Blue-Green Algal Blooms:
An Emerging Issue in Western Lake Superior

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National Park Service

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LARGE LAKES OBSERVATORY
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LAKE SUPERIOR NATIONAL ESTUARINE RESEARCH RESERVE

USGS science for a changing world

Great Lakes RESTORATION

CIGLR

Lake Superior Bloom History

- 2012 – First well-documented bloom
  - Short lived (July 14-15) and relatively localized (Cornucopia to Little Sand Bay, 20 km)
  - Warm, calm weather, weeks after the Duluth flood event
  - Thought to be a fluke
- 2016 and 2017 – Bloom conditions observed in Apostle Islands Meyers Beach/Sea Caves area
  - Short-lived, localized, not widely observed or reported

Meyers Beach, Apostle Islands, August 21, 2016

Then, in 2018…

- Large algal bloom occurred from Superior to the Apostle Islands
- Lasted ~5 days
- Very noticeable from beaches
- Lots of visitor and media attention!


The New York Times

Algae Bloom in Lake Superior Raises Worries on Climate Change and Tourism

Bloom interest continues in 2019…despite lack of bloom!

MAZINA'IGAN PAGE 8 • GICHIGAMI/NAMÊ • FALL 2019

When Gichigami turns green:

Harmful algae blooms and the big lake

By Rob Croll, GLIFWC Climate Change Program Coord.

What is known

The summer of 2018 saw the largest blue-green algae bloom ever reported on Gichigami (Lake Superior). The bright green slick, known as a Harmful Algae Bloom (HAB), stretched along the shoreline from Superior, Wisconsin to the Apostle Islands and persisted for several days.

A "bloom" refers to algal or cyanobacterial growth that reaches nuisance levels. Records indicate that HABs have occurred on the Big Lake in five of the past seven years and appear to be increasing in frequency. The other Great Lakes, especially Lake Erie, frequently experience HABs, as do many inland waters. The being responsible for these blooms is not algae, but actually one of several species of cyanobacteria—bacteria that can photosynthesize, or make their own food, similar to plants. While many cyanobacteria are beneficial, some cyanobacteria have the ability to produce toxins that can be harmful to humans, domestic animals, and fish and wildlife.

The bacteria identified in the HAB events on Lake Superior, *Dolichospermum lemmermanni*, is capable of producing toxins, but researchers say samples from blooms to date have not tested positive for them. As with other types of algae blooms, decaying material from a HAB can also cause a decrease in dissolved oxygen in the water which can harm fish and other aquatic life.

HABs, whether on Lake Superior or on inland waters, are associated with shoreline locations, warm water temperatures, sunlight, a nutrient source and calm waters. Blooms on Gichigami in 2012, 2016, 2017 and 2018 were associated with heavy rains and flooding which transported sediment and nutrients into the lake; however, bloom events occurred 1-2 months after the floods, once sediments settled out, allowing sunlight to penetrate the water column.

"One day last summer I stood at Cornucopia Beach and looked out at the lake. The water was bright green and while there were lots of people on the beach no one was swimming. I put down my asemaa and I prayed for the water."

Chairman Mike Wiggins Jr., Bad River Band of Lake Superior Chippewa, speaking at the Climate Strong! Institute, July 2019

What remains to be determined

Scientists with a number of agencies and universities note that in western Lake Superior there is no single factor that can be used to predict HAB formation. They suspect blooms occurring in this part of the lake may be sourced from rivers and streams that contain seed populations of the bacteria that are washed into the lake along with sediments and nutrients during heavy rain events. Questions also remain about why some cyanobacteria produce toxins while others do not, and why those that can produce toxins sometimes do not.

Information on effects on fish and wildlife, including those beings who may consume fish associated with HABs, such as miguziwag (bald eagles) is also limited. Researchers from the University of Minnesota's Large Lakes Observatory, the National Park Service, and the Wisconsin DNR have increased algal bloom monitoring efforts along the south shore of Lake Superior and are conducting research to better understand what's driving HAB formation and predict future occurrences.

Is there a climate change connection?

The GLIFWC Climate Change Program does not specifically research harmful algae blooms in the Ceded Territories. We do know, however, that climate predictions for Minnesota, Wisconsin and Michigan suggest that growing seasons are lengthening, summers are getting warmer, lake water temperatures are increasing and more precipitation is coming in the form of heavy rain events, all of which can set the stage for HAB formation, and may contribute to the increasing frequency of blooms on Gichigami and inland waters.

Unlike with some of our other Climate Change projects, traditional ecological knowledge (TEK) is currently lacking when it comes to assessing the effect of algae blooms. Efforts have been made in the past to locate those with historical knowledge of this phenomena with no results; if you or a family member have memories or stories about algae blooms, either on the Big Lake or on other waters, and how Anishinaabe people were affected, or may have used the algae as a resource, please contact either GLIFWC Climate Change Program Coordinator Rob Croll (*rcroll@glifwc.org*) or Climate Change TEK Outreach Specialist Melonee Montano (*mmontano@glifwc.org*)

