Managing Harmful Algal Blooms in Tribal Waters Webinar Series

Day 1: Overview of HABs in Marine & Fresh Waters

March 10, 2021

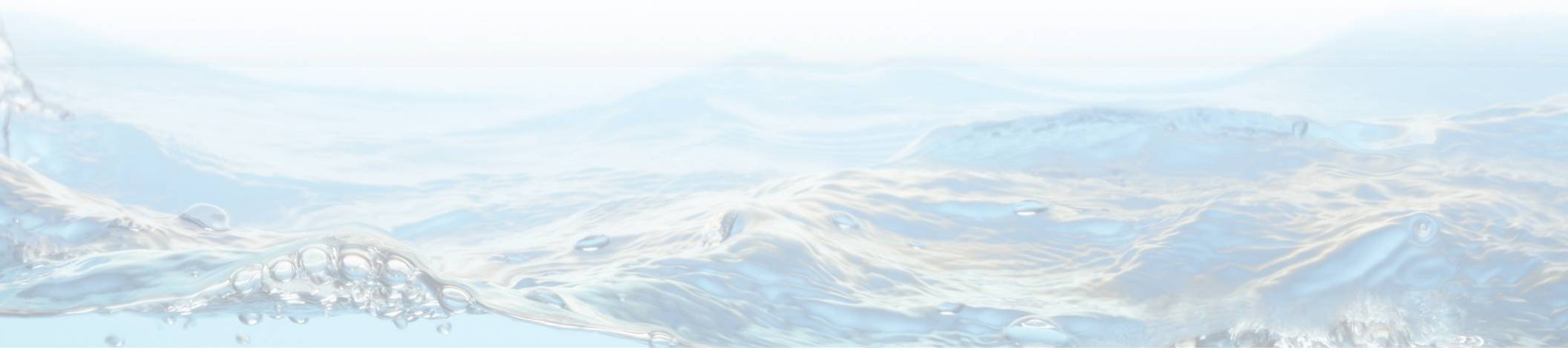
1:00 – 3:30 PM EST/10:00 AM – 12:30 PM PST

Reminders

- Slide presentations and speaker bios are downloadable as handouts
- If you are having technical difficulties, let us know in the chat box
- If you have a question for a speaker, type it in the chat box
  - Moderators will ask questions at the end of each session, time permitting
- Participants on the phone will be given an opportunity to ask live questions during each Q&A session

Welcoming Remarks

- Raymond E. Paddock III, Central Council Tlingit & Haida Indian Tribes of Alaska and Southeast Alaska Tribal Ocean Research (SEATOR)
- Wenona Wilson, U.S. EPA Region 10



Roles of EPA & NOAA in Managing HABs

- Deborah Nagle, Office of Science and Technology (OST), U.S. EPA Office of Water
- Dave Kidwell, Competitive Research Program, NOAA/National Centers for Coastal Ocean Science

Session 1: Harmful Algal Blooms Along the Freshwater to Marine Continuum

- Jennifer Graham, U.S. Geological Survey

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Harmful Algal Blooms Along the Freshwater to Marine Continuum

Jennifer L. Graham

U.S. Geological Survey

U.S. EPA Managing Harmful Algal Blooms in Tribal Waters Webinar Series

March 10, 2021

U.S. Department of the Interior
U.S. Geological Survey

What are Algae?

- Algae are simple photosynthetic plants
- Like all plants, algae have chlorophyll-*a*, which is a pigment used to capture light for photosynthesis
- Algae are an important part of the food web in aquatic ecosystems and are eaten by many simple animals and some fish.

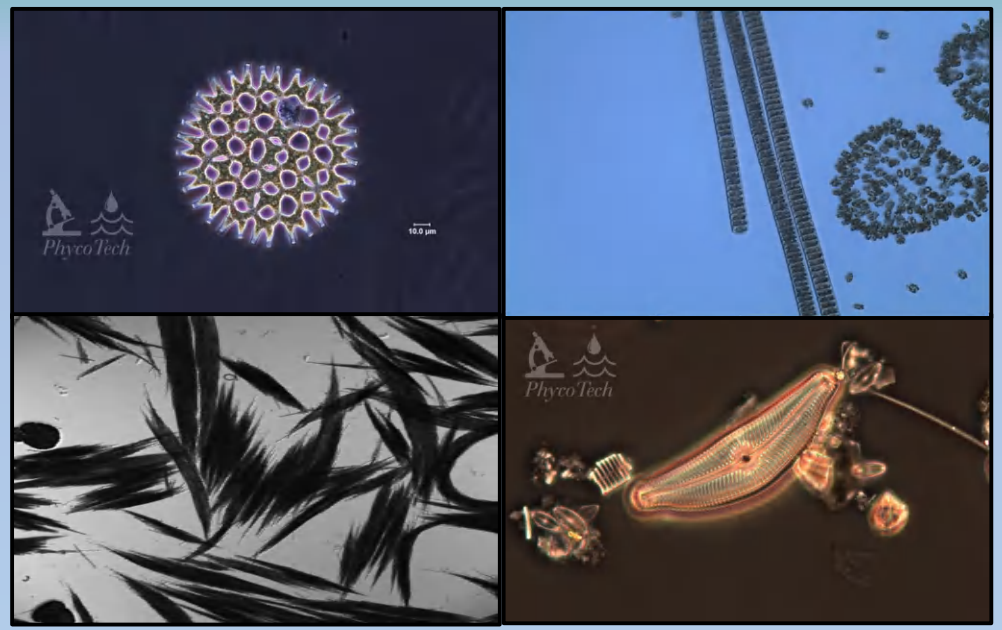

Photo Credits: A. St. Amand, PhycoTech

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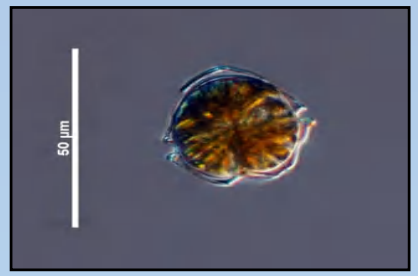
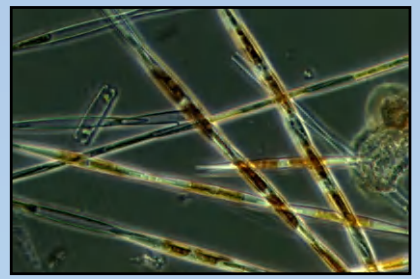
What is an Algal Bloom?

- Definition is subjective
- Common definitions
  - High cell densities
  - Dominance by a single or a few species
  - Visible accumulation of algae
- Not all algal blooms are harmful, and not all harmful blooms are toxic

Michalak and others, 2013





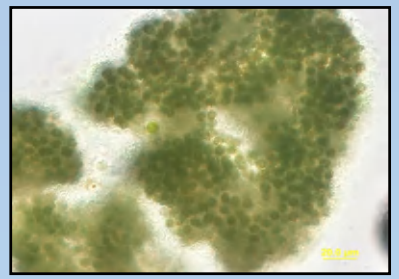


Photo Credits: B. Rosen, Florida Gulf Coast University

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What Makes Some Algal Blooms Harmful?

- **Human Health**
  - Illness and death (rare cases in humans)
  - Multiple exposure routes: recreation, drinking water, foods, aerosols, skin contact
- **Ecological Health**
  - Degraded water quality
  - Food web alteration
  - Mass mortalities of fish, birds, and mammals
- **Economics and Aesthetics**
  - Decreased tourism and property values
  - Commercial fishery losses
  - Increased drinking water treatment costs

Photo Credit: A. Gorichky

Indian River Lagoon, Florida, 2016

Photo Credit: G. Early

Cape Cod, Massachusetts, 2007

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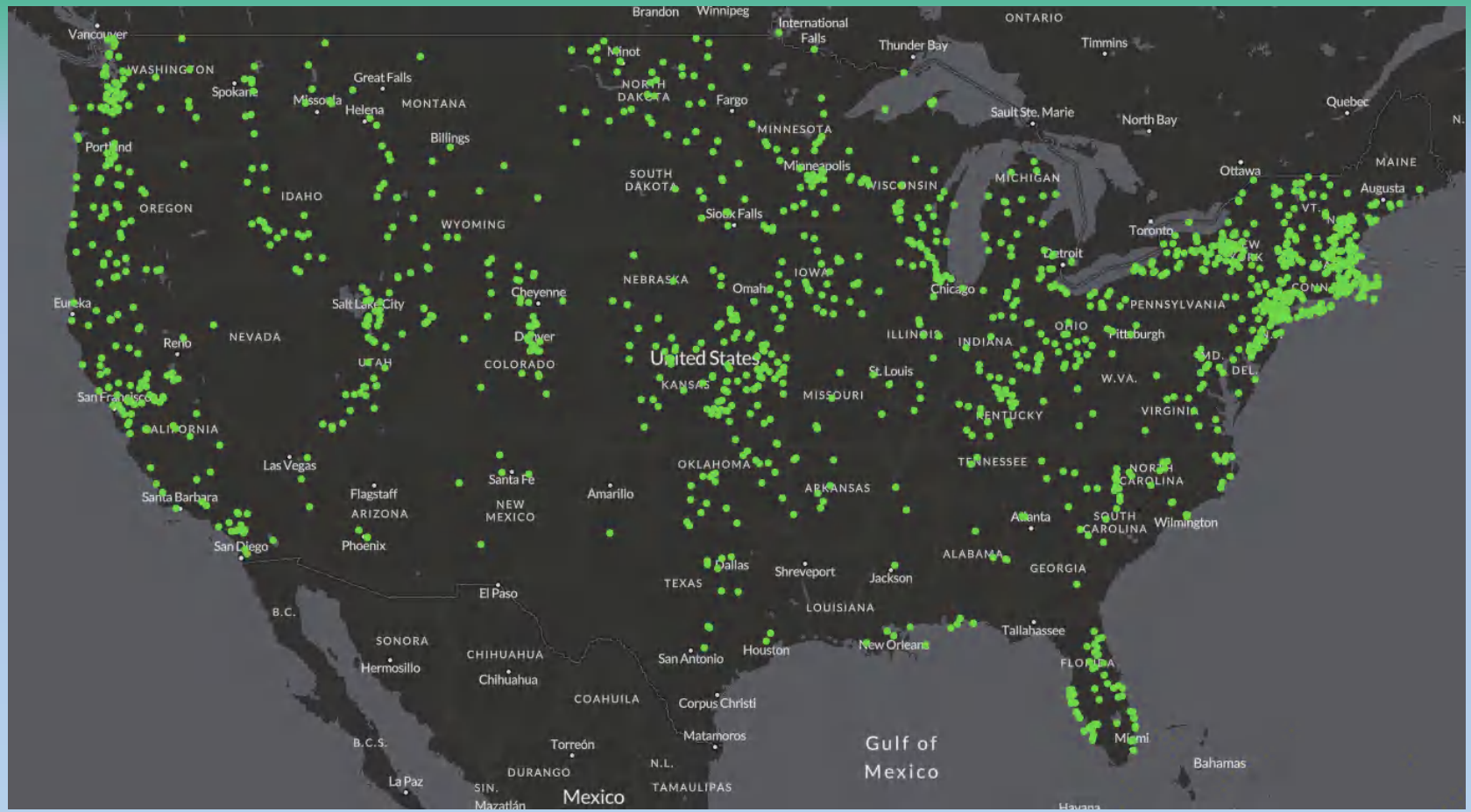
Algal Blooms Have Occurred in All 50 U.S. States



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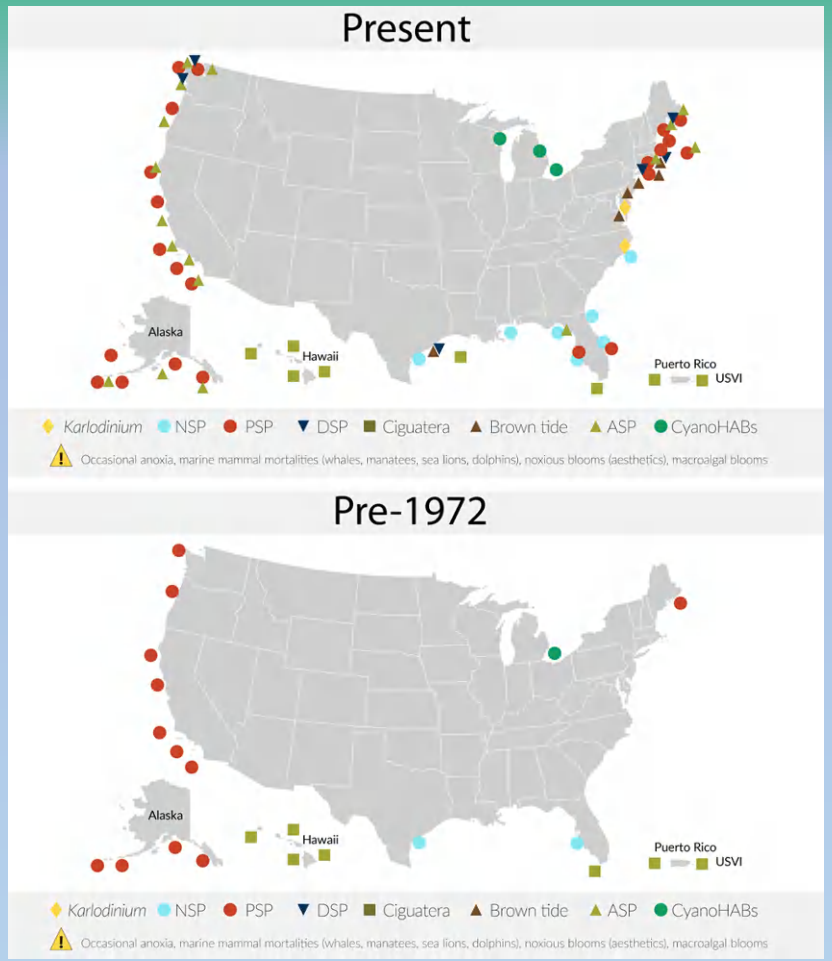
[Environmental Working Group Interactive Map]

Algal Blooms Appear to Be Increasing



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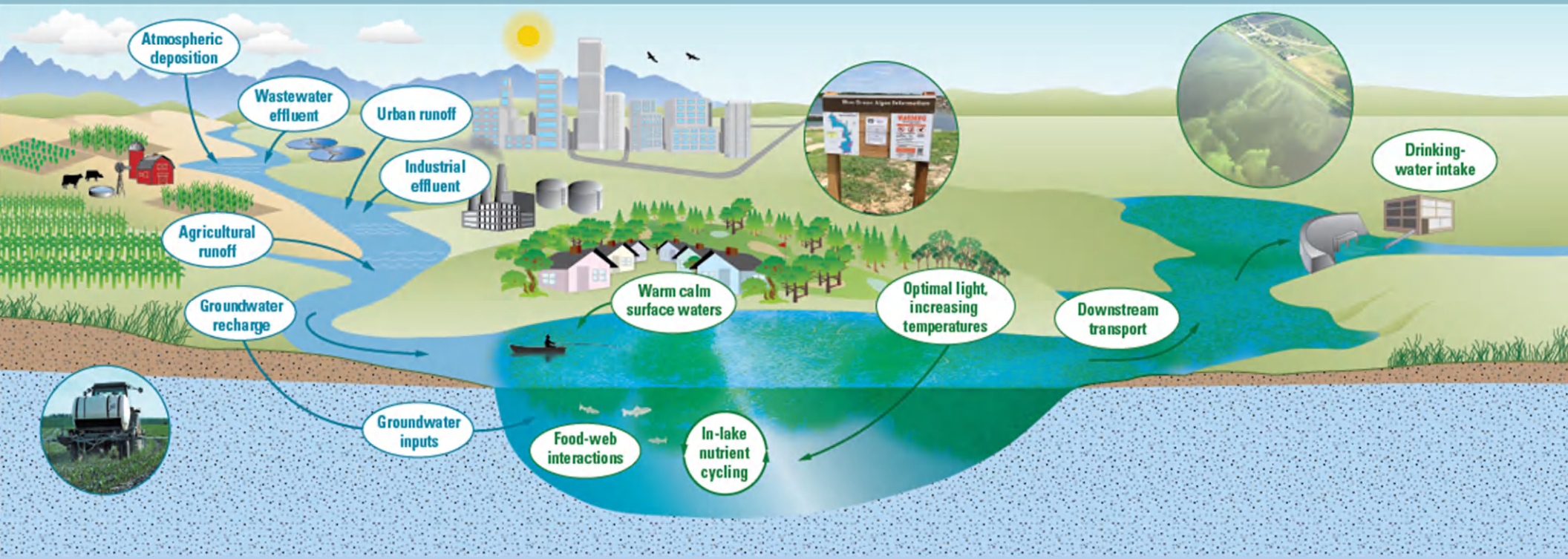
U.S. National Office for Harmful Algal Blooms

Causes of Algal Booms



Graham et al., 2016

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Paradigms Are Changing

Marine Pollution Bulletin 124 (2017) 591–606

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Eutrophication, harmful algae and biodiversity — Challenging paradigms in a world of complex nutrient changes

Patricia M. Glibert

University of Maryland Center for Environmental Science, Horn Point Laboratory, PO Box 6775, Cambridge, MD 21613, USA

