

Characterizing potentially expanding *Dreissena* distribution and composition in Lake Superior

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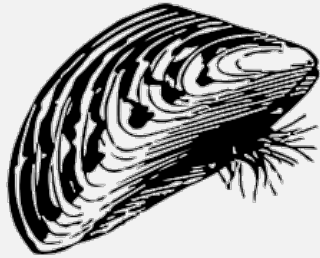
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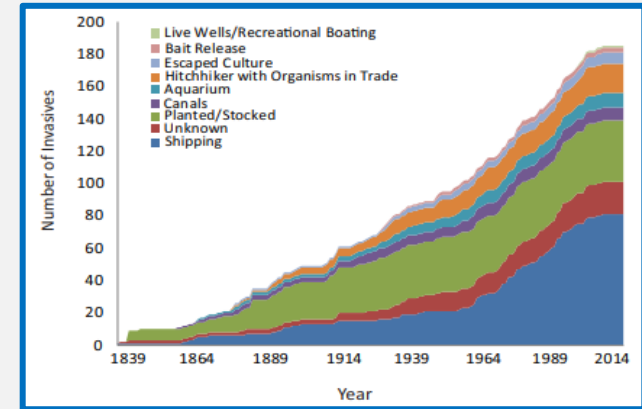
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**2023 Great Lakes Science for National Parks symposium,
March 21-23, Ashland WI**

Aquatic Invasive Species are major concern in GL's

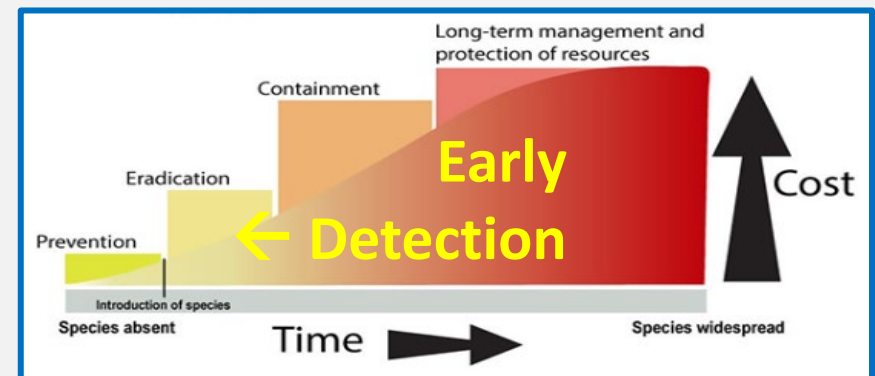
AIS continue to arrive in and impact the Great Lakes →

EPA and other agencies have responsibility to address AIS under GLWQA and GLRI ↓



Broad-spectrum early-detection monitoring is emphasis at EPA Duluth ↓

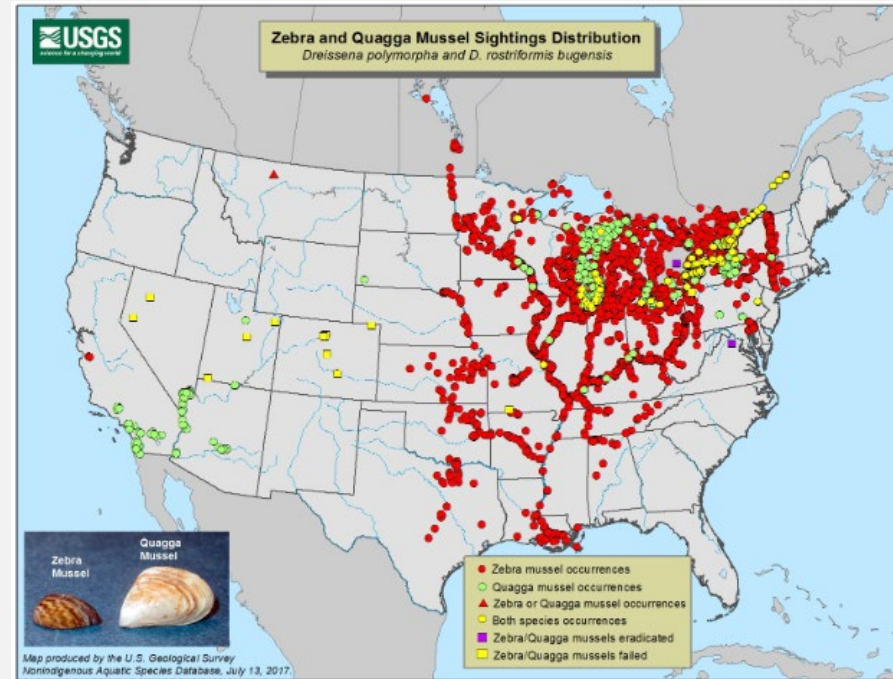
This talk is about work on *Dreissena* as focal species



Dreissena are widespread and damaging in GL's

Dreissena well established in Great Lakes:

- *D. polymorpha* (zebra) since 1986, *D. bugensis* (quagga) since 1989
- Cover the bottom of Lakes Erie, Huron Michigan, Ontario and many smaller waterbodies
- Substantial impacts to water clarity, food-webs, nutrient & energy cycling, human infrastructure
- In general, partition as zebra inshore, quagga offshore



Dreissena in Lake Superior, especially Apostle Islands

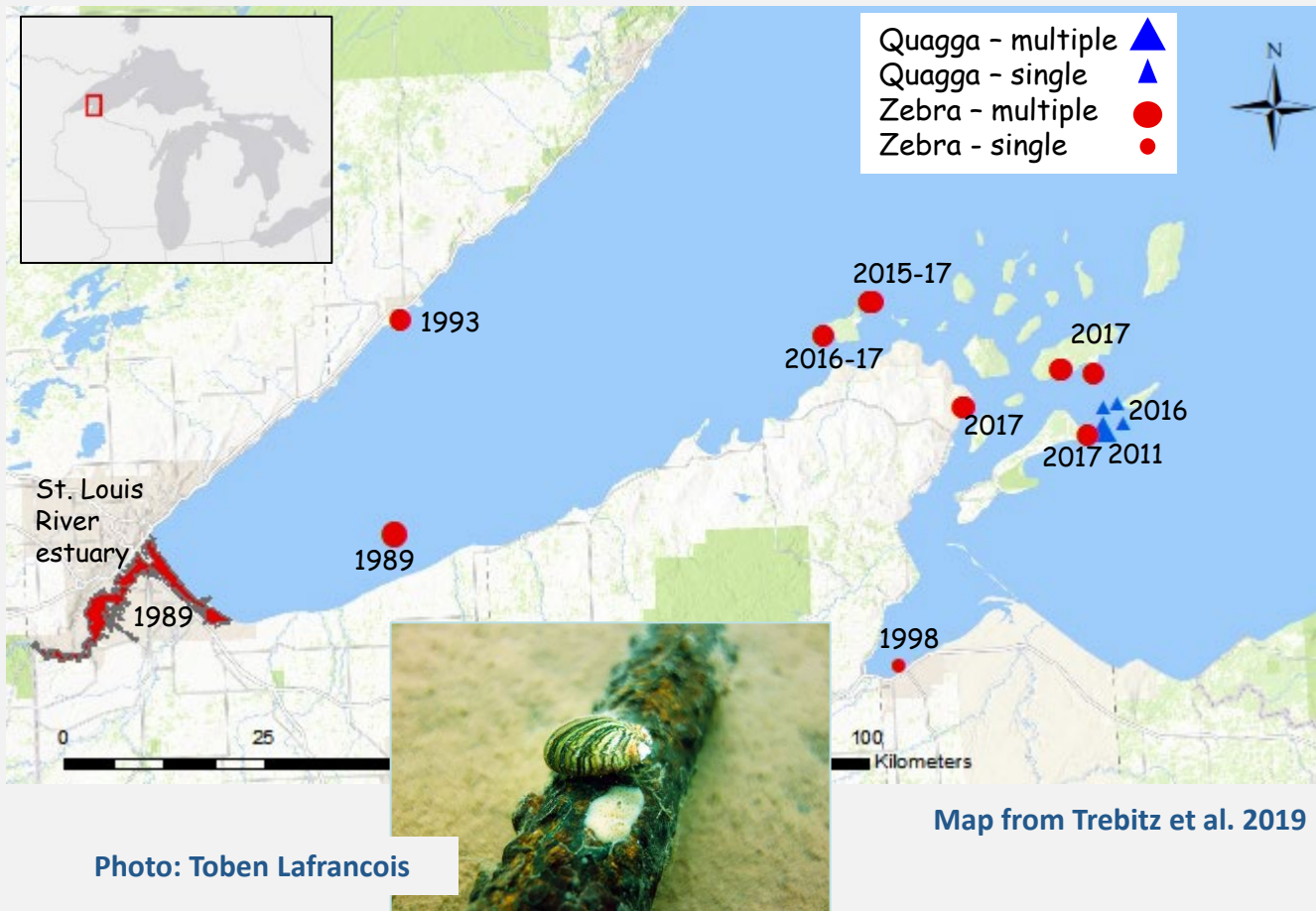
Lake Superior has been the exception to other GL's:

