals and humans. Figure provided by Kathi Lefebvre.

Lefebvre went on to describe her research in Alaska, explaining that HAB toxins have been detected in stranded and harvested marine mammals from all regions of Alaska. She has been collecting opportunistic samples from all over Alaska and the west coast of North America. The WARRN-West Lab measures domoic acid and saxitoxin in marine mammal species, birds, and fish from the Arctic down to Southern California.

Lefebvre described the movement of HAB toxins through the marine food web and the many pathways and trophic levels involved. An example of one food web dynamic, looks at the route of toxin transfer between diatoms who get eaten by anchovies who in turn are eaten by sea lions. Dozens to hundreds of sea lions are poisoned every year by domoic acid on the West Coast of the United States. Some common signs of domoic acid poisoning in marine mammals are seizures, head weaving or other abnormal migratory behavior (animals going places they don't normally go). Saxitoxin has not been diagnosed as often in marine mammals as domoic acid has. This could be because saxitoxin causes paralysis and when the marine mammal is poisoned at sea it may become paralyzed immediately and drown without any observable clinical signs and away from coastal residents or scientists.

Raphaela Stimmelmayr of the North Slope Borough Department of Wildlife Management spoke about their local subsistence harvest monitoring program. She explained that HABs have been an interest of the North Slope Borough (NSB) because environmental conditions are likely to increase HABs which could negatively affect subsistence species. The NSB is learning how to provide information and help when it comes to HABs and marine mammals. They are aiming to answer questions like: 'Does it impact food safety?' and 'Is it harmful to the animal'? The NSB opportunistically take samples from subsistence harvested or stranded whales, seals, and walrus for HABs analysis. This is an ongoing process of figuring out what toxins are present, how they are accumulating, and what they mean for local species.

Human Aspect: Joe McLaughlin, MD, MPH, Alaska Division of Public Health
Dr. Joe McLaughlin from the Alaska Division of Public Health presented on the public health aspects of HABs. There are two common ways for humans to get poisoning from algal toxins: ingestion and skin contact. McLaughlin emphasized that you cannot cook (heat or freeze) algal toxins out of food. The toxins are odorless and tasteless, so it is impossible to be sure of their presence or absence unless a sample is tested in a lab. Paralytic Shellfish Poisoning symptoms can start presenting in as few as five minutes but the average time from ingestion to symptom onset is 30-60 minutes.

PSP symptoms are classified into three levels of severity: mild, medium, and severe. Mild symptoms include numbness, headache, dizziness, nausea, and vomiting. Medium symptoms include incoherent speech, rapid pulse, shortness of breath, and backache. Severe symptoms include motor speech disorder, difficulty in swallowing, suspension of breathing, muscle paralysis, respiratory arrest, and death.

Dr. Joe McLaughlin of the ADPH explaining the symptoms of PSP. Photo by Beverly Bradley.

The State of Alaska strongly advises Alaskans not to consume self-harvested shellfish due to the risk of PSP. However, if people choose to disregard this advice, they should never eat alone and be near a healthcare facility or hospital to receive immediate care if symptoms arise. If you think someone has PSP, bring them to the nearest medical facility immediately or call 911 if the patient has more severe symptoms. If the patient stops breathing, perform CPR until help arrives.

A ‘possible case’ of PSP is defined as PSP symptoms occurring within 12 hours of eating shellfish. A ‘probable case’ is defined as PSP symptoms within 12 hours of eating shellfish *and* laboratory evidence confirming the presence of toxins. Symptoms usually resolve between 24-72 hours. There is no antitoxin for PSP. Patients with difficulty breathing may require mechanical ventilation.

Between the years 1993-2014 there were 117 PSP cases reported from 70 outbreaks in Alaska. The median age of cases was 42 years old (range: 2-72 years old). Over half of the cases were male. Case counts by race were highest in Alaska Native people. Eighty-two percent of cases received medical attention, four percent needed mechanical ventilation, and four people died. Nine out of ten of the highest SXT levels in these cases were found in blue mussels. PSP outbreak cases occur in <u>every</u> month of the year, with the most common shellfish in reported cases being butter clams (about a third), followed by blue mussels, cockles, and razor clams.

McLaughlin finished by touching on Amnesic Shellfish Poisoning (ASP) caused by domoic acid. Similar to PSP, it cannot be cooked out of food. ASP can leave the victim with permanent memory problems. A deadly outbreak in Canada in the 1980's involved over 100 cases, however, there have been no confirmed human cases in the US.

Panel 2: Bering Strait & Western Alaska Response and Results

Seawater: Dean Stockwell, UAF-CFOS

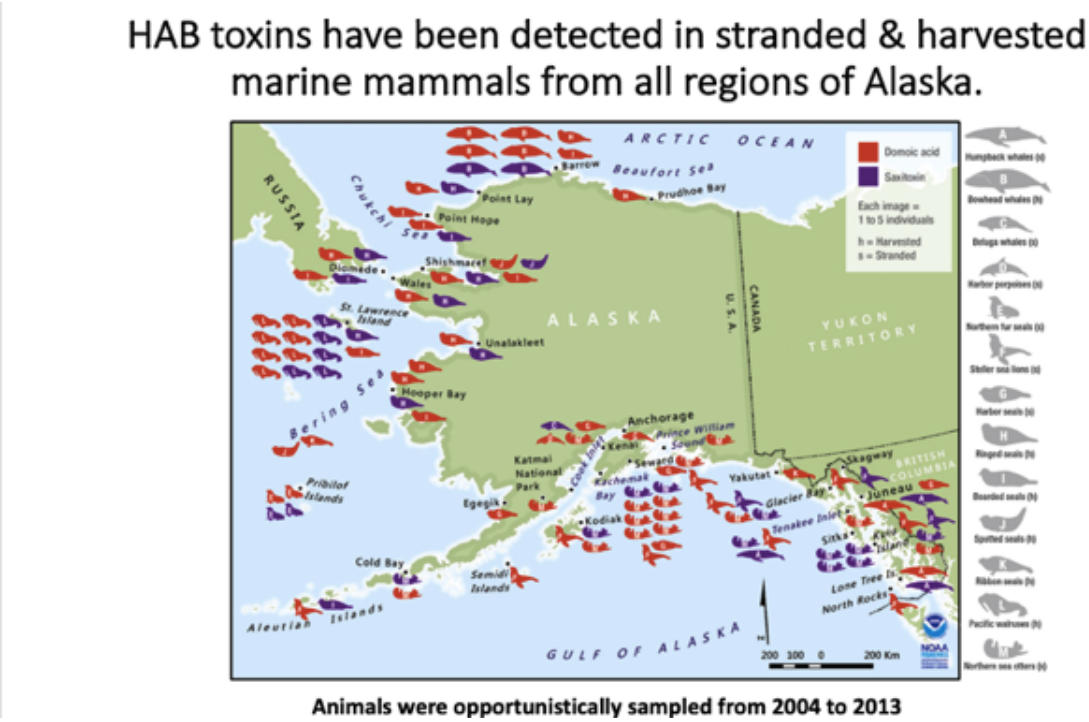
Dean Stockwell, a phytoplankton and algae researcher, from the University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, provided seawater monitoring results from the Bering Strait and Western Alaska. Water flow plays a large role in plankton transport, and Stockwell showed three or four flow regimes within the Bering Strait. The variability influences the entire food web and makes future predictions challenging.

Stockwell emphasized the importance of local observations during a HAB events and noted residents should look for discolored water or birds stumbling around with drooped heads. His most recent research focused on saxitoxin and domoic acid distribution in the Arctic 2017-2018. Water transported from the south throughout the Bering Strait is bringing larger numbers of algae at a faster rate. The entire system is in flux, driven by the unprecedented temperature changes (described by Rick Thoman).

Dean Stockwell talking about the uncertainty of detecting HAB events in Western Alaska. Photo by Beverly Bradley.

Large numbers of cysts have been found in the Bering Strait region. These findings have been reported in the literature (Natsuike et al., 2013; Abundance and distribution of toxic *Alexandrium* tamarense resting cysts in the sediments of the Chukchi Sea and the eastern Bering Sea). The importance of their presence in shallow water sediments is that they serve as an active repository for *Alexandrium* cells. Given the proper growth conditions (i.e., temperature, light, resuspension and nutrients) these cells can excyst or emerge from the cysts and repopulate the water column with viable and active cells. The cysts, similar to the vegetative cells, also contain algal toxins. Animals feeding within the muds can accumulate the toxins.

Marine Mammals: Kathi Lefebvre, NOAA WARRN-West Lab
Between 2004-2013, around one thousand opportunistic samples were taken from marine mammals around the state, covering 13 species. The WARRN-West lab looked at feces and stomach contents and found detectable amounts (low levels) of the algal toxins domoic acid and saxitoxins in all regions and all species. This confirmed that algal toxins were present in the ocean waters surrounding Alaska but were not at levels that were known to impact the health and behavior of marine mammals.



Map of where saxitoxin and domoic acid toxins have been detected in marine mammals. Figure provided by Kathi Lefebvre.

During August and September 2017, approximately 39 walruses in good body condition, washed ashore along the Northern Seward Peninsula raising questions about the cause of death. Samples from 12 individual walruses were sent to the WARRN-West lab and analyzed for the presence of algal toxins. Algal toxins were detected in eight of the 12 walruses and two of those animals had very high toxin concentrations in fecal samples. The high toxin levels were above the established seafood safety regulatory limit for shellfish intended for human consumption, suggesting that walrus gastrointestinal content can contain unsafe levels of toxins. These results highlight the need for continued research on the impacts of HAB toxins on walrus health and the tissue distribution of toxins in subsistence harvested animals. For more information please see Sheffield, G. 2017. Bering Strait: Walruses and Saxitoxin, late summer/fall 2017, UAF Alaska Sea Grant, MAB-74, Nome, Alaska. 2pp.

Lefebvre is currently collaborating with partners to look at algal toxins in Alaska's food webs. The project team (included in graphic below) will be collecting samples during eight research cruises already planned for the Arctic in the late summer and fall of 2019.

They plan to capture sediments samples, water samples, zooplankton samples, krill samples, copepod samples, multiple species of fish, bivalves, and the continuation of sampling subsistence-harvested and dead stranded marine mammals.

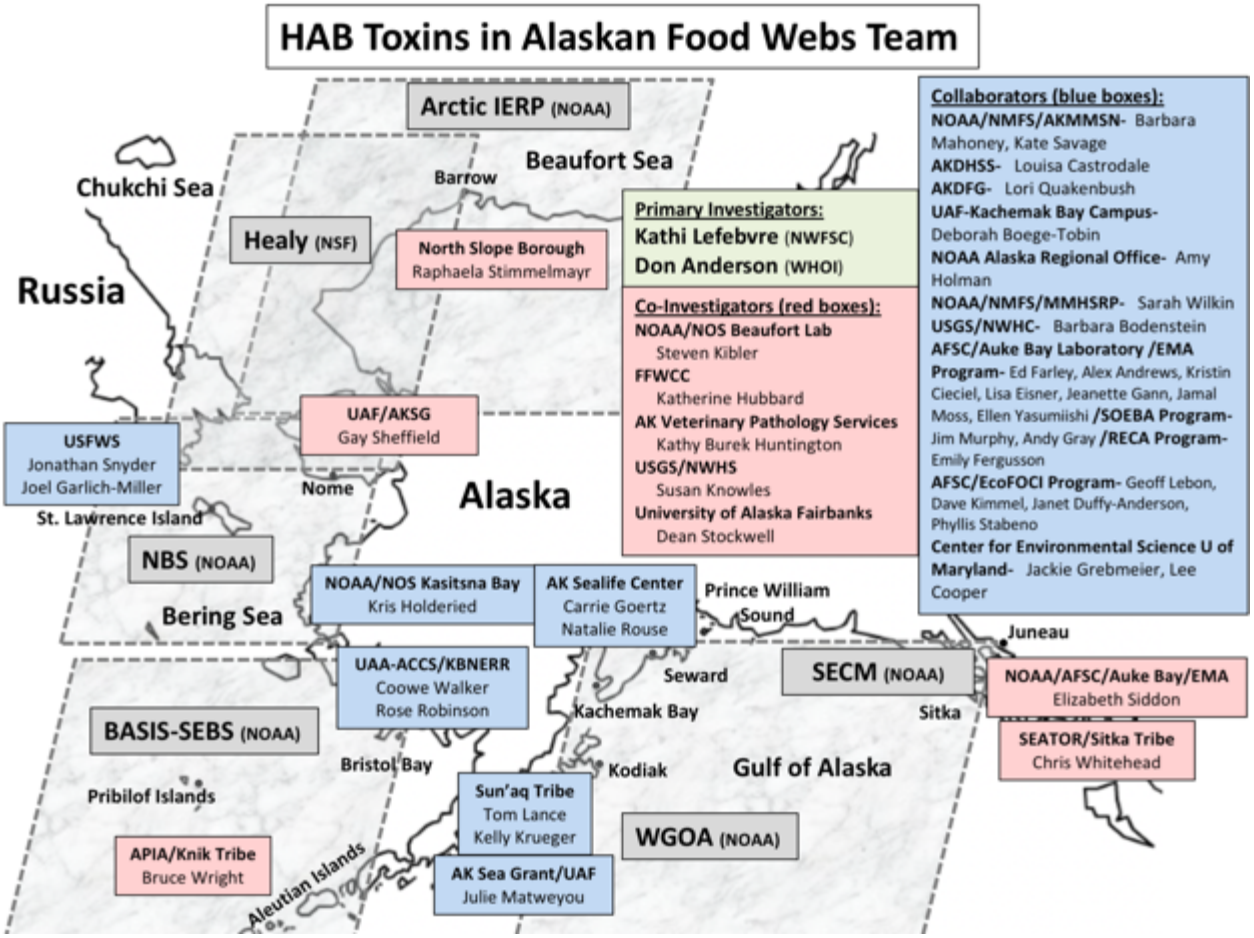


Figure representing the proposed ECOHAB team working on HAB toxins in Alaskan Food Webs. Figure provided by Kathi Lefebvre.

Seabirds: Caroline Van Hemert & Matt Smith, USGS

Caroline Van Hemert and Matt Smith provided research results about seabirds in Western Alaska. Starting with the Bering and Chukchi bird die-off from 2017, they explained that over 1,500 fulmars, shearwaters, and kittiwakes were found dead from the Aleutian Islands to Point Hope. Saxitoxin was detected in 88% of dead fulmars sampled but not in any of the other species. Domoic acid was below detection in all species. The highest concentration of saxitoxin was found in the gastrointestinal tract. Smith emphasized that there is no baseline information for these species or region and that is the first step in teasing out trends in a complex system.

A second study was conducted during 2018 where samples were taken from multiple individuals from ten seabird species. Samples were received from Cook Inlet, Kodiak, the Bering Sea, and Chukchi Sea. No samples had quantifiable levels of toxins. In both years there were signs of emaciation and low stomach content in the birds they were sampling. Smith and Van Hemert once again emphasized that is there is no direct

evidence suggesting recent bird die offs in Alaska were caused by algal toxins but that there is still much research to be done.

Looking forward, Smith and Van Hemert will continue testing dead birds using both field and community-based sampling. They will also focus on food web dynamics toxin effects on captive birds to help better understand how algal toxins affect seabirds.

Discussion: Public Health Response (Moderator: Dr. Joe McLaughlin, Alaska Division of Public Health)

Joe McLaughlin led a discussion on the public health response to algal toxins. He began by taking everyone through the steps of response once a possible case of algal toxin poisoning has been reported.
The first step is to verify the diagnosis by going through the common signs and symptoms. Sometimes someone from the Alaska Department of Health and Social Services (DHSS) will fly to the site, depending on the number of people involved and severity of the symptoms. This is done to help characterize the outbreak and prevent additional cases from occurring. DHSS and partners (e.g., DEC and local communities) will also post warning signs at implicated beaches in an attempt to reach any harvesters they may have missed. Everyone with symptoms should go to an emergency room or urgent care doctor immediately for evaluation.

Any leftover shellfish are sent to the Alaska Department of Environmental Conservation lab in Anchorage for testing. This can take up to a week for results; they will also collect urine samples from patients for testing.

DHSS communicates their findings to the local communities by way of social media, press releases, health alert messages, and an Epidemiology bulletin. You can sign up for these for free on the following website:
http://dhss.alaska.gov/dph/Epi/Pages/bulletins/subscribe.aspx

After McLaughlin explained the steps of response and communication about PSP from the state, the group discussed the need for a rapid PSP testing field kit. Some research is being conducted on these, but it will not be an option in the near future. The second best option right now for Alaska are regional monitoring programs. These are not perfect but they can at least provide some form of local information.

Participants listen during the group discussion. Photo by Beverly Bradley.

Discussion: HAB Response and Communications (Moderator: Gay Sheffield, Alaska Sea Grant)

Gay Sheffield (UAF College of Fisheries and Ocean Sciences, Alaska Sea Grant) led a final discussion on algal toxins, HAB event response, and communication for western and northern Alaska. This was an open floor discussion where participants could ask questions. Sheffield began by providing a summary of what they had learned.

Sheffield emphasized that there is not currently a PSP problem in Western Alaska. Rather, the purpose of this workshop was to inform the regional healthcare community and community members of what to expect in case algal toxins and a HAB event becomes a problem in the future. It was noted that Bering Sea residents are sometimes gifted shellfish from other parts of the state, so communities need to be aware and know the signs.

The next big question addressed to the group was “how a community develops a plan to be a step ahead of these things?” The resounding answer was to create a monitoring program, as we cannot detect change without baseline monitoring. Since there are over 44,000 miles of coastline in Alaska, the place to begin is identifying key locations that are important to the community.

The group agreed that the following communications efforts would be useful:

- A PSP behavioral checklist for marine mammals. That way the community could know who to report to when they see a suspected behavior.
- A close connection with the LEO network. The Alaska Native Tribal Health Consortium’s LEO network acts as a citizen science platform where community members can report observations in their region.

- An emphasis on partnering with the AHAB network to work with regional communication networks out of the transportation and/or governmental regional hubs.
- A 2-pager on HABs in Western Alaska covering what we know, what scientists are doing, and what to look out for. This could be created by the Alaska HAB Network.

Participants joining in on the final discussion and recap. Photo by Beverly Bradley.

Thank you to all of the sponsors and participants. If you have any questions about the workshop or would like to get into contact with algal toxin experts, please email Gay Sheffield at ggsheffield@alaska.edu or Darcu Dugan at dugan@aoos.org.