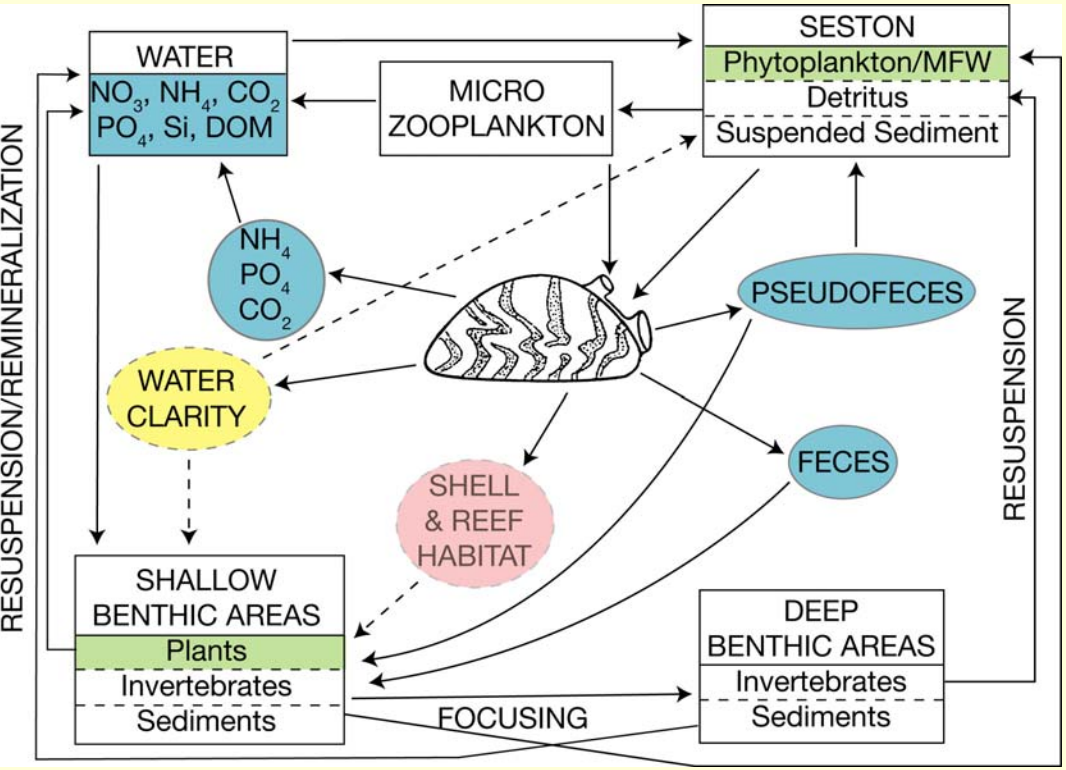
"Complex interactions between dreissenid mussels and *Microcystis* blooms in the Great Lakes"

Hank Vanderploeg, Miguel Dionisio-Pires, Juli Dyble, Tom Johengen, Jim Liebig, Nancy Morehead, Sander Robinson, Orlando Sarnelle (MSU), and Alan Wilson



Western Lake Erie, August 2003

The story started here on Saginaw Bay in 1996:

1) Vic Bierman said water quality models and P reduction are not consistent with blooms in 1994.

2) Hank blamed mussels.

Bay City Times

Tuesday, March 19, 1996

Concerns about algae, mussels pack Bangor hall

■ Residents eager for information about water problems

By Kelly Adrian Frick
TIMES WRITER

Scientific researchers are in many ways still puzzled by the effects of zebra mussels and algae in the Saginaw Bay.

What became clear Monday night, however, was that their research has an interested audience.

About 140 people, mostly fishermen and shoreline pro owners, packed Bangor Town Hall for what was hailed as State of the Bay" presentation. The two-hour program, sponsored by the Bay County Waterfront Task Force, gave audience members highly technical lectures filled with scientific data and long, complex names for Bay inhabitants such as zebra mussels and algae.

