AOOS
Alaska Ocean Observing System

The Eye on Alaska's Coasts and Oceans

Underwater Storms: How Harmful Algal Blooms Form and Their Impacts on Alaska's Oceans

Thomas J. Farrugia, PhD
Alaska Ocean Observing System (AOOS)
Alaska Harmful Algal Bloom Network

March 4, 2026 - VAWS

IOOS Integrated Ocean Observing System

ALASKA HARMFUL ALGAL BLOOM NETWORK
ahab.aoos.org

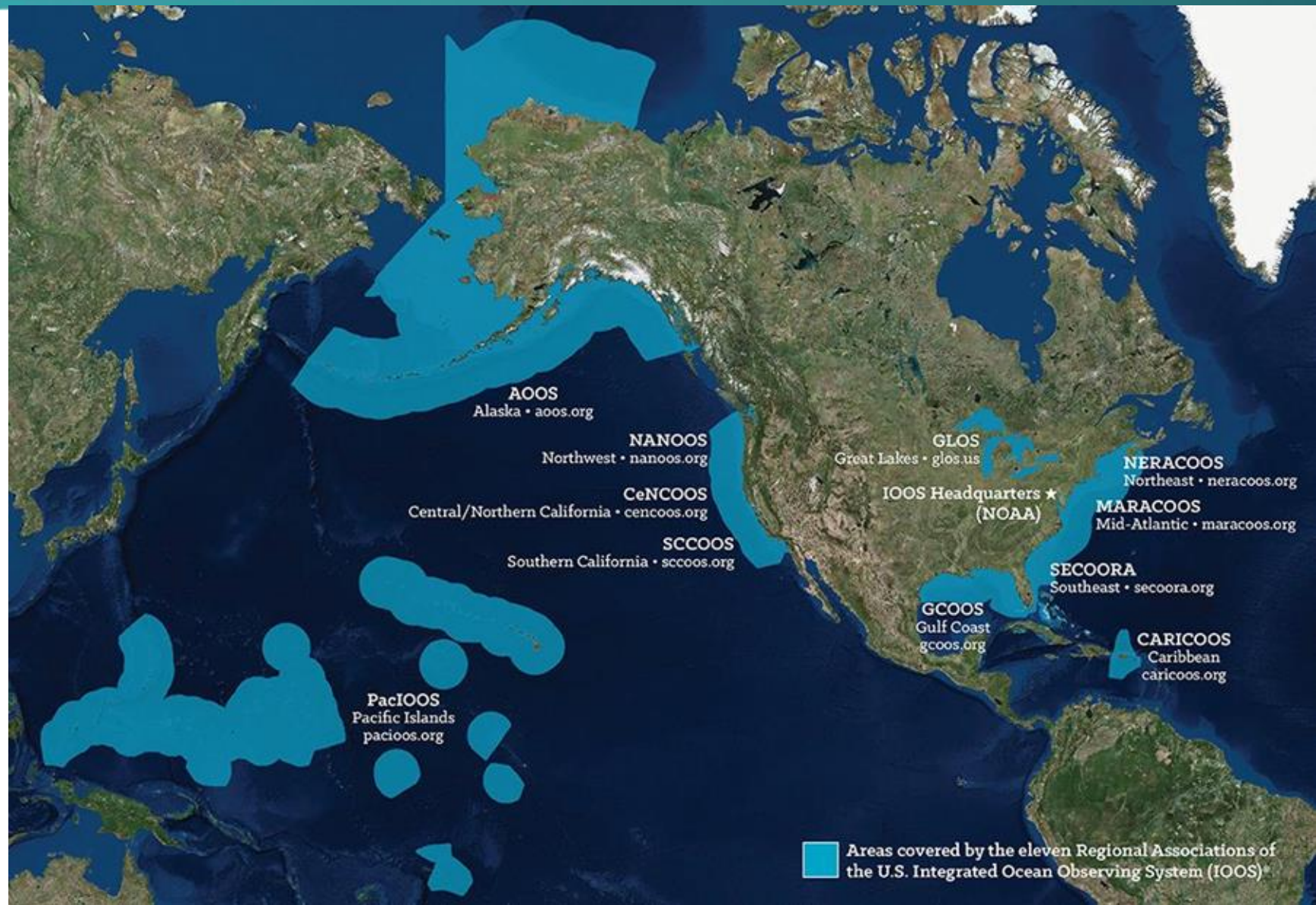
U.S. INTEGRATED OCEAN OBSERVING SYSTEM
CERTIFIED REGIONAL ASSOCIATION

What is AOOS?

1 of 11 regional programs of NOAA's Integrated Ocean Observing System

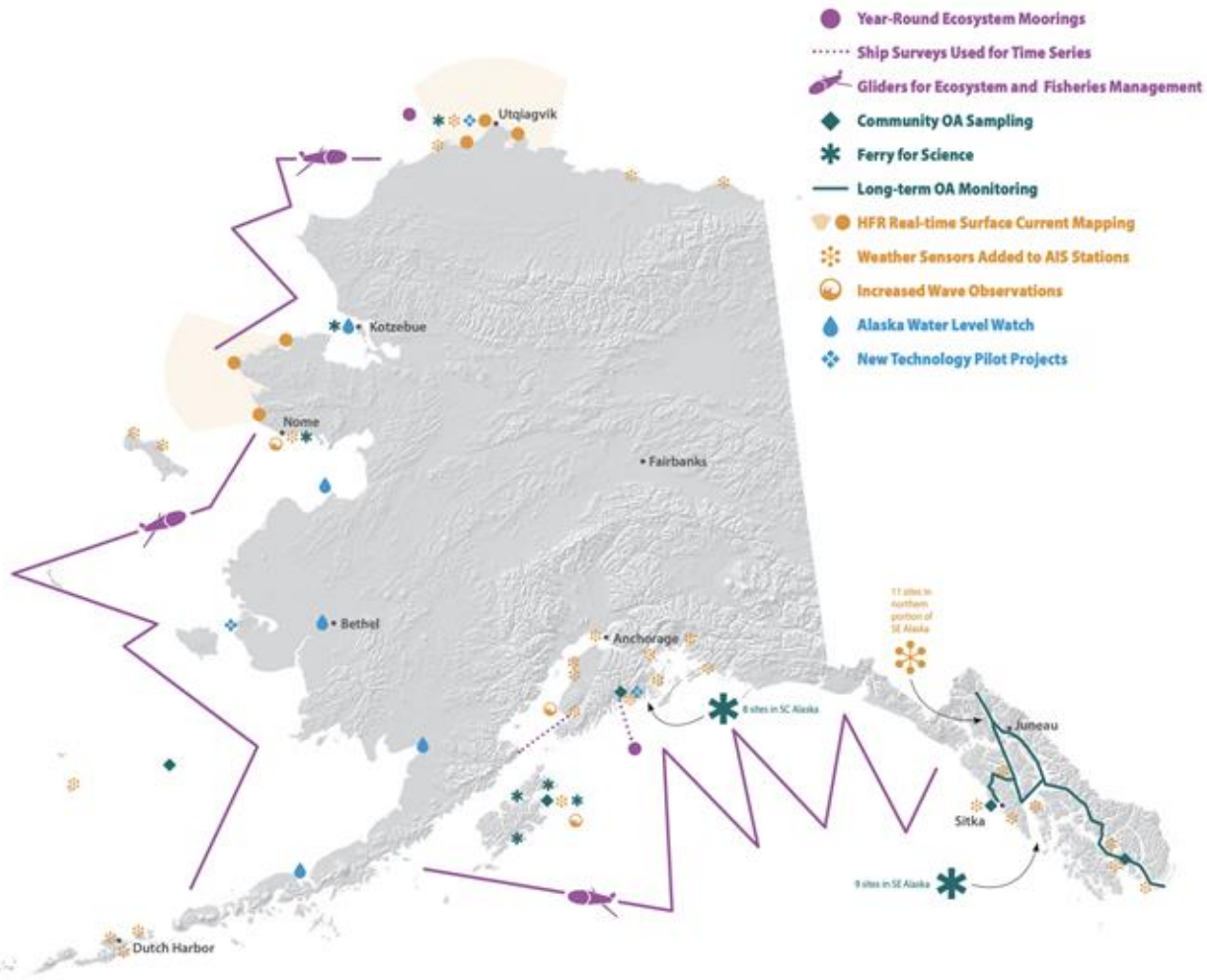
Mission:

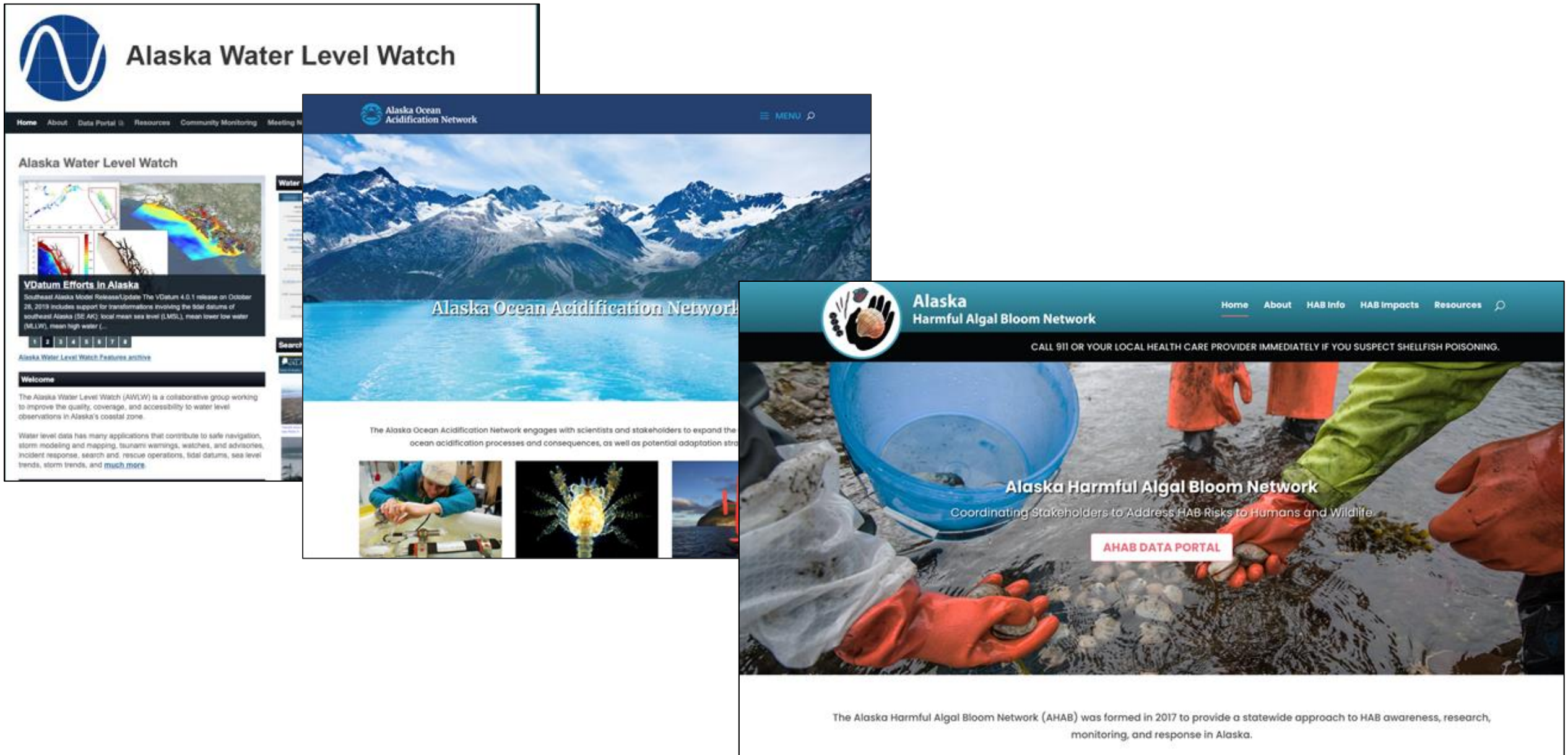
- Fill gaps in monitoring
- Facilitate partnerships
- Serve data