Blurred lines: Multiple freshwater and marine algal toxins at the land-sea interface of San Francisco Bay, California

Melissa B. Peacock[a,b,c,*], Corinne M. Gibble[b,d], David B. Senn[d], James E. Cloern[e], Raphael M. Kudela[b]

[a] *Northwest Indian College, 2522 Kwina Rd, Bellingham, WA, 98226, USA*
[b] *Ocean Sciences Department, 1156 High Street, University of California, Santa Cruz, CA 95064, USA*
[c] *San Francisco Estuary Institute, 4911 Central Avenue, Richmond, CA 94804, USA*
[d] *California Department of Fish and Wildlife, Office of Spill Prevention and Response, Marine Wildlife Veterinary Care and Research Center, 151 McAllister Way, Santa Cruz, CA 95060, USA*
[e] *United States Geological Survey MS496, 345 Middlefield Rd, Menlo Park, CA 94025, USA*

Review

Harmful algal blooms: A climate change co-stressor in marine and freshwater ecosystems

Andrew W. Griffith[a,b], Christopher J. Gobler[a,*]

[a] *School of Marine and Atmospheric Sciences, Stony Brook University, Southampton, NY, 11968, United States*
[b] *Department of Biological Sciences, University of Southern California, Los Angeles, CA 90089, United States*

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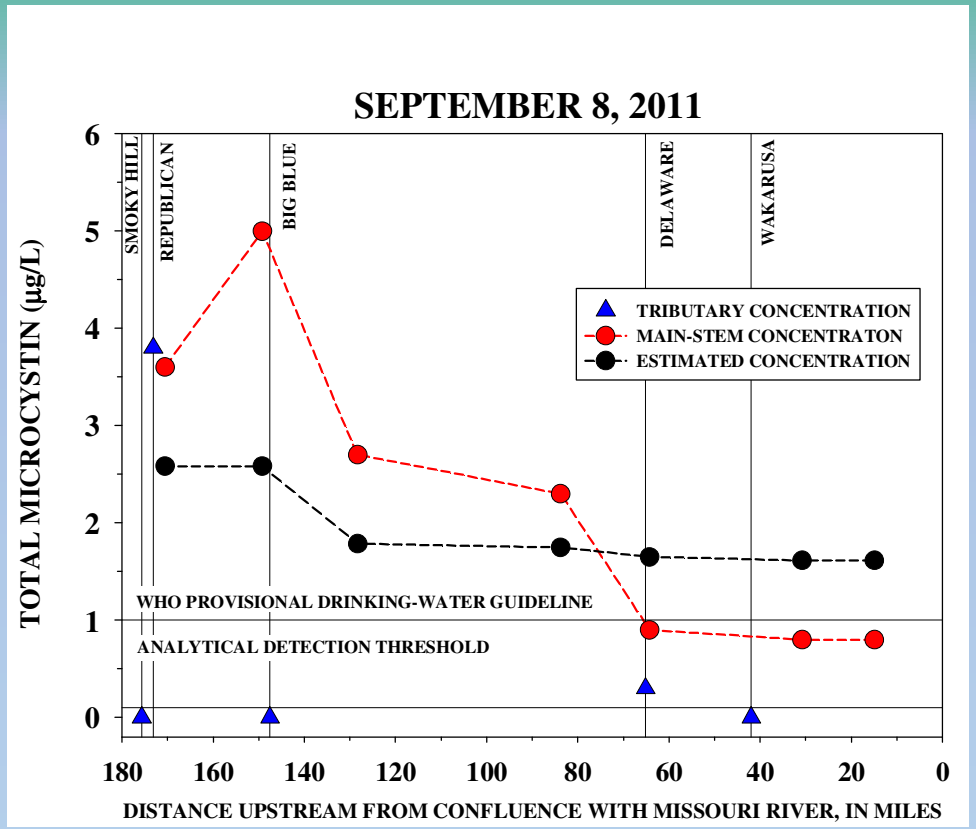
Freshwater Algae and Toxins May Be Transported for Long Distances Downstream of Source Areas



Graham et al., 2012

OPEN ACCESS Freely available online

PLoS one

Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters

Melissa A. Miller[1,2*], Raphael M. Kudela[2], Abdu Mekebri[3], Dave Crane[3], Stori C. Oates[1], M. Timothy Tinker[4], Michelle Staedler[5], Woutrina A. Miller[6], Sharon Toy-Choutka[1], Clare Dominik[7], Dane Hardin[7], Gregg Langlois[8], Michael Murray[5], Kim Ward[9], David A. Jessup[1]

1 Marine Wildlife Veterinary Care and Research Center, California Department of Fish and Game, Office of Spill Prevention and Response, Santa Cruz, California, United States of America, 2 Ocean Sciences Depart
California Department of Fish and Game, C
Center, United States Geological Survey, Lo
States of America, 6 Department of Patholo
of America, 7 Applied Marine Sciences, Live
America, 9 Division of Water Quality, State

Photo Credit: Getty Images

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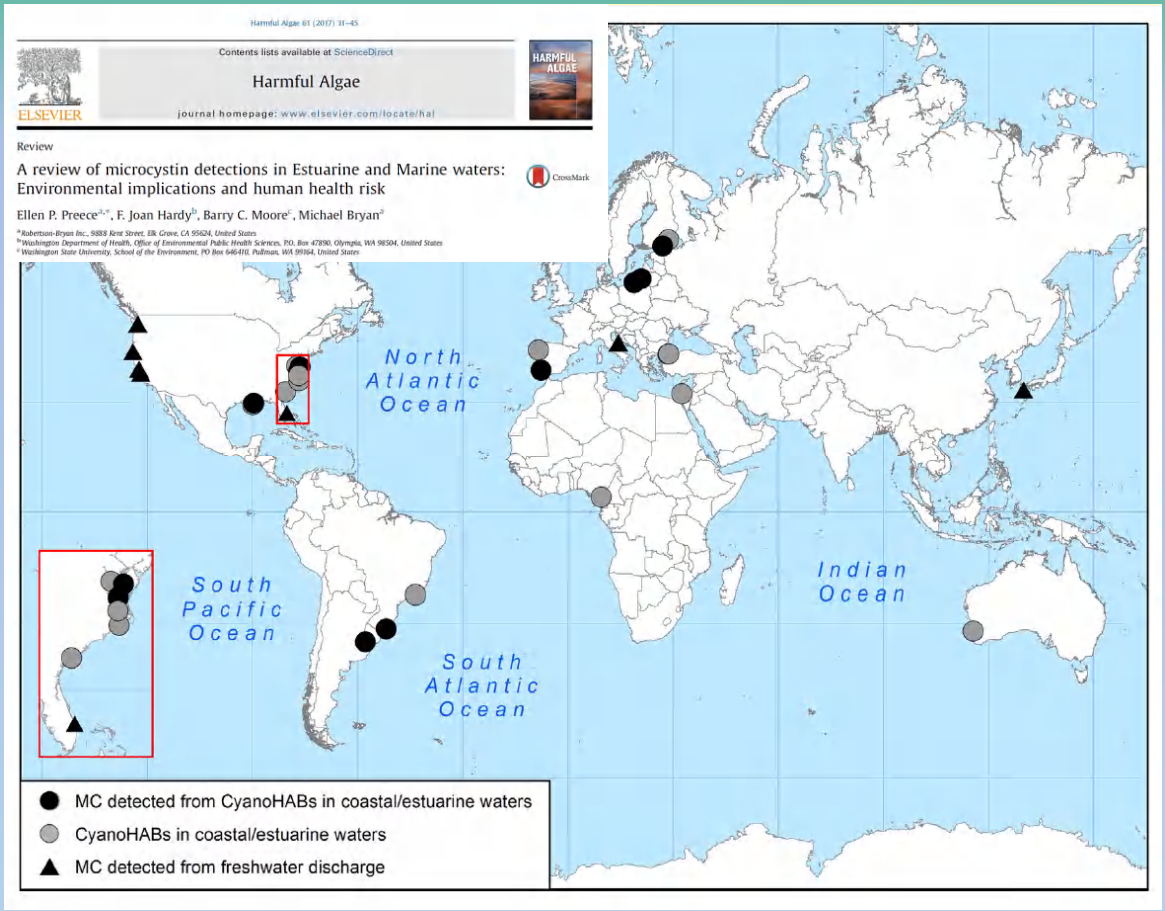
Freshwater Algal Toxins May Occur in Coastal and Estuarine Environments



Preece et al., 2017

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Environmental Conditions have Independent and Interactive Influences on Harmful Algal Bloom Development

Harmful Algae 91 (2020) 101590

Contents lists available at ScienceDirect

Harmful Algae

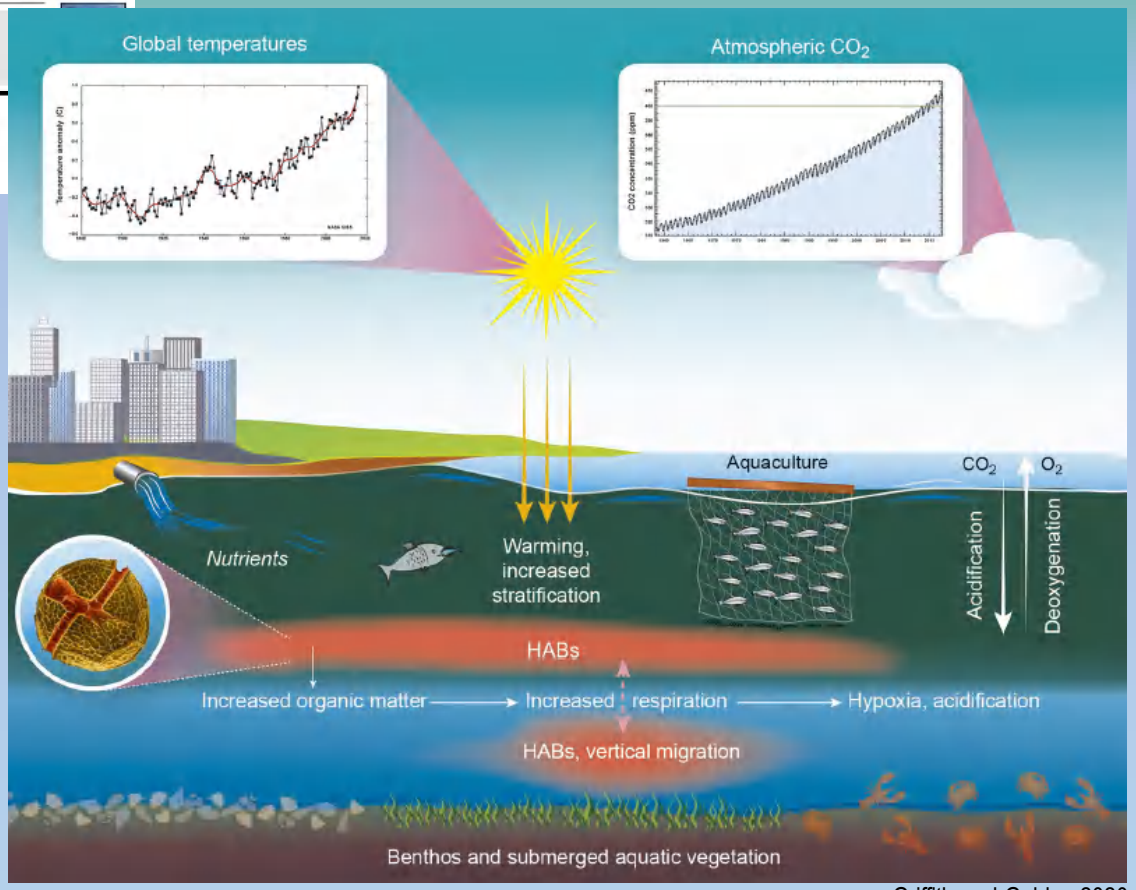
journal homepage: www.elsevier.com/locate/hal

ELSEVIER

Review

Harmful algal blooms: A climate change co-stressor in marine and freshwater ecosystems

Andrew W. Griffith[a,b], Christopher J. Gobler[a,*]



Griffith and Gobler, 2020

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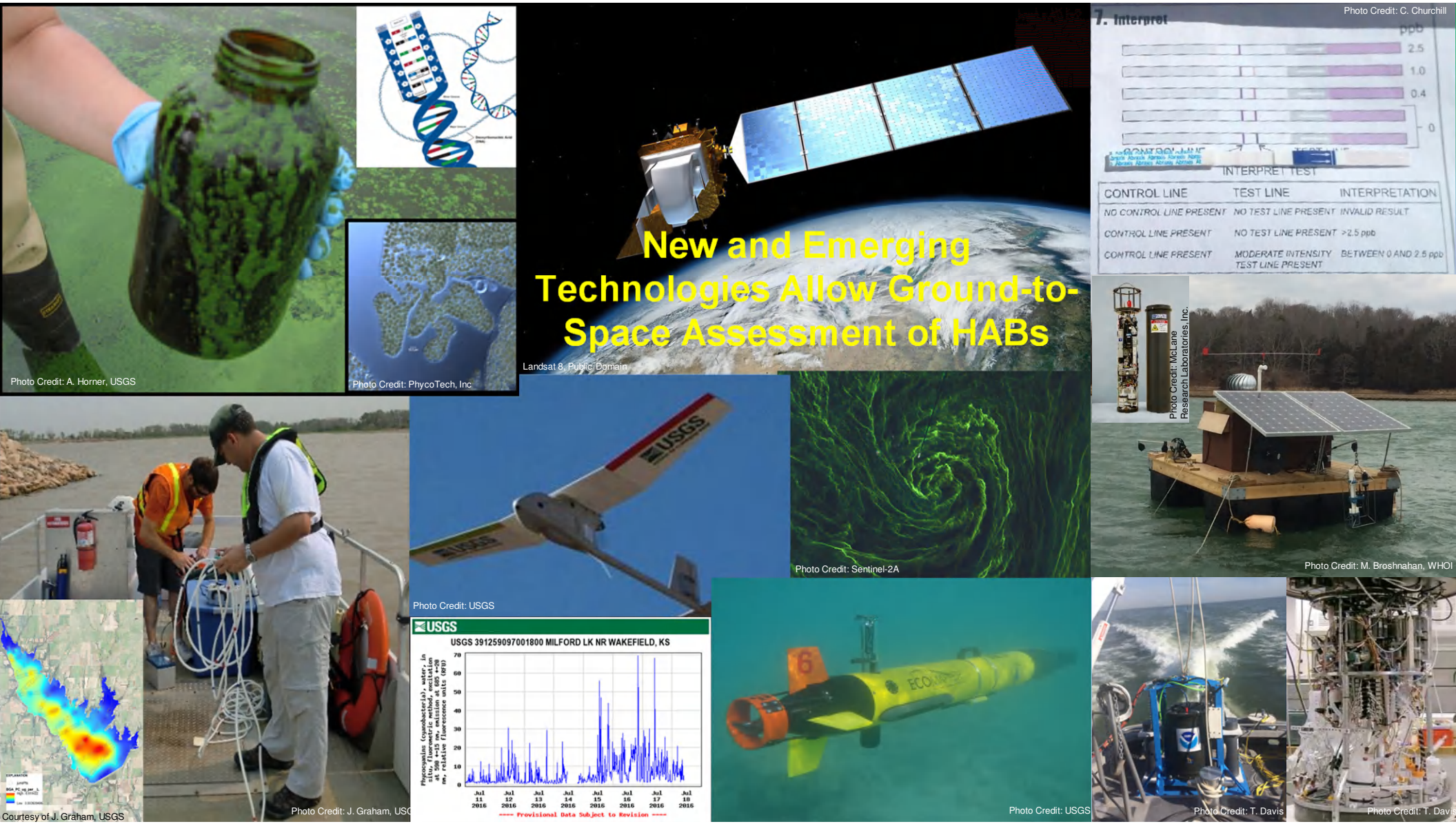
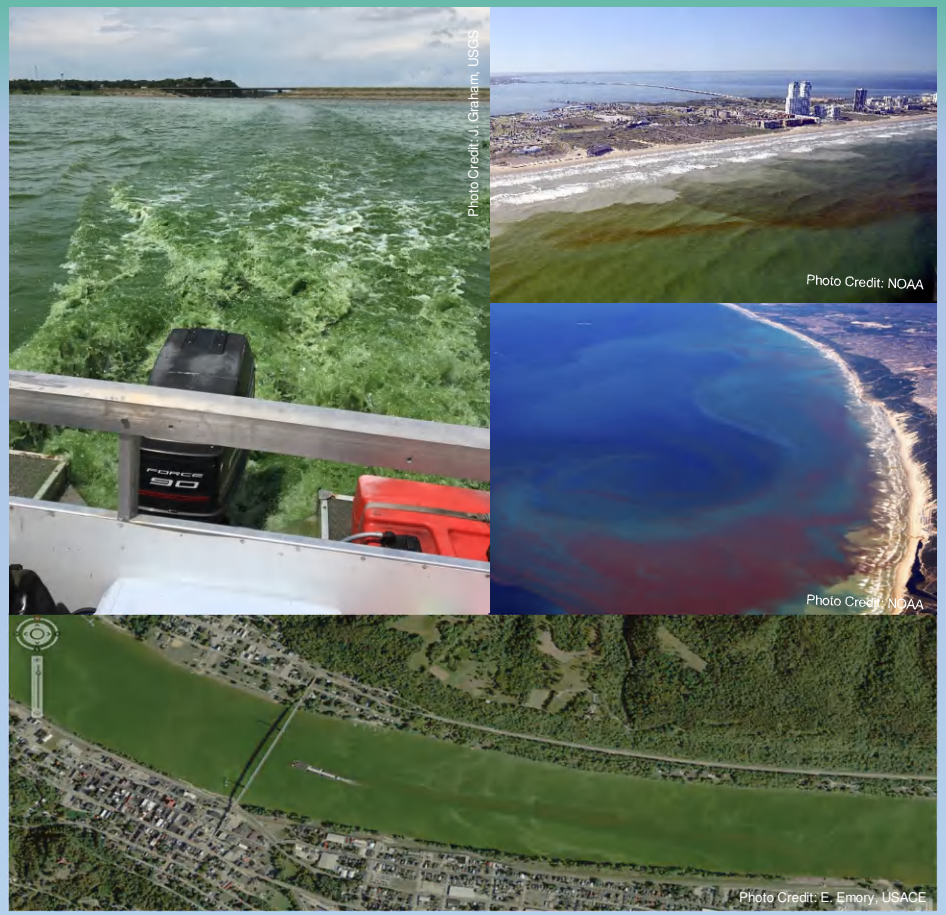