- Only isolated *Dreissena* finds from open lake
- Plenty of transport vectors; e.g., shipping & boating
- Lake too cold, too unproductive, too low calcium?

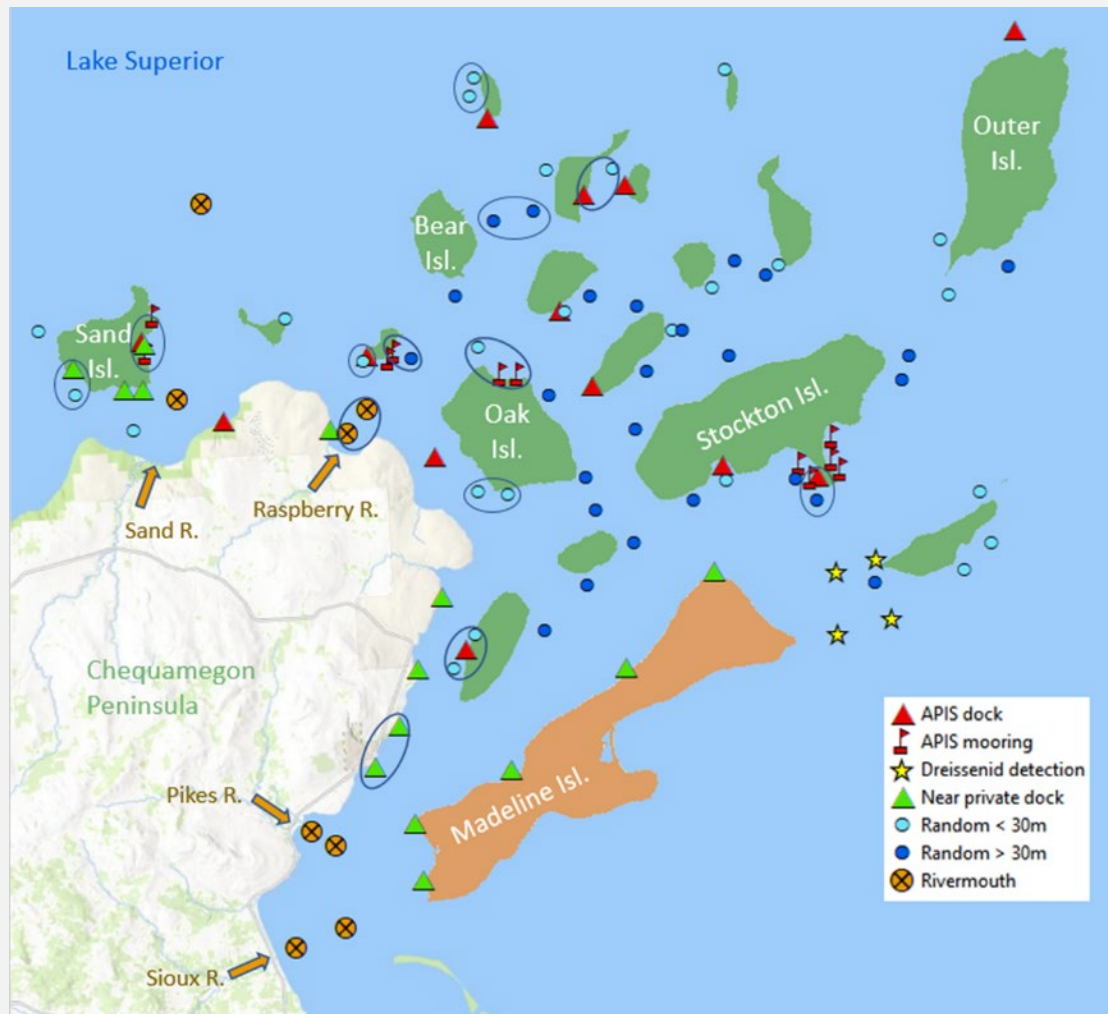
Recent finds in APIS waters raise questions:

- What is *Dreissena* prevalence and distribution?
- Where are they coming from?
- What species are they?
- What can be done about them?

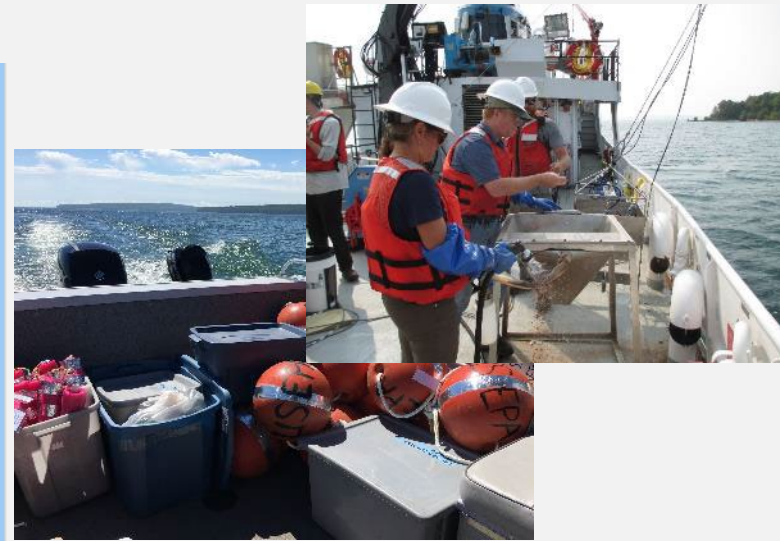
NPS conducting annual removals...



EPA 2017 APIS survey, motivated by NPS ask



More info in Trebitz et al. (2019) *Dreissena veligers* in western Lake Superior— inference from new low-density detection. J Great Lakes Res, 45:691-699.