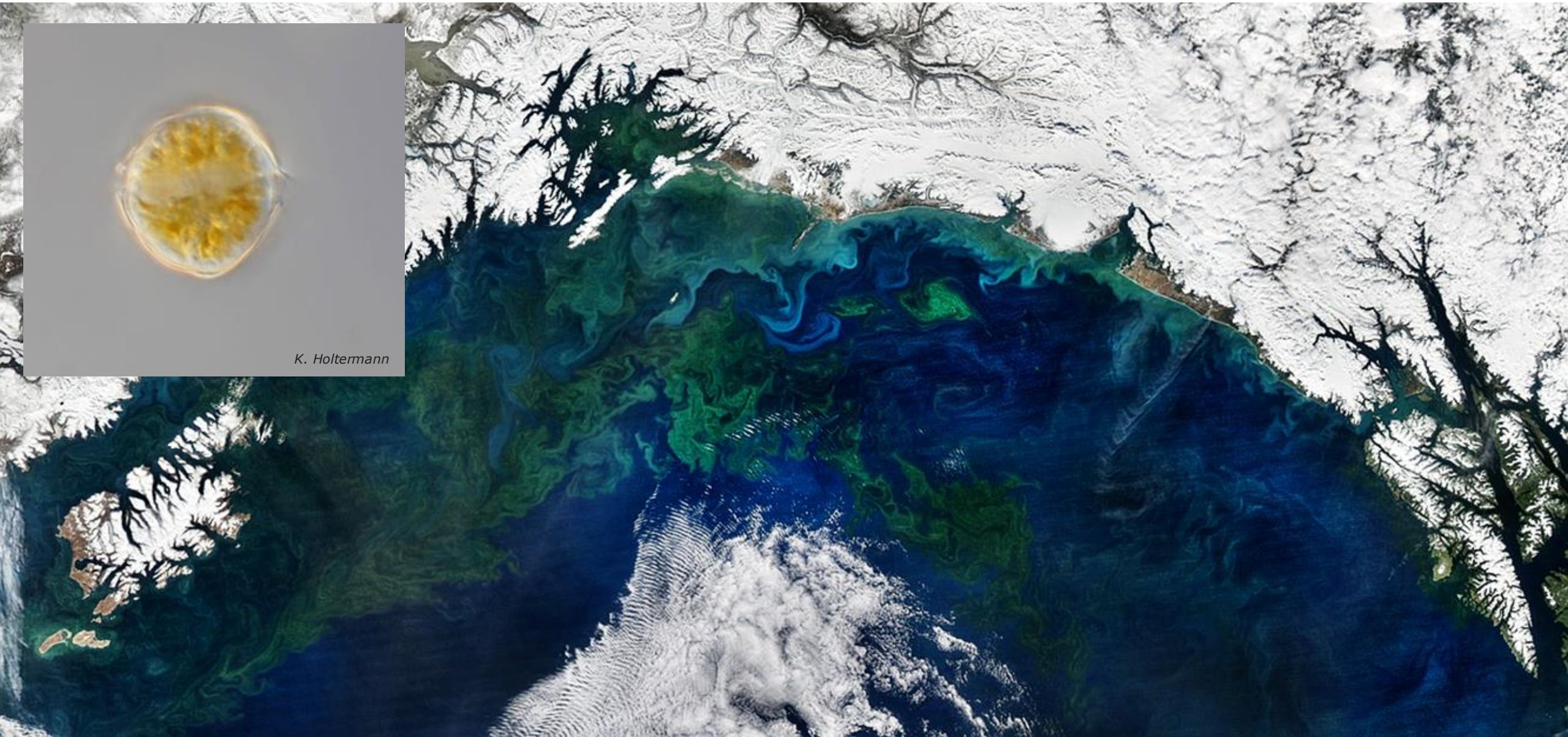


Overview of AOOS Approaches

- Sustained observations and assets
  - Moorings, gliders, high frequency radar (HFR), ship surveys
- Fund/test new and innovative tech
  - Coastal hazards assets, Sofar wave buoys
- Work with stakeholders to collect, use and show data in a meaningful way
  - Data portal, incident response tools
- Collaborations and partnerships
  - Collaborative networks, leveraging funding




Alaska Water Level Watch
Home
About
Data Portal
Resources
Community Monitoring
Alaska Water Level Watch
VDatum Efforts in Alaska
Southeast Alaska Model Release/Update The VDatum 4.0.1 release on October 28, 2019 includes support for transformations involving the tidal datums of southeast Alaska (SE AK): local mean sea level (LMSL), mean lower low water (MLLW), mean high water (...
Alaska Water Level Watch Features archive
Welcome
The Alaska Water Level Watch (AWLW) is a collaborative group working to improve the quality, coverage, and accessibility to water level observations in Alaska's coastal zone.
Water level data has many applications that contribute to safe navigation, storm modeling and mapping, tsunami warnings, watches, and advisories, incident response, search and rescue operations, tidal datums, sea level trends, storm trends, and much more.
Alaska Ocean Acidification Network
MENU
Alaska Ocean Acidification Network
The Alaska Ocean Acidification Network engages with scientists and stakeholders to expand the
ocean acidification processes and consequences, as well as potential adaptation stra
Alaska
Harmful Algal Bloom Network
Home
About
HAB Info
HAB Impacts
Resources
CALL 911 OR YOUR LOCAL HEALTH CARE PROVIDER IMMEDIATELY IF YOU SUSPECT SHELLFISH POISONING.
Alaska Harmful Algal Bloom Network
Coordinating Stakeholders to Address HAB Risks to Humans and Wildlife
AHAB DATA PORTAL
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.


K. Holtermann

HAB Species in Alaska

Alexandrium *sp.*
- Dinoflagellate algae
- **Produces 20+ saxitoxins**
- Leads to Paralytic Shellfish Poisoning (PSP)
- Responsible 5 human deaths since 1993 in AK

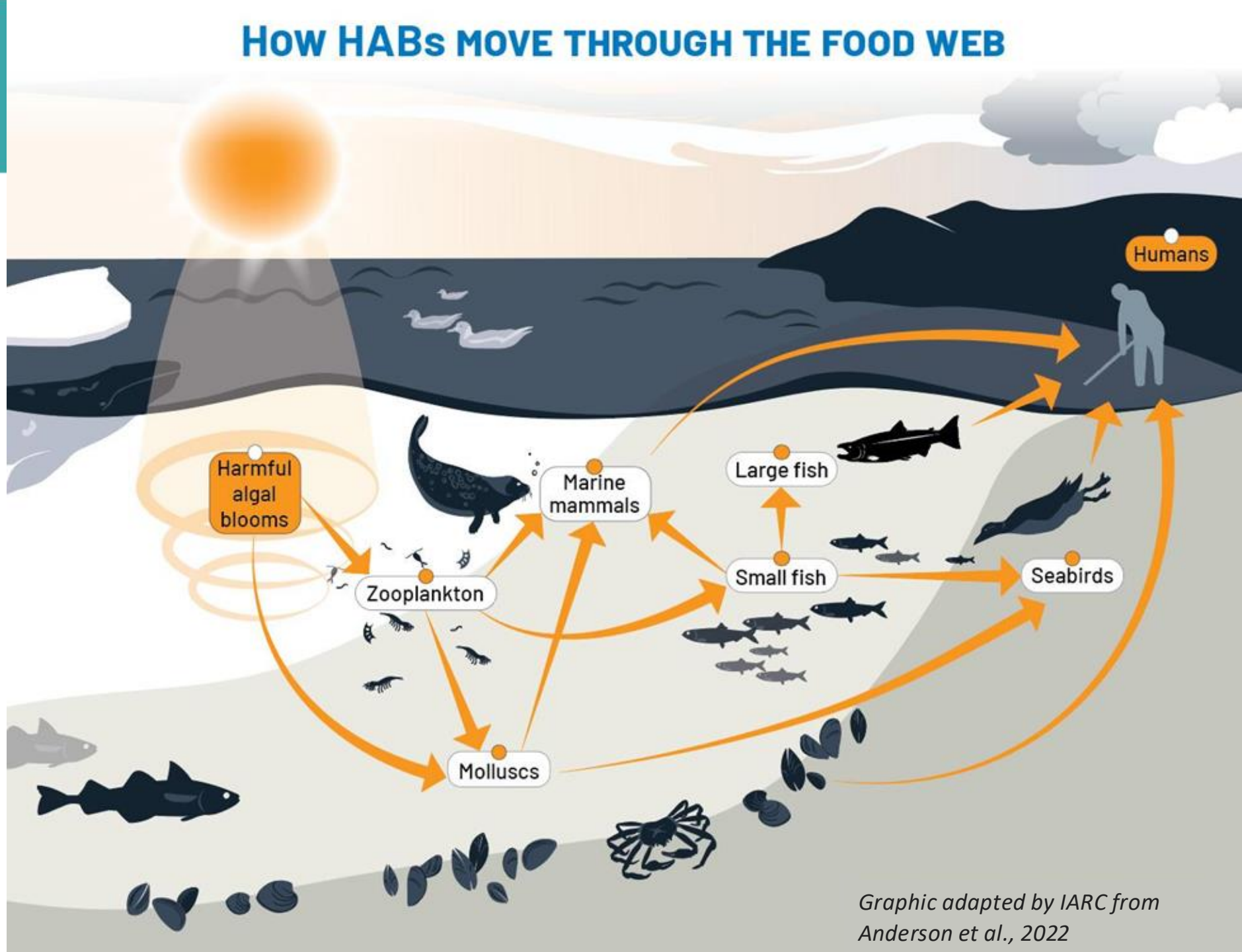
Dinophysis *sp.*
- Dinoflagellate algae
- Produces okadaic acid
- Leads to Diarrhetic Shellfish Poisoning (DSP)
- Occasionally in AK, but no reports of DSP yet

Pseudo-nitzschia *spp.*
- Diatom
- Produces domoic acid
- Leads to Amnesic Shellfish Poisoning (ASP)
- Big impacts on wildlife, humans and fisheries in BC, WA, OR, CA

Cyanobacteria
- “Blue-green algae"
- Brackish and freshwater
- Some produce suite of cyanotoxins (hepatotoxins)
- Can also leads to anoxic conditions
- **Drinking water threat**

From HABs to Humans

- HAB toxins can take several routes to humans
- Impact food safety
- Could impact the health of the animals
- Food security issue!



Graphic adapted by IARC from Anderson et al., 2022

- Toxins found in inverts, marine fish, seabirds, and marine mammals
- Still need much more testing of food components
- Food web impacts are not well known, but being researched

Threat to Human Health - PSP

Category of Symptoms	Symptoms
1	Headache
1	Paresthesia (abnormal sensation such as tingling, pricking, numbness)
1	Dizziness (impairment in spatial perception and stability)
1	Nausea, vomiting
1	Vertigo
2	Incoherent speech
2	Nystagmus (involuntary eye movement)
2	Rapid pulse
2	Ataxia (lack of voluntary coordination of muscle movements)
2	Dyspnea (shortness of breath)
2	Backache
3	Dysarthria (motor speech disorder)
3	Dysphagia (difficulty in swallowing)
3	Apnea (suspension of breathing)
3	Weakness of arms and legs
3	Pronounced respiratory difficulties
3	Muscular paralysis
3	Respiratory arrest (without death)
4	Death

Arnich and Thebautl (2018) Dose-response modeling of PSP in humans

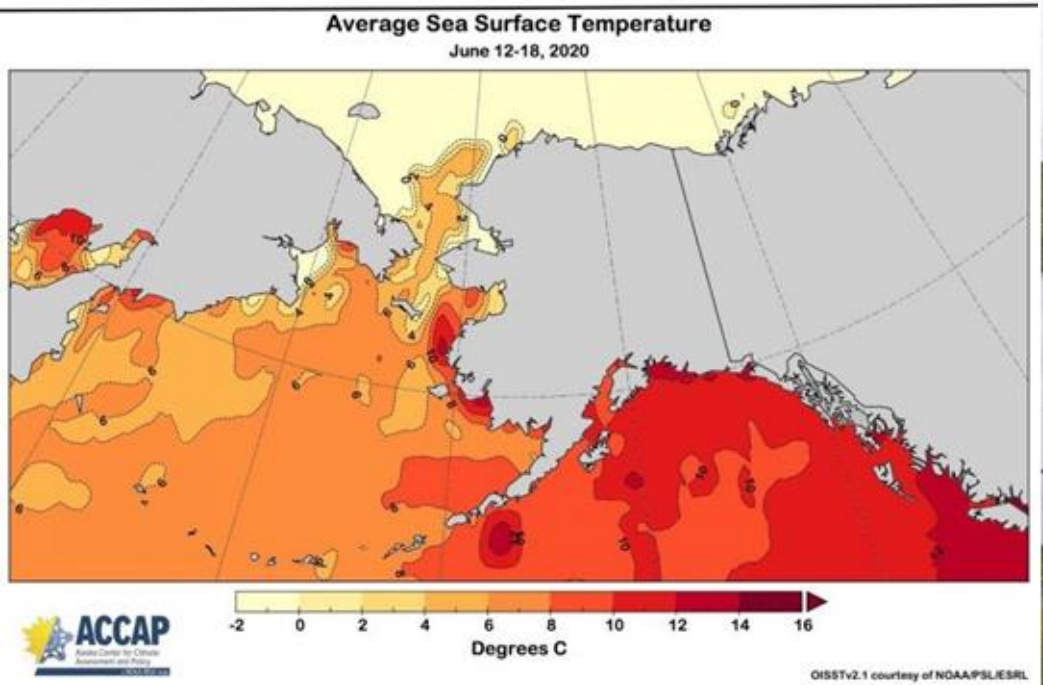
When humans consume food with PSP toxin levels above 80µg / 100g of food tissue