New and Emerging Technologies Allow Ground-to-Space Assessment of HABs
Photo Credit: A. Horner, USGS
Photo Credit: PhycoTech, Inc
Landsat 8, Public Domain
Photo Credit: C. Churchill
7. Interpret
ppb
2.5
1.0
0.4
0
INTERPRET TEST
CONTROL LINE
TEST LINE
INTERPRETATION
NO CONTROL LINE PRESENT
NO TEST LINE PRESENT
INVALID RESULT
CONTROL LINE PRESENT
NO TEST LINE PRESENT
>2.5 ppb
CONTROL LINE PRESENT
MODERATE INTENSITY TEST LINE PRESENT
BETWEEN 0 AND 2.5 ppb
Photo Credit: McLane Research Laboratories, Inc.
Photo Credit: M. Broshnahan, WHOI
USGS
Photo Credit: USGS
Photo Credit: Sentinel-2A
USGS 391259097001800 MILFORD LK NR WAKEFIELD, KS
Phycocyanins (cyanobacteria), water, in situ, fluorometric method, excitation at 590 +-15 nm, emission at 685 +-20 nm, relative fluorescence units (RFU)
70
60
50
40
30
20
10
0
Jul 11 2016
Jul 12 2016
Jul 13 2016
Jul 14 2016
Jul 15 2016
Jul 16 2016
Jul 17 2016
Jul 18 2016
---- Provisional Data Subject to Revision ----
Courtesy of J. Graham, USGS
Photo Credit: J. Graham, USG
Photo Credit: USGS
Photo Credit: T. Davis
Photo Credit: T. Davis

Modeling and Forecasting is an Active Area of Research

- Seasonal outlook
- Real-time, Nowcast, and Forecast
- Long-term change
- Process-based understanding



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Knowledge Gaps

A considerable amount of research is being conducted…toward the determination of causes and control of algal blooms. An expansion and integration of these studies is indicated as a very real need.

~E. T. Rose, 1953

- Status and trends
- Environmental fate and transport
- Environmental drivers
- Ecosystem effects
- Exposure and health
- Drinking water and food impacts
- Mitigation and management
- Interactive influences of climate change


Photo Credit: B. Rosen, USGS

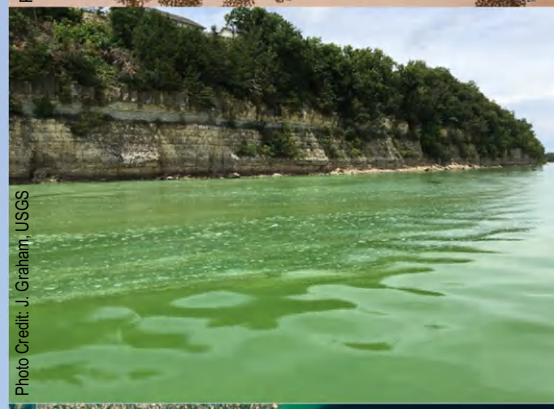
Photo Credit: J. Graham, USGS


Photo Credit: NASA

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Jennifer Graham
jlgraham@usgs.gov

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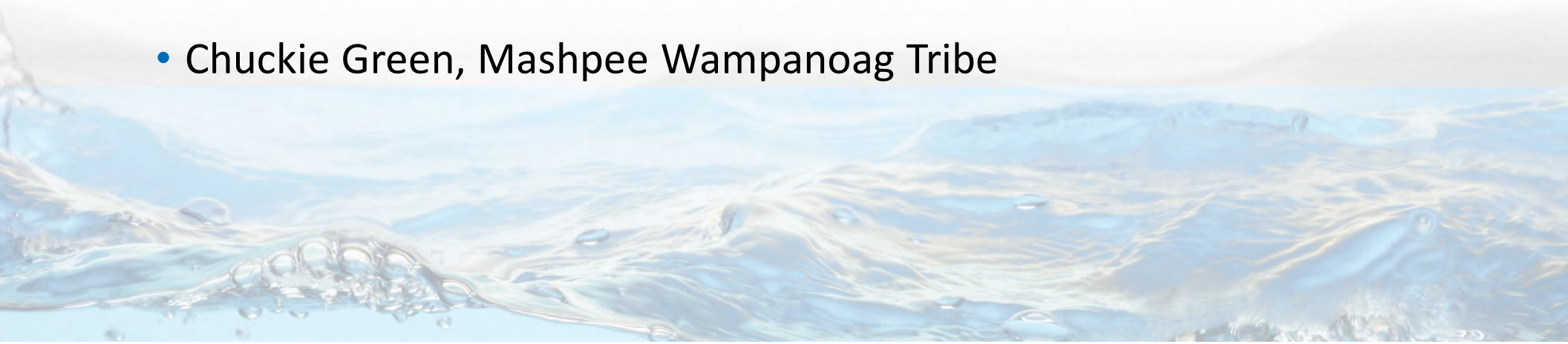
Session 2: Case Studies in Managing HABs

- Neil Harrington, Jamestown S'Klallam Tribe
- Linnea Jackson, Hoopa Valley Tribe
- Kari Lanphier, Southeast Alaska Tribal Ocean Research (SEATOR)
- Chuckie Green, Mashpee Wampanoag Tribe



Jamestown S'Klallam Tribe's HAB monitoring program

By: Neil Harrington, Environmental Biologist, Jamestown S'Klallam Tribe

Jamestown S'Klallam Tribe

- Tribe retained fishing and shellfish harvest rights in the 1855 Treaty of Point No Point
- Shellfish remain important subsistence, ceremonial and economic resource
- Commercial oyster farm and clam beach

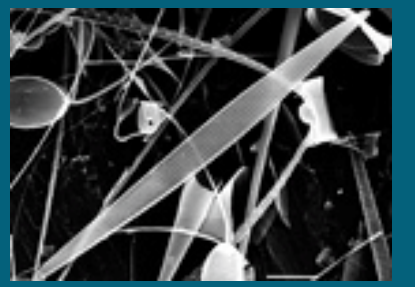
General Review of Harmful Algal Blooms (HABs) in Sequim Bay

<u>Paralytic Shellfish Poisoning</u>

- *Alexandrium cattenella*- dinoflagellate
- Reoccurring blooms in SB since 1957
- Saxitoxins: high doses lead to paralysis

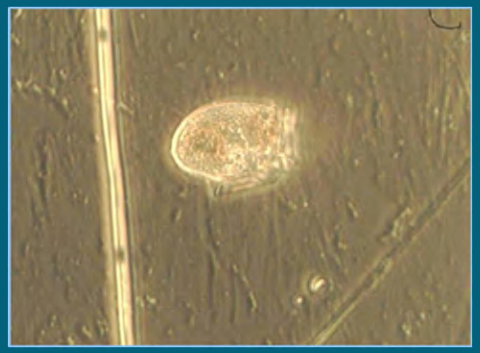
<u>Amnesiac Shellfish Poisoning</u>

- *Pseudo-nitzschia spp.* of diatoms
- Domoic acid- loss of short term memory



<u>Diarrhetic Shellfish Toxins (DTXs)</u>

- *Dinophysis spp*. of dinoflagellates
- Causes severe gastrointestinal distress
- 1st confirmed US cases at Sequim Bay S.P. in 2011



HAB monitoring and shellfish safety program

- Started Soundtoxins sampling 2008
- Submit shellfish samples to WDOH biotoxin lab (sampling informed by phytoplankton)
- Intensive study of PSP and ASP in 2009-2010 w/ NOAA
- DSP Studies 2012-2016
  - Determined cell abundance thresholds for shellfish toxicity
  - Assisted WDOH and NOAA in getting routine DSP monitoring into place

HAB monitoring informs management

- September 30th *Alexandrium* count of 30,000cells/L (close fishery)
- October 2nd mussels 1864 µg/100g shellfish (limit is 80 µg/100g)
- October 7th 49,000cells/L of *Alexandrium*
- October 8th mussels 6007 and oysters 335 µg/100g

Managing Harmful Algal Blooms In Tribal Waters

Linnea Jackson, General Manager
Hoopa Valley Public Utilities District

Hoopa Valley Tribe


Hoopa Valley Indian Reservation
Northern California
THE GREAT SEAL OF THE
HOOPA VALLEY TRIBE

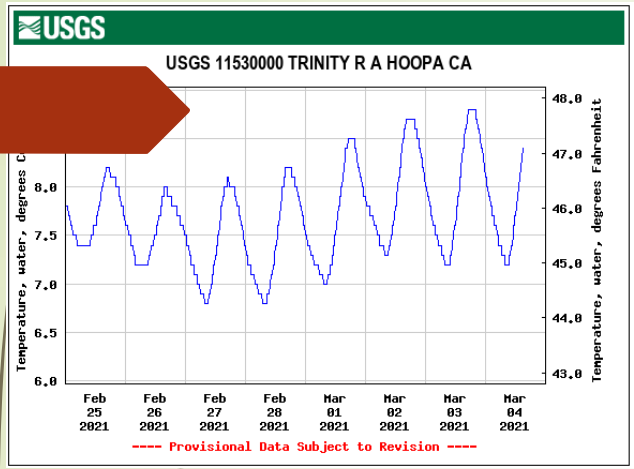
Humboldt County

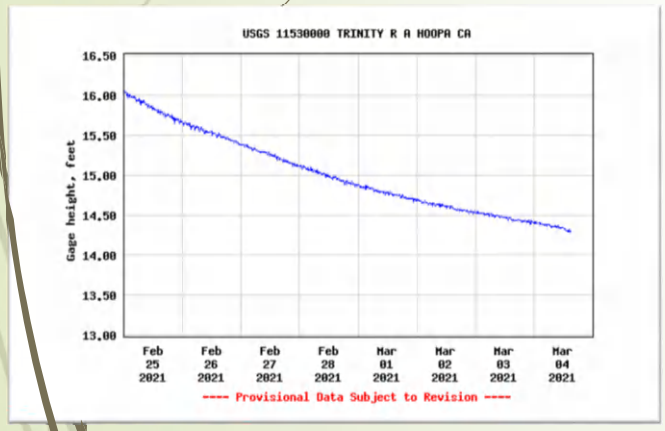
HVPUD is as chartered entity of the Hoopa Valley Tribe. For the past 40 years, we have provided utility services of high quality to the community including water (both irrigation and domestic), sanitation facilities, solid waste management, electrical services and now wireless internet services.

HVPUD manages the largest tribal water utility in the State of California. The Hoopa Valley Tribe has one of the largest land bases in the State of California.

Julius Marshall Water Treatment Plant

* 3 PALL Aria AP-4 Microfiltration Systems
* Each Skid can produce 350 gpm
* Our Source Water is the Trinity River





Trinity River Intake 3/4/2021, 48° F, 14.5 Feet

Conditions on 08/23/2014
River Temperature 75° , 11.3 Feet

Samples taken by the Tribal Environmental Protection Agency (TEPA) on 8/23/2014

In 2015, the U.S. EPA awarded Hoopa a grant to address the algal blooms that occur in the Trinity River due to drought, rising temperatures and climate change. During the summer months when water consumption demands area at their highest, the Trojan UV unit is utilized to oxidize and treat any cyanotoxins, including anatoxin-a and microcystin. Note: No presence of cyanotoxins have been detected in finished drinking water.

MANAGEMENT REQUIREMENTS FOR HABs

- Water Quality Testing schedule of raw water and finished drinking water
- Develop a system for evaluating potential contaminants, stringent monitoring activities and communication methods to stakeholders
- Secure infrastructure for treatment methods to treat cyanobacteria and cyanotoxins in source water

BARRIERS FOR MANAGING HABs

- Cost to procure treatment infrastructure
- Cost to maintain equipment, chemicals, test strips, lab fees
- Staff turnover and loss of operational knowledge
- Seasonal Use; retrain and relearn process and methodology
- Loss of chlorine residual due to use of hydrogen peroxide

As a Tribal nation, we are dependent on water as a cornerstone of life, as well as recreational and cultural uses. The Hupa people have always lived along the Trinity River and it is an intrinsic part of who we are. We have a responsibility to protect and manage it.