But that didn't scare audience members who asked questions for more than 30 minutes after the presentations. Many of the

See BANGOR, 2A

From 1A

questions asked didn't directly deal with the research shown Monday night. Residents asked about the green algae — often referred to as muck — that washes ashore in the summer and about fish populations.

"People have a big concern about the bay. The Saginaw Bay is a tremendous resource that perhaps people have taken for granted," said Dan Manyen, owner of Steelie Dan's River Charters, a charter fishing business.

"I understand that science can't answer everything. But I know that the fishing isn't what it was in 1986 or 1987 and I'd like to know why."

Greg Little, a worker at the Bay Metropolitan Water Treatment Plant and sport fisherman, said he learned many new things about the Saginaw Bay waters but that many residents came hoping to hear solutions.

"We have to realize the zebra mussels aren't going away. The muck on the beaches probably isn't going away. We have to learn how to deal with that," Little said.

"I've got a lot of questions," said Mary Jo Braman, a Brissette Beach resident with six kids. "My kids swim in that water and I think we need to do even more research to find out exactly what is happening. There is so much that doesn't seem to have been researched."

The Saginaw Bay health report given Monday night addressed two specific research projects — the decrease of phosphorous in the Bay and the relationship between zebra mussels and different types of algae. The researchers were in town for today's Saginaw Bay Watershed conference at Saginaw Valley State University.

Victor Bierman, with Limno-Tech Inc. in South Bend, Ind., said the high phosphorous content in the water during the 1970s caused a large amount of algae in the water, particularly blue-green algae — an unhealthy type of phytoplankton. But after $500 million of governmental funding was thrown at the problem, phosphorous has greatly declined in the water, he said.

That would be good news, except that blue-green algae that disappeared in the late 1970s reappeared in the water in 1994.

Hank Vanderploeg, an ecologist with the Great Lakes Environmental Research Laboratory in Ann Arbor, gave a detailed discussion on his research group's theory that zebra mussels are more than a nuisance to water intake plants and boaters. The creatures may also be partly to blame for the increase in blue-green algae. The algae, which is microscopic and not the same as the muck that washes to shore in the summer, may also be slightly toxic, Vanderploeg told the crowd Monday night.

Bierman said he was surprised at the intensity of the crowd and by the educated questions asked.

"I was actually frustrated," he said after the question-and-answer period. "I wish we were able to give more answers, but unfortunately science doesn't have all the answers."