Substantial field effort:

- 50 random depth-stratified sites
- 50 sites targeting potential *Dreissena* introduction points
- 3 vessels, ~20 crew, ~2 weeks work to deploy & retrieve
- Gear combo included video, eDNA water, bottom samplers, zoop nets, veliger traps

No bottom-settled *Dreissena* found

Video, down-
looking and
oblique



PONAR
grab



Rock bag
colonizer

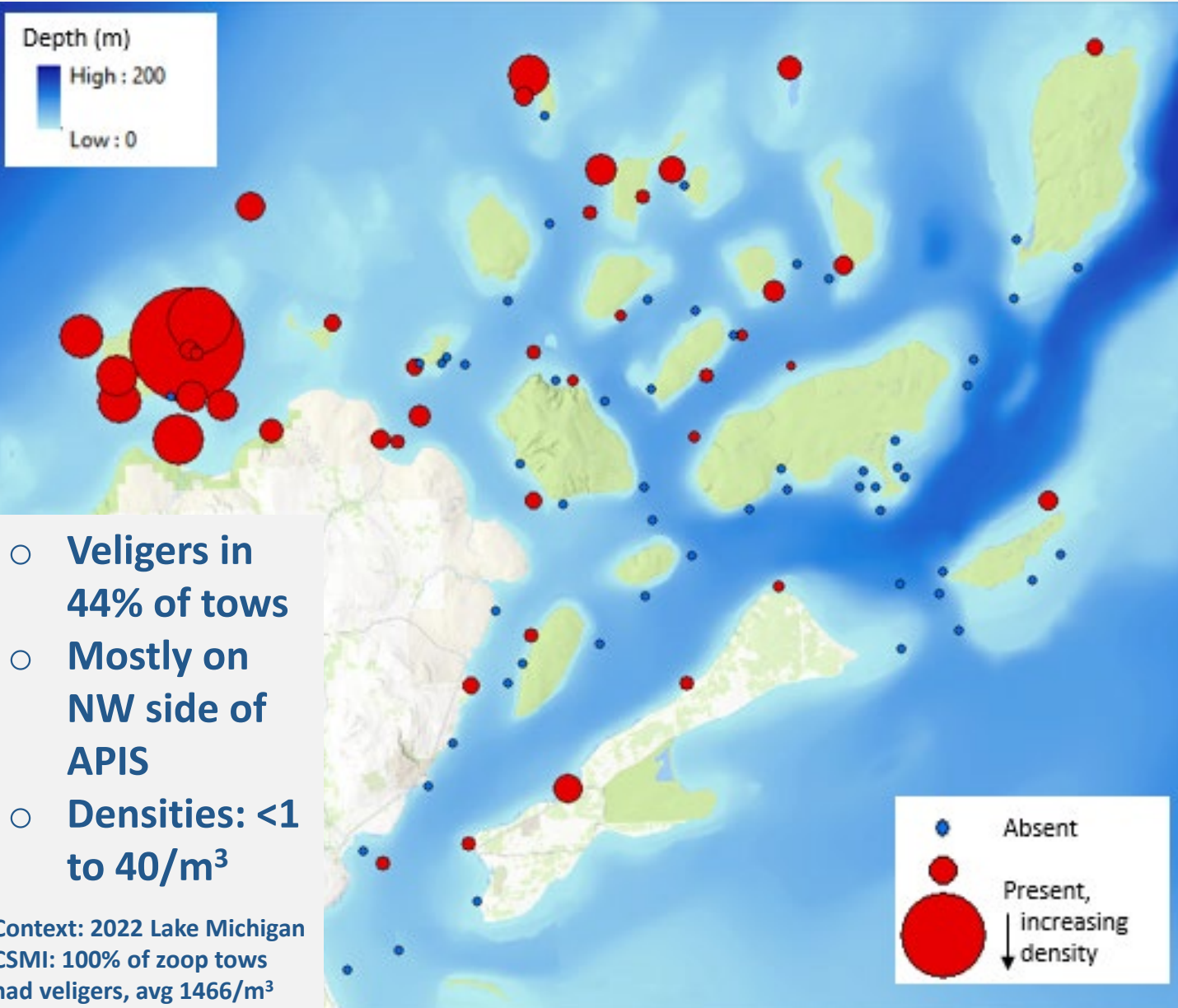


No bottom-settled
Dreissena in any of
almost 200 samples
taken

Hester
Dendy
colonizer



Veligers in many zoop tows albeit very low density

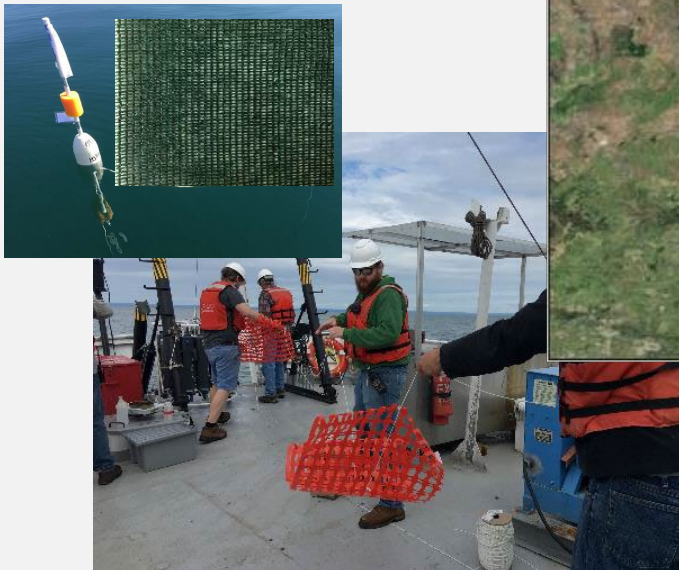
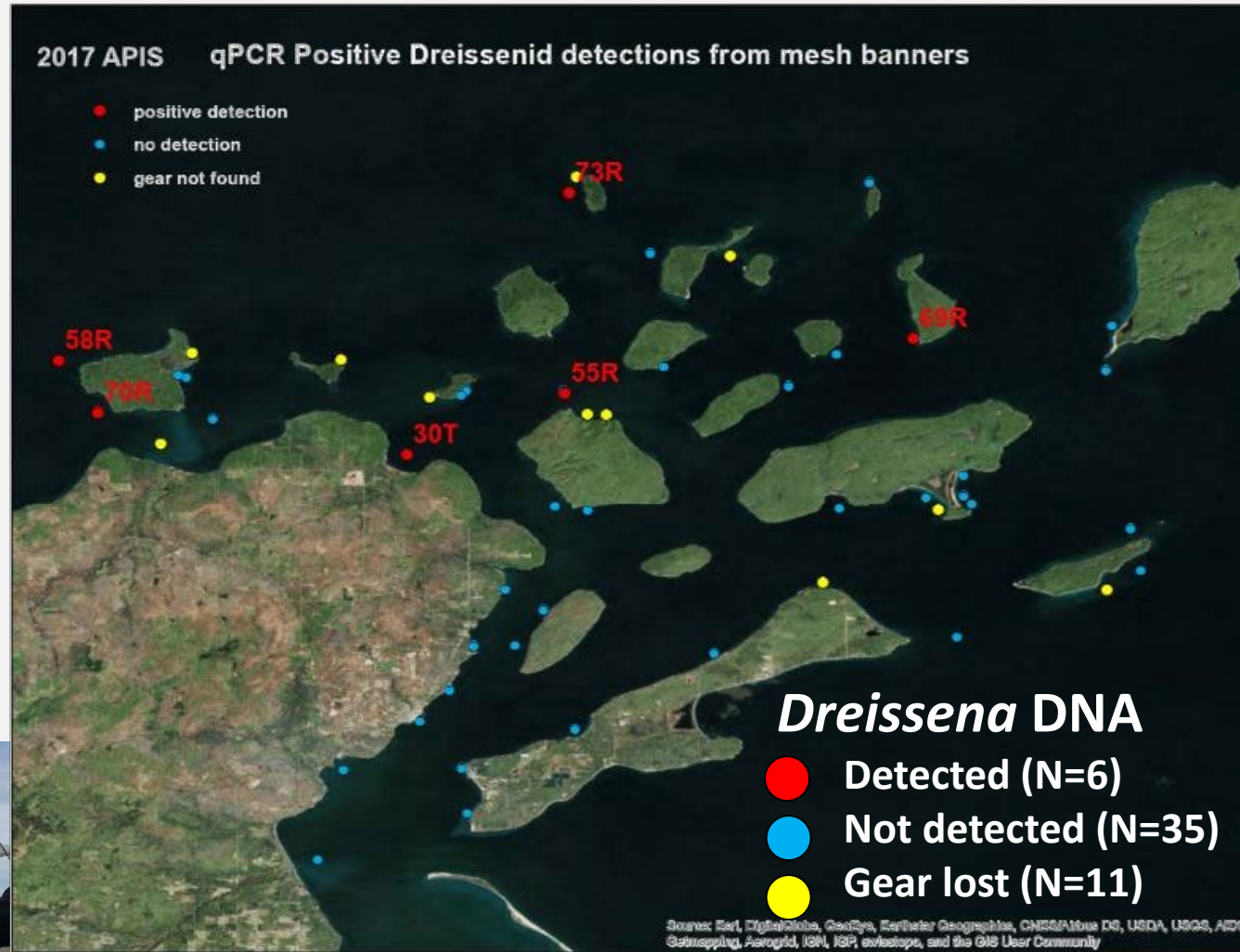


Zooplankton net



Dreissena DNA also in veliger traps

- Mesh panels strung along vertical ropes as settlement habitat
- Biofilm scrubbed off, 64 micron filter rinse, 95% EtOH preserved
- qPCR analysis for Dreissenid signal



Veliger trap 'hits' match pattern of zoop
tows with veligers -- NW side of APIS

What does it take to find veligers? And ID to species?