Health effects

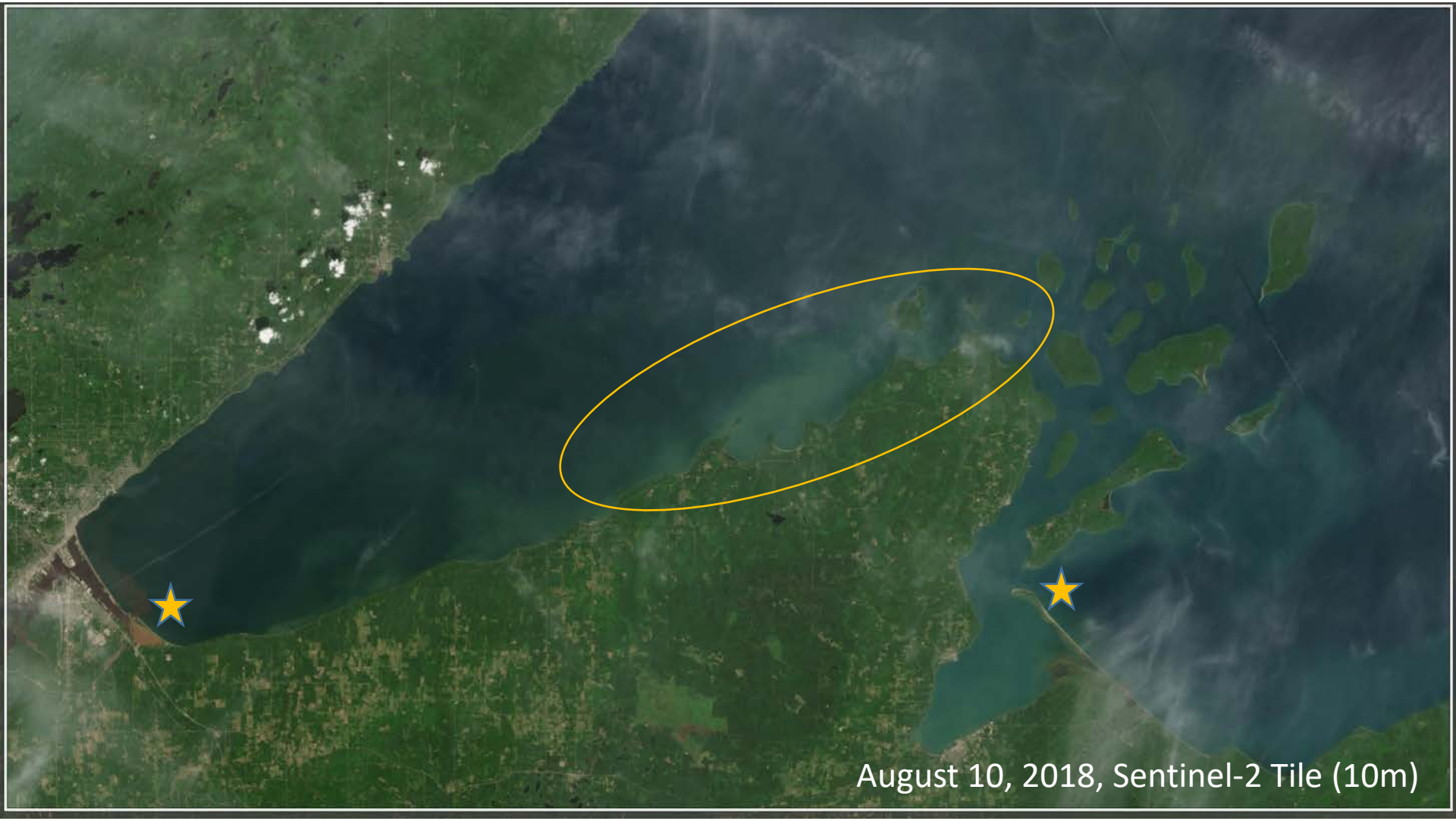
Humans can be exposed to cyanobacterial toxins through water contact during recreation, drinking from an affected water source or through occupational contact, including commercial fishing. Toxin exposure can be through skin contact, ingestion or inhalation. Symptoms of skin contact include rashes, hives or blisters. Ingested toxins can cause abdominal pain and nausea, diarrhea and vomiting.

(See Algae bloom page 21)

Algae bloom in Chequamegon Waters Flowage, north central Wisconsin, 2009. (P. David photo)

- Ashland Daily Press. August 5, 2019.
  - *Researchers search for answers to algae threat.*
- KBJR 6 News. August 18, 2019.
  - *Researchers continue to monitor formation of toxic algae in Lake Superior.*
- WPR. September 3, 2019.
  - State health officials develop signs warning about blue-green algae blooms - signs seek to educate public about harmful blooms.
- CBC. September 11, 2019.
  - Lake Superior among the fastest warming lakes in the world, U.S. researcher says: University of Minnesota Duluth also studying whether warming contributing to algae blooms on south shore.

2018 Bloom Spatial Extent



Imagery: Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com


Bloom conditions most apparent in
narrow band near shore – but
that’s where all the people are!

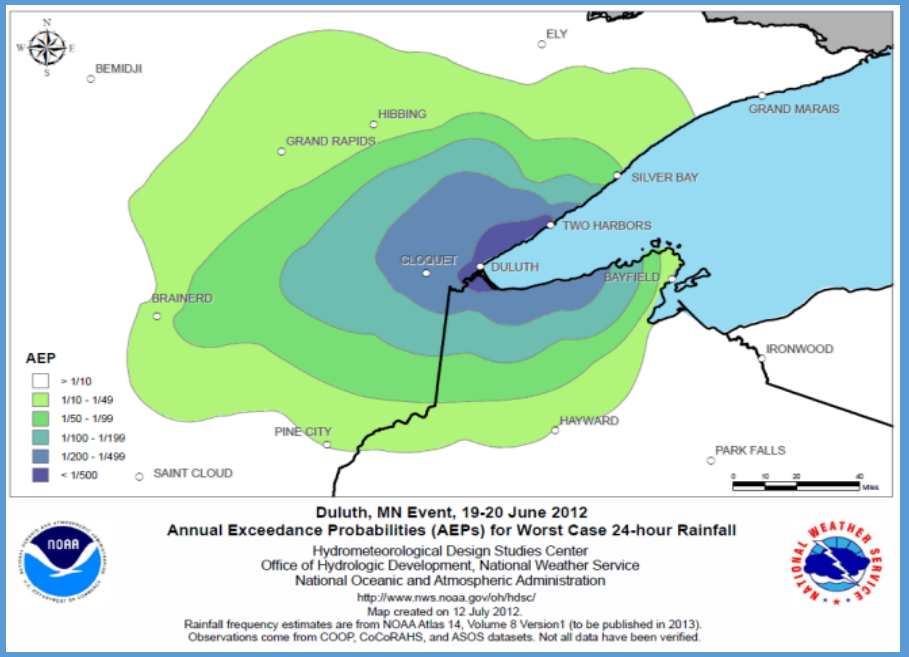
Dolichospermum lemmermannii

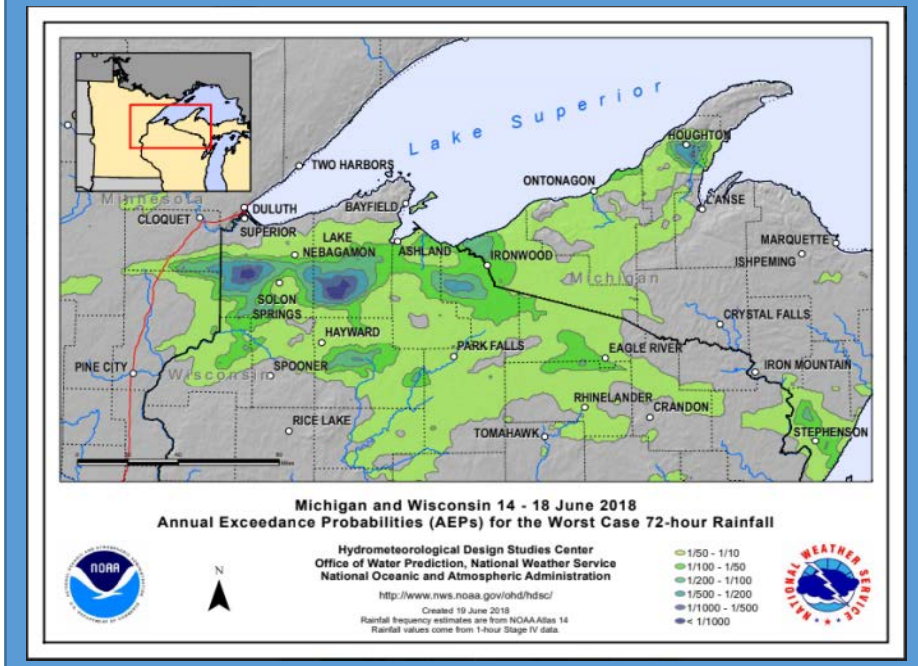
- Filamentous species of cyanobacterium
- Potential toxin producer
- Found in atypical bloom environments; cold or temperate climates, deep clear lakes