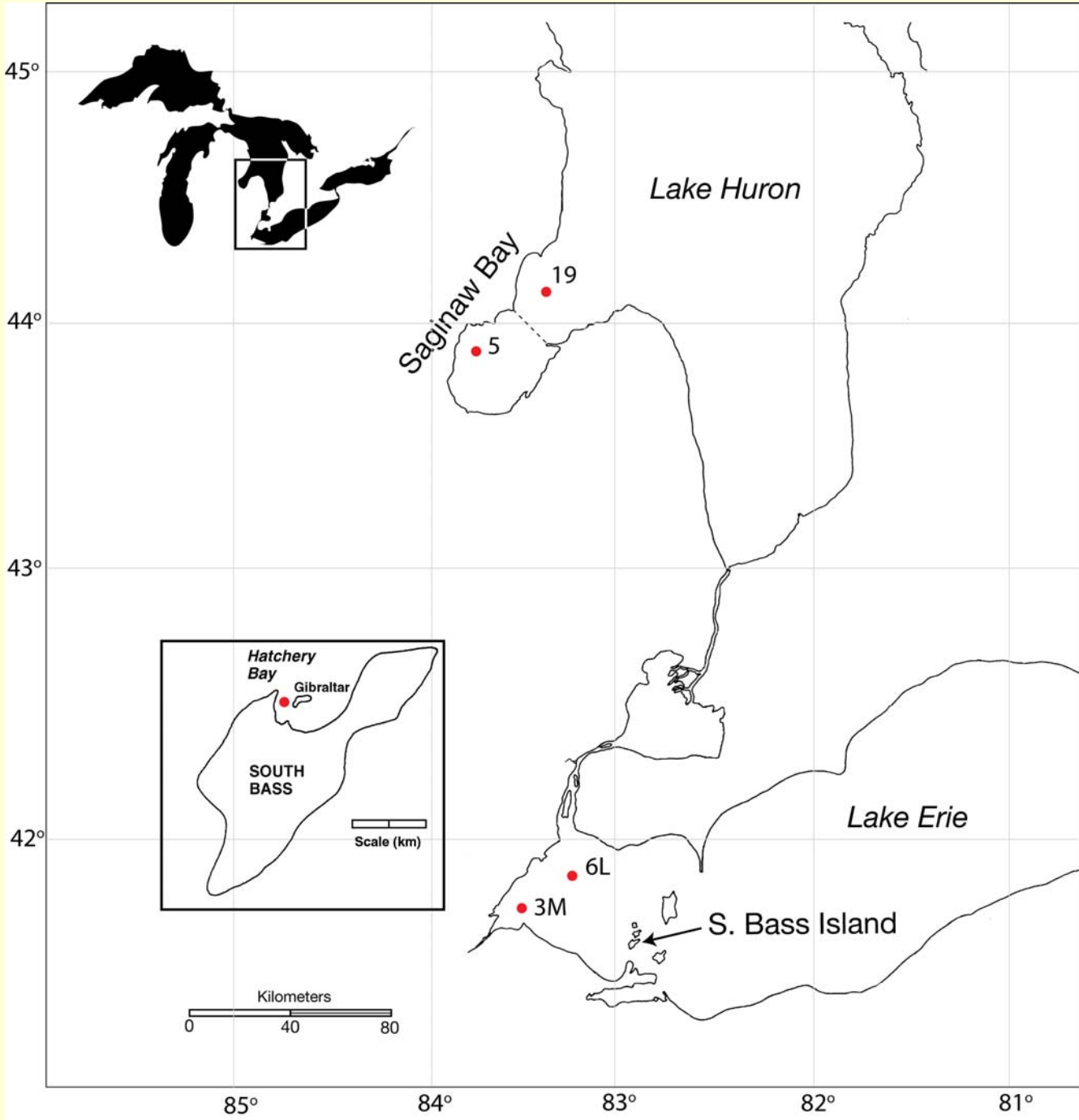
Joseph Rivet, Bangor Township supervisor and a member of the Bay County Waterfront Task Force, said the questions may prompt future programs on other Saginaw Bay issues and discussions on what residents can do to help.

"This really shows that there is a need for increased research and more understanding about what is happening in the Bay," he said.

Charter captain Dan Manyen agreed.

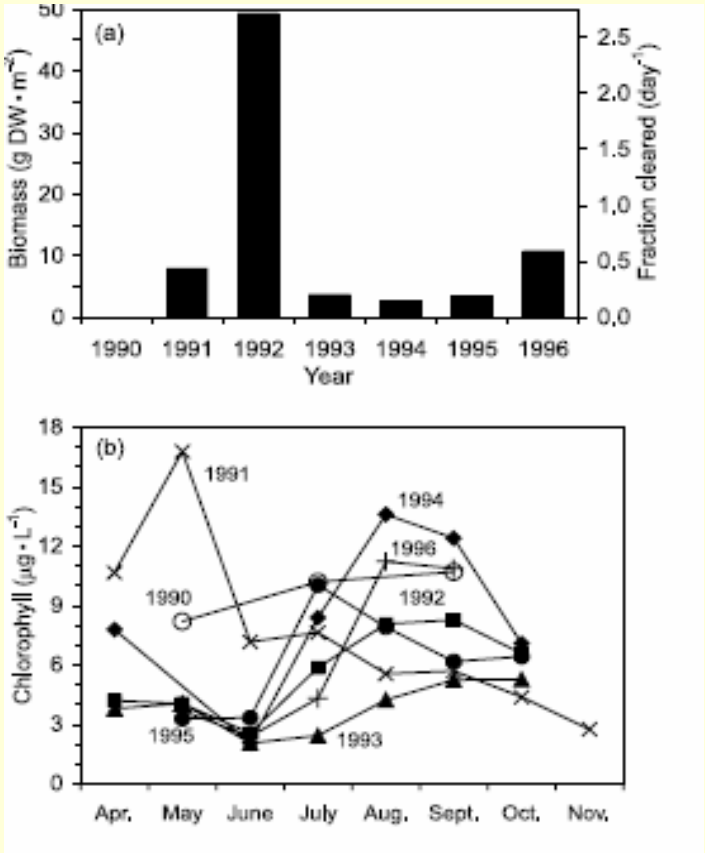
"We've got to start caring about this, and not just the property owners and fishermen," he said. "It affects the guy who sells pop and beer and gas to people coming out here too. The bay affects us all."