Sitka Tribe of Alaska
Southeast Alaska Tribal Ocean Research

Sovereignty through Science in Southeast Alaska

Kari Lanphier

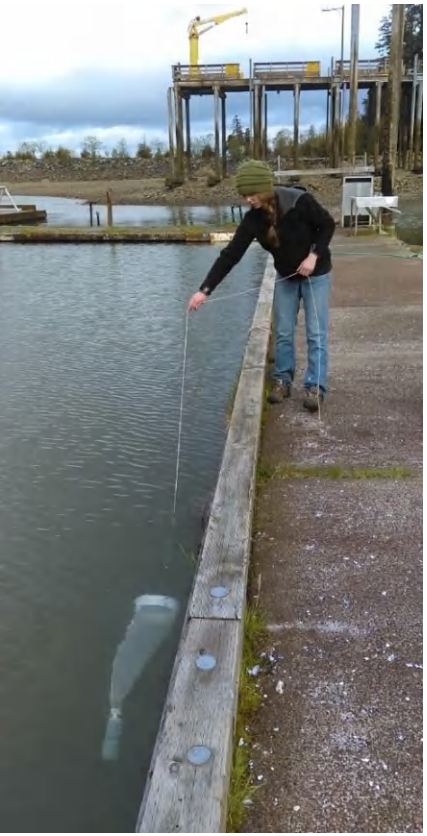
State of Shellfish

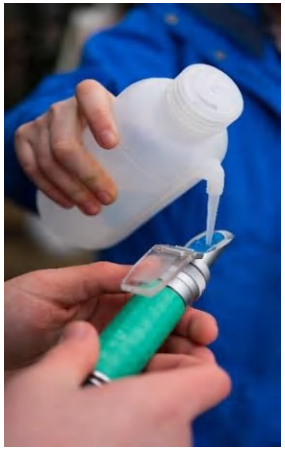
SEATOR

Southeast Alaska Tribal Ocean Research Network

SEATOR Workshop, Sitka 2019

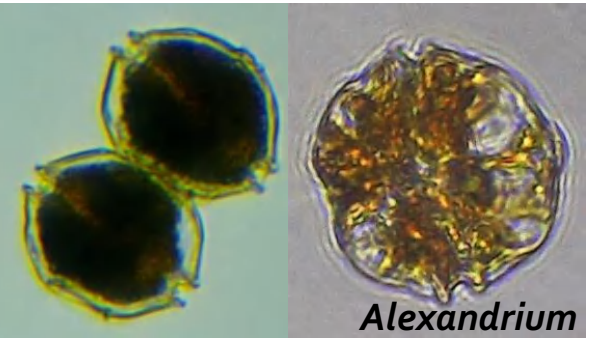
SEATOR Program

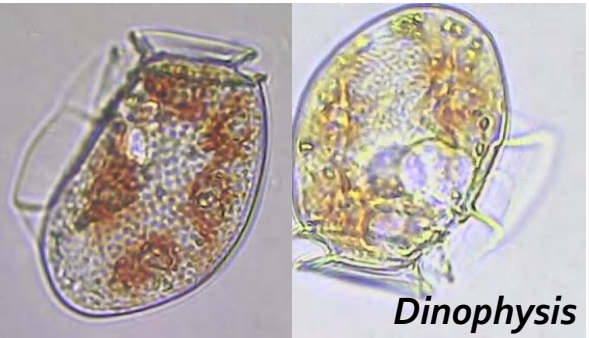




- Phytoplankton Observations
- Shellfish Toxin Testing
- Communicating Results

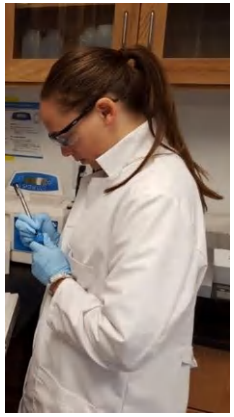
Phytoplankton Observations



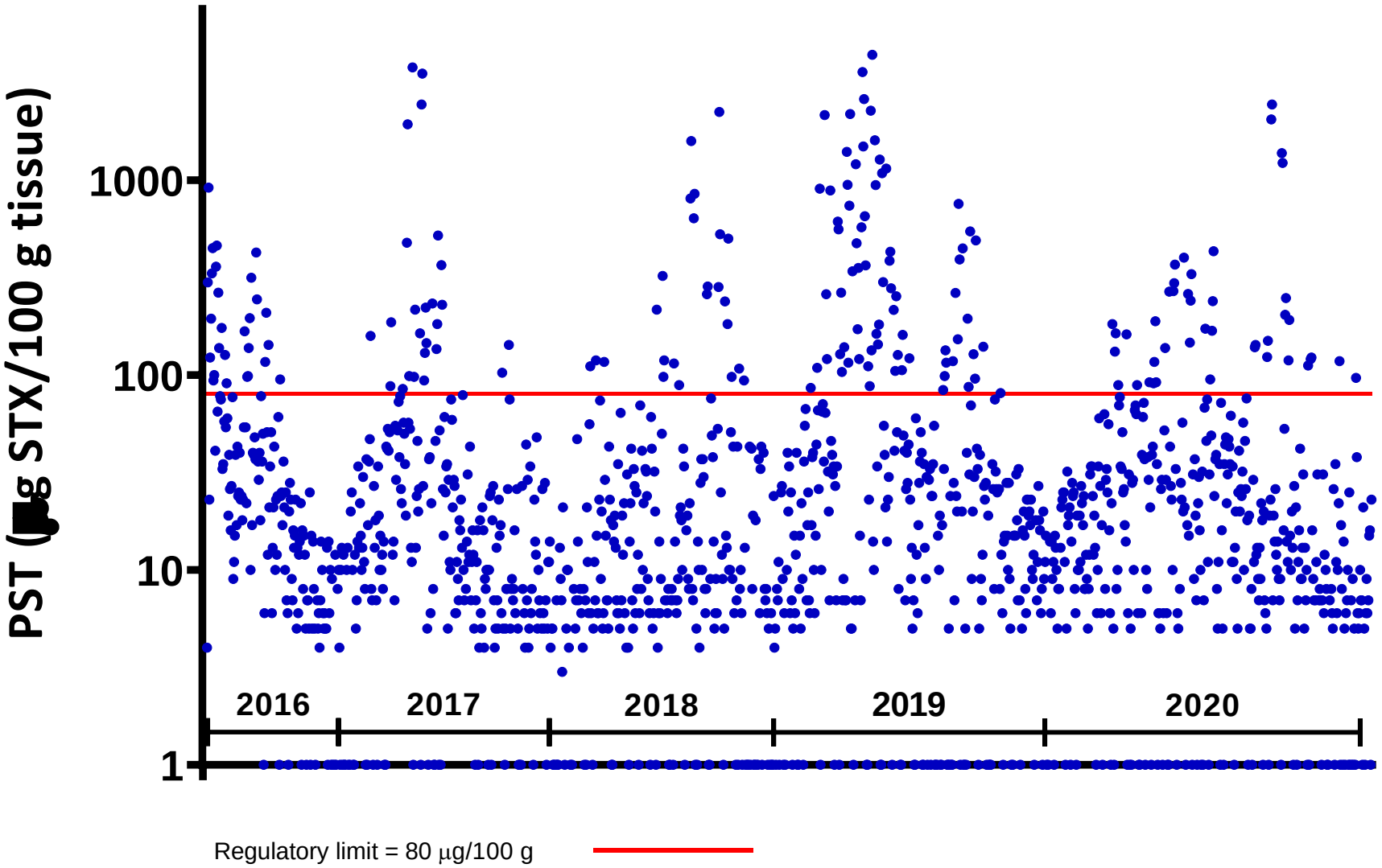


- Prioritize HAB species in microscopy
- Categorized by abundance (bloom, common, present, absent)
- Phytoplankton observations inform shellfish testing
- Over 3,000 phytoplankton observations made by SEATOR partners

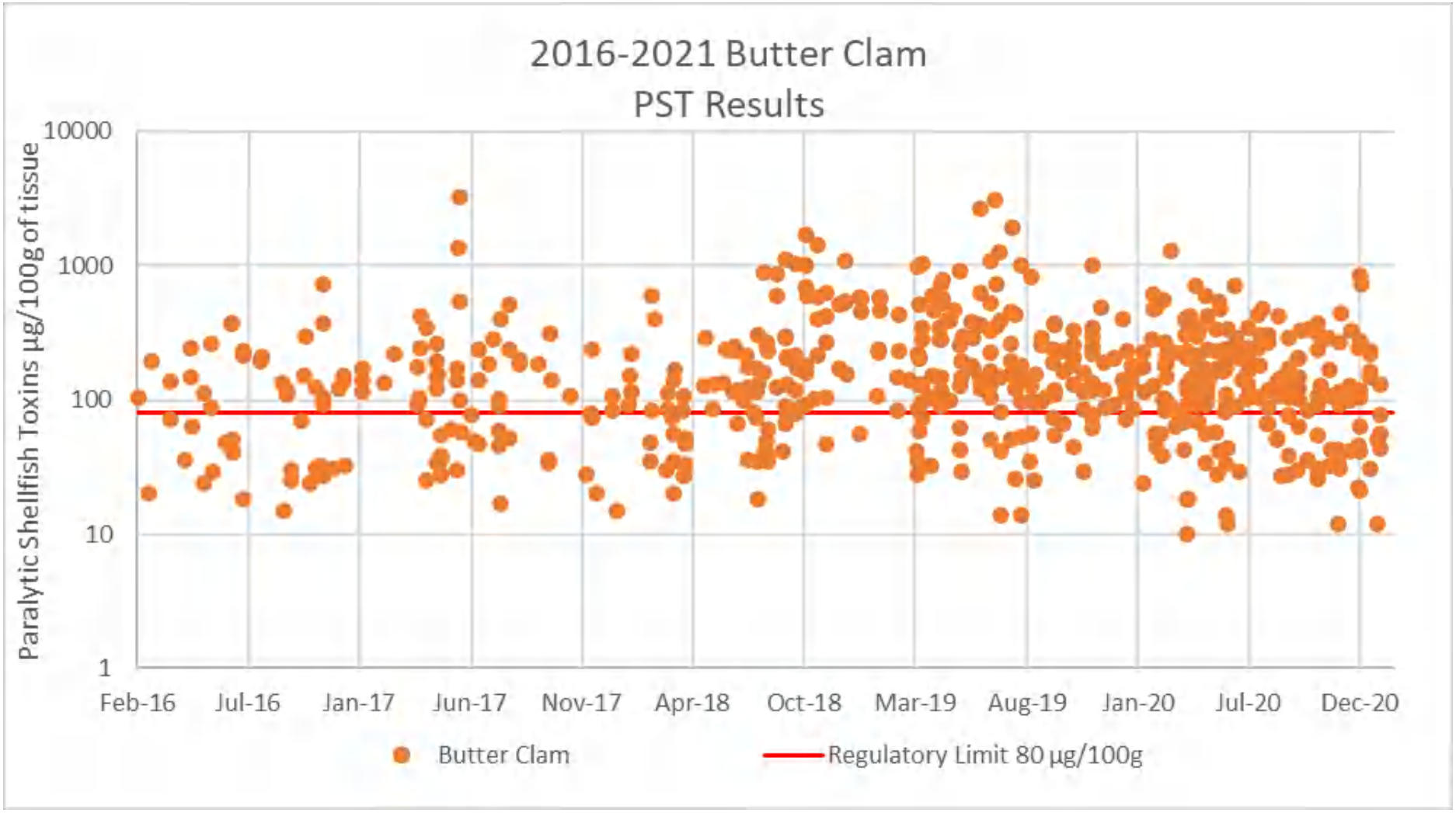
Shellfish Testing Program



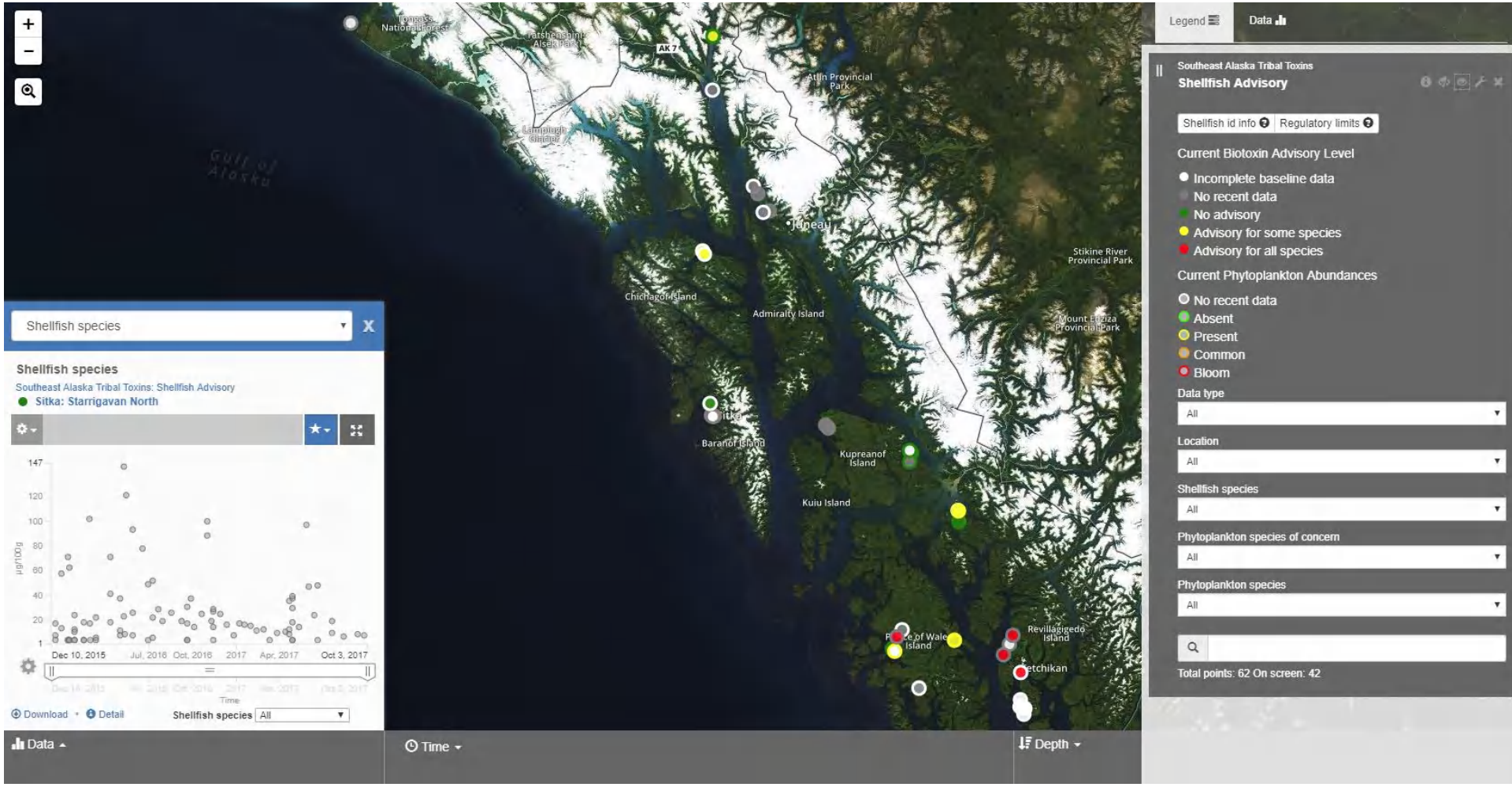
Blue Mussel Results



Shellfish Testing Program



Data Community



Communicating Results

Southeast Alaska Tribal Ocean Research

Sitka Tribe of Alaska Environmental Research Laboratory
429 Katlian Street, Sitka Alaska (907) 966-9650
seator@sitkatribe-nsn.gov

PSP Report
06/11/2019

STAERL ID	Date Collected	Location	Sample Site	Species	PSP Result* (µg/100g)	Sample Type	Collector
190577	6/4/2019	Klawock	City of Klawock Boat Launch	Blue Mussel	949	whole	Klawock Cooperative Association
190578	6/4/2019	Klawock	Big Salt	Blue Mussel	116	whole	Klawock Cooperative Association
190585	6/4/2019	Juneau	Auke Rec/Pt. Louisa	Blue Mussel	1211	whole	Central Council of Tlingit and Haida Indian Tribes of Alaska
190586	6/5/2019	Juneau	Auke Rec/Pt. Louisa	Cockle	726	whole	Central Council of Tlingit and Haida Indian Tribes of Alaska
190588	6/4/2019	Juneau	Amalga Harbor	Blue Mussel	2187	whole	Central Council of Tlingit and Haida Indian Tribes of Alaska
190589	6/4/2019	Juneau	Amalga Harbor	Cockle	943	whole	Central Council of Tlingit and Haida Indian Tribes of Alaska
190602	6/4/2019	Craig	False Island Boat Launch	Blue Mussel	341	whole	Craig Tribal Association
190616	6/5/2019	Haines	Kochu Island	Blue Mussel	476	whole	Chilkoot Indian Association
190617	6/6/2019	Kodiak	Mission Beach NE	Blue Mussel	122	whole	Kodiak Area Native Association

Communicating Results

Communicating Results

ADVISORY - EXTREMELY ELEVATED PARALYTIC SHELLFISH TOXINS FOUND IN JUNEAU SHELLFISH

Blue mussel, cockle clam and **butter clam** samples collected from **Auke Rec./Point Louisa Beach** and **Amalga Harbor** on **6/4/19 and 6/5/19** have extremely elevated levels of **paralytic shellfish toxins** – above the FDA regulatory limit of 80µg/100g. **Consuming any wild harvested shellfish from these areas is considered dangerous and potentially lethal.**

Thank You Partners!

UAF
UNIVERSITY OF
ALASKA
FAIRBANKS

AOOS
Alaska Ocean Observing System

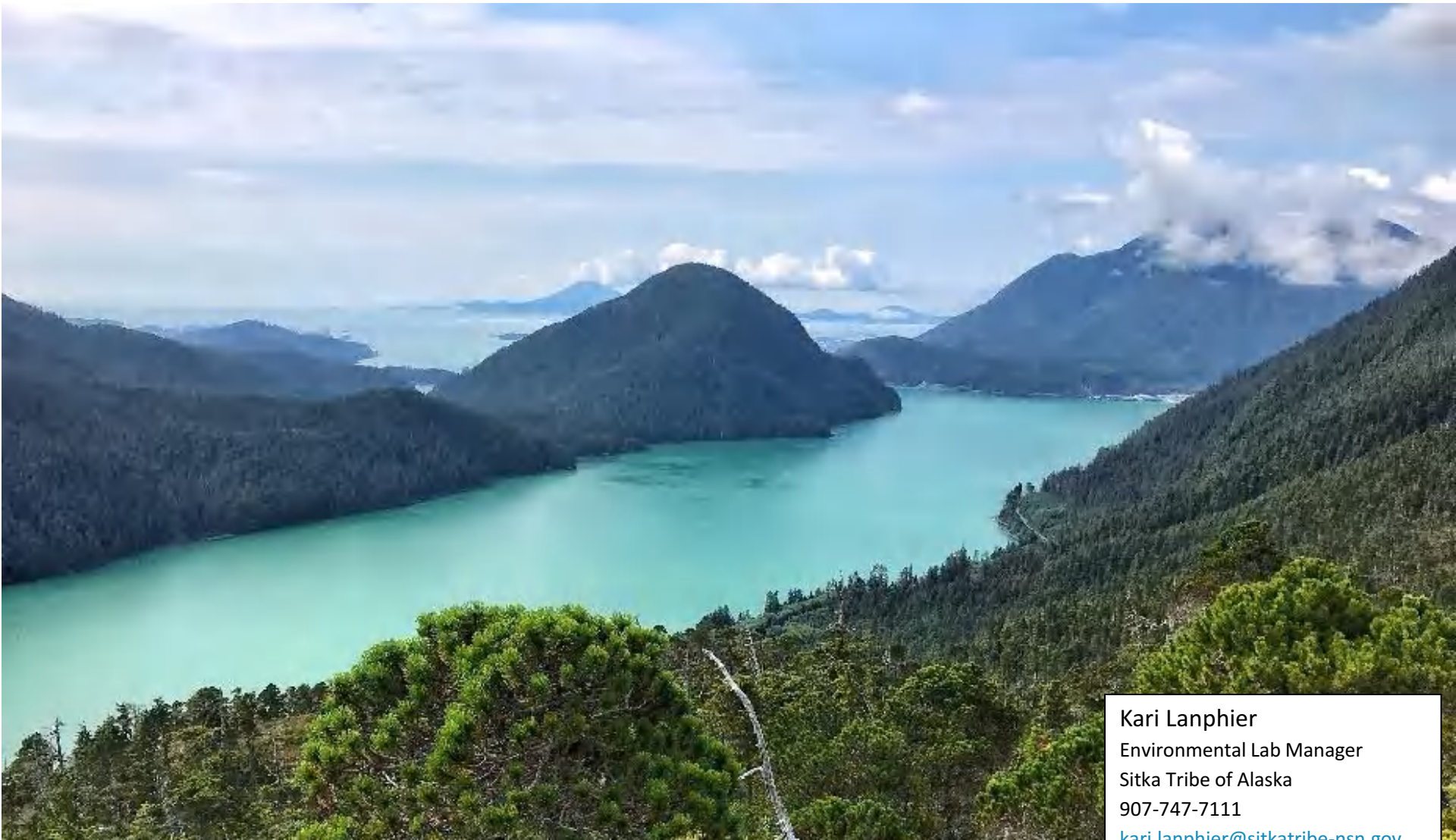
NOAA NCCOS

NIH
NIEHS

Washington State Department of Health

UNIVERSITY
of ALASKA
SOUTHEAST

Questions



Kari Lanphier
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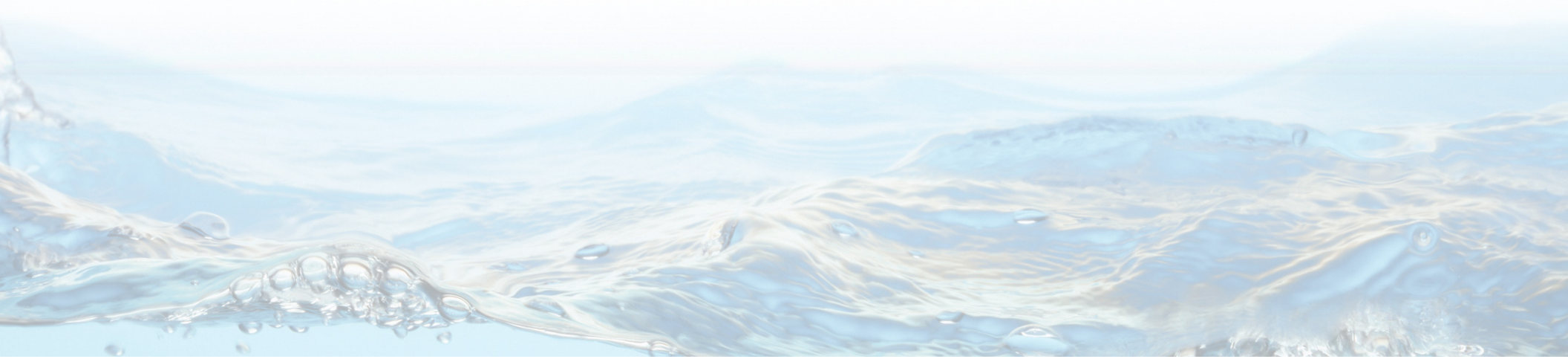
kari.lanphier@sitkatribe-nsn.gov

Chuckie Green, Mashpee Wampanoag Tribe



BREAK AND AUDIENCE POLL

What is your biggest challenge in managing HABs?