- Expanding elsewhere, including deep lakes of the Italian Alps
  - "The appearance of extended surface blooms has caused serious concerns..." (Salmaso et al. 2015)

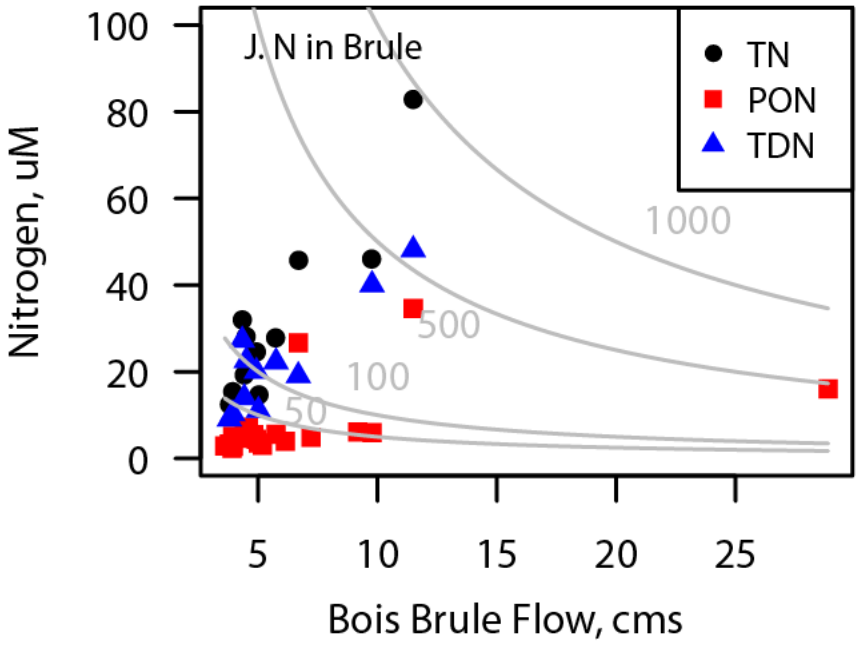
Why are we seeing algal blooms in Lake Superior?

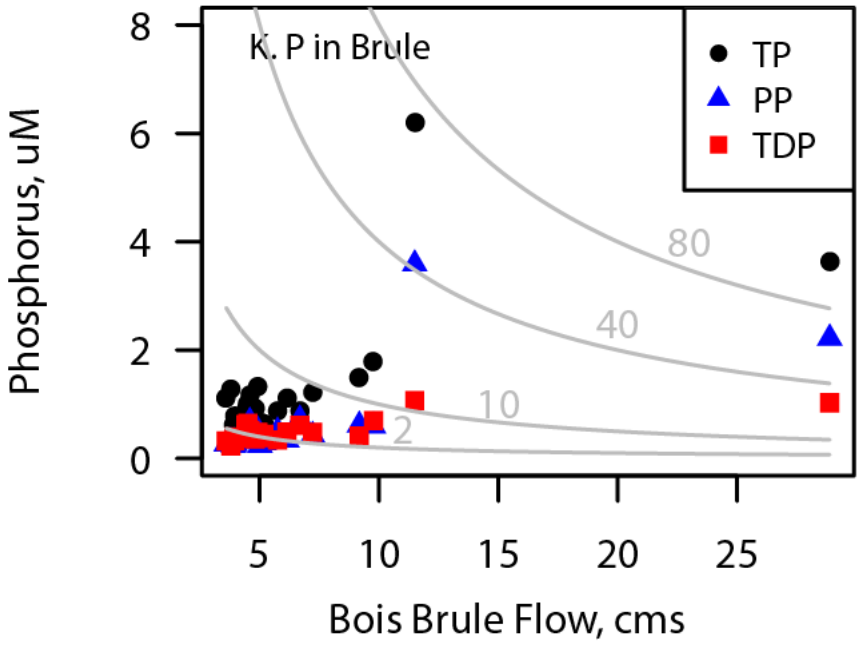
Biggest blooms followed historic floods.