IMPORTANT TAKE-HOME POINTS

- Symptoms within minutes to hours.
- Cooking does not remove toxins.
- No antitoxin, supportive care only.
- **SEEK IMMEDIATE MEDICAL CARE!**

Blue mussels: 11,200 µg/100g

Snail: 287 µg/100g



ANCHORAGE DAILY NEWS

Alaska News

Person dies of paralytic shellfish poisoning after eating snails and mussels from Dutch Harbor beach

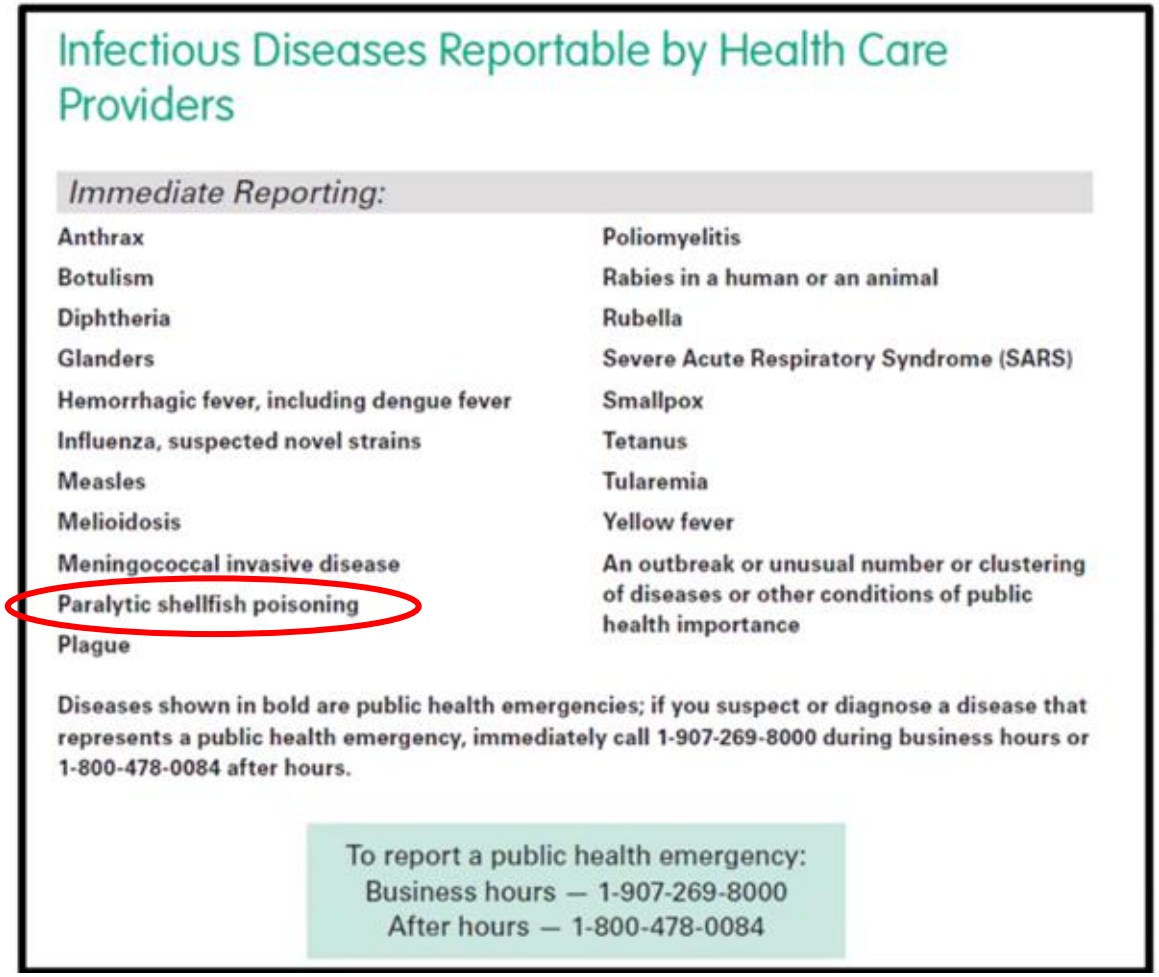
Author: Tess Williams Updated: July 16, 2020 Published July 15, 2020

Public Health Response

State statutes require health care providers and labs to report specific diseases and conditions

In Alaska, DoH will respond and investigate

About 200 cases and 5 deaths confirmed in Alaska since 1993



Infectious Diseases Reportable by Health Care Providers

Immediate Reporting:

Anthrax
Botulism
Diphtheria
Glanders
Hemorrhagic fever, including dengue fever
Influenza, suspected novel strains
Measles
Melioidosis
Meningococcal invasive disease
Paralytic shellfish poisoning
Plague
Poliomyelitis
Rabies in a human or an animal
Rubella
Severe Acute Respiratory Syndrome (SARS)
Smallpox
Tetanus
Tularemia
Yellow fever
An outbreak or unusual number or clustering of diseases or other conditions of public health importance

Diseases shown in bold are public health emergencies; if you suspect or diagnose a disease that represents a public health emergency, immediately call 1-907-269-8000 during business hours or 1-800-478-0084 after hours.

To report a public health emergency:
Business hours — 1-907-269-8000
After hours — 1-800-478-0084

Commercial Shellfish


Log floats for oyster cultures


OceansAlaska floating hatchery

- ADEC closely regulates commercial sector
  - testing of product, closing of areas over limits
  - saxitoxin levels need to be below 80 µg/100g
- No reported human cases from commercial product in Alaska

- BUT there is no state monitoring/regulation of subsistence or recreational harvests!

Minimizing Risks to Food Safety/Security

Needs 3 approaches used simultaneously

I. Monitoring of algae

- What organisms are in the water?
- Simple, great for understanding bloom dynamics
- Cannot determine safety of food items

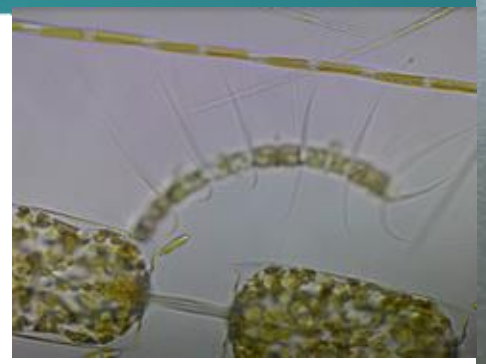
II. Toxin testing

- Sample different organisms (food items and other species in ecosystem)
- Requires labs and advanced techniques (PSP)
- Can aid in food safety decision if results are rapid
- Also helpful in HAB research

III. Communication/Outreach

I. Very important to increase awareness

II. Can limit impacts of toxins by modifying behavior



Alexandrium bloom in Northern Bering Sea (2022)

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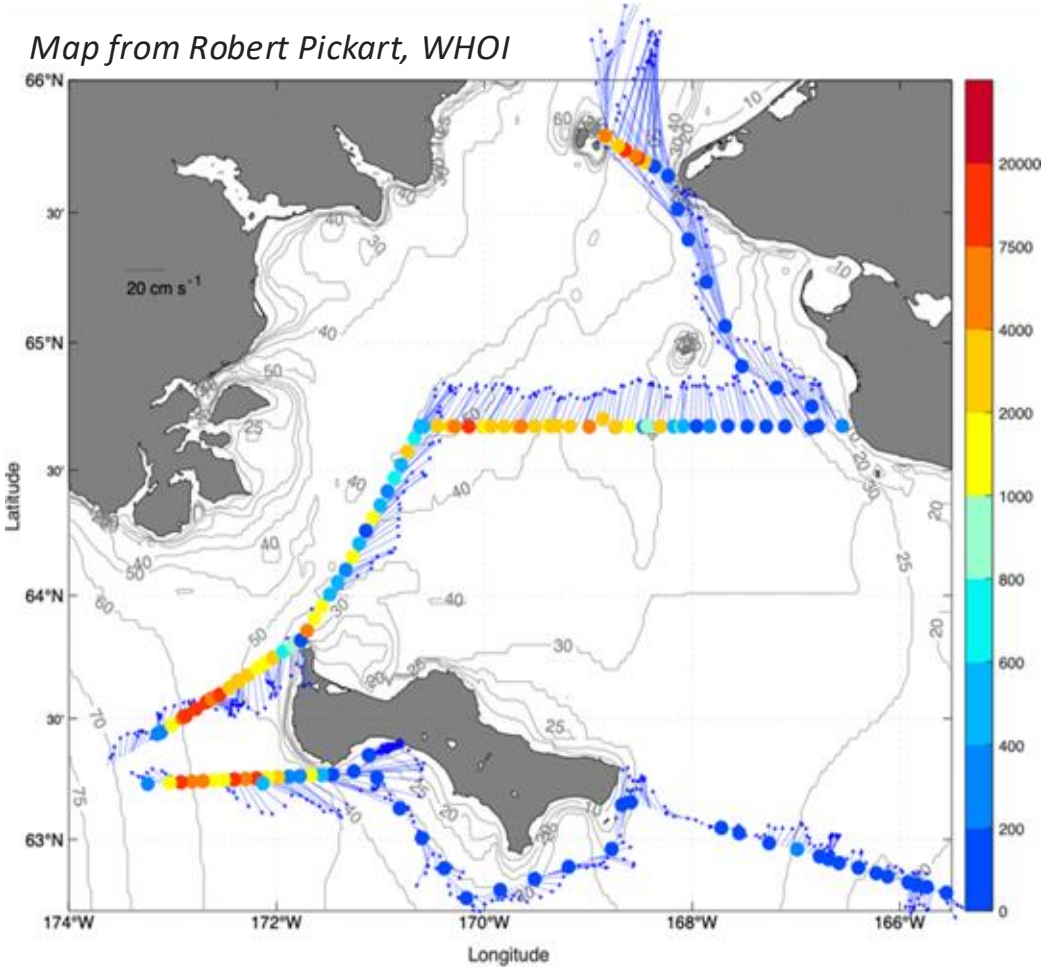
Map from Robert Pickart, WHOI



- Regional response/communication network was created through a lot of work and collaboration
- Arctic surf clam sent for testing rather than consumed

The Nome Nugget

Alaska's Oldest Newspaper

• USPS 598-200 • Single Copy Price - 50 Cents in Nome •

Saxitoxin Detected In Regional Clam

THU, 10/06/2022 - 6:50PM admin

knom RADIO MISSION

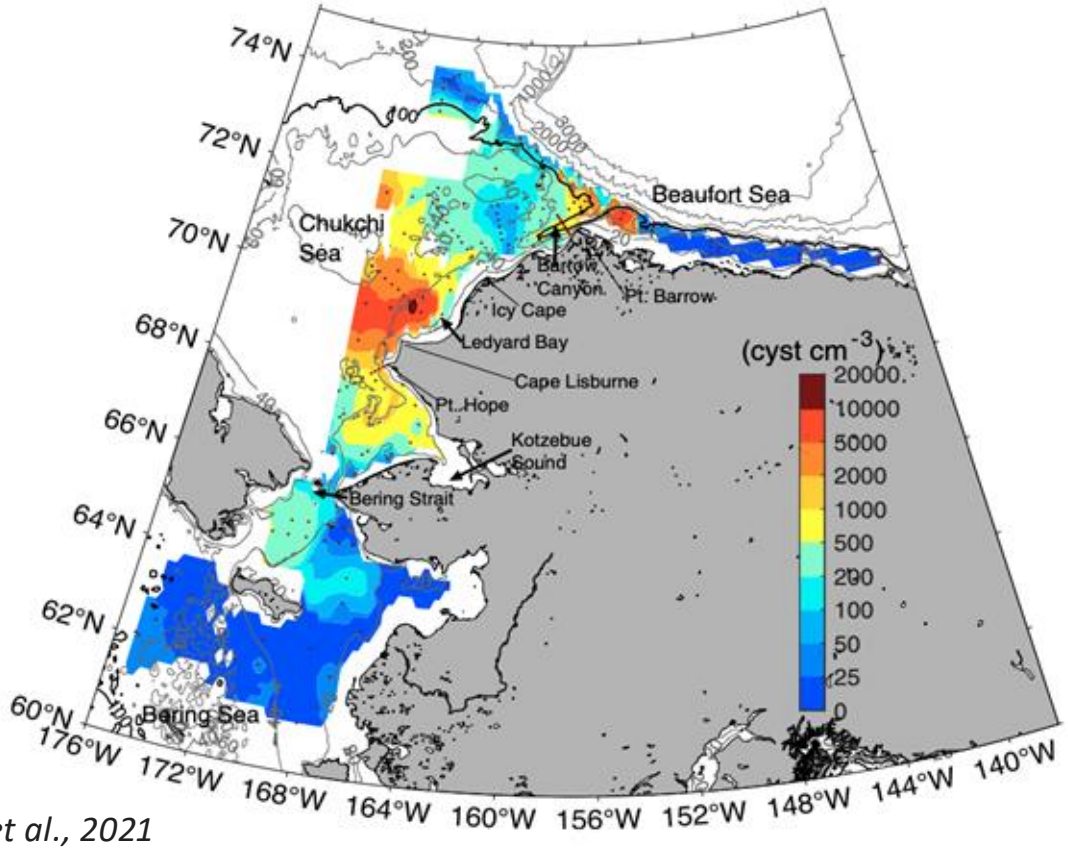
Authorities warn subsistence users about potentially harmful algal blooms