- Limited or no in-house expertise for sample collection and analysis
- Limited or no equipped chemical/biological laboratory
- Limited funding and support staff
- Don’t know where and how to get started
- Other (enter response in chat box)

The webinar will resume at 2:45 p.m.

Session 3: Understanding and Communicating the Impacts of HABs

- Lorraine Backer, CDC
- William Houle, Turtle Mountain Band of Chippewa Indians
- Willow Hetrick, Chugach Regional Resources Commission
- Maile Branson, Alutiiq Pride Marine Institute

Harmful Algal and Cyanobacterial Blooms Overview

Lorraine C. Backer

Senior Environmental Epidemiologist

Tribal HABs Webinar Series

March 10, 2021

Outline

- What are blooms?
- What makes some blooms harmful?
- Marine algal toxins
- Cyanobacterial toxins
- Emerging issues

What is a bloom?

- What is a bloom?
  - A proliferation of microscopic and/or macroscopic algae or phytoplankton in water
    - Supported by nutrients, warm water temperatures

Copco Lake, California, Summer 2007. Photo by Lorrie Backer

Karenia brevis red tide, Sarasota, Florida; Photo by Lorrie Backer

What makes a bloom harmful?

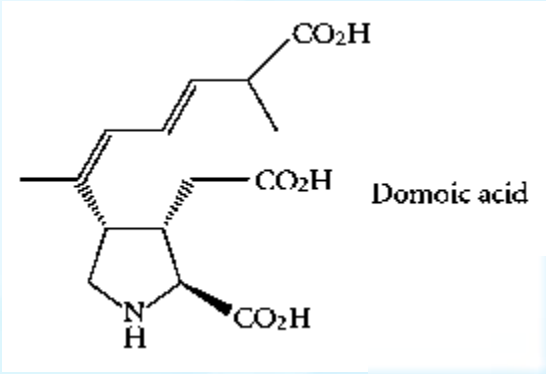
- Biomass limits sunlight penetration
- Senescence creates hypoxic conditions
  - Fish kills
  - Release of irritant gases
    - hydrogen sulfide
- Events cause substantial economic damage
  - beach and shellfish harvesting closures
  - livestock deaths
- Organisms produce toxins

Photo courtesy of Allan Wilson

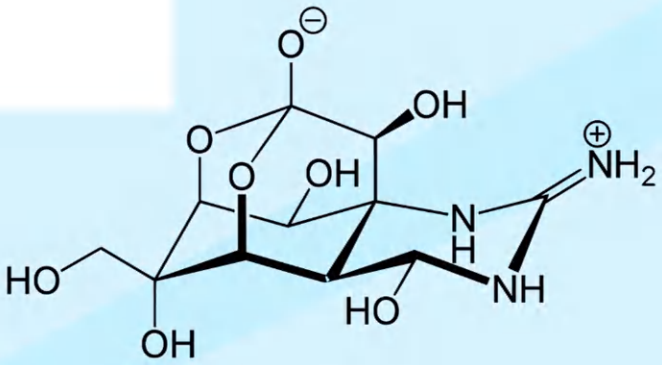
Photo by Lorrie Backer

Marine Algal Toxins that affect people

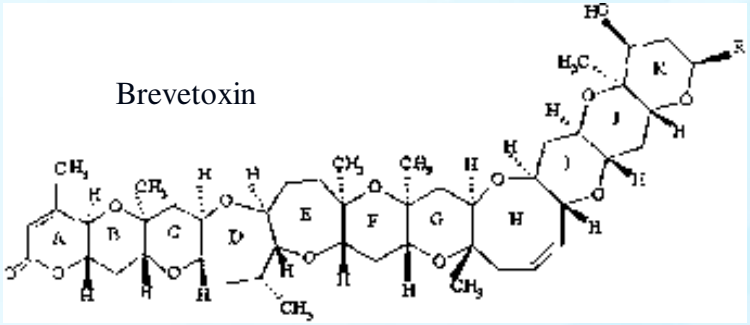
Saxitoxin



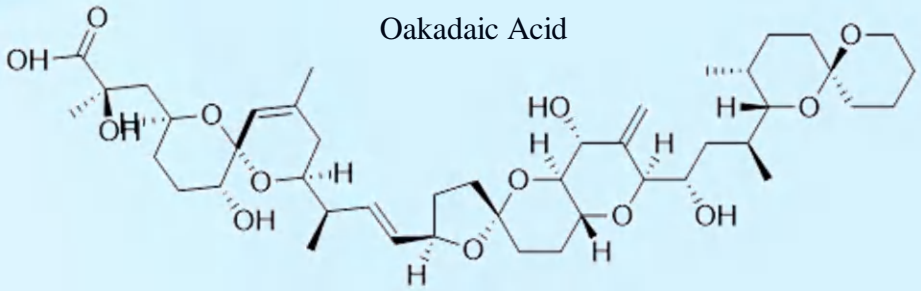
Domoic acid



Tetrodotoxin



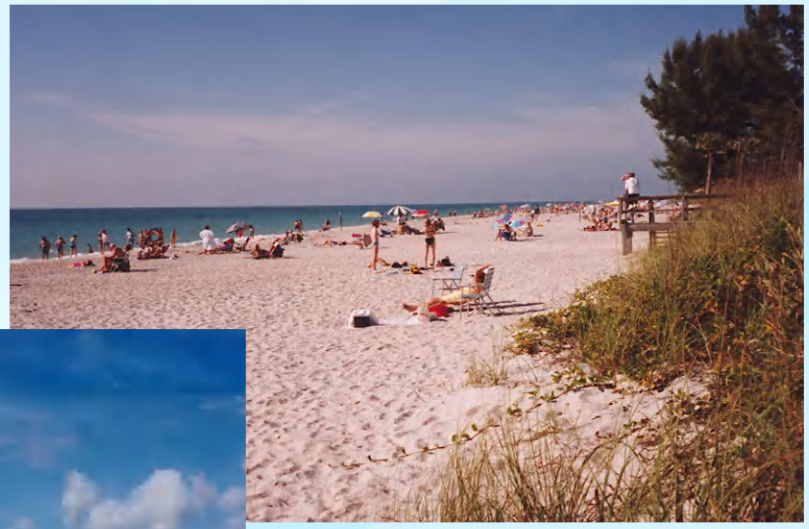
Brevetoxin



Oakadaic Acid

Marine algal toxins: potential sources of human and/or animal exposure

- Recreational waters
- Shellfish
- Finfish
- Aerosols



Photos by Lorrie Backer

Photo courtesy of Dr. Robert Dickey

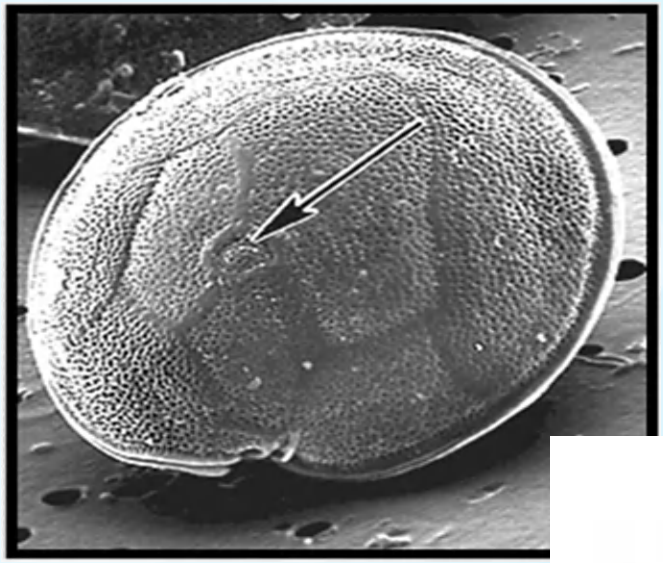
Courtesy of Dr. Lora Fleming

Marine algal toxins produce named diseases

- Shellfish Poisonings
  - Diarrheic Shellfish Poisoning (okadaic acid)
  - Neurotoxic Shellfish Poisoning (brevetoxin)
  - Paralytic Shellfish Poisoning (saxitoxin)
  - Amnesic Shellfish Poisoning (domoic acid)
- Fugu (pufferfish) poisoning (tetrodotoxin)
- Pufferfish poisoning (saxitoxin)
- Respiratory distress (aerosolized brevetoxins)

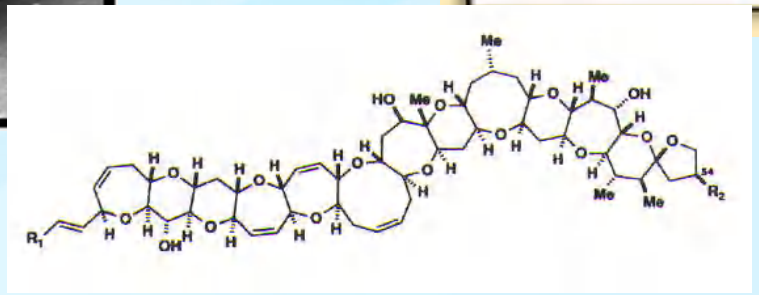
Marine algal toxins: Ciguatera fish poisoning

- Most common food poisoning associated with a non-infectious agent
- Most common food poisoning associated with eating finfish
- ~50,000 cases annually world wide, many more unreported



Gambierdiscus toxicus

Food web transfer



Ciguatoxin

Diseases/conditions from algal toxins in seafood

Disease or condition	Toxin-producing organism	Toxin(s)	Food	Acute symptoms	Chronic Symptoms
Azaspiracid poisoning (AZP)	Dinoflagellates *Properidiunium* species	Azaspiracid	Shellfish	GI distress, diarrhea, vomiting, stomach pain	Unknown
Diarrheic shellfish poisoning (DSP)	Dinoflagellates *Dinophysis* species, *Prorocentrum lima*	Okadaic acid	Scallops, mussels, clams, and oysters	Gastrointestinal distress, diarrhea, nausea, vomiting, stomach pain, possibly chills, headache, fever	Unknown
Domoic acid poisoning	Diatoms *Pseudo-nitzchia* species	Domoic acid	Scallops, oysters, mussels, clams, oysters, possibly fish	Diarrhea, vomiting, abdominal pain	Possibly amnesia, impacts on cognitive function

Diseases/conditions from algal toxins in seafood, cont'd

Disease or condition	Toxin-producing organism	Toxin(s)	Food	Acute symptoms	Chronic Symptoms
Neurotoxic shellfish poisoning (NSP)	Dinoflagellates *Karenia brevis* and other *Karenia* species	Brevetoxins	Mussles, oysters, scallops	GI distress, diarrhea, nausea, vomiting, numbness of lips, tongue, and throat, dizziness	Unknown
Paralytic shellfish poisoning (PSP)	Dinoflagellates *Gymonodinium catenatum*, *Pyrodinium bahamense*, *Alexandrium* species	Saxitoxins	scallops, mussels, clams, oysters, and cockles; some fish and crabs	GI distress, diarrhea, nausea, vomiting, shortness of breath, heart arrythmias, numbness of mouth and lips, weakness	Unknown
Ciguatera fish poisoning	Dinoflagellates *Gambierdiscus toxicus*, possibly others	Ciguatoxins, Maitotoxin, Scaritoxin	Reef fish such as barracuda, grouper, red snapper, and amberjack	GI distress, diarrhea, vomiting	Pain, weakness, abnormal sensations, low blood pressure

Marine Algal Toxins: Animal Health Impacts

- 2004 dolphin mortality in the Florida Panhandle
- Contaminated menhaden identified as the source of brevetoxin poisoning
- Fish were vectors to transfer brevetoxins to higher trophic levels.

Courtesy of Florida Fish & Wildlife Conservation Commission

Fleweling L., Naar J. *et al.* 2005 *Nature* 435:755-756

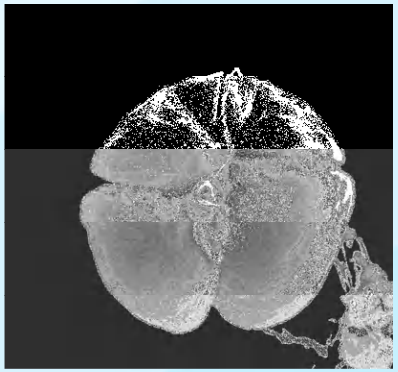
Marine Algal Toxins: Animal Health Impacts

California sea lions affected by domoic acid exposure from *Pseudo-nitzchia* bloom

Photos courtesy of Lori Schwacke

Marine Algal Toxins: Ecologic impacts

- *Karenia brevis*
- Naturally-occurring dinoflagellate that produces brevetoxin
- Documented in Florida since the 1800s



Karenia brevis courtesy of Dr. Karen Steidinger

Photo by Lorrie Backer

Marine Algal Toxins: Socio-economic impacts

Karenia brevis red tide

Photo by Lorrie Backer

Marine algal toxins: public health challenges

- Harmful in minute (picogram) doses
- Cannot be detected by taste or smell
- Cannot be eliminated by storing or cooking
  - Heat and acid stable
- No cures for poisonings
  - Supportive care
  - For ciguatera, IV mannitol
- Efforts to mitigate the blooms limited

Freshwater blooms: cyanobacteria

Utah Lake, Utah, summer 2016.
Photo by permission, Rick Egan, The Salt Lake Tribune

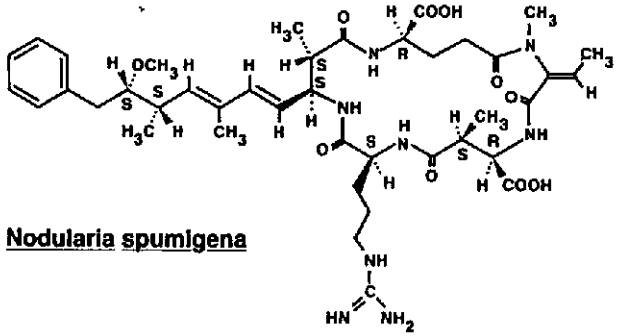
Algal bloom in Lake Okeechobee, Palm Beach, Florida, summer 2016.
Photo by permission: Greg Lovett, The Palm Beach Post, via Associated Press

Cyanobacterial toxins

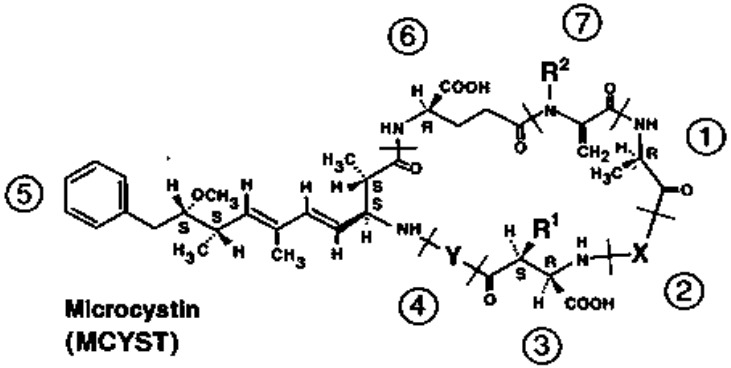
- Hepatoxins
  - Microcystins
  - Nodularins
  - Cylindrospermopsin
- Tumor promotor
  - Microcystins