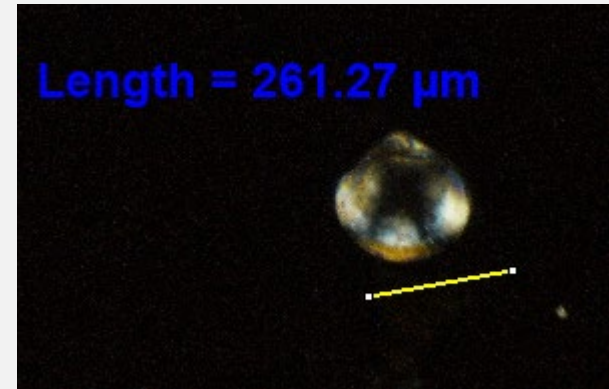
Usual open-lake zooplankton protocol:

- Count crustacea in 163 μ m net splits
- Count veligers in 1-mL aliquots from 63 μ m net samples (with rotifers)
- Works fine in lower GL's where veliger densities are 10,000 to 100,000/m³ but not for <1 to <100/m³

We had veligers counted like crustacea. Past Lake Superior work did not and could have missed them.



Veligers cannot be ID'd to species by morphology (ditto small settled mussels).

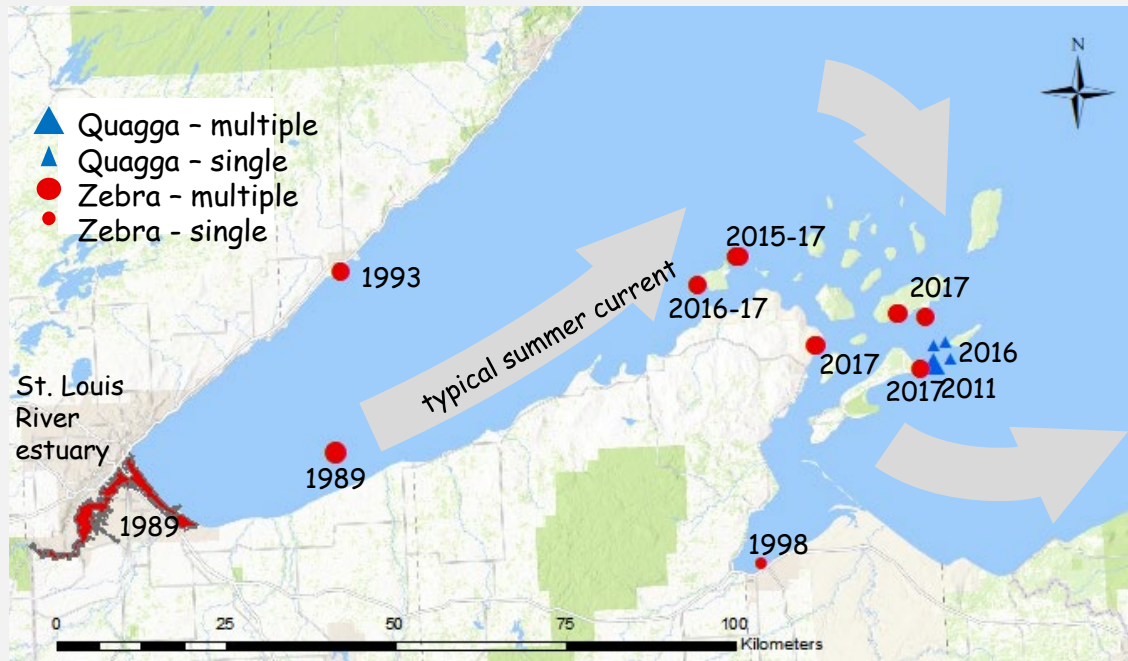


Veligers can be ID'd to species by DNA methods but this is new: In 2017 only genus-level qPCR marker was available, species-level marker became available in 2019 (Chris Rees w/US FWS).

Speculation: APIS veligers not local but from SLRE ?

We suspect the veligers weren't produced by APIS adults because:

- Adult numbers very low
- Spatial mismatch between adults and veligers
- Calcium marginal: above 12 mg/L veliger “survive” threshold, but below 20 mg/L “thrive” threshold



Currents can transport water from SLRE to APIS in 2-3 weeks, well within veliger viability time frame

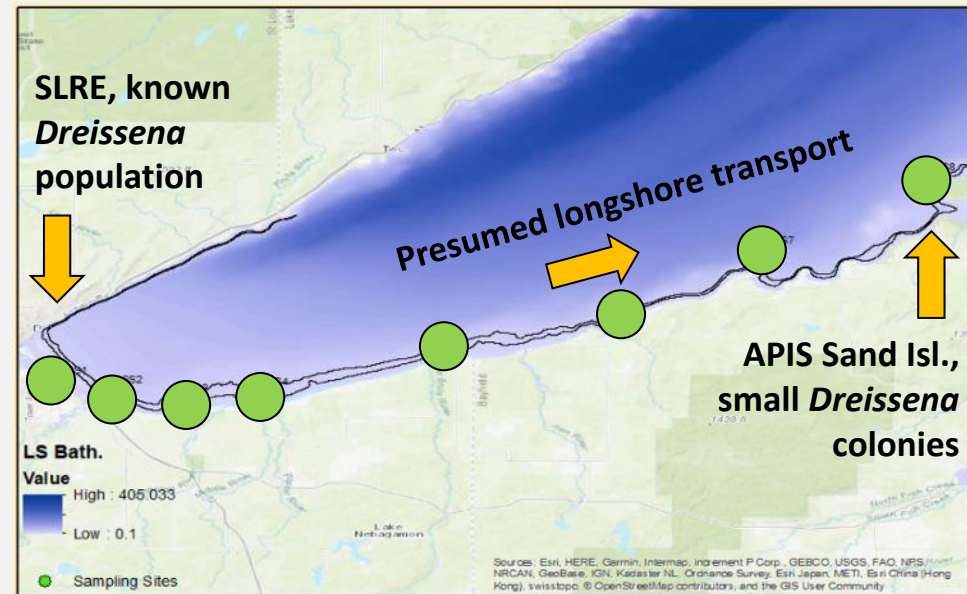
St. Louis River estuary has:

- Largest GL shipping port and major recreational boating traffic
- Established *Dreissena* population
- Documented veliger production
- Suitable water quality (calcium, productivity, temperature)