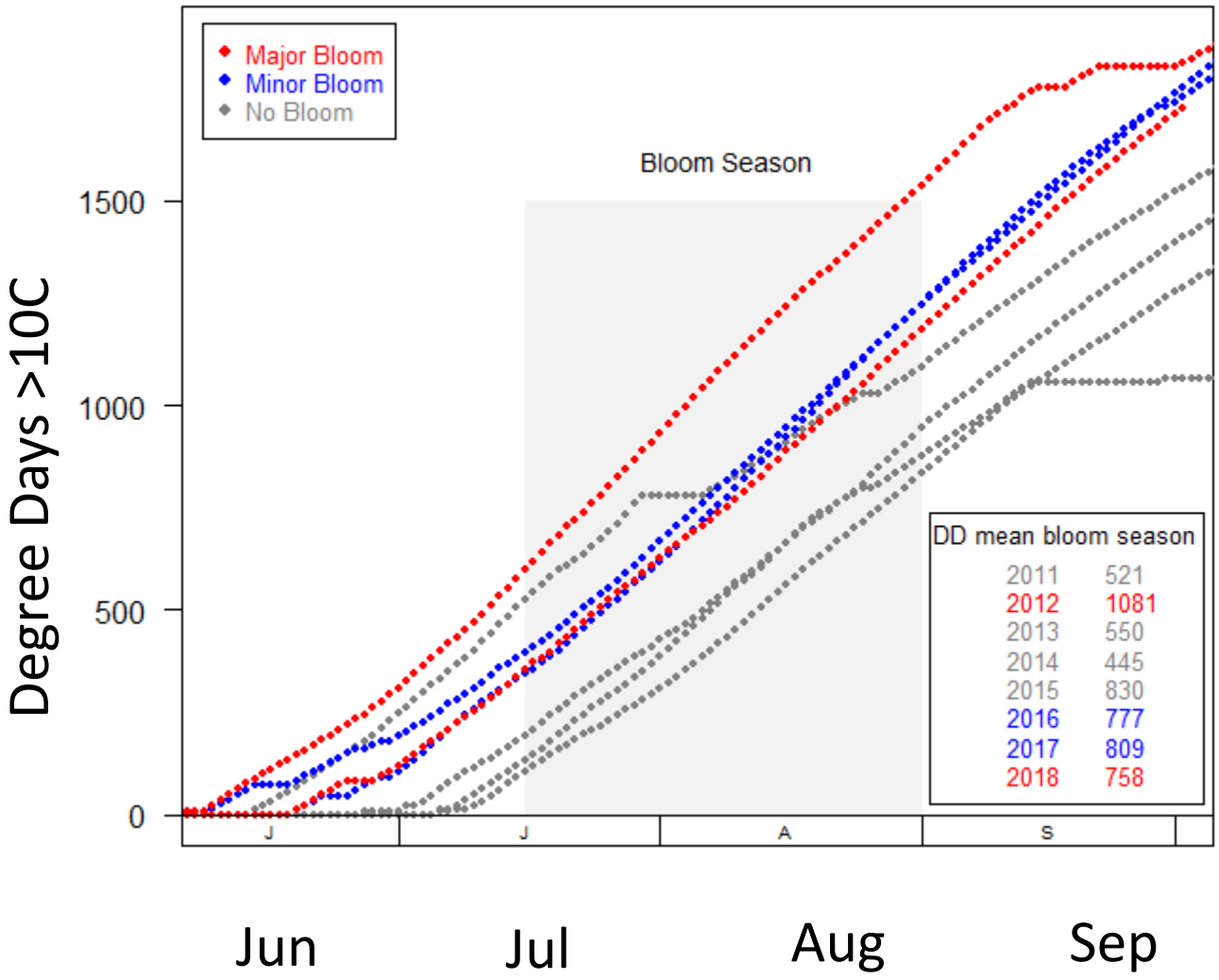


Floods may help stimulate blooms.
(higher streamflow = higher nutrient delivery)

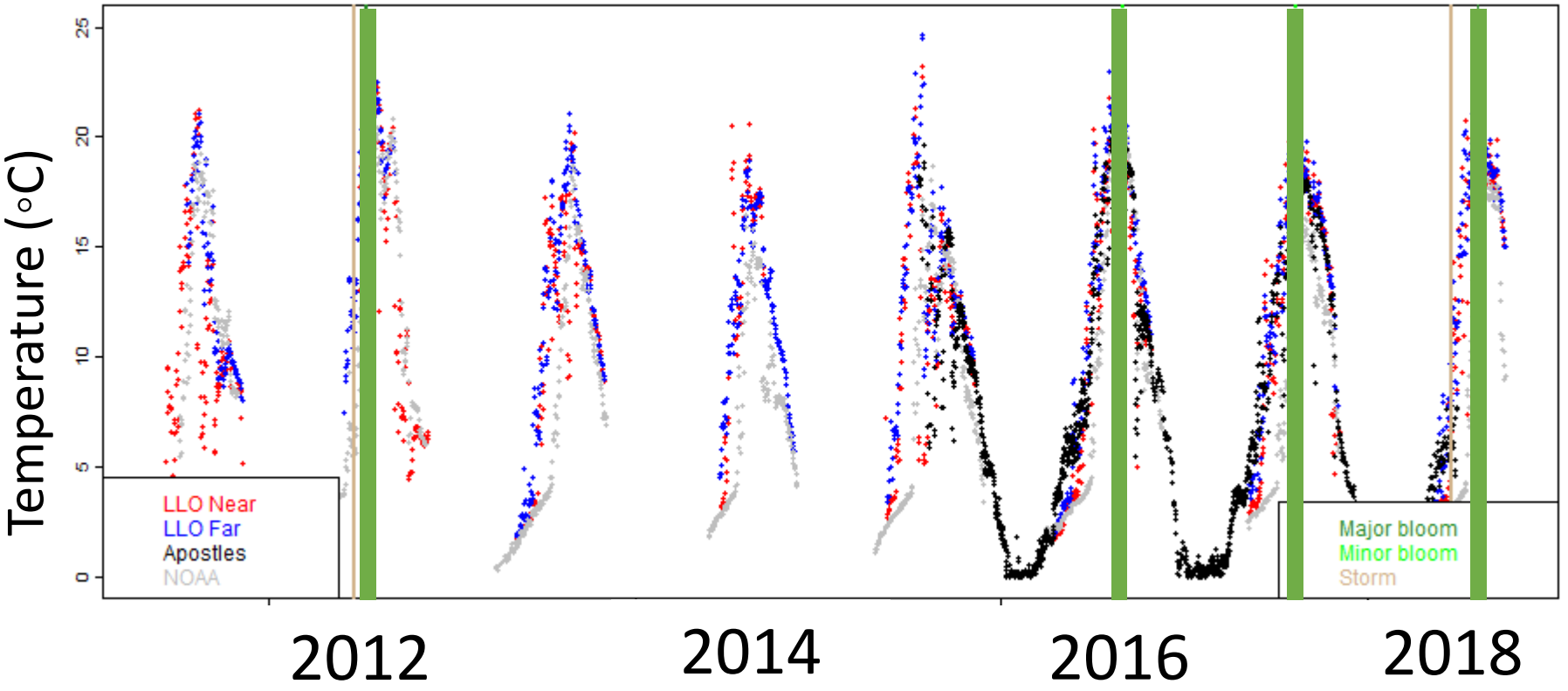




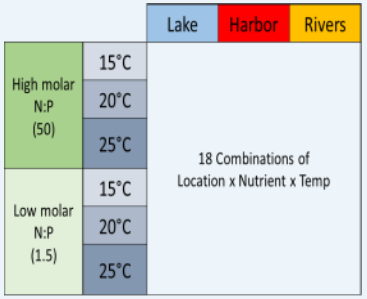
Blooms occurred in warm years. (years with highest degree-days)



Blooms occurred near peaks in water temperature.