Microcystis aeruginosa, Copco Lake, California

Photo by Lorrie Backer



Nodularia spumigena



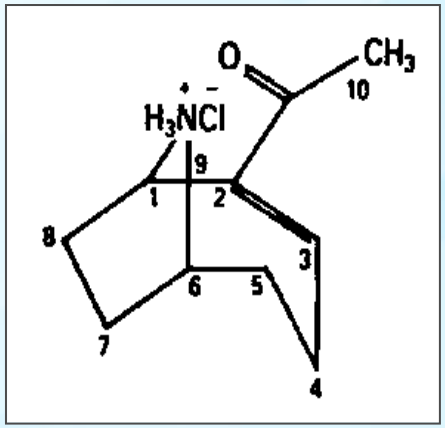
Microcystin
(MCYST)

Cyanobacterial toxins

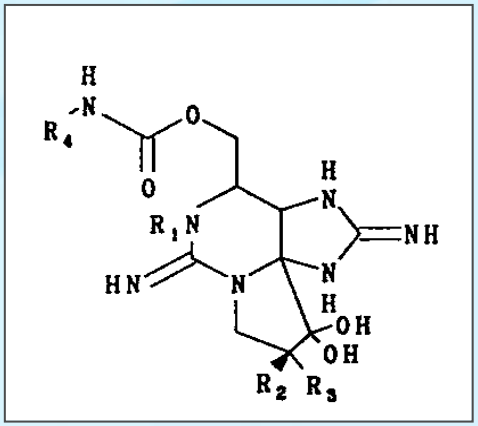
- Dermatologic toxins
  - Lyngbyatoxin
- Neurotoxins
  - Anatoxin
  - Anatoxin(a)
  - Saxitoxin
  - Neosaxitoxin

Lyngbya wollei, Florida

Photo courtesy of Andy Reich



Anatoxin-a hydrochloride

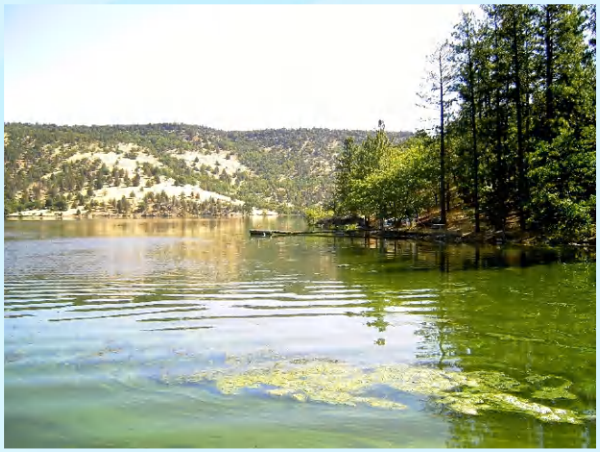


Saxitoxin

Cyanobacterial toxins: potential sources of human and/or animal exposure

- Surface waters used for drinking water
- Recreational waters
- Hemodialysis using contaminated water
- Dietary supplements
  - Klamath Blue-green Algae
- Freshwater fish

Lake Erie *Microcystis* bloom 2014.
Photo from NOAA.



Copco Lake, California, October 2007.
Photo by Lorrie Backer

Potential Chronic Human Health Effects

- No “named” diseases as with marine HABs
- Potential effects
  - Primary liver cancer
  - Kidney damage
  - Neurodegenerative disease

Cyanobacterial Toxins: Animal Health Impacts. Sea Otters in Monterey Bay, California, 2007

- 21 southern sea otters succumbed to poisonings
  - Necropsies found liver toxicity typically associated with microcystin poisoning
- High concentrations of microcystins in farmed and free-living shellfish
  - Transferred via food web
  - Potential for human exposure
- Three nutrient-impaired rivers that support *Microcystis* blooms drained into the Bay
- Newly named poisoning:
  - Hepatotoxic shellfish poisoning

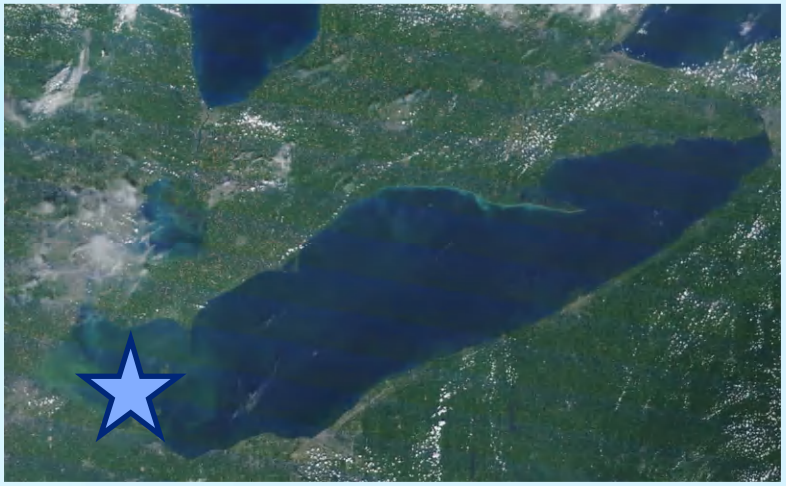
Photo from Internet, no attribution

Miller et al. 2010. Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) transfer from Land to Sea Otters, PLOS One;5(9): e12576.

Cyanobacterial Toxins: Socioeconomic impacts

Microcystis aeruginosa bloom affects Toledo drinking water source (August 2014)

- *Microcystis* bloom in Lake Erie
- Near Toledo's water supply intake
  - Utilities had to respond
- Do Not Drink & Do Not Boil advisories for about 2 days
- Federal government, other entities supplied bottled water



Satellite photo: MODIS 8-13-14

Cyanobacterial Toxins: Ecologic impacts

Copco Lake, California, Summer 2007. Photo by Lorrie Backer

Emerging Issues

- Benthic blooms
  - Produce anatoxin and homoanatoxin
- Increased frequency and geographic extent of harmful blooms
- Monitoring and predicting toxicity

Public Health Response: Guidance

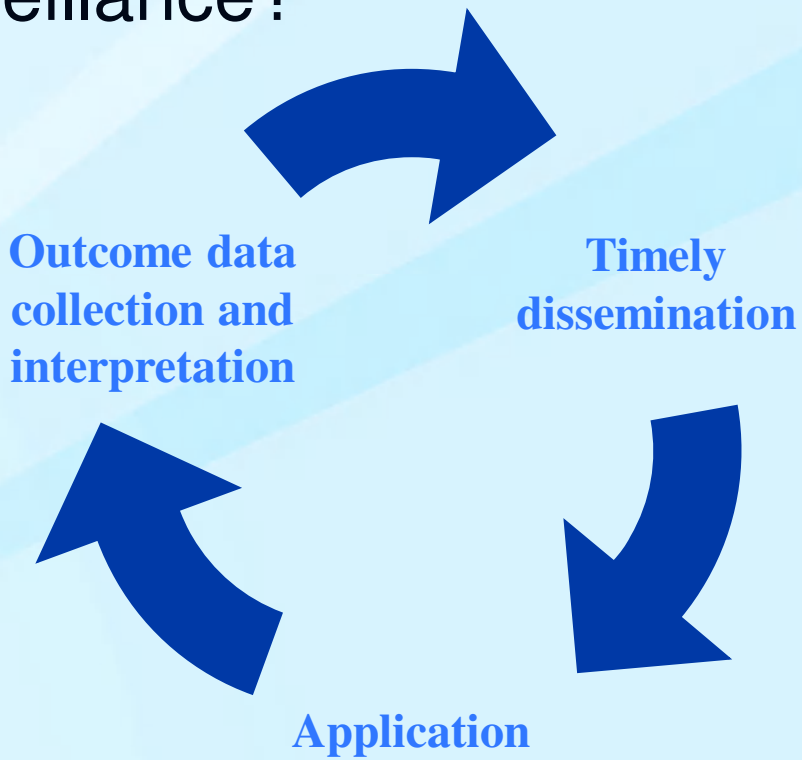
- WHO health-based reference for anatoxin-a
  - Drinking water (acute) 30 µg/L
  - Recreational waters 60 µg/L
- Countries and states developed guidance
- U.S. EPA Health Advisories

Cyanotoxin	Drinking Water Health Advisory (10-day)	
	Bottle-fed infants and pre-school children	School-age children and adults
Cylindrospermopsin	0.7 µg/L	3.0 µg/L
Microcystins	0.3 µg/L	1.6 µg/L

Public Health Response: Disease surveillance

What is public health surveillance?

The ongoing, systematic collection, analysis, and interpretation of outcome-specific data for use in the planning, implementation, and evaluation of public health practice.



Teutsch and Churchill , Principles and Practice of Public Health Surveillance. 2000. Oxford University Press

Public Health Response: OHHABS

- Electronic reporting
  - Web-based, password-protected system
- One Health surveillance for fresh and marine water events
  - Events (environmental data)
  - Associated human cases of illness
  - Associated animal cases of illness
- Voluntary reporting to CDC
  - Nationally available to local, state, and territorial public health partners
  - Their designated environmental health and animal health partners
- Reporting frequency
  - Event-based, not routine water monitoring
  - Not a real-time notification or case investigation system
  - Passive surveillance

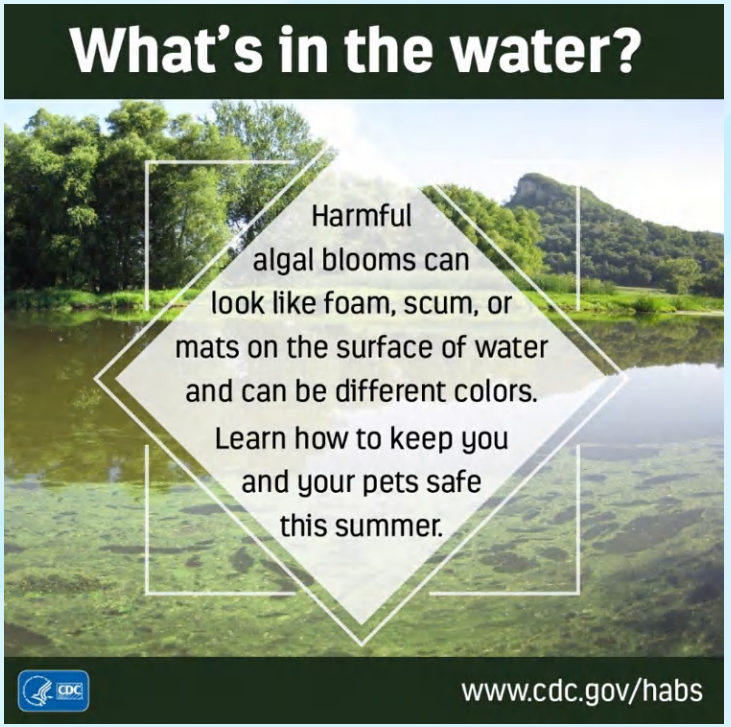
Public Health Response: OHHABS

- 18 states reported 421 bloom events for 2016-2018
  - 90% occurred in freshwater
- 389 human cases of illness
  - ~50% from a single event
- 64 animal case reports
  - 81% from a single bird die off
  - Most frequently affected animals were dogs (96%)

Roberts VA, Vigar M, Backer L, et al. Surveillance for Harmful Algal Bloom Events and Associated Human and Animal Illnesses — One Health Harmful Algal Bloom System, United States, 2016–2018. MMWR Morb Mortal Wkly Rep 2020;69:1889–1894. DOI: http://dx.doi.org/10.15585/mmwr.mm6950a2external icon.

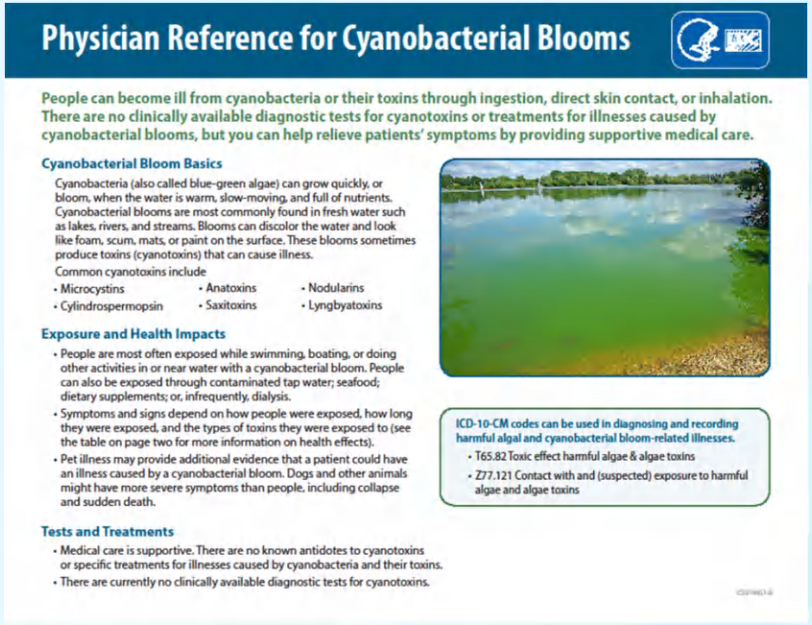
Public Health Response: Communication

https://www.cdc.gov/habs/materials/buttons-badges.html



Public Health Response: Communication

https://www.cdc.gov/habs/materials/reference-cards.html



Physician Reference for Cyanobacterial Blooms

People can become ill from cyanobacteria or their toxins through ingestion, direct skin contact, or inhalation. There are no clinically available diagnostic tests for cyanotoxins or treatments for illnesses caused by cyanobacterial blooms, but you can help relieve patients' symptoms by providing supportive medical care.

Cyanobacterial Bloom Basics

Cyanobacteria (also called blue-green algae) can grow quickly, or bloom, when the water is warm, slow-moving, and full of nutrients. Cyanobacterial blooms are most commonly found in fresh water such as lakes, rivers, and streams. Blooms can discolor the water and look like foam, scum, mats, or paint on the surface. These blooms sometimes produce toxins (cyanotoxins) that can cause illness.

Common cyanotoxins include

- Microcystins
- Anatoxins
- Nodularins
- Cylindrospermopsin
- Saxitoxins
- Lyngbyatoxins

Exposure and Health Impacts

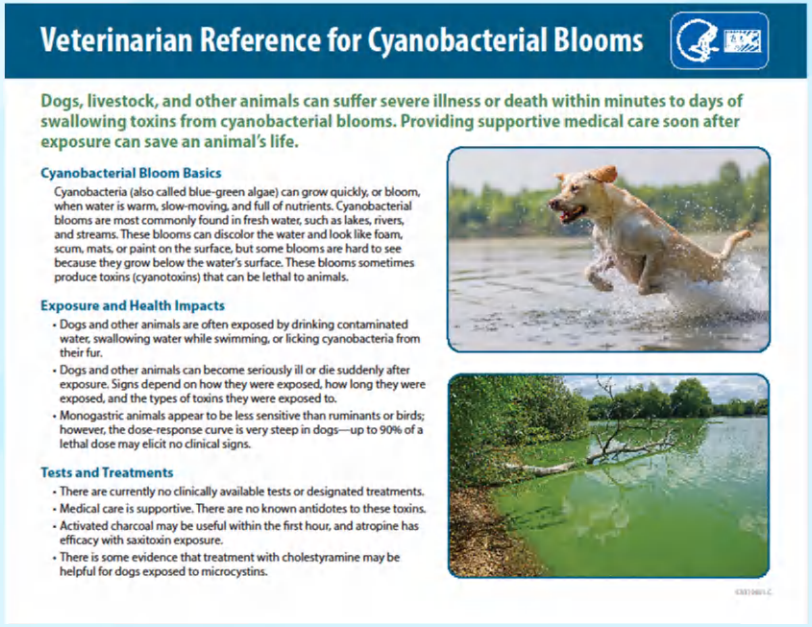
- People are most often exposed while swimming, boating, or doing other activities in or near water with a cyanobacterial bloom. People can also be exposed through contaminated tap water; seafood; dietary supplements; or, infrequently, dialysis.
- Symptoms and signs depend on how people were exposed, how long they were exposed, and the types of toxins they were exposed to (see the table on page two for more information on health effects).
- Pet illness may provide additional evidence that a patient could have an illness caused by a cyanobacterial bloom. Dogs and other animals might have more severe symptoms than people, including collapse and sudden death.

ICD-10-CM codes can be used in diagnosing and recording harmful algal and cyanobacterial bloom-related illnesses.

- T65.82 Toxic effect harmful algae & algae toxins
- Z77.121 Contact with and (suspected) exposure to harmful algae and algae toxins

Tests and Treatments

- Medical care is supportive. There are no known antidotes to cyanotoxins or specific treatments for illnesses caused by cyanobacteria and their toxins.
- There are currently no clinically available diagnostic tests for cyanotoxins.