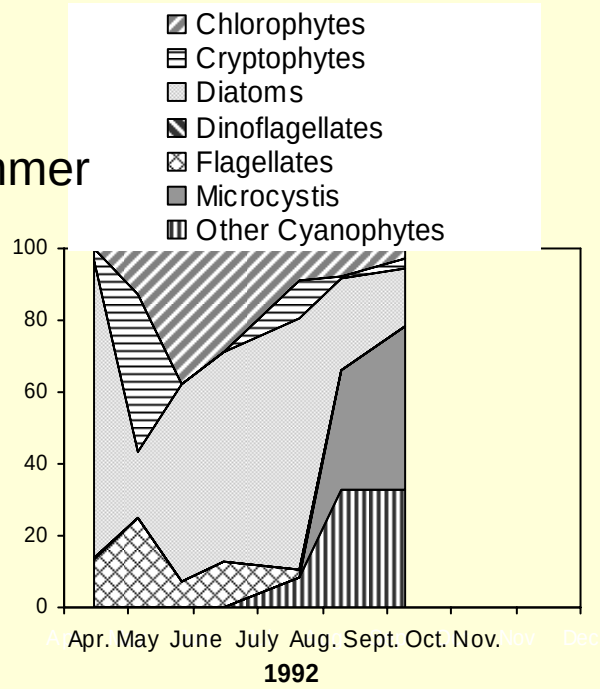
Our study sites on the Great Lakes

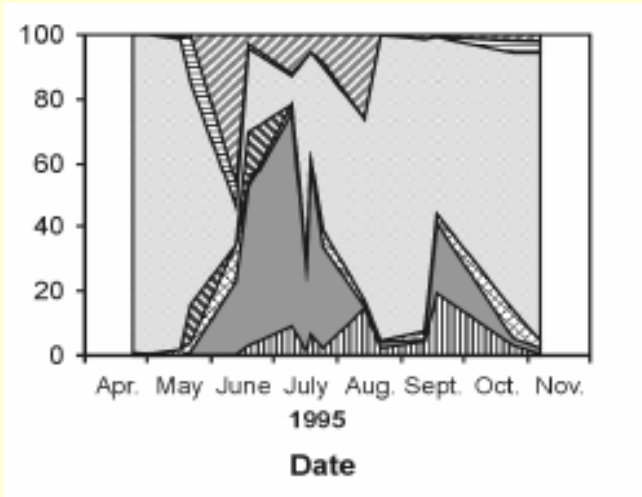


Saginaw Bay Story

- Mussels knock down chlorophyll in Spring
- Chlorophyll & *Microcystis* increase during summer