EPA 2019 gradient survey, to elucidate veliger source

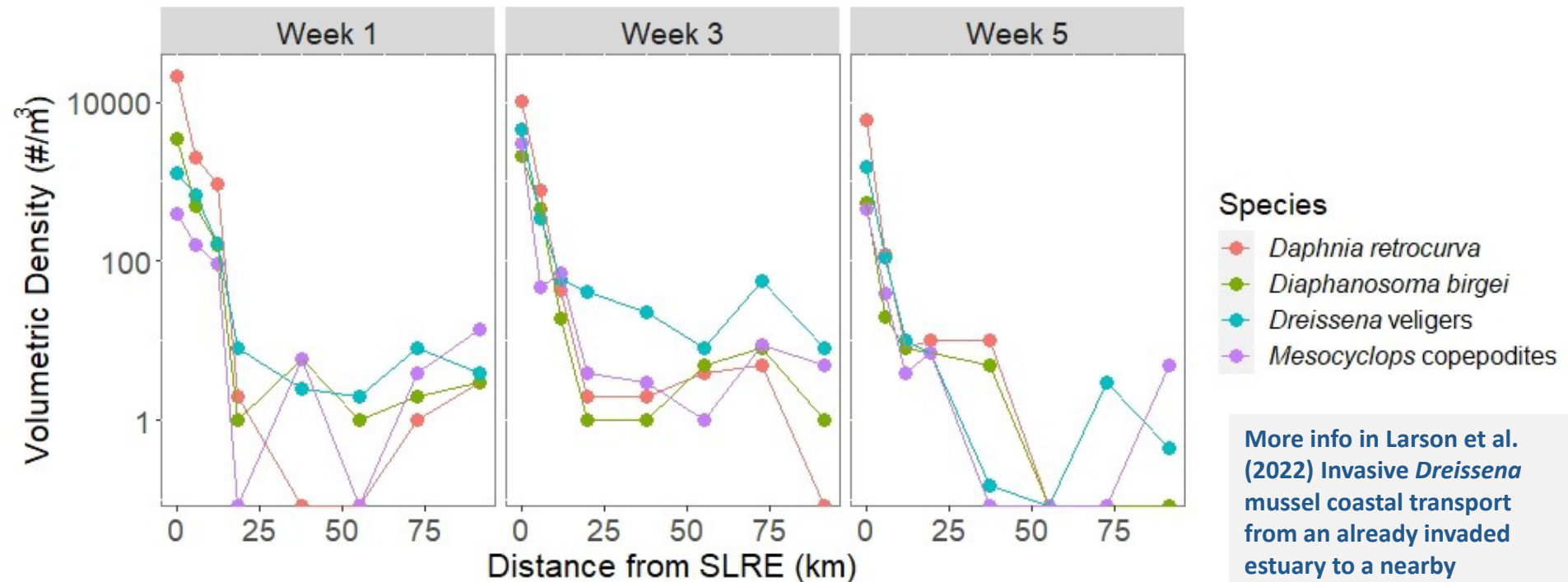
Evidence to examine:

- Veliger # decline away from SLRE
- Veliger size & viability change
- Zooplankton community change
- Water chemistry change



Type of sample	Analysis target	Sample size
Zoop tow, 64µm	Zoop community, <i>Dreissena</i> DNA	8 sites x 3 visits
Settlement traps	<i>Dreissena</i> DNA	8 sites, top & bottom
eDNA, top & bottom	<i>Dreissena</i> eDNA	8 sites x 3 visits
Meter & lab chem	Temp, calcium	8 sites x 3 visits

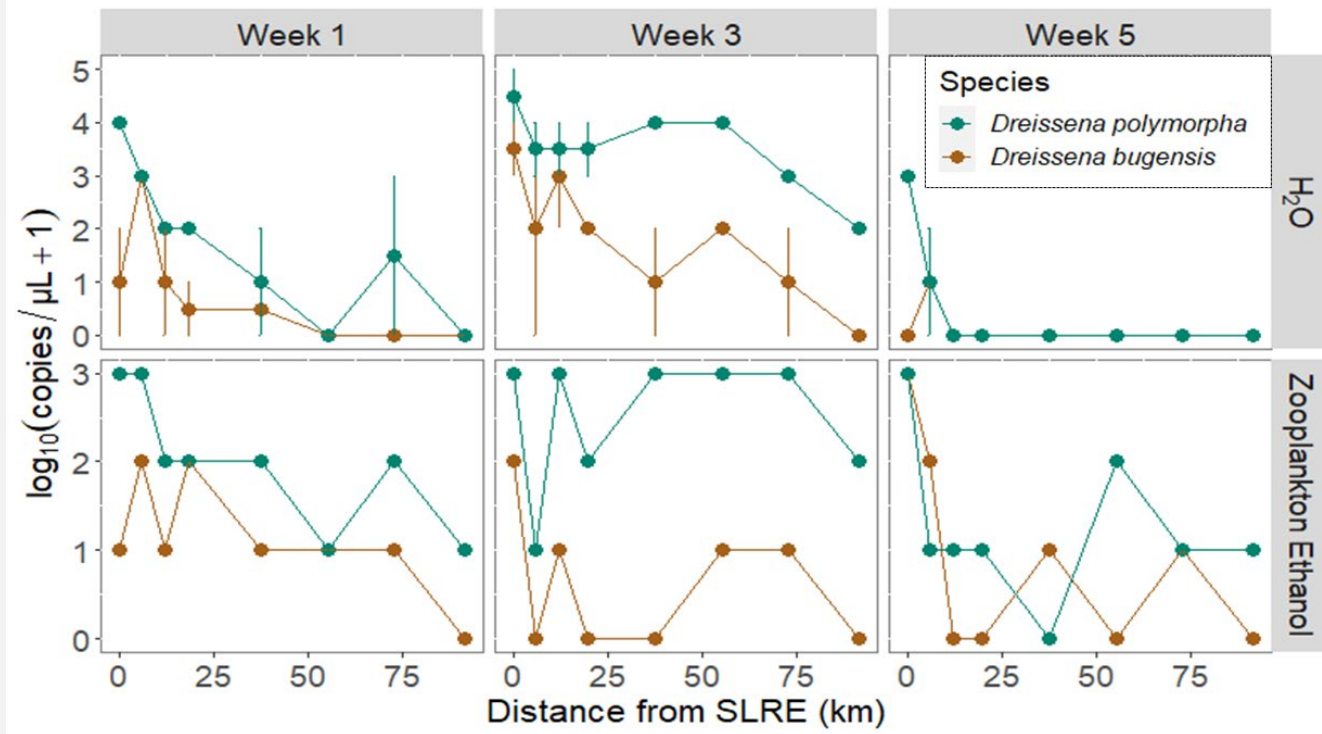
2019 gradient survey: current transport vector



We found:

- Declining veliger density from west to east consistent with SLRE as source and current transport as vector
- Similar pattern for other zooplankters that inhabit SLRE but not open Lake Superior, reinforcing transport vector