By Miriam Trujillo | August 26, 2022

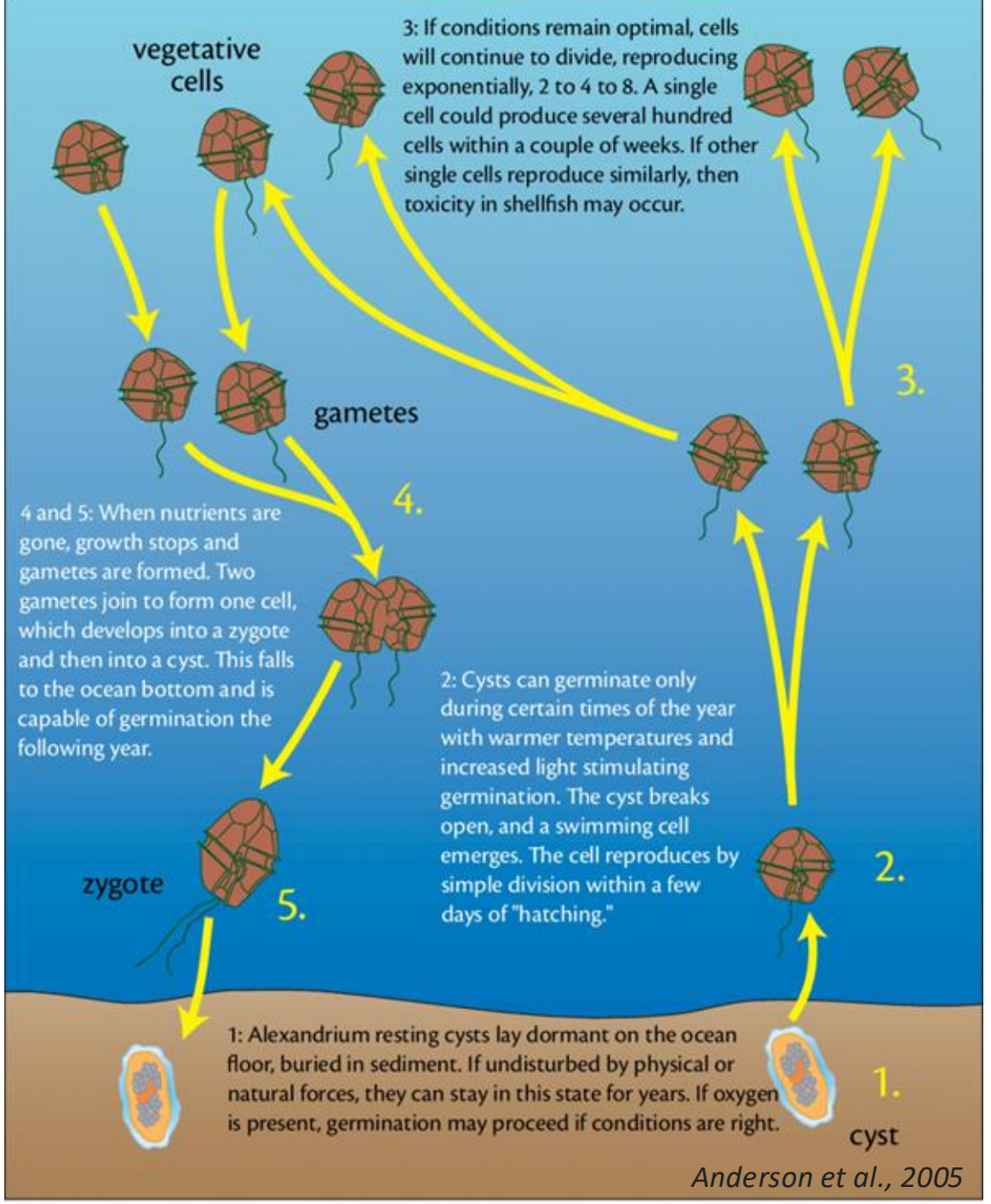
An Underwater Storm

George Karbus

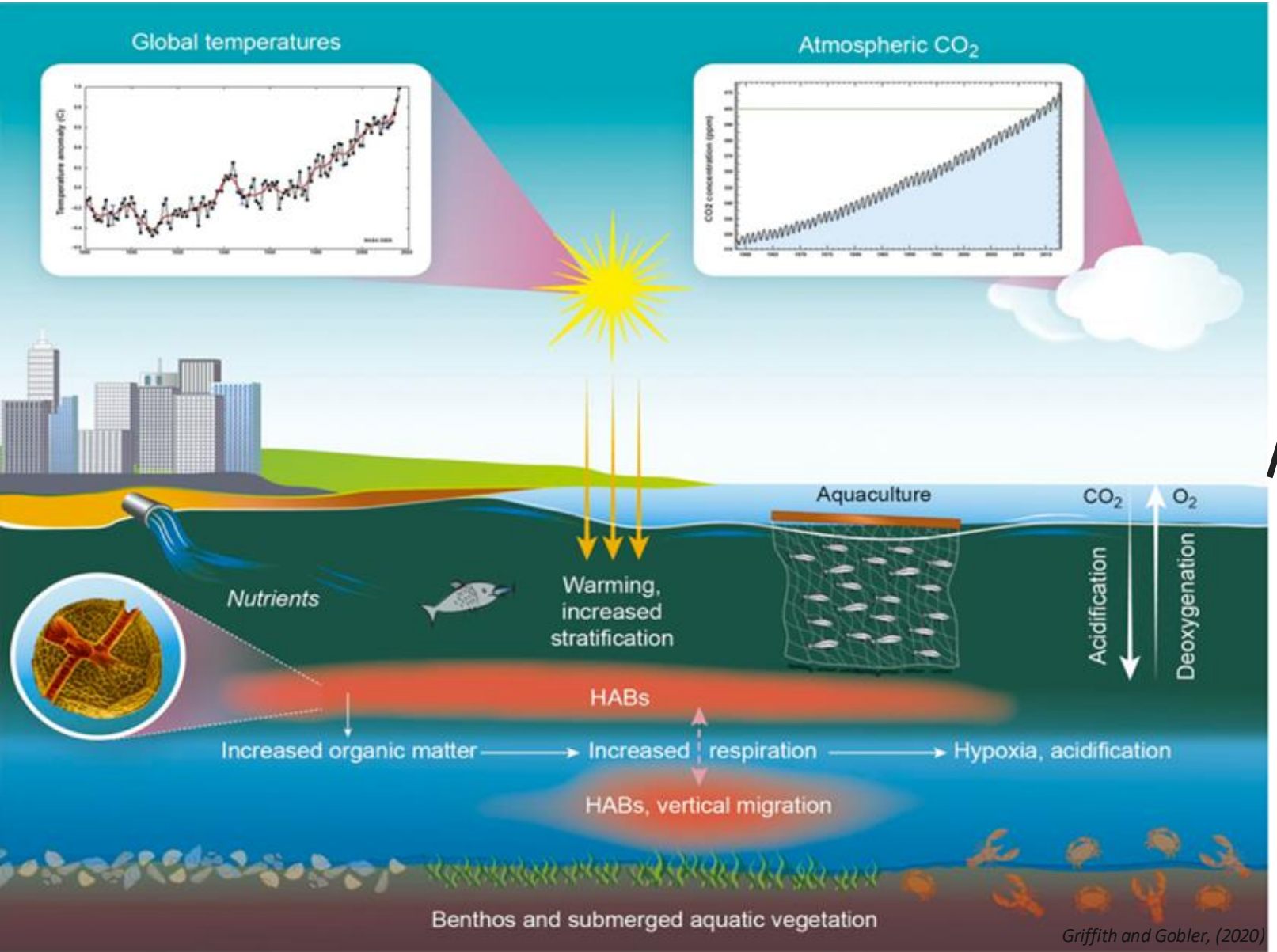
- Dormant cysts in the sediment can germinate with the right conditions
- Free floating vegetative cells can divide quickly leading to exponential growth ➔ HAB