Veterinarian Reference for Cyanobacterial Blooms

Dogs, livestock, and other animals can suffer severe illness or death within minutes to days of swallowing toxins from cyanobacterial blooms. Providing supportive medical care soon after exposure can save an animal's life.

Cyanobacterial Bloom Basics

Cyanobacteria (also called blue-green algae) can grow quickly, or bloom, when water is warm, slow-moving, and full of nutrients. Cyanobacterial blooms are most commonly found in fresh water, such as lakes, rivers, and streams. These blooms can discolor the water and look like foam, scum, mats, or paint on the surface, but some blooms are hard to see because they grow below the water's surface. These blooms sometimes produce toxins (cyanotoxins) that can be lethal to animals.

Exposure and Health Impacts

- Dogs and other animals are often exposed by drinking contaminated water, swallowing water while swimming, or licking cyanobacteria from their fur.
- Dogs and other animals can become seriously ill or die suddenly after exposure. Signs depend on how they were exposed, how long they were exposed, and the types of toxins they were exposed to.
- Monogastric animals appear to be less sensitive than ruminants or birds; however, the dose-response curve is very steep in dogs—up to 90% of a lethal dose may elicit no clinical signs.

Tests and Treatments

- There are currently no clinically available tests or designated treatments.
- Medical care is supportive. There are no known antidotes to these toxins.
- Activated charcoal may be useful within the first hour, and atropine has efficacy with saxitoxin exposure.
- There is some evidence that treatment with cholestyramine may be helpful for dogs exposed to microcystins.

Public Health Response: Field Research

- Past work: respiratory effects from brevetoxins and microcystins
- Current project: Aerosols from cyanobacterial blooms: exposures and health effects in a highly exposed population
  - Recruiting in Florida near Lake Okeechobee
  - Biospecimens:
    - Blood, urine, nasal swabs
  - Pulmonary function tests
  - Symptom survey
  - Environmental samples:
    - Ambient air, personal air, water

Public Health Response: Research with existing data

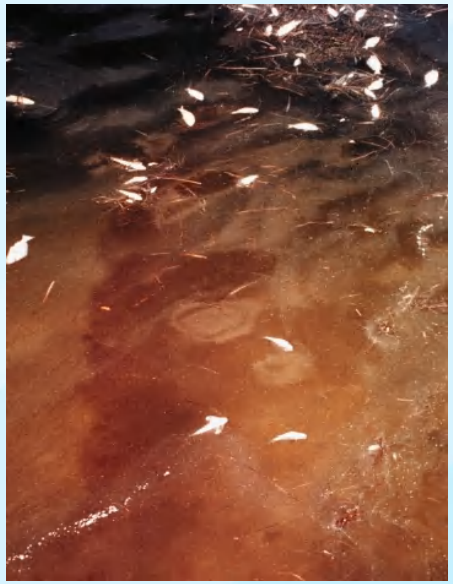
- Lavery et al. Evaluation of Electronic Health Records to Monitor Illness From Harmful Algal Bloom Exposure in the United States
  - Marketscan research databases
  - Journal of Environmental Health
- Lavery et al. Evaluation of Syndromic Surveillance Data to Monitor Illness from Harmful Algal Bloom Exposure, United States 2017 – 2019
  - MMWR
- Long-term project to use existing data to estimate the probability a given water body will experience a bloom that poses a public health risk
  - Partners: U.S. EPA, USGS, NOAA, NASA, states
  - Environmental data
    - CyAn
    - USGS monitoring
  - Health data
    - Electronic health records

Conclusions

- Toxins from algae and cyanobacteria pose a public health threat
- Historic record of marine HAB toxin poisonings
- Much more to learn about the harmful cyanobacterial blooms

Thank you!

Contact information
Lorraine (Lorrie) Backer
lbacker@cdc.gov
770-488-3426



Karenia brevis red tide fish kill. Photo by Lorrie Backer

Cyanobacterial bloom in Bear Lake, MI. Photo by Lorrie Backer

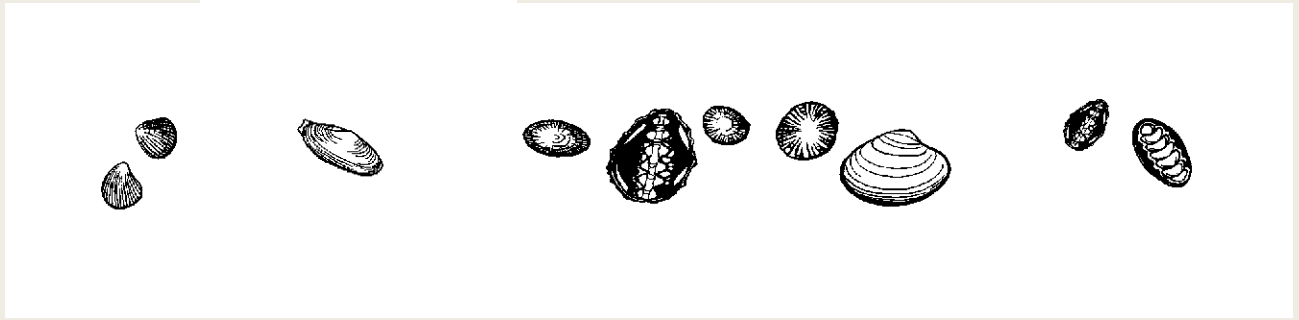
Turtle Mountain Band of Chippewa
Belcourt, North Dakota


LAKE CLOSED
DUE TO HIGH LEVELS OF ALGAE IN BELCOURT LAKE
NO RECREATIONAL ACTIVITY IS ADVISED WHICH
INCLUDES: SWIMMING, BOATING, WATER SKIING, ETC.
UNTIL FURTHER NOTICE
ANY QUESTIONS PLEASE CONTACT
THE TURTLE MOUNTAIN EPA OFFICE
AT 477-8328 OR 477-8332
09/16/2015


HONDA
01/28/2006


08/28/2015

ember 9, 2015
Shinabe Beach #1



MANAGING HARMFUL ALGAL BLOOMS IN TRIBAL WATERS

CHUGACH REGIONAL OCEAN MONITORING PROGRAM

Willow Hetrick-Price & Maile Branson

A Tribal Organization Focusing on Natural Resource Issues affecting the Chugach Region of Alaska

Outline

- Overview of Alaska Native Tribes in the region CRRC serves (Willow)
- CRRC's Alutiiq Pride Marine Institute Chugach Regional Ocean Monitoring Program (Maile)

~When the tide is out, the table is set~

Message from CRRC's Chairman of the Board and Port Graham Village Council Chief

Patrick Norman

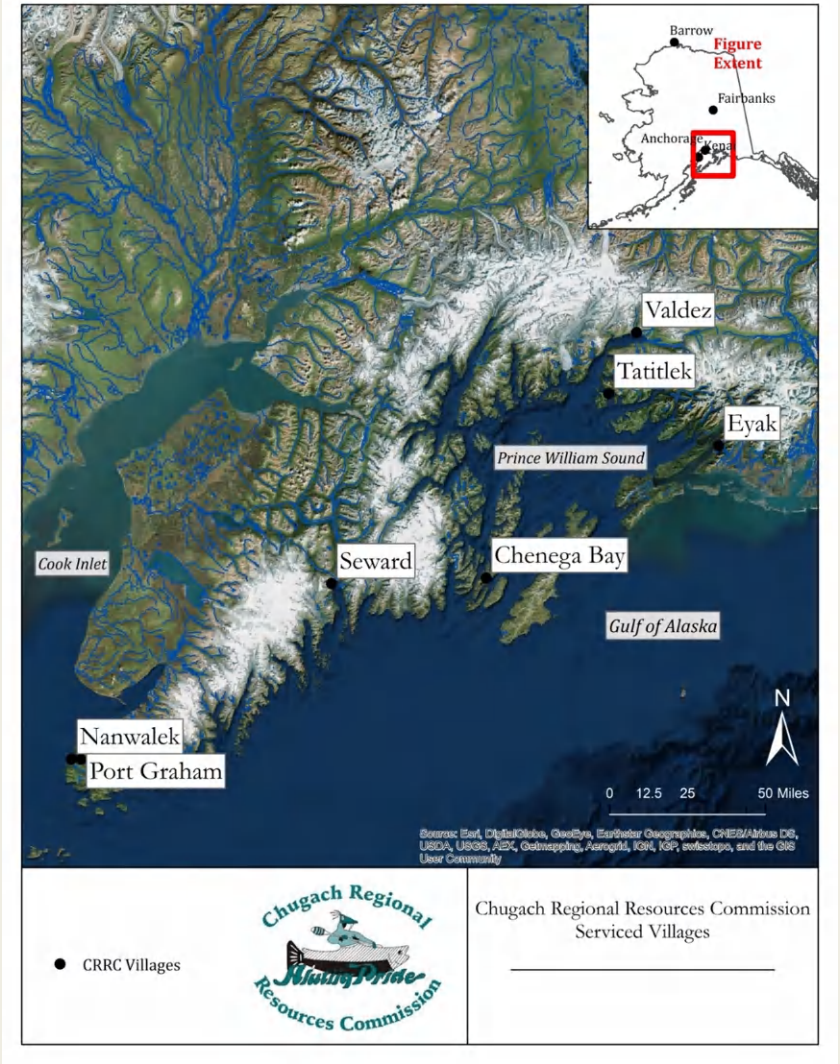
Suumacirpet asirpiartuq Our way of living is the best

Port Graham

Chenega

Seward (Qutekcak)

Valdez



Nanwalek

Tatitlek

Cordova (Eyak)

The First Peoples have an expression...

When the Tide Goes Out, the Table is Set

Location: Georgia Strait
Date: 1992
Informant: British Columbia Folklore Society
Source: original words and music by Brian Robertson http://cdbaby.com/cd/brianrobertson
The following is a slight adaptation.

Along the shore is where life began,
Fed by sea and formed by land,
Under the sun and the moon's command,
Feeding the family of woman and man.

Oh when the tide goes out, the table is set,
And the sea serves up her bounty bless'd;
Come with me while the sand's still wet-
When the tide goes out, the table is set.

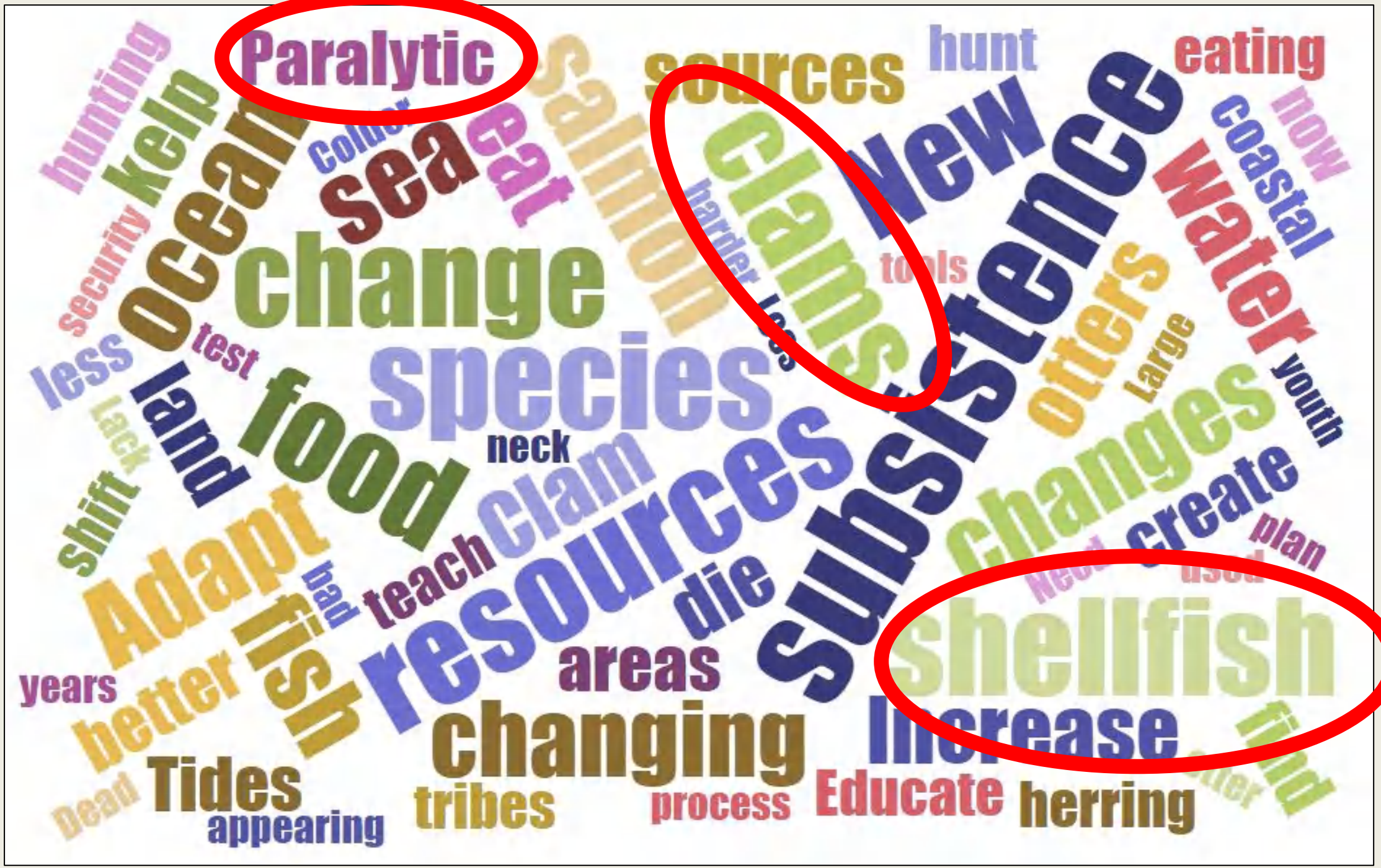
I know some people whose minds get stuck;
To them low tide means slime and muck.
But when I go there I'm prepared to ... shuck
The oyster, the clam and the geoduck.

Now go a little further, put your foot in the sea,
Then try wading out, say up to your knees:
There are crab and abalone, and special seaweed
Fix them up right, and they're bound to please

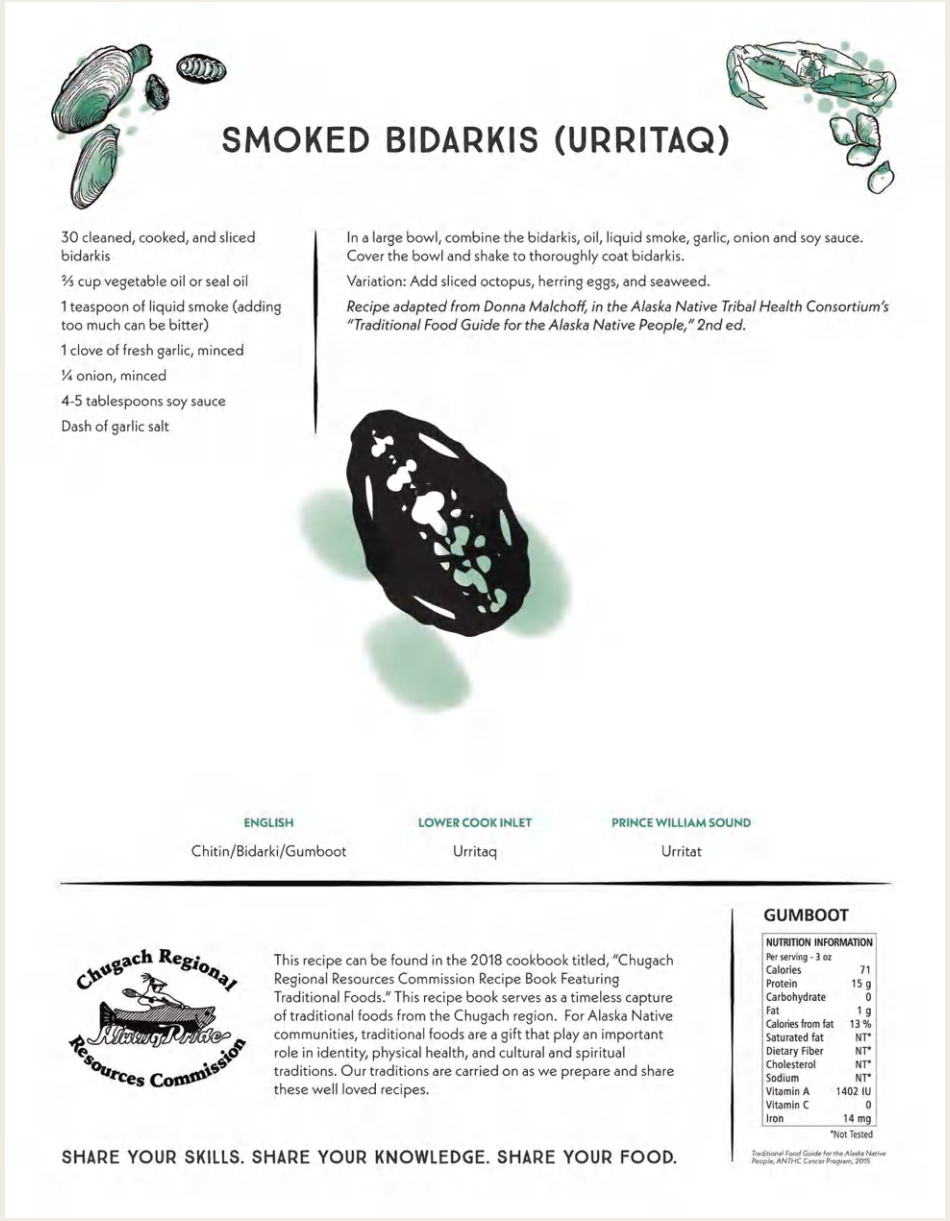
Now the driftwood fire is burning hot
Drop your catch in the cooking pot
Come on, everybody, find a place on the log
Share a steamingbowl and a grateful thought

Well, I was born and raised by Salish Sea
I share her fate 'cause she's a part of me.
She offers such beauty, provides such wealth
I promise to always take care of her health.
'Cause when the tide goes out, the table is set."