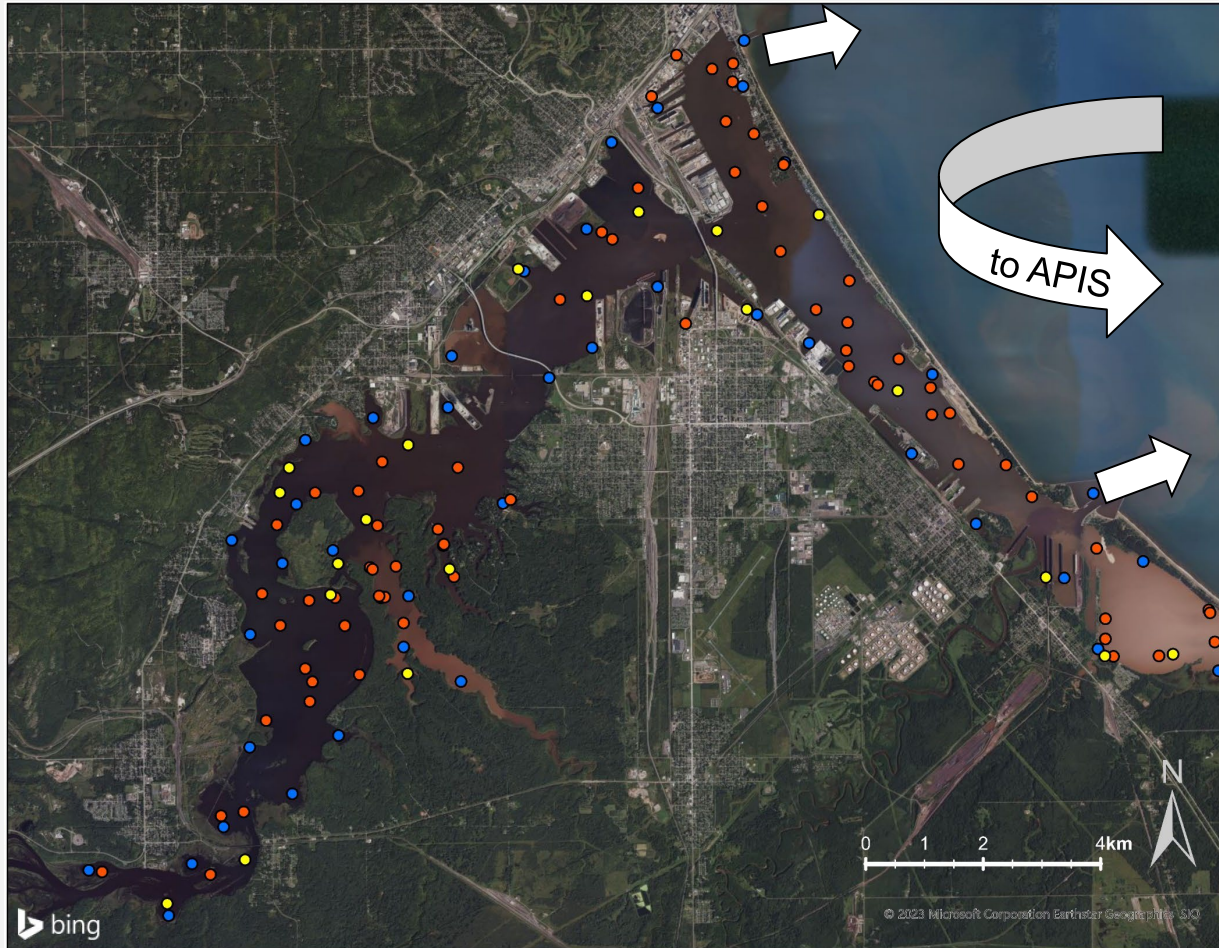
2019 gradient survey: both *Dreissena* species found



Surprising that quagga made up substantial portion of veligers; we expected veligers emanating from SLRE to be zebras:

- Quagga better suited to open GL's; dominate offshore lower lakes
- But zebra better suited to estuaries, past SLRE surveys found almost all *Dreissena* large enough to ID to be zebras

2022 revisit of *Dreissena* distribution in SLRE



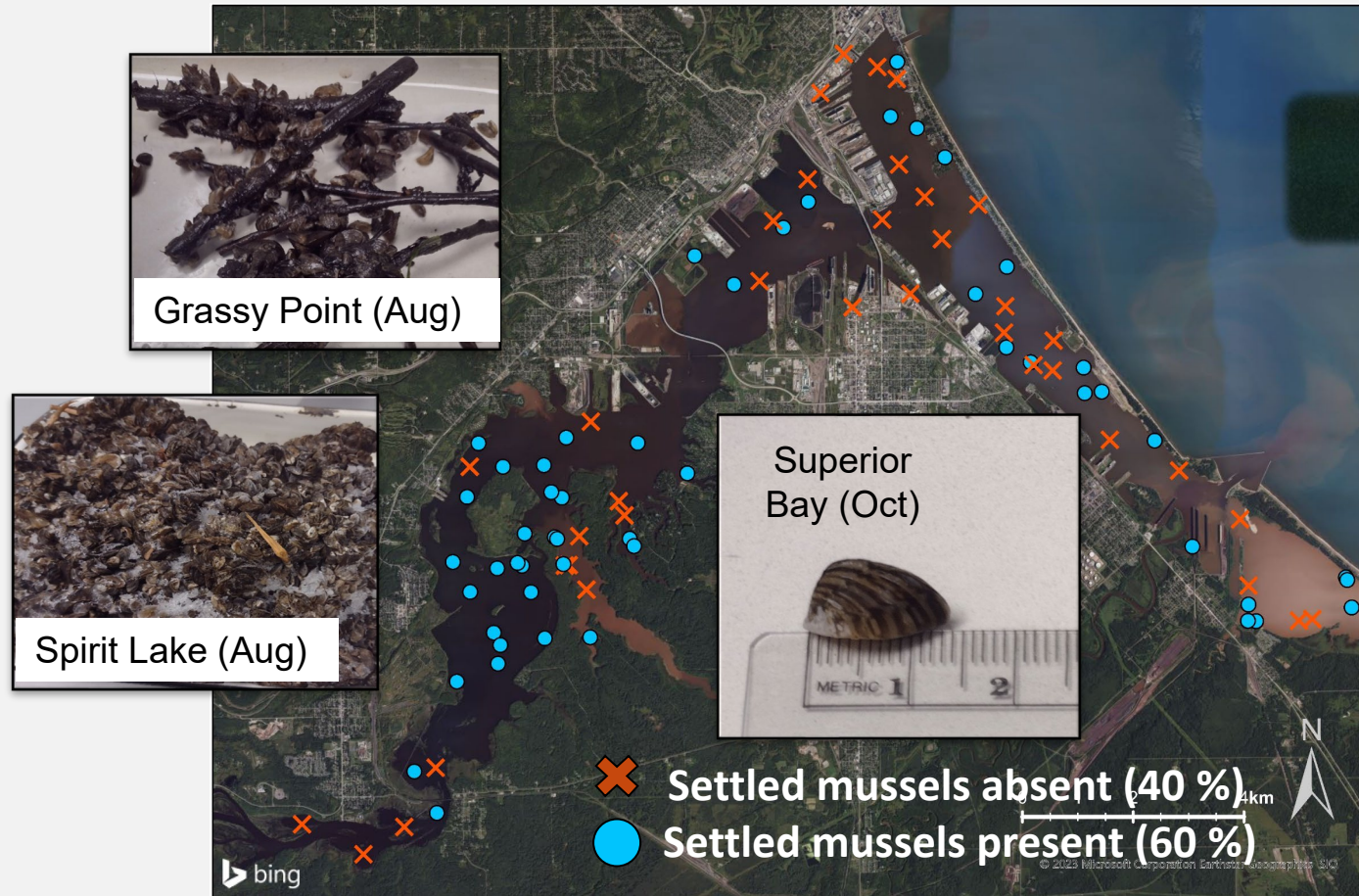
Where might that quagga DNA be coming from?

- Are quagga now a higher proportion of *Dreissena* than before?
- Are mussels morph-ID'd as zebra in fact quagga?
- Are there quagga near Lake Superior even if zebra elsewhere?
- Do quagga contribute more strongly to veligers & shed DNA?

Sampling locations (during veliger season):

- Adult mussels, as bycatch from bottom trawling for fish (N=80)
- Zooplankton tows (N=24)
- eDNA water samples (N=46)