Anderson et al., 2021



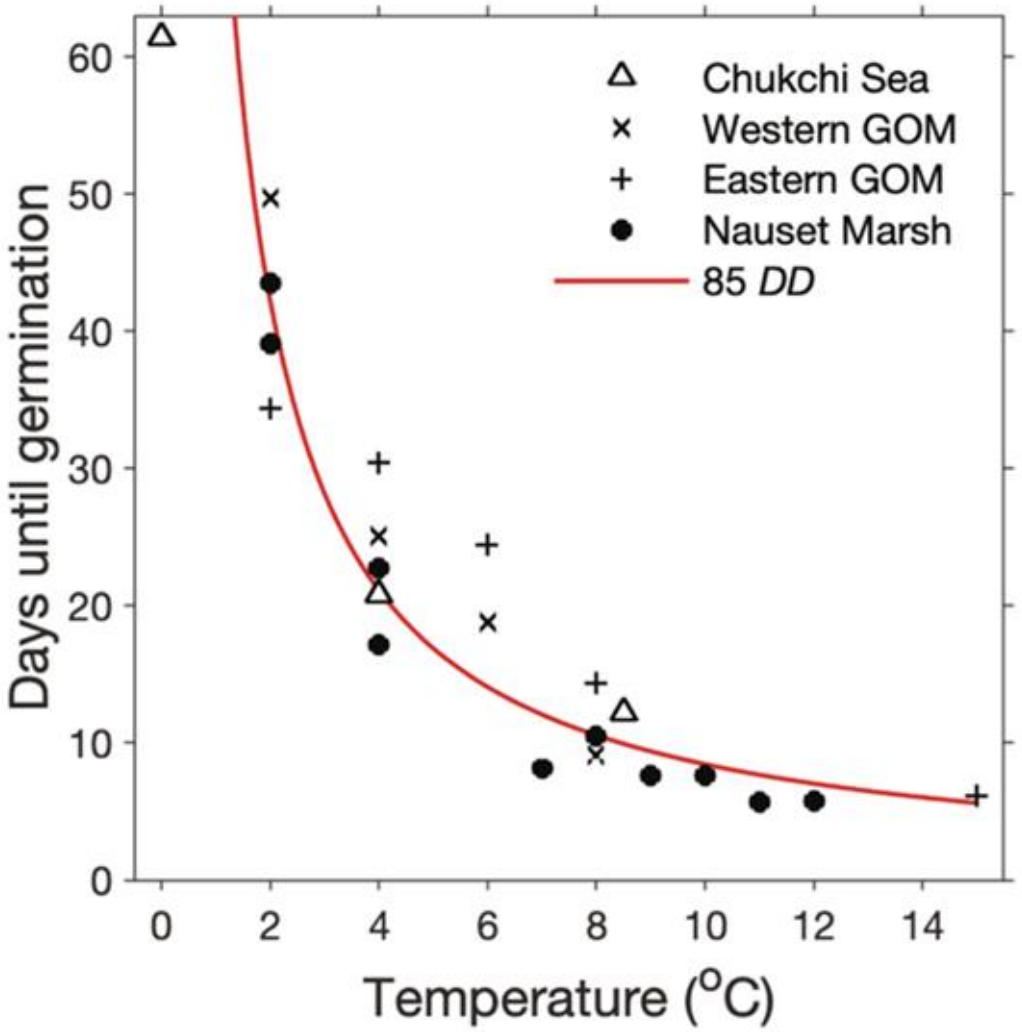
Anderson et al., 2005



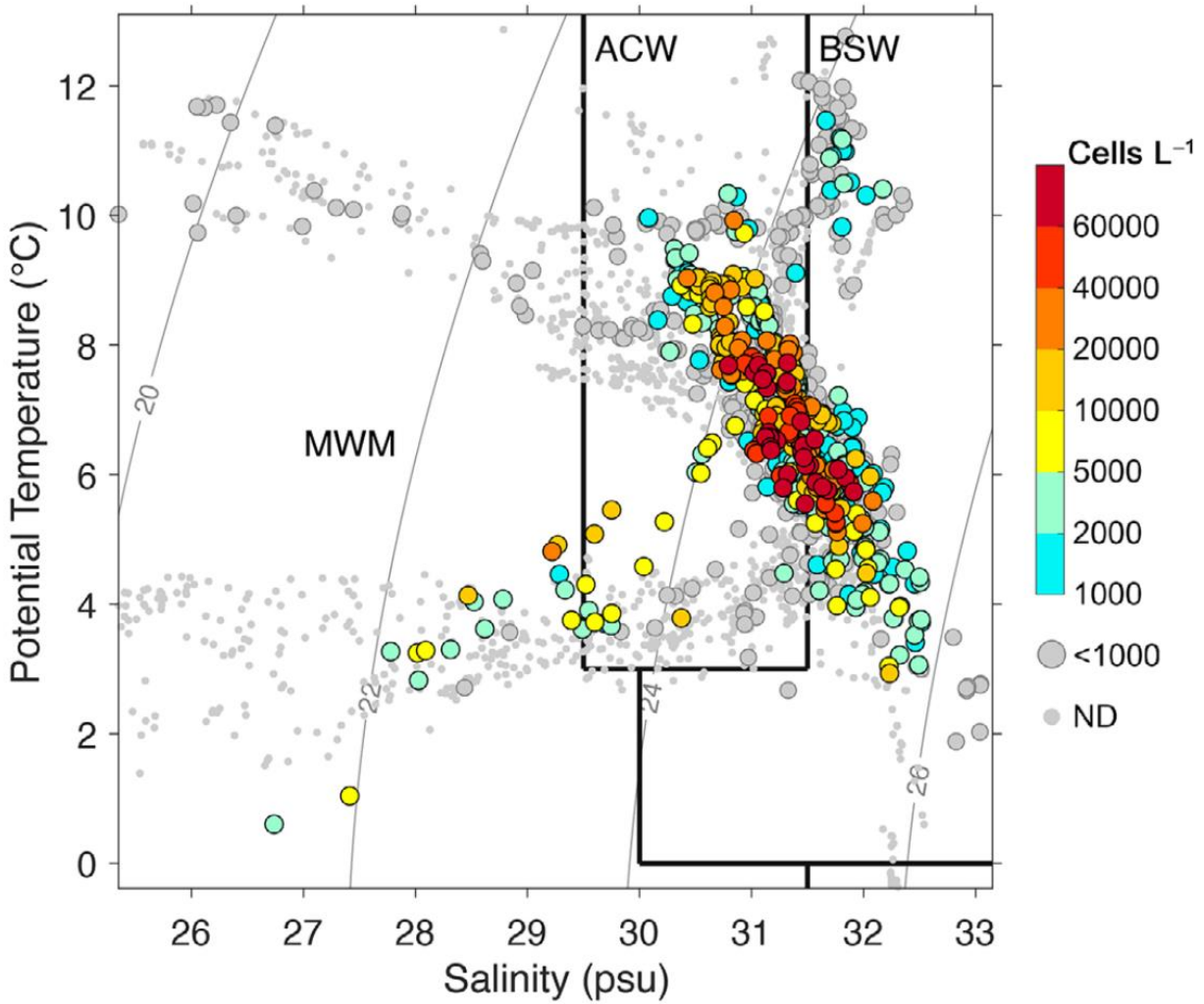
Griffith and Gobler, (2020)

- Env. Conditions
- HAB Species
- HAB Toxicity
- Toxin Uptake
- Food Web Impacts

Importance of Water Temperature



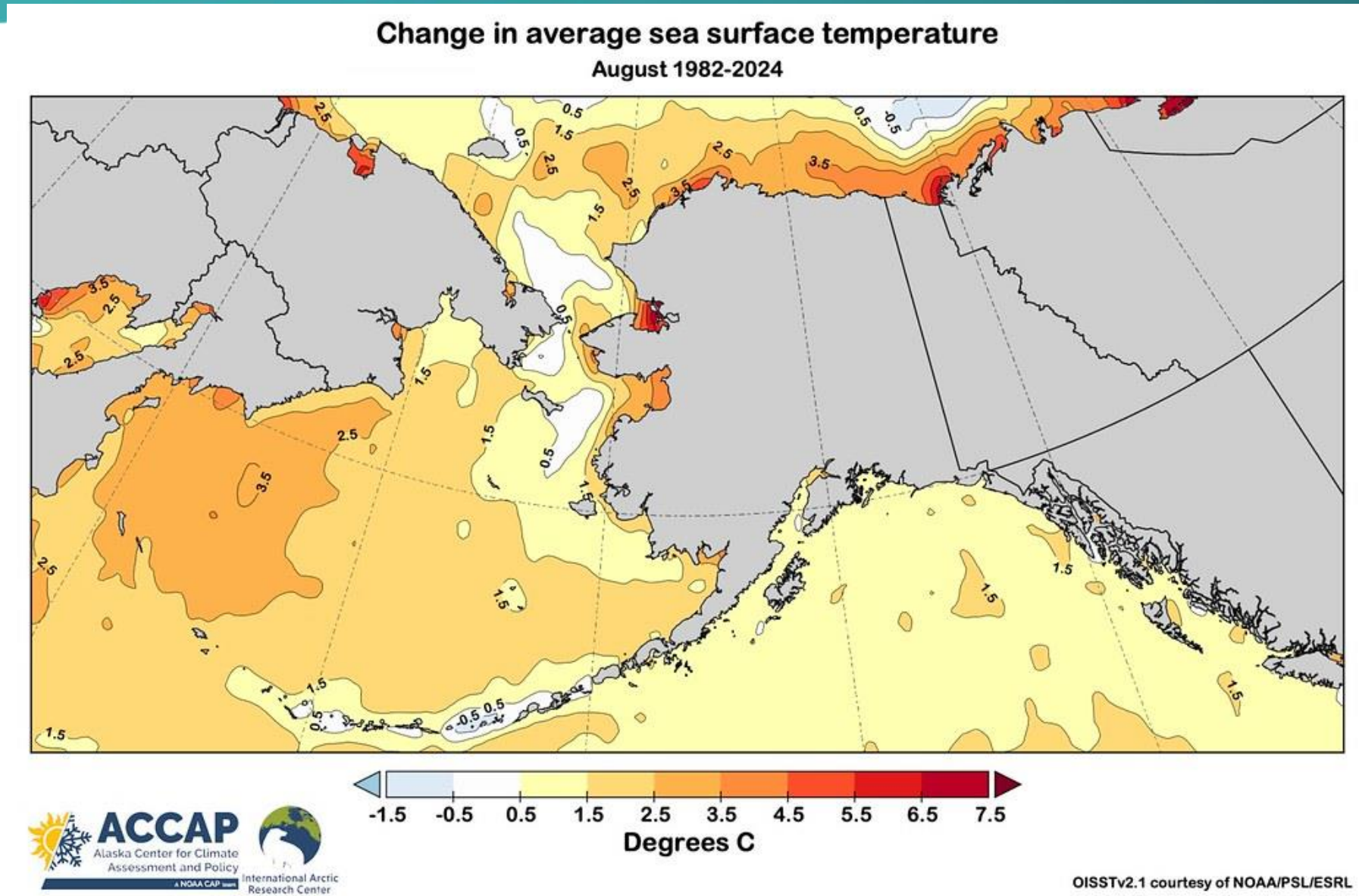
Anderson et al., 2021



Fachon et al., 2024

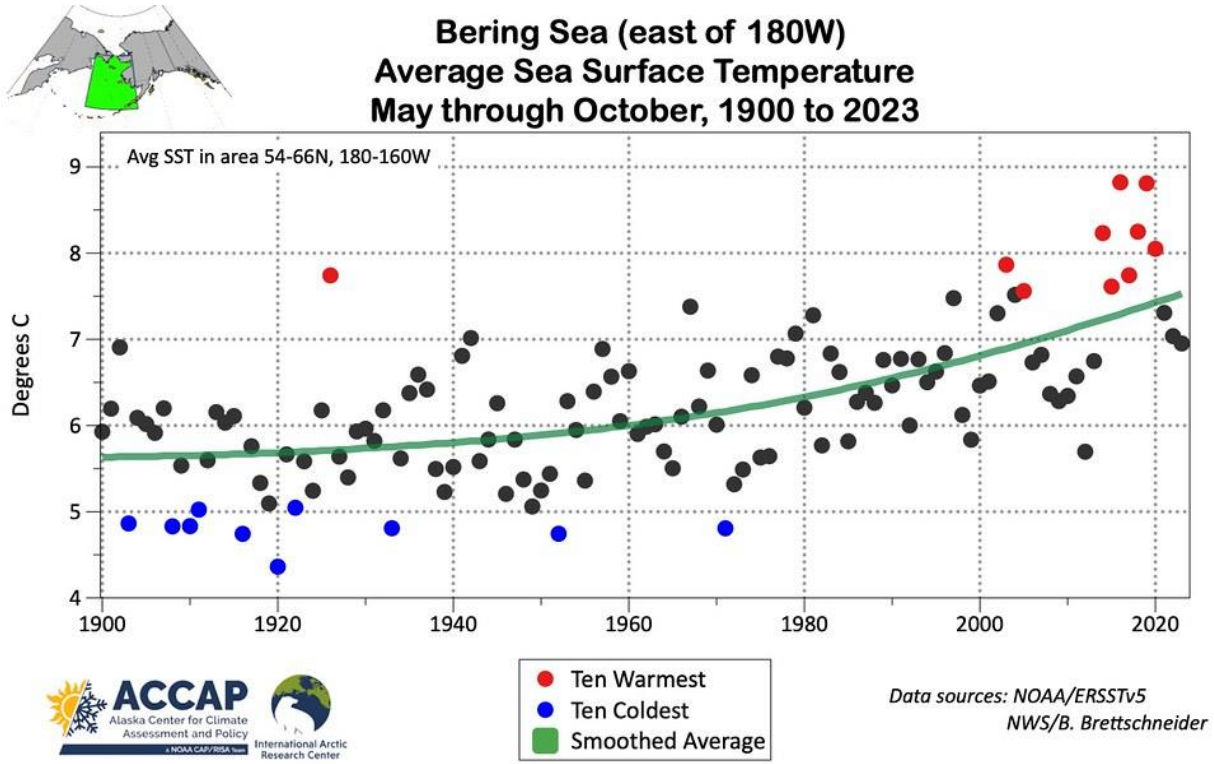
Ocean Warming Impacts on HABs

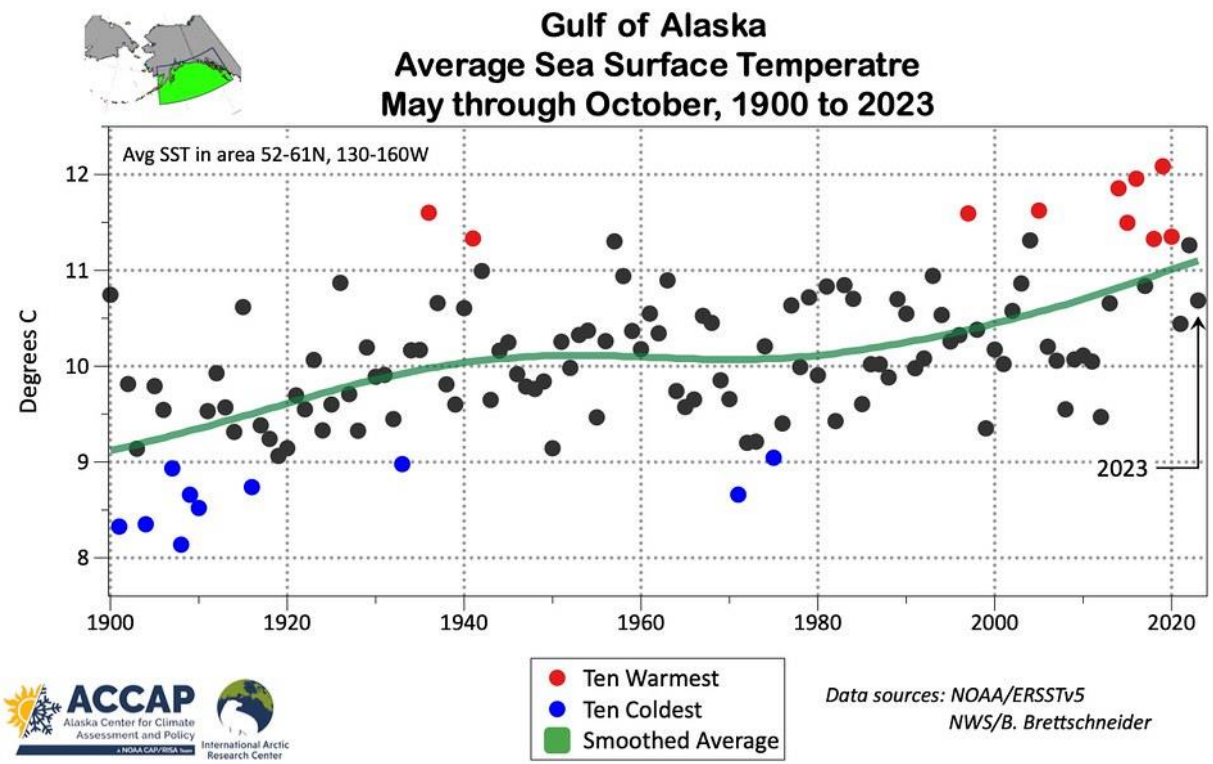
AOOS



Ocean Warming Impacts on HABs

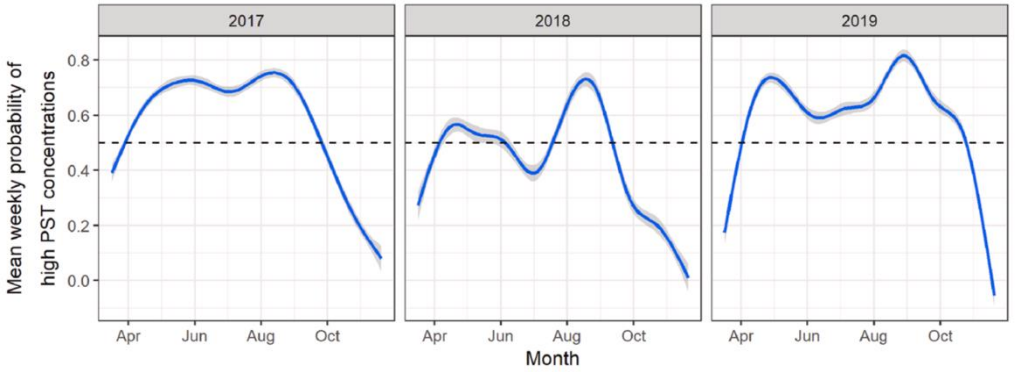
- Increased water temp ➔ less sea ice ➔ increased probability of blooms
- As with storms, HABs will likely get worse with climate change…