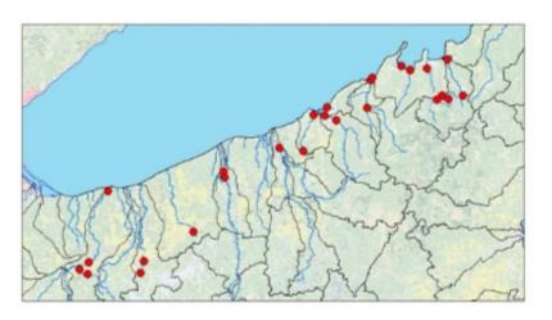


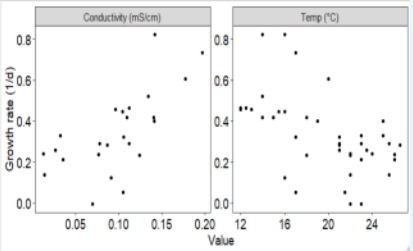
Blooms may originate from upland sources.



Incubated samples from three locations in different chemical and temperature conditions.

***1. Dolichospermum* grew from Harbor and River but not from Lake samples.**





Growth = Temp. X Cond.
R^2 =0.57, p=0.00015

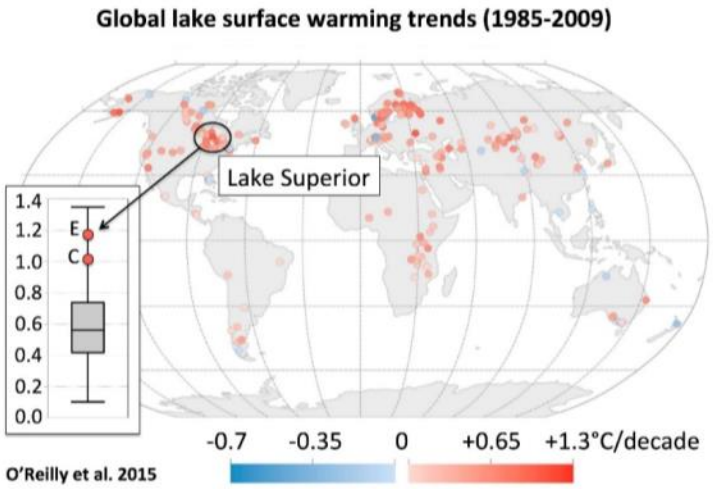
***2.* Blue-green algal growth highest in certain eastern tribs (high cond, low temp).**

Kaitlin Reinl, UMD PhD candidate

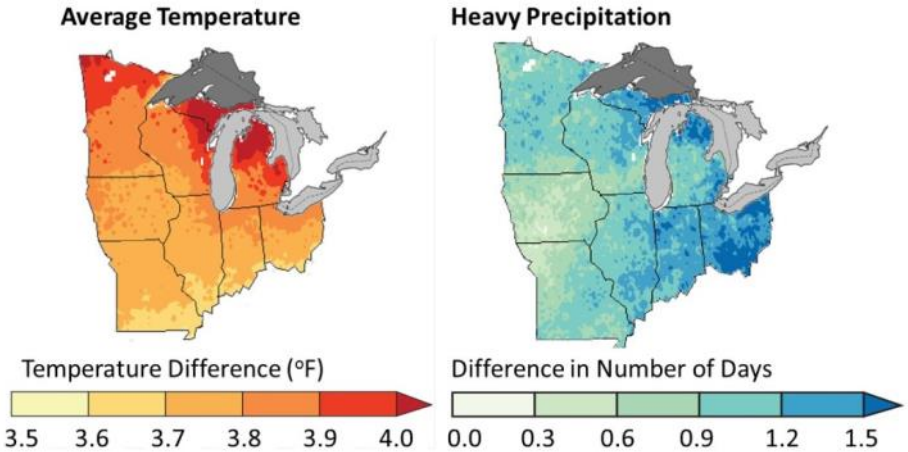
Blooms do not appear to be producing toxins.

- Toxins analyzed by WDPH in 2012 and 2017, and by UWM in 2018.
- To date, no samples above health thresholds.
- However – small sample set, toxin list not extensive in 2012 or 2017, and health standards not available for many toxins.

Conditions may be getting more favorable for blooms.



Based on O'Reilly CM, et al. . 2015. Rapid and highly variable warming of lake surface waters around the globe. Geophysical Research Letters: 2015GL066235.



Wuebbles et al. . 2019. An assessment of the impacts of climate change on the Great Lakes. Environmental Law and Policy Center, p71.

Lake Superior is among Earth's most rapidly warming lakes (peak summer surface temp).

Projections are for a warmer, stormier future.

As bloom issues have emerged, so have gaps in our knowledge.

- Tailoring monitoring
  - Focusing on nearshore waters, filling spatial gaps
  - Incorporating algal indicators
- Developing bloom predictive models
- Conducting additional experiments
- Coordinating rapid response
- Developing bloom outreach materials