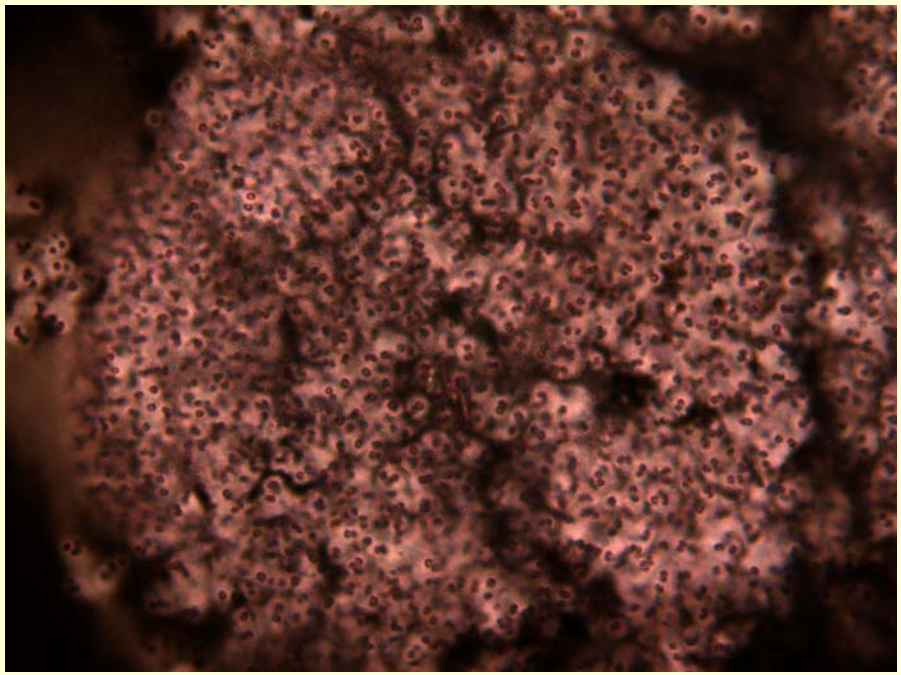


Some characteristics of *Microcystis aeruginosa*

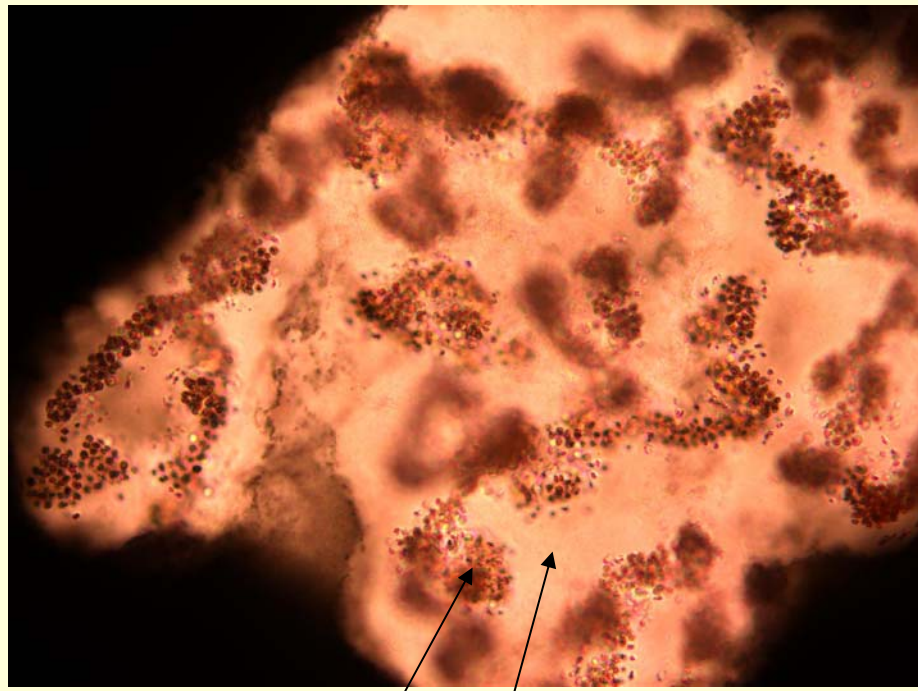
- There used to be 5 species (morphotypes), but now there is 1 genetically identified species
- Slow growing
- Typically colonial in nature
- Gas vacuoles
- Toxic
- Low P uptake but can utilize pulses of P for luxury uptake and later growth
- Likes high light
- Efficient ammonia uptake
- Grazing resistant for some zooplankton—large size & toxicity

Typical morphs