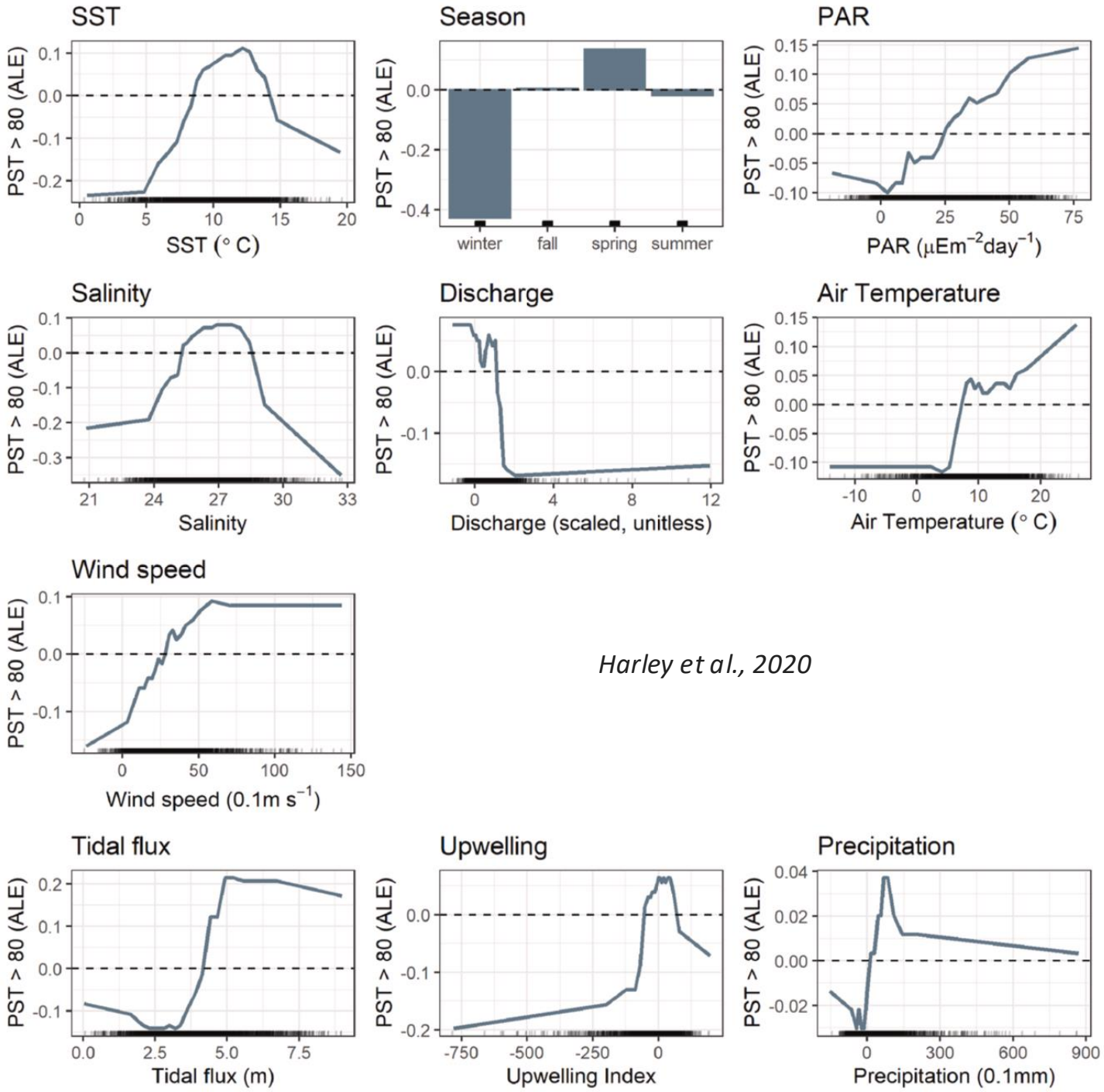




Other Potential Factors for HAB Formation

- We are still researching what other factors contribute to the formation of HABs in Alaska
- SST, salinity, wind, freshwater likely play a role
- More complicated biotic factors like presence of other plankton?





Harley et al., 2020

- HABs can form anywhere in the ocean
- Currents can bring them close to shore, where impacts are felt by communities and the ecosystem
- We need both better understanding of the dynamics, and more monitoring for signs of HABs to mitigate impacts

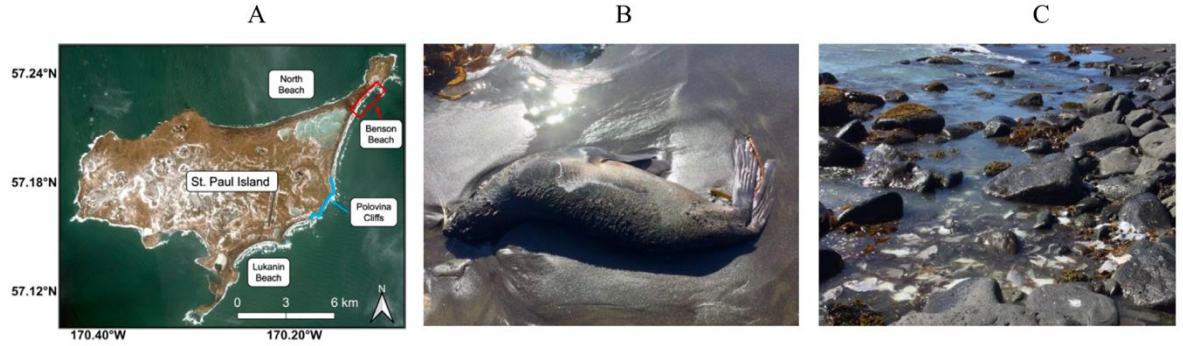
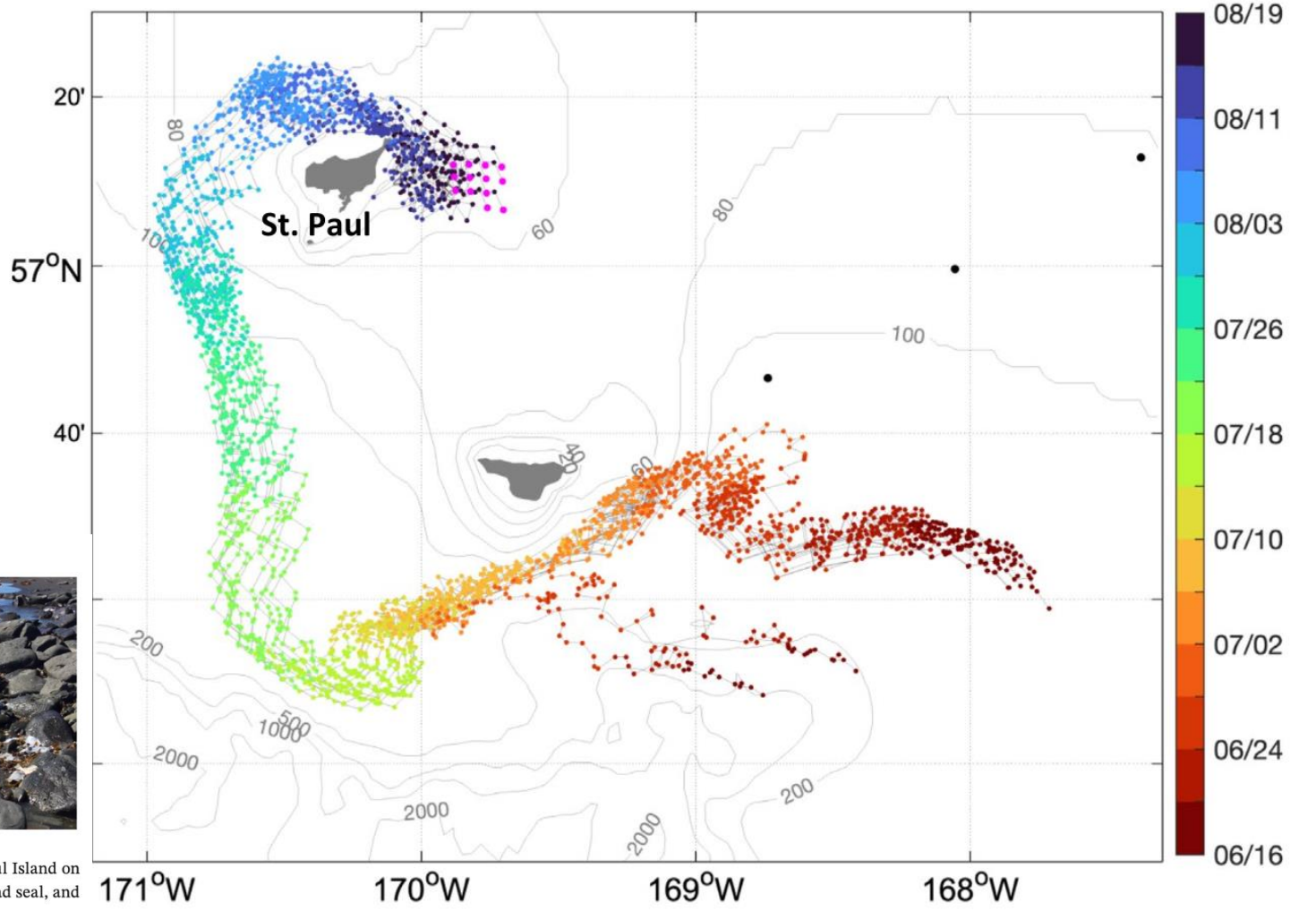


FIGURE 1 | Aggregates of dead unidentified fish and 10 dead Northern Fur seals (NFS) were found on the northeast side of St. Paul Island on Benson Beach, AK on August 18, 2024. Figure panels show (A) map of St. Paul Island with Benson Beach (red square), (B) photo of dead seal, and (C) photo of dead fish.