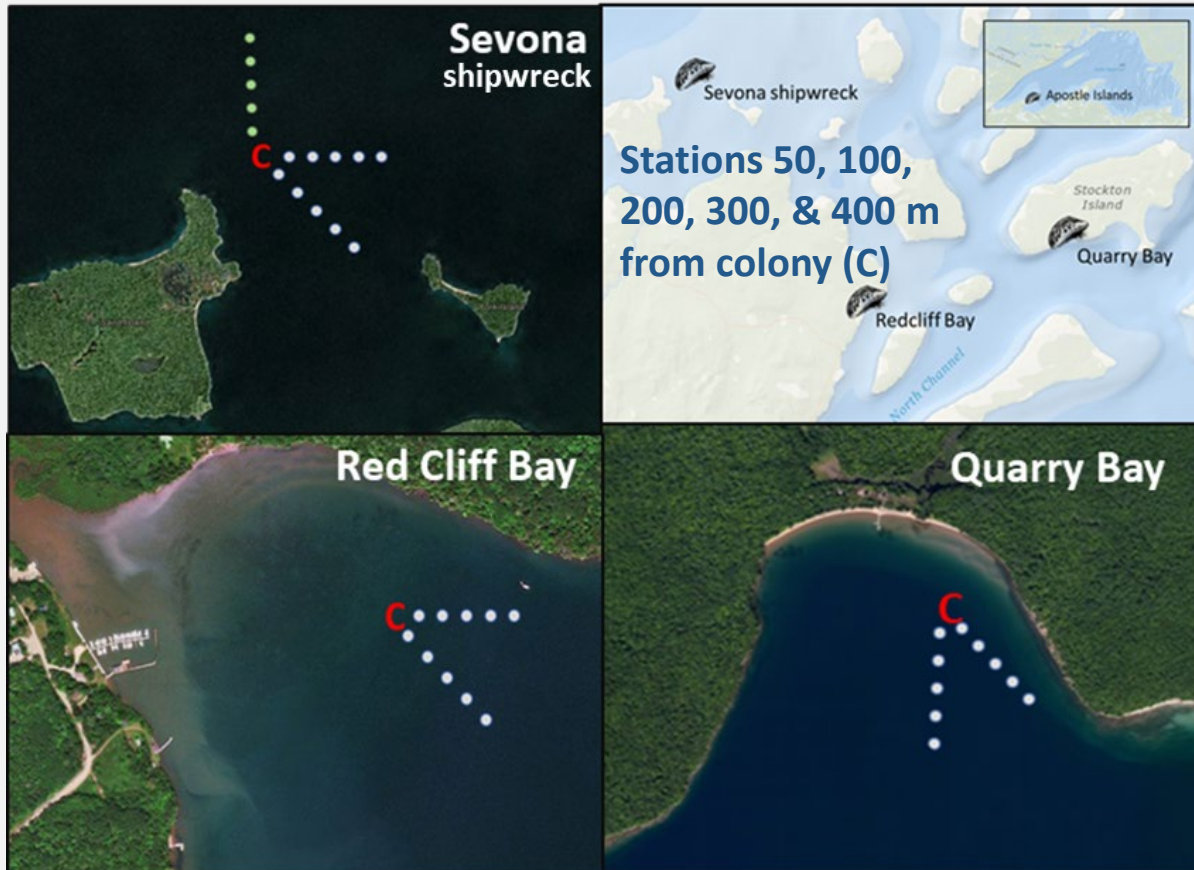
2022 revisit of *Dreissena* distribution in SLRE



Findings:

- Mussels throughout on wood & other substrates (*tissue method TBD*)
- zooplankton tows? *DNA results pending...*
- eDNA water samples? *DNA results pending...*

2019 APIS: eDNA colony detectability distance



eDNA & zoop tow samples collected before & after NPS divers removed mussels from largest colony (Sevona)



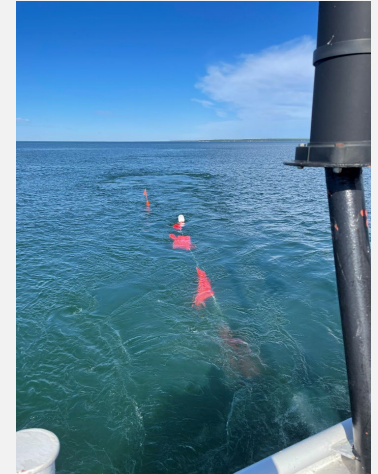
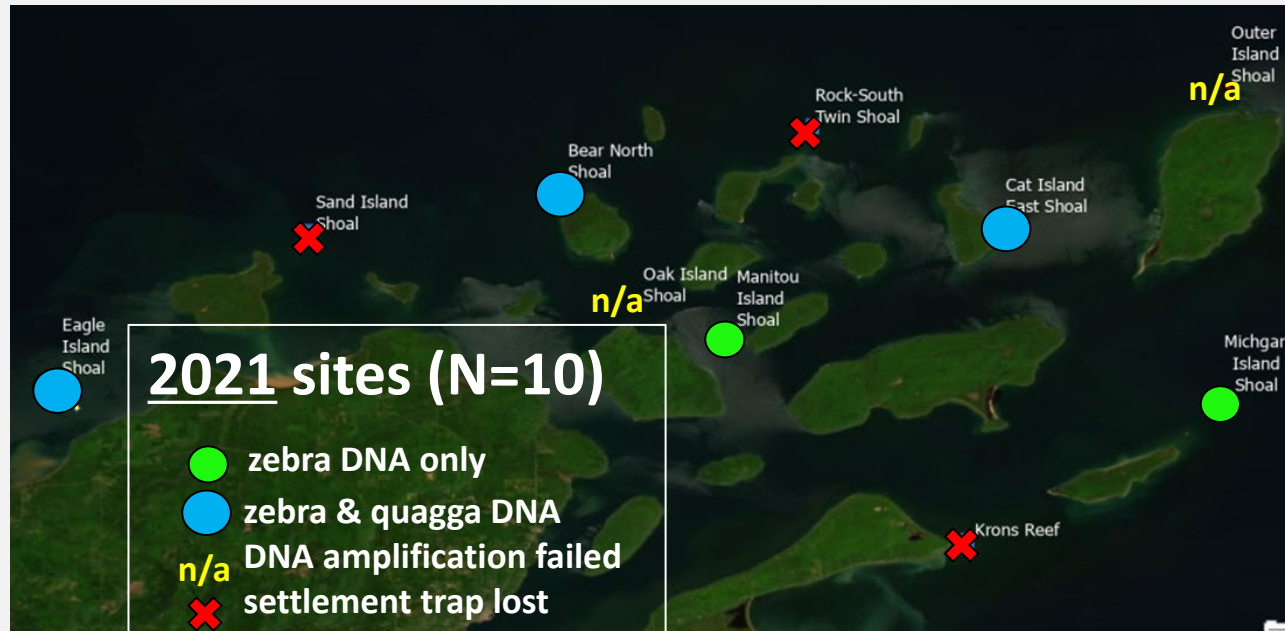
No eDNA hits* but veliger finds in zoop tows:

- Sevona: hits at “C” ($5.1/\text{m}^3$) + 5 others (1 to $4/\text{m}^3$)
- Quarry Bay: 1 hit at “C” ($0.4/\text{m}^3$)
- Red Cliff Bay: none

Maybe these aren’t local veligers either

* This was before we got the more sensitive species-specific DNA marker

2021 & 2022 APIS: veliger trap monitoring



10 shallow reefs also sampled by NPS for settled *Dreissena*:

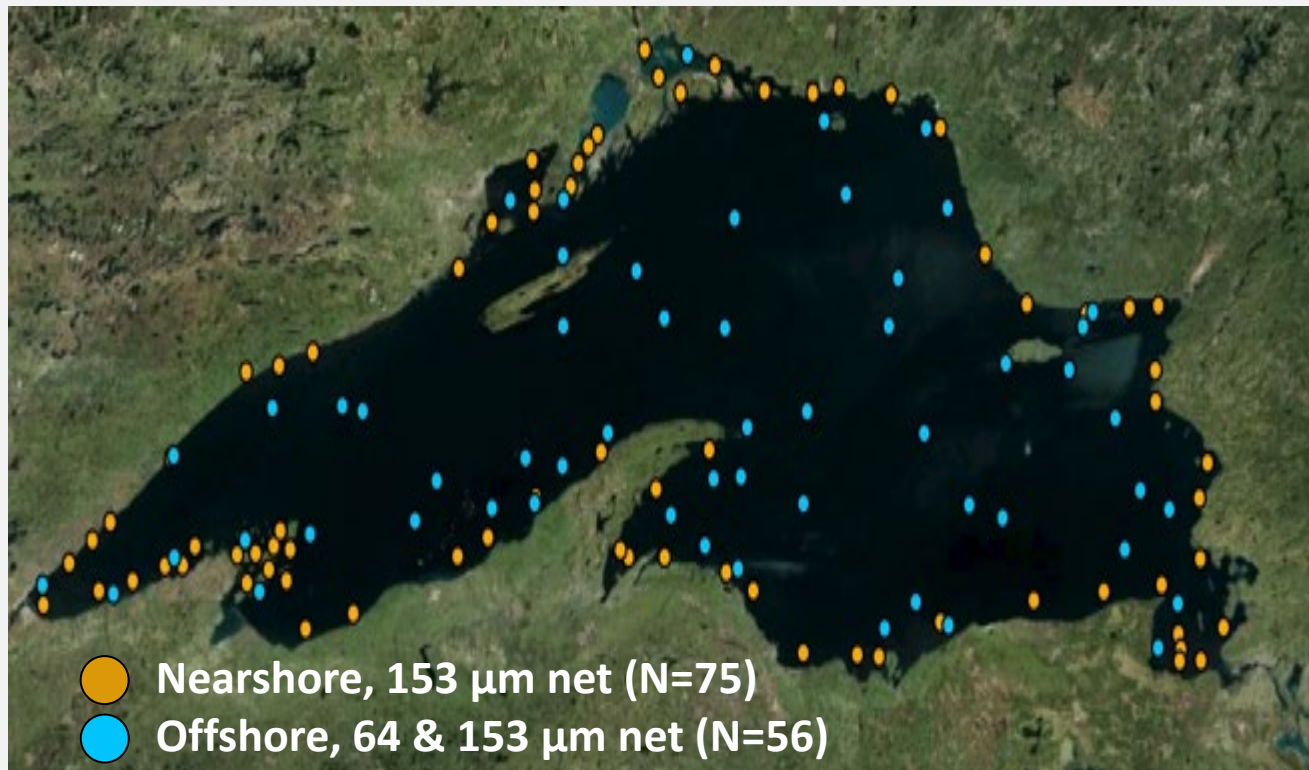
- 2021: veligers from both species found
- 2022: DNA results pending...