Conclusions

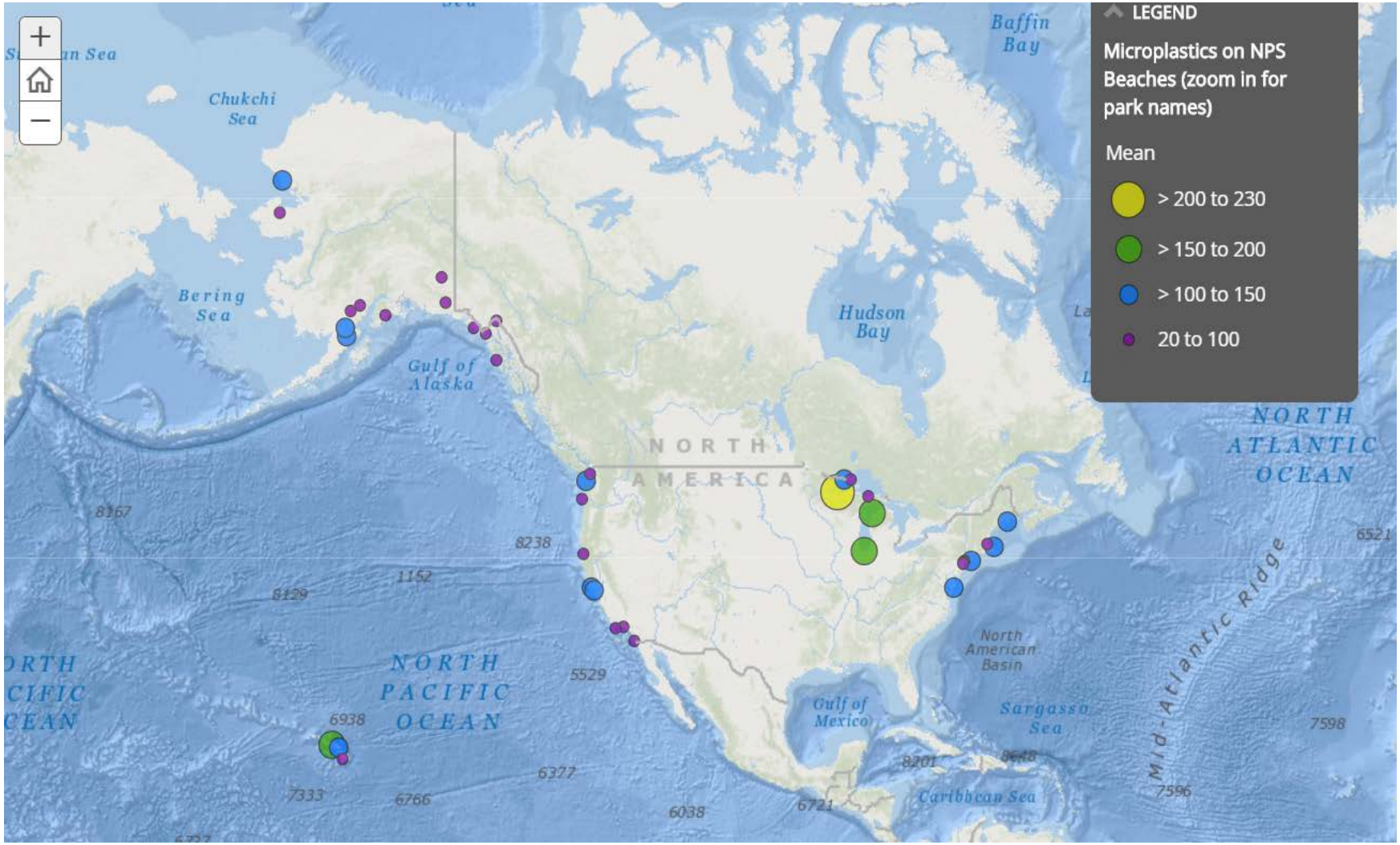
- Algal blooms are an episodic but recurring water quality issue in SW Lake Superior
- Warming waters and major flood events may help stimulate blooms
  - Future blooms likely?
- A lesson in vulnerability.

Lake Superior is not immune to environmental change.

Beach Microplastics Issues in the Apostle Islands Area

- Plastic pollution = global concern
- Degrades slowly, has ecological and economic impacts
- Microplastics are pieces <5 mm
  - Breakdown of larger pieces
  - Manufactured products like cosmetic beads, clothing
- Can be ingested by organisms, with potential physiological and food web effects

Nationwide Study - 2015



NPS, NOAA, Clemson University

Nationwide Study - 2015

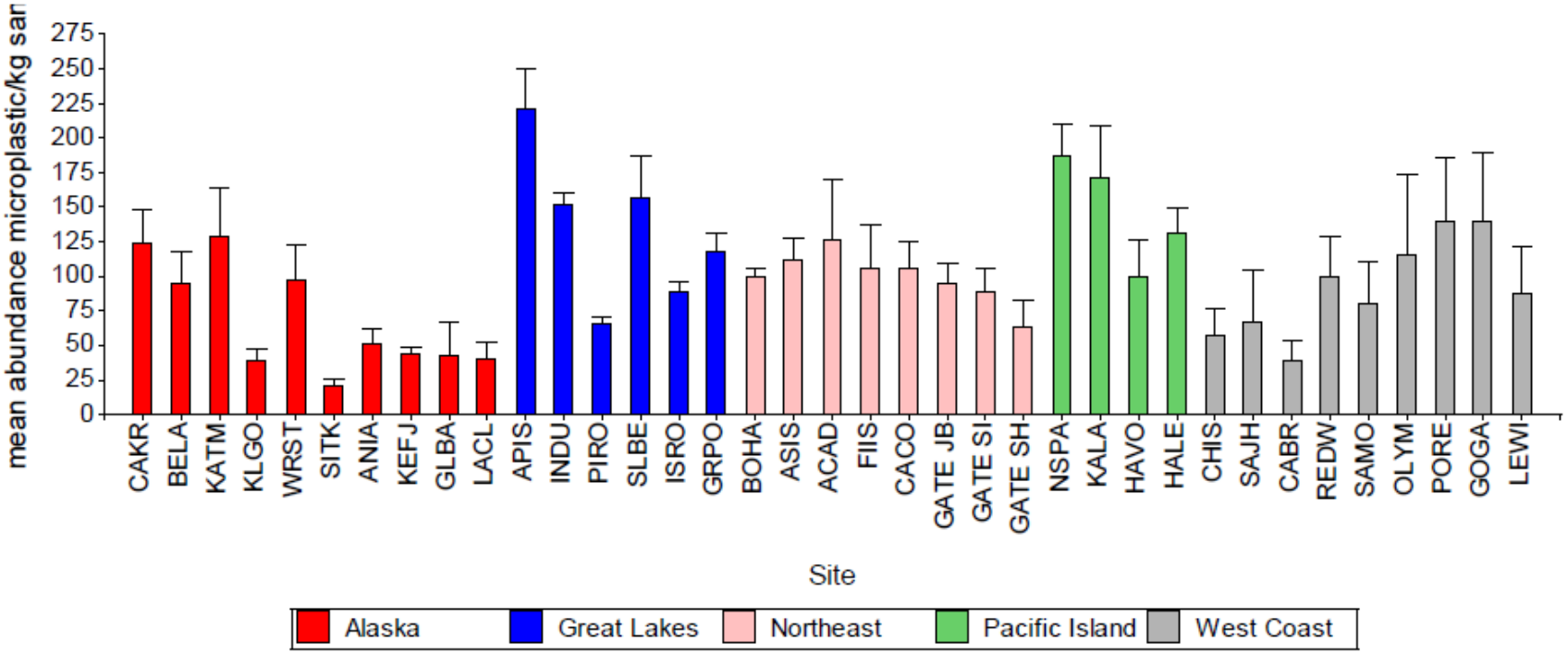


Figure 2: Mean abundance of microplastics per kg of sand for thirty-seven NPS units sampled during 2015 and 2016. Colors represent the region the park is located. Error bars represent standard error.