The Alaska Harmful Algal Bloom Network

Alaska Harmful Algal Bloom Network

- AHAB Network formed in 2017
- Platform to communicate and support HAB monitoring, research and outreach across Alaska
- Strength of the network comes from our members who contribute to a shared goal

Network Members and HAB Monitors

Sitka Tribe of Alaska/SEATOR

KBNERR

Knik Tribe

Alutiiq Pride Marine Institute

Kodiak Area Native Association

Alaska Sea Grant

Qawalangin Tribe of Unalaska

Aleut Community of St Paul

Norton Sound Health Corporation

Native Village of Kotzebue

North Slope Borough

USGS Alaska Science Center

NCCOS

Alaska Veterinary Pathology Services

Woods Hole Oceanographic Institute

Alaska Dept of Health and Social Services

Alaska Dept of Environmental Conservation

Alaska Dept of Fish and Game

NOAA WARRN-West Lab

Alaska Fisheries Science Center

North Pacific Research Board

US Arctic Research Commission

US Fish and Wildlife Service

US Forest Service

Agency for Toxic Substances and Disease Registry

Alaska Pacific University

Columbia University

University of Alaska Fairbanks

University of Alaska Anchorage

Aleutian Pribilof Islands Association

Chugach Regional Resources Commission

Seldovia Village Tribe

Native Village of Port Graham

Sun'aq Tribe of Kodiak

Community members of Utqiagvik

Alaska Conservation Foundation

Applied Research in Environmental Sciences

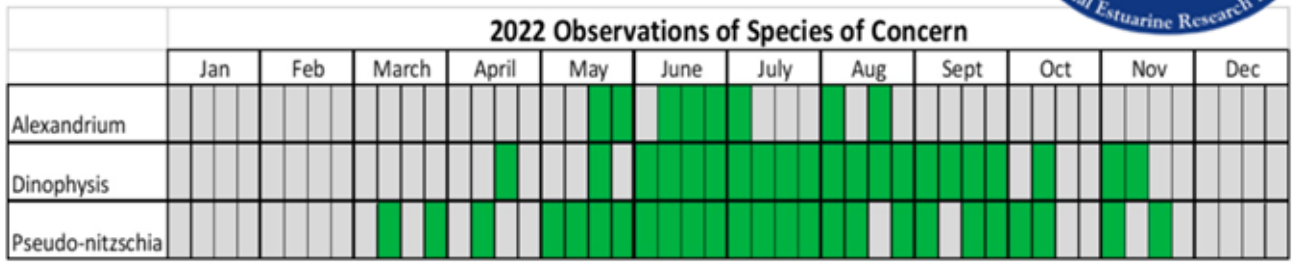
Center for Alaskan Coastal Studies

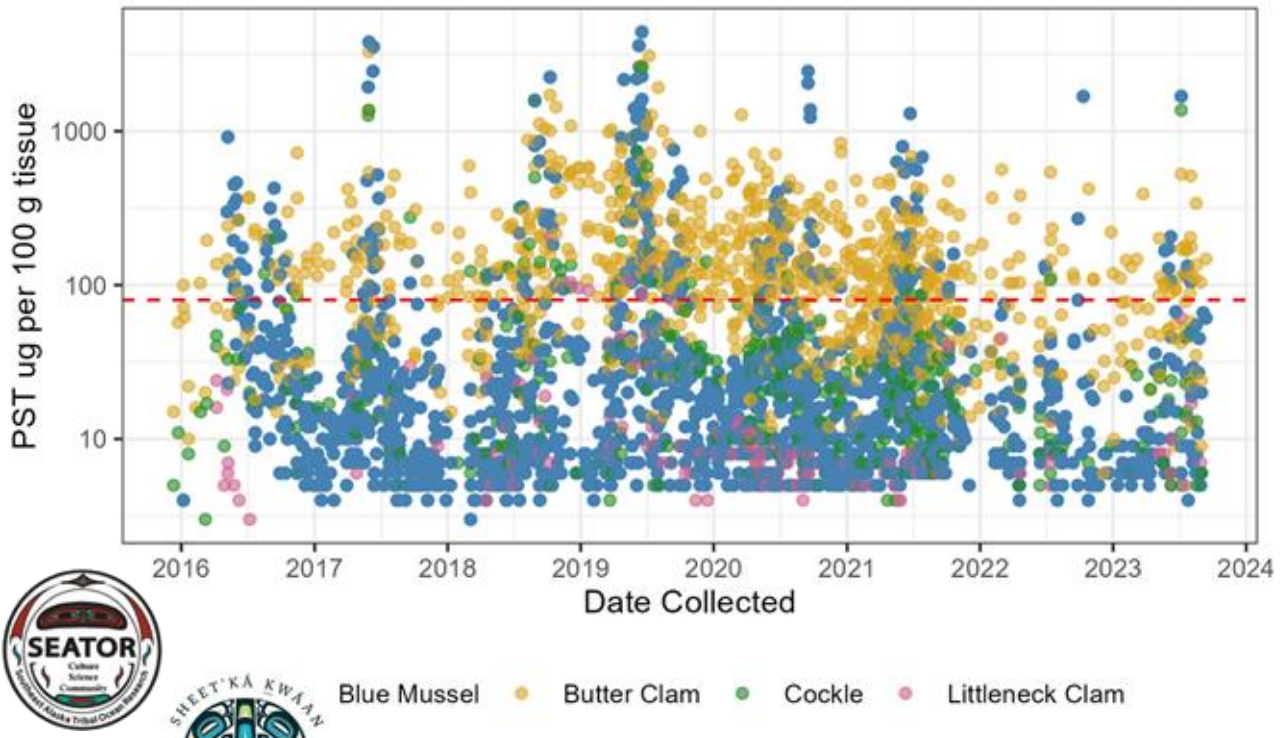
Coastal Observation and Seabird Survey Team

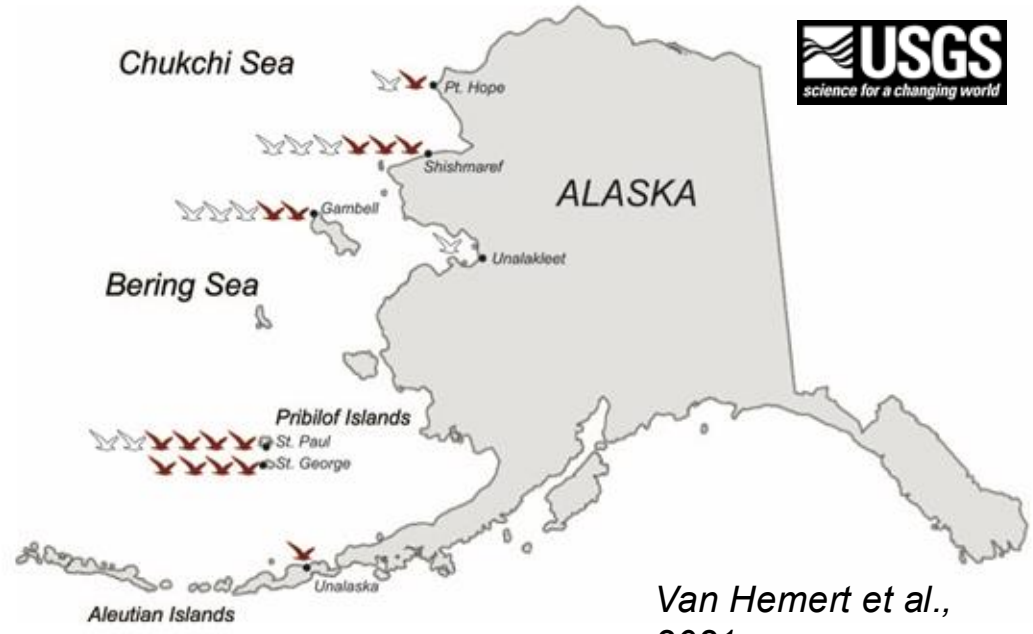
Prince William Sound Stewardship Foundation