APIS SHOALS DREISSENID MONITORING 2022
Settlement Trap Sites



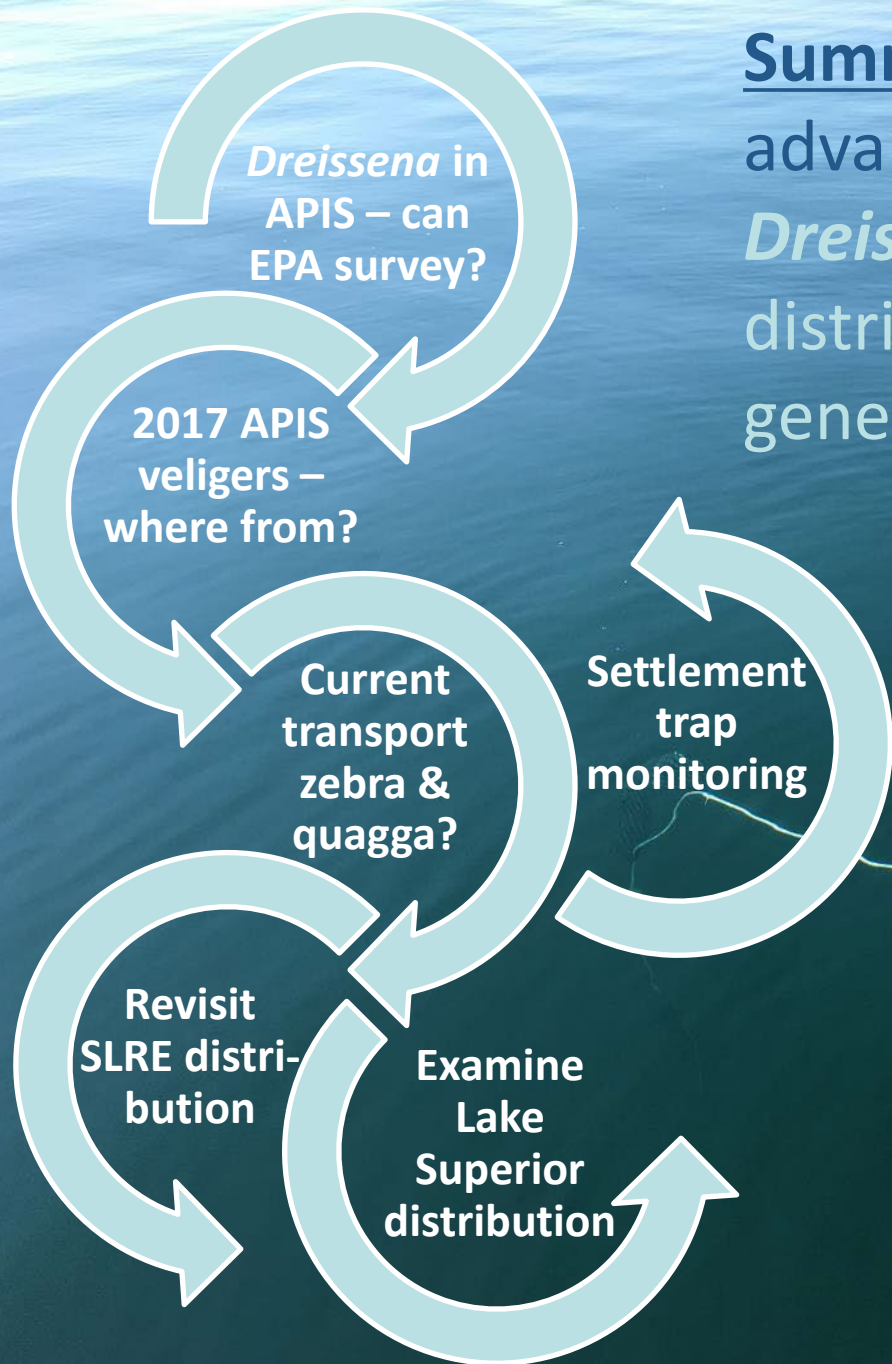
2022 CSMI – extent of veligers in Lake Superior?

Zooplankton samples collected during the 2022 cross-agency Coordinated Science and Monitoring Initiative survey allowed us to revisit open-lake veliger knowledge:



- Do veligers remain rare in open water or are they just going undetected?
- Are the veligers zebra or quagga?

DNA results pending...



Summary: Ongoing efforts are advancing understanding of *Dreissena* sources, abundance, and distribution in Lake Superior generally and APIS in particular

Acknowledgments

- EPA Duluth team invasives
- EPA Duluth vessel ops staff
- EPA Cincinnati team DNA
- National Park Service permits & staff
- USGS & 1854 Treaty Authority samples
- UWS taxonomists
- EPA GLNPO/GLRI funding



Abstract: Lake Superior stands as an exception to the other Laurentian Great Lakes when it comes to *Dreissena* mussels, with these invasive species established in the St. Louis River estuary (SLRE) since 1989 but seeming not to colonize the lake proper. In the last few years, however, *Dreissena* have been appearing on shipwrecks and reefs around the Apostle Islands National Lakeshore (APIS), prompting the National Park Service (NPS) to undertake removal efforts and us to better characterize their distribution. In 2017, we conducted intensive sampling in APIS that found no new settled *Dreissena* but low-density planktonic veligers in almost half the zooplankton samples, with a spatial distribution suggesting they were not locally spawned but rather transported to APIS from the direction of the SLRE. In 2019 we followed up with sampling the SLRE to APIS gradient, which yielded declining veliger density west to east consistent with SLRE as the source and longshore current as the transport mechanism. Veligers cannot be morphologically identified to species, but our 2019 work employed a new DNA marker that showed veligers to be a mix of *D. polymorpha* (zebra) and *D. bugensis* (quagga) mussels. The quagga DNA was unexpected, since previous SLRE data reported almost all *Dreissena* to be zebras, so in 2022 we revisited the SLRE species distribution using DNA markers to analyze water, zooplankton, and settled mussels. Also in 2022, we extracted DNA from a large set of open-lake zooplankton samples to look for veligers further out into Lake Superior. Finally, in both 2021 and 2022 we deployed veliger settlement traps at APIS reefs -- also analyzed with DNA markers -- to complement NPS monitoring for larger mussels. Collectively, these efforts are advancing understanding of *Dreissena* sources, abundance, and distribution within Lake Superior generally and APIS in particular.