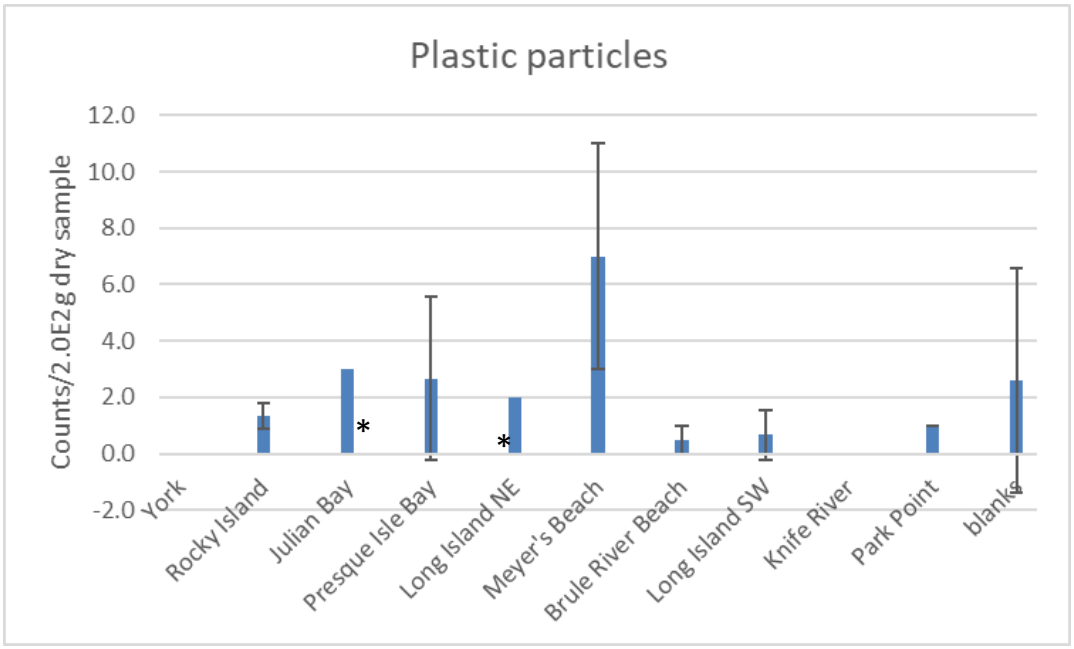
- Lots of press – *"Study finds highest microplastic concentration in the Apostle Islands",* WPR, MPR, KBJR6, Chicago Tribune, etc.

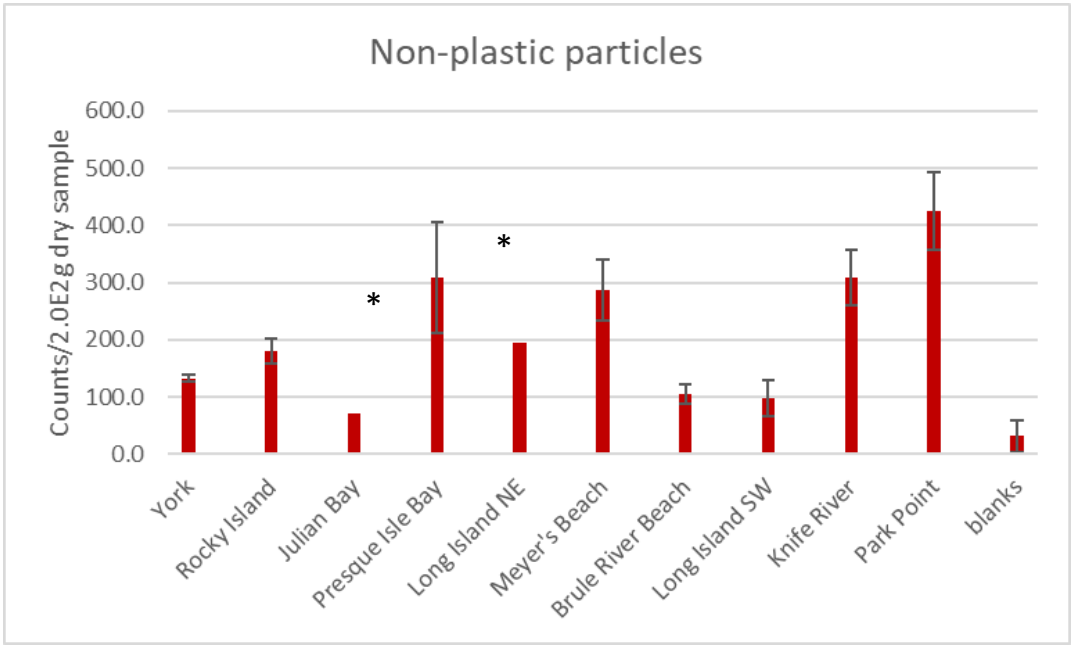
NPS, NOAA, Clemson University

Apostles Study – 2018

- Same methods as in 2015 (density separation, filtration, microscopy)
- Melt test; SEM new

UMD Duluth





- Far fewer plastic particles in 2018 vs. 2015 (by 1-2 orders of magnitude)
- But many non-plastic particles!
  - Organic plant fibers
  - Mineral fibers w/ silicate and aluminum
- Melt test critical for distinguishing plastics from non-plastics.

UMD
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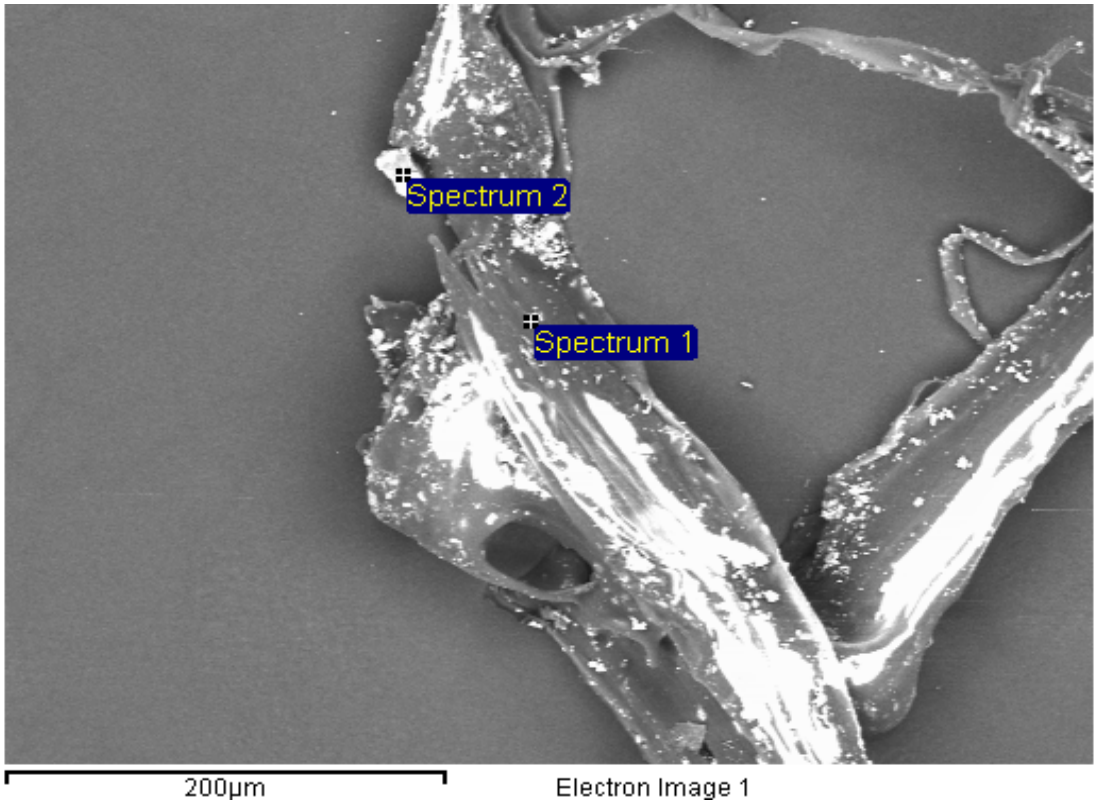
Testing chemical composition via scanning electron microscopy (SEM): *Rocky Island particle*



Spectrum	In stats.	C	O	Al	Si	Total
Spectrum 1	Yes	85.56	12.99	0.38	1.07	100.00
Spectrum 2	Yes	33.34	3.38		63.28	100.00

- Carbon-rich; low in O
- Positive melt-test
- → Plastic

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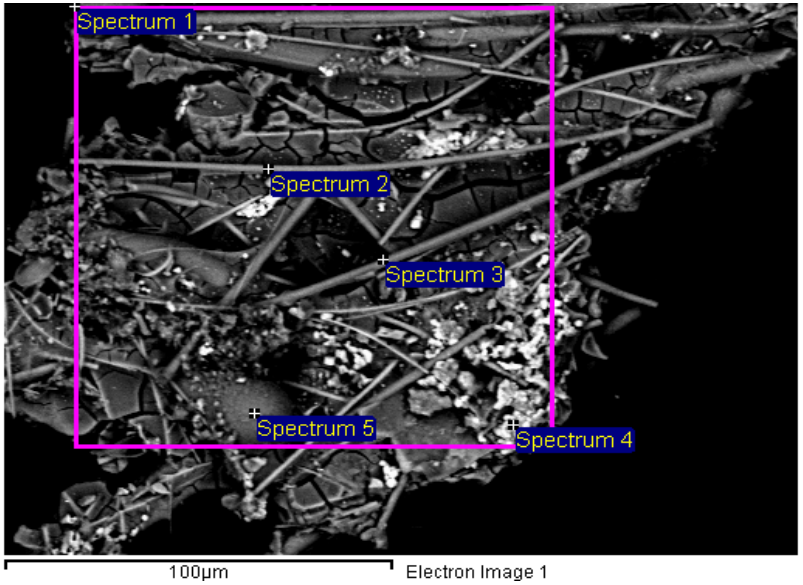
Testing chemical composition via scanning electron microscopy (SEM): *Presque Isle Particle 1*



Spectrum	In stats.	O	Na	Al	Si	Cl	K	Br	Total
Spectrum 1	Yes	46.61	4.24	9.46	32.80	6.56	0.33		100.00
Spectrum 2	Yes	55.47	0.65	20.93	22.65	0.30			100.00
Spectrum 3	Yes	56.34	0.62	20.64	22.16	0.23			100.00
Spectrum 4	Yes	12.28	26.87		2.90	56.65		1.30	100.00
Spectrum 5	Yes	52.52	1.01	24.18	21.91	0.38			100.00

- Floated in density separation
- Negative melt test
- High Si, Al, and O levels
- Appears mineral (aluminosilicate, natural or fiberglass?)
- → Not plastic

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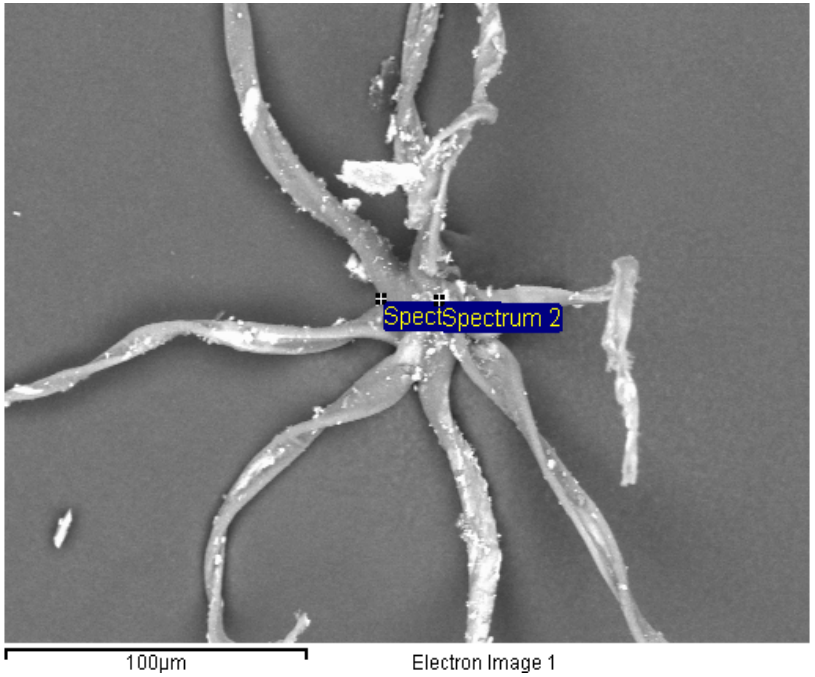
Testing chemical composition via scanning electron microscopy (SEM): *Presque Isle Particle 2*



Spectrum	In stats.	C	O	Na	Al	Si	Cl	Total
Spectrum 1	Yes	56.77	34.36	2.43		0.84	5.61	100.00
Spectrum 2	Yes		17.90	35.44	0.78	0.63	45.25	100.00

Spectrum 1 looks organic, spectrum 2 looks mainly like salt (perhaps residual from density fractionation). Not a plastic (fails melt test) but organic.

- Spectrum 1 looks organic
- Spectrum 2 looks like a salt
- Negative melt test
- → Not plastic

UMD Duluth

Beach Microplastics – Conclusions

- Good news:
  - Not that many microplastics found here in 2018 study
  - Improved methods (melt test, chemical analysis); → fewer false positives
- Bad news:
  - Beach plastics and beach trash still a concern in many areas.


Thank
you!
Photo credit: James Dexter
August 9, 2018


Ziploc

Field Methods