Food represents culture. Food is an intimate personal choice that is influenced by historical patterns, environmental considerations and, most importantly, cultural norms.


Paralytic
sources
hunt
eating
hunting
kelp
ocean
sea
eat
Salmon
clams
New
subsistence
Water
coastal
now
security
collect
harder
less
tools
otters
Large
youth
change
species
less
test
land
food
Lack
shift
neck
clam
changes
create
plan
Adapt
fish
had
teach
resources
die
shellfish
areas
years
better
changing
Increase
find
Tides
Dead
appearing
tribes
process
Educate
herring

Shellfish - Traditional Foods



SMOKED BIDARKIS (URRITAQ)

30 cleaned, cooked, and sliced bidarkis
⅔ cup vegetable oil or seal oil
1 teaspoon of liquid smoke (adding too much can be bitter)
1 clove of fresh garlic, minced
¼ onion, minced
4-5 tablespoons soy sauce
Dash of garlic salt

In a large bowl, combine the bidarkis, oil, liquid smoke, garlic, onion and soy sauce. Cover the bowl and shake to thoroughly coat bidarkis.

Variation: Add sliced octopus, herring eggs, and seaweed.

Recipe adapted from Donna Malchoff, in the Alaska Native Tribal Health Consortium's "Traditional Food Guide for the Alaska Native People," 2nd ed.

ENGLISH	LOWER COOK INLET	PRINCE WILLIAM SOUND
Chitin/Bidarki/Gumboot	Urritaq	Urritat

Chugach Regional Resources Commission — Alutiiq Pride

This recipe can be found in the 2018 cookbook titled, "Chugach Regional Resources Commission Recipe Book Featuring Traditional Foods." This recipe book serves as a timeless capture of traditional foods from the Chugach region. For Alaska Native communities, traditional foods are a gift that play an important role in identity, physical health, and cultural and spiritual traditions. Our traditions are carried on as we prepare and share these well loved recipes.

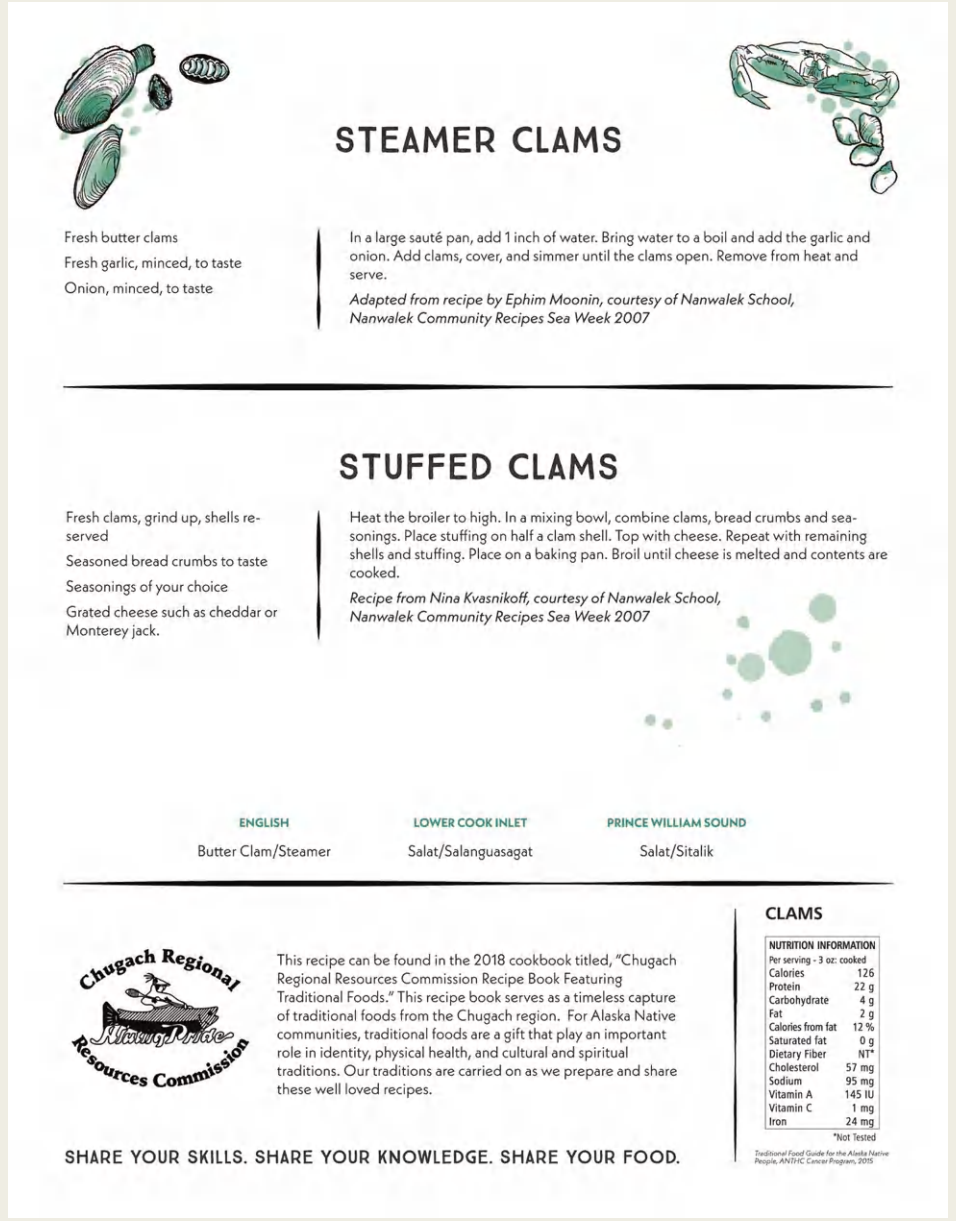
GUMBOOT

NUTRITION INFORMATION	
Per serving - 3 oz	
Calories	71
Protein	15 g
Carbohydrate	0
Fat	1 g
Calories from fat	13 %
Saturated fat	NT*
Dietary Fiber	NT*
Cholesterol	NT*
Sodium	NT*
Vitamin A	1402 IU
Vitamin C	0
Iron	14 mg

*Not Tested

SHARE YOUR SKILLS. SHARE YOUR KNOWLEDGE. SHARE YOUR FOOD.

Traditional Food Guide for the Alaska Native People, ANTHC Cancer Program, 2015



STEAMER CLAMS

Fresh butter clams
Fresh garlic, minced, to taste
Onion, minced, to taste

In a large sauté pan, add 1 inch of water. Bring water to a boil and add the garlic and onion. Add clams, cover, and simmer until the clams open. Remove from heat and serve.

Adapted from recipe by Ephim Moonin, courtesy of Nanwalek School, Nanwalek Community Recipes Sea Week 2007

STUFFED CLAMS

Fresh clams, grind up, shells reserved
Seasoned bread crumbs to taste
Seasonings of your choice
Grated cheese such as cheddar or Monterey jack.

Heat the broiler to high. In a mixing bowl, combine clams, bread crumbs and seasonings. Place stuffing on half a clam shell. Top with cheese. Repeat with remaining shells and stuffing. Place on a baking pan. Broil until cheese is melted and contents are cooked.

Recipe from Nina Kvasnikoff, courtesy of Nanwalek School, Nanwalek Community Recipes Sea Week 2007

ENGLISH	LOWER COOK INLET	PRINCE WILLIAM SOUND
Butter Clam/Steamer	Salat/Salanguasagat	Salat/Sitalik

Chugach Regional Resources Commission — Alutiiq Pride

This recipe can be found in the 2018 cookbook titled, "Chugach Regional Resources Commission Recipe Book Featuring Traditional Foods." This recipe book serves as a timeless capture of traditional foods from the Chugach region. For Alaska Native communities, traditional foods are a gift that play an important role in identity, physical health, and cultural and spiritual traditions. Our traditions are carried on as we prepare and share these well loved recipes.

CLAMS

NUTRITION INFORMATION	
Per serving - 3 oz: cooked	
Calories	126
Protein	22 g
Carbohydrate	4 g
Fat	2 g
Calories from fat	12 %
Saturated fat	0 g
Dietary Fiber	NT*
Cholesterol	57 mg
Sodium	95 mg
Vitamin A	145 IU
Vitamin C	1 mg
Iron	24 mg

*Not Tested

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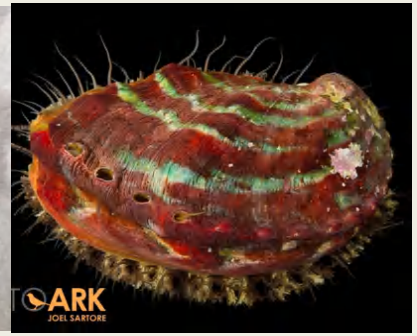
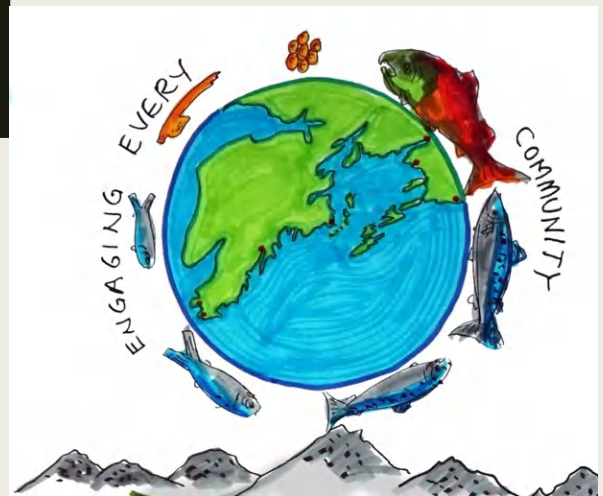
Traditional Food Guide for the Alaska Native People, ANTHC Cancer Program, 2015





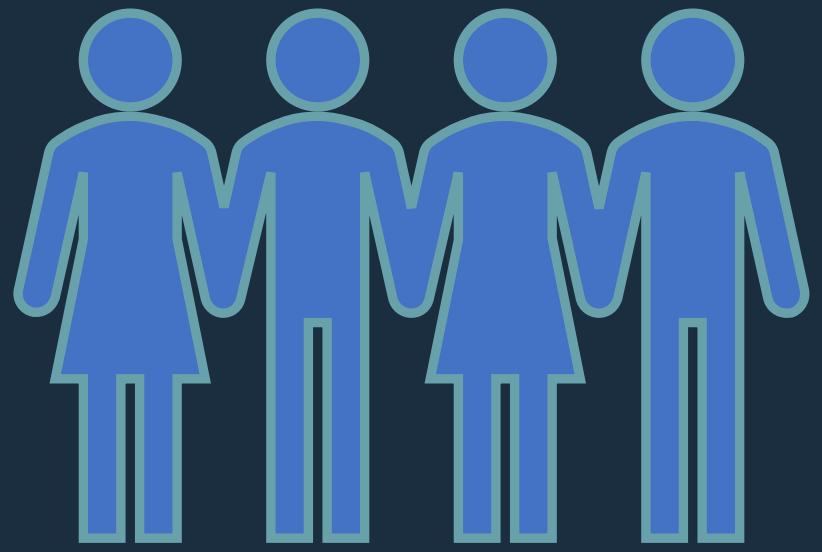
CHUGACH REGIONAL OCEAN MONITORING PROGRAM

Research Conducted at the Alutiiq Pride Marine Institute

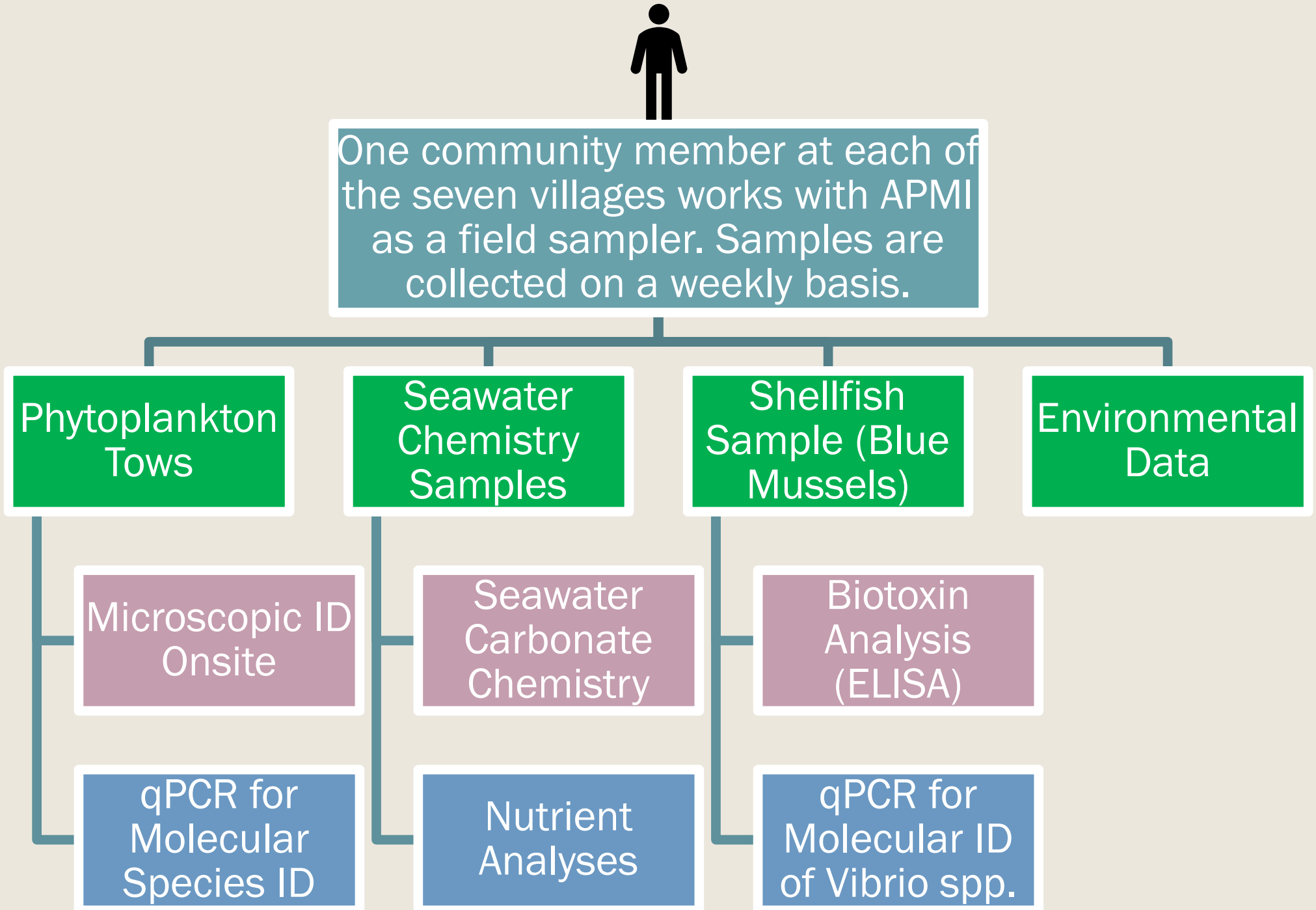


Ocean Acidification & Shellfish Research Laboratory

ALUTIIQ PRIDE
MARINE INSTITUTE



COMMUNITY SAMPLING


One community member at each of the seven villages works with APMI as a field sampler. Samples are collected on a weekly basis.
Phytoplankton Tows
Seawater Chemistry Samples
Shellfish Sample (Blue Mussels)
Environmental Data
Microscopic ID Onsite
qPCR for Molecular Species ID
Seawater Carbonate Chemistry
Nutrient Analyses
Biotoxin Analysis (ELISA)
qPCR for Molecular ID of Vibrio spp.

Objectives and Outcomes

- Safe shellfish harvest for all stakeholders (subsistence, mariculture, and recreational users)
- Baseline coastal marine conditions in Prince William Sound and Lower Cook Inlet
- HAB precipitating factors and .....forecasts?

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Wrap-up

- Thank you for attending!
- Day 2: Monitoring for HABs and Creating Partnerships
  - Tuesday, March 16, 1:00-3:30 PM EDT/10:00 AM-12:30 PM PDT
- Day 3: Funding HABs Management and Communicating Risks
  - Thursday, March 18, 1:00-3:30 PM EDT/10:00 AM-12:30 PM PDT
- Please complete the attendee survey after the webinar ends

Questions? Send an email to CyanoHABs@epa.gov