Axiom Data Science

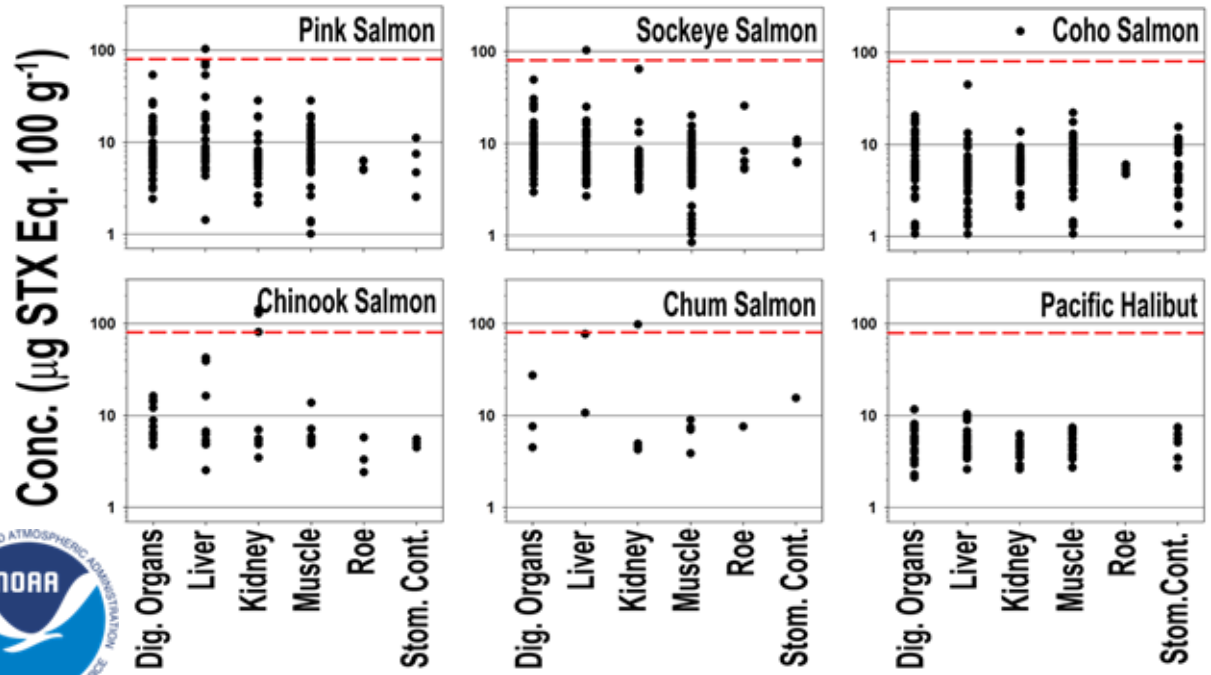
Work by AHAB members





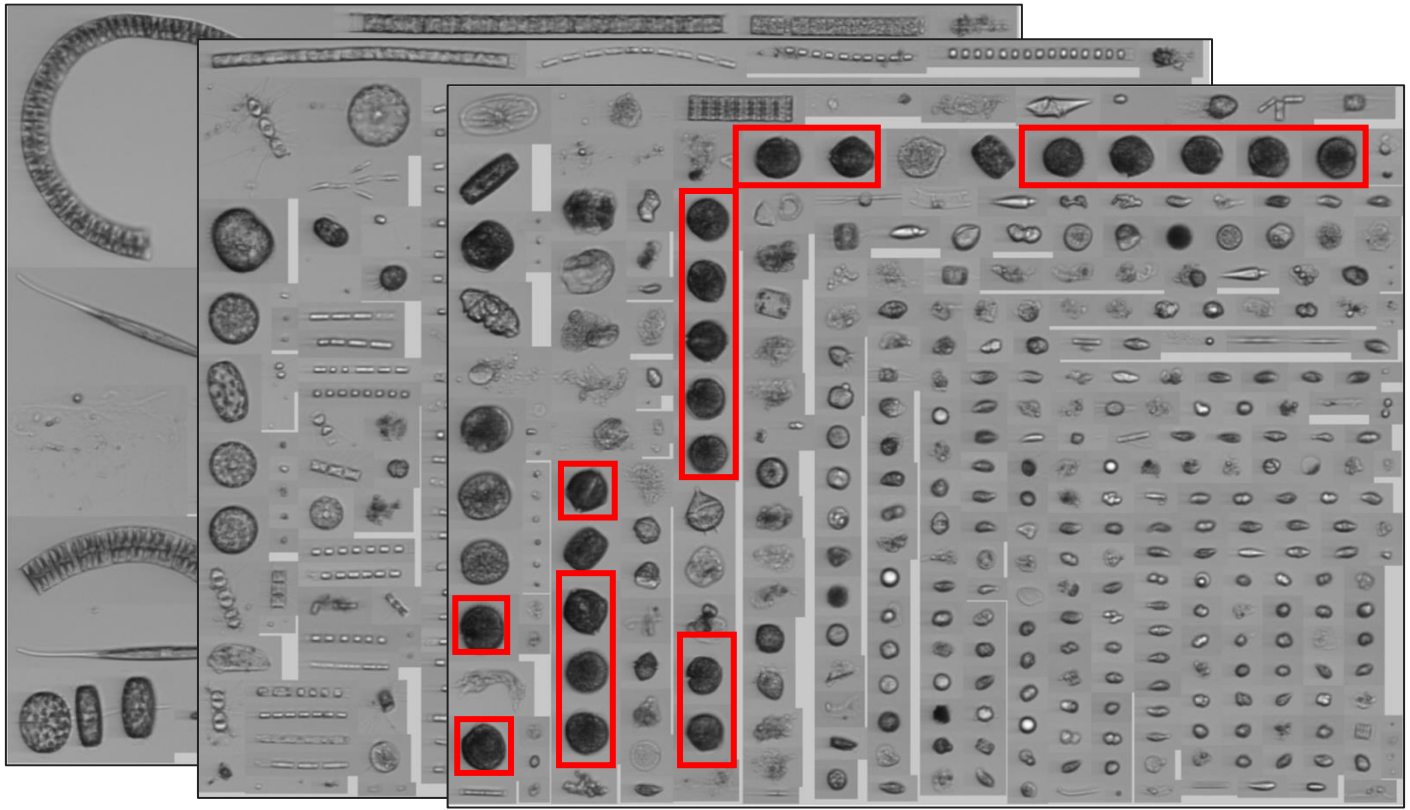


Van Hemert et al., 2021



Data from Steve

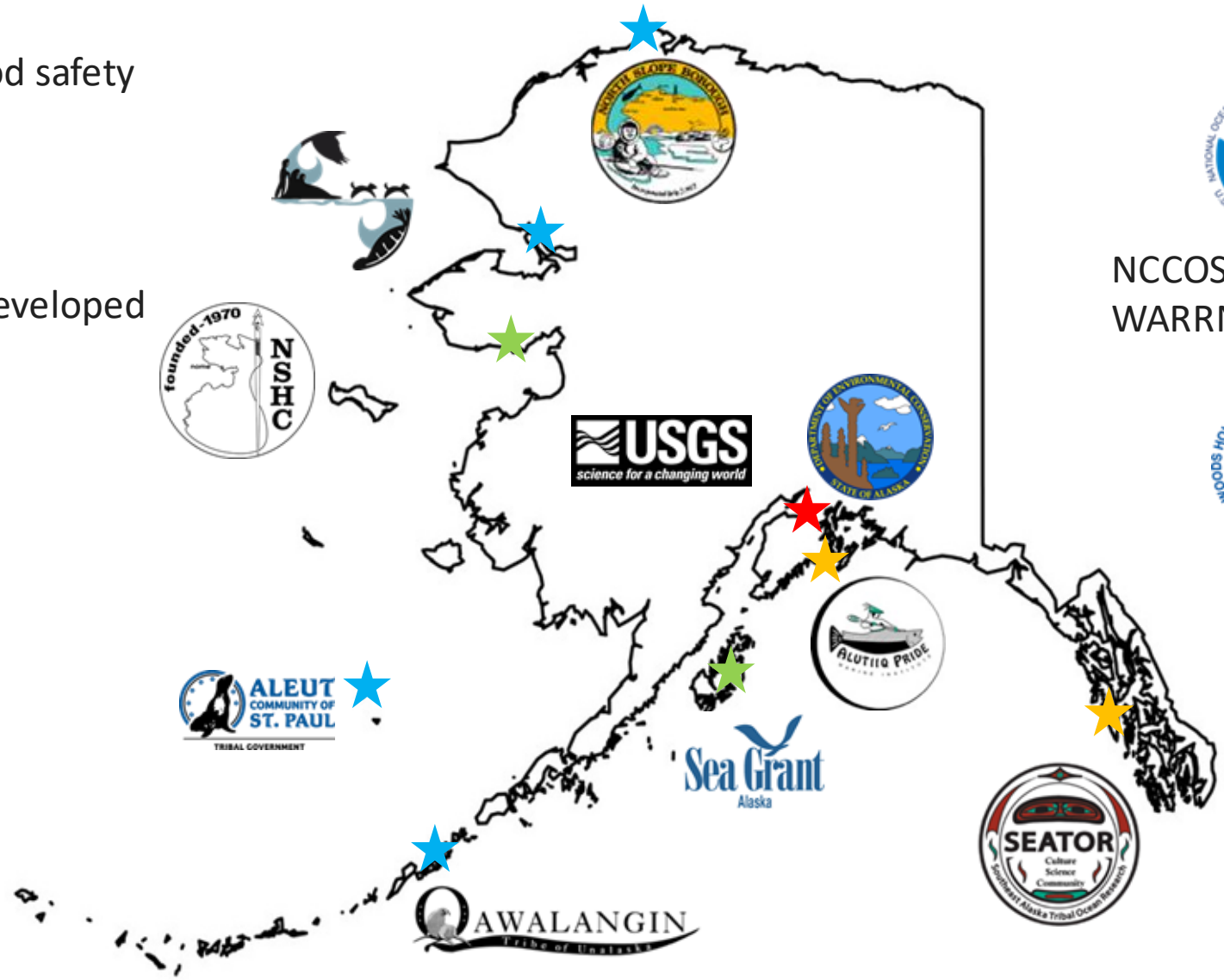
- Continuous phytoplankton sampling
  - Just needs power and seawater access
  - Sample ~5ml every 20 minutes
- Can be deployed on vessels or on shore



Toxin work by AHAB Members

AOOS

- FDA-approved lab for food safety
- Active toxin-testing labs
- Labs being considered/developed
- Other potential labs



NCCOS (Charleston/Beaufort)
WARRN-West (Seattle)

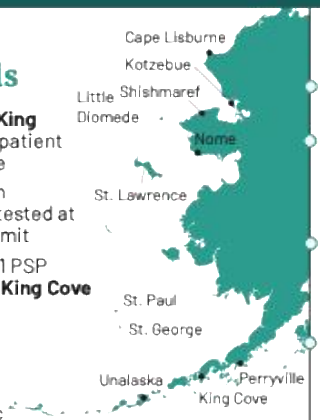
WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Commonly tested species




HABs and PSP through history*

North Slope to Aleutian Islands



- **July 1980**: 1 PSP case at **King Cove** from butter clams, patient medevaced to Anchorage
- **Aug. 1982**: 5 PSP cases in **Perryville** from mussels tested at 62 times the regulatory limit
- **June 1990**: 5 PSP cases, 1 PSP death, butter clams near **King Cove**
- **April 1995**: 7 PSP cases in **Perryville** from razor clams tested at 12 times the regulatory limit
- **May & June 2012**: Pacific Walrus** off of **St. Lawrence Island** tested positive for saxitoxin
- **2014:** Suspect PSP case recorded in Nome Census Area
- **Aug. & Sept.2017:** Pacific Walrus die-off, 37 walruses found dead near **Diomede** and **Shishmaref**, 1 of 37 had detectable saxitoxin concentrations above the regulatory limit
- **Aug. 2018:** HAB detected in northern Bering Sea by icebreaker USCGC *Healy*
- **July 2019**: 1 PSP case in **Perryville** from butter clams
- **Aug. 2019**: HAB detected in northern Bering Sea by icebreaker *Healy*, clams near **St. Lawrence Island** and **Cape Lisburne** tested above the regulatory limit
- **July 2020:** PSP Death in **Unalaska** from blue mussels tested at 100 times the regulatory limit
- **Dec. 2021:** Multiple beached herring in **Kotzebue** tested positive for saxitoxin
- **June & July 2022: King Cove** shellfish advisory, Razor clams tested 6-7 times the regulatory limit, mussels tested at the regulatory limit
- **Aug. 2022**: Largest, most toxic *Alexandrium* bloom ever in the US detected in the **Bering Strait** by the *Norseman II*. Clams and gastropods tested above regulatory limit.
- **Aug. 2023:** *Alexandrium* bloom in **Bering Strait** linked to clams and worms testing above regulatory limit.
- **Summer 2024:** *Alexandrium* bloom detected in Bering Sea, northern fur seal mortality event on **St. Paul Island**
- **July 2025:** *Alexandrium* bloom detected in Bering Sea, seabird and northern fur seal die offs on **St. George Island**

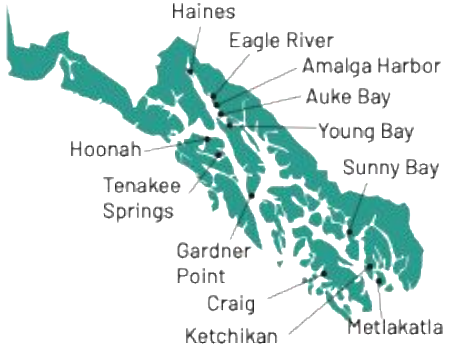
Kodiak

- **May 1976**: 1 confirmed PSP case from razor clams
- **July 1987**: 2 PSP cases in **Monashka Bay** from mussels tested at 70 times the regulatory limit
- **July 1990**: 1 confirmed PSP case from mussels, shellfish found at 25 times the regulatory limit
- **May 1994:** 16 confirmed PSP cases around Kodiak, 1 PSP death from mussels, 3 patients required hospitalization in **Kalsin Bay** and 1 death in **Old Harbor**, mussels tested at ~230 times the regulatory limit at **Chiniak Bay** and **Old Harbor**
- **February 1995:** 1 confirmed PSP case from butter clams tested 2-3 times the regulatory limit
- **June 1997:** 3 confirmed PSP cases, 1 PSP death near **Sturgeon River Lagoon** and **Larsen Bay** from butter and littleneck clams tested at 100 times the regulatory limit.
- **Summer 2012:** Kittlitz's Murrelet nestling die off tied to high saxitoxin levels in prey sand lance
- **July 2014:** Butter clam levels reported as highly toxic at **Old Harbor** (2-2.5 times more toxic than the rest of the island)
- **July 2016:** 1 confirmed PSP case at **Roslyn Beach**, butter clams tested at 8 times the regulatory limit in **Old Harbor**
- **April, Aug., Dec. 2018:** Butter clam levels reported as highly toxic at **Ouzinkie** (2-2.5 times more toxic than the rest of the island)
- **May & June 2019:** State shellfish advisory, butter clam toxin levels high (some 50 times the regulatory limit)
- **June 2021:** Region-wide shellfish advisory, all species tested high in the **City of Kodiak** and **South Trident Basin** (including mussels, butter clams, oysters, and moon snails)

HABs through history (cont'd)

Southeast

- **Aug. 1973**: 2 families report PSP from butter clams in **Tenakee Springs**
- **June 1980**: 2 PSP cases reported from butter clams which tested at 22 times the regulatory limit at Sunny Bay near **Wrangell**
- **July 1980**: 2 PSP cases reported from mussels near **Young Bay** and **Eagle River**. Both people medevaced to Juneau
- **May 1982**: 14 PSP cases reported in **Ketchikan** and **Craig**. Butter clams, cockles, and mussels all tested at dangerous PSP levels, one clam found at 151 times the regulatory limit
- **June 1997:** 2 PSP cases
- **Nov. 1997:** 4 PSP cases reported from butter clams at **Auke Bay** and **Amalga Harbor**. Both families "taste tested" clams but still got sick
- **June 2010:** 3 PSP cases, 1 death in **Haines** from dungeness crab viscera, 1 death in **Auke Bay** from cockles tested at 25 times the regulatory limit
- **May 2011:** 5 confirmed, 8 probable PSP cases in **Metlakatla** from cockles and 3 confirmed, 5 probable cases in **Ketchikan** from mussels, littleneck, and butter clams. Cockles tested ~6.25 times the regulatory limit, mussels tested at 62 times the regulatory limit
- **Dec. 2014:** PSP case reported in the Southeast region from 4 butter clams
- **May & June 2019:** State shellfish advisory. Butter clam toxin levels high (some 50 times the regulatory limit)
- **June 2021:** Region-wide shellfish advisory. All species tested high in **Hoonah** and **Ketchikan** (including mussels, butter clams, oysters, and moon snails)



Kenai Peninsula

- **June 1977:** 17 PSP cases reported in **Homer** from sea snails
- **Sept. 2025:** Saxitoxin event at **Kachemak Bay**. At Yukon Island, Homer Harbor, Gull Island, and Peterson Bay, butter clams tested at 1.5 times regulatory limit and blue mussels as high as 2 times regulatory limit

Event Spotlight: 2022 Bering Strait

In 2022, researchers aboard the *Norseman II* in the Bering Strait region detected the largest, most toxic HAB event ever recorded in the United States, an area with historically low PSP rates. *Alexandrium* cell concentrations were up to 173,000 cells per liter, 173 times the advisory limit of 1,000 cells/liter. Though the shellfish toxin levels were pending lab analysis, regionally-based Alaska Sea Grant and Norton Sound Health Corporation in Nome worked to notify Bering Strait regional community leadership and healthcare facilities by providing awareness, education, and updates. While there were no PSP reports in people, results for harvested seafood sent for testing showed saxitoxin at 5 times the regulatory limit, marking a close call.

** This timeline is non-exhaustive. It only includes events pertaining to the Alexandrium genus and non-commercial harvests. Many PSP cases go unreported.*

***The Pacific Walrus is an important nutritional and cultural food source for people throughout Northern and Western Alaska*

https://uaf-accap.org/projects/extreme_events_library/harmful-algal-blooms/

AOOS
Alaska Ocean Observing System

The Eye on Alaska's Coasts and Oceans

ALASKA HARMFUL ALGAL BLOOM NETWORK
ahab.aoos.org

Thank you

AHAB Network Members

Community Monitors

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U.S. INTEGRATED OCEAN OBSERVING SYSTEM
CERTIFIED
REGIONAL ASSOCIATION

Emergency Response Needed

AOOS

1. Communication on HABs to increase awareness of dangers, symptoms and correct course of action (immediate medical care to assist respiration)
2. If a bloom of *Alexandrium* is detected:
    1. Communication to nearby communities
    2. Alert the medical providers and first responders to be on the lookout for symptoms
    3. Increase testing of food items and/or suspension of harvesting
3. If high toxins are detected or a PSP case is reported:
    1. Investigation of PSP case (DoH Epi)
    2. Communication to people in the area
    3. Immediate increase of toxin testing in the area
    4. Suspension of harvesting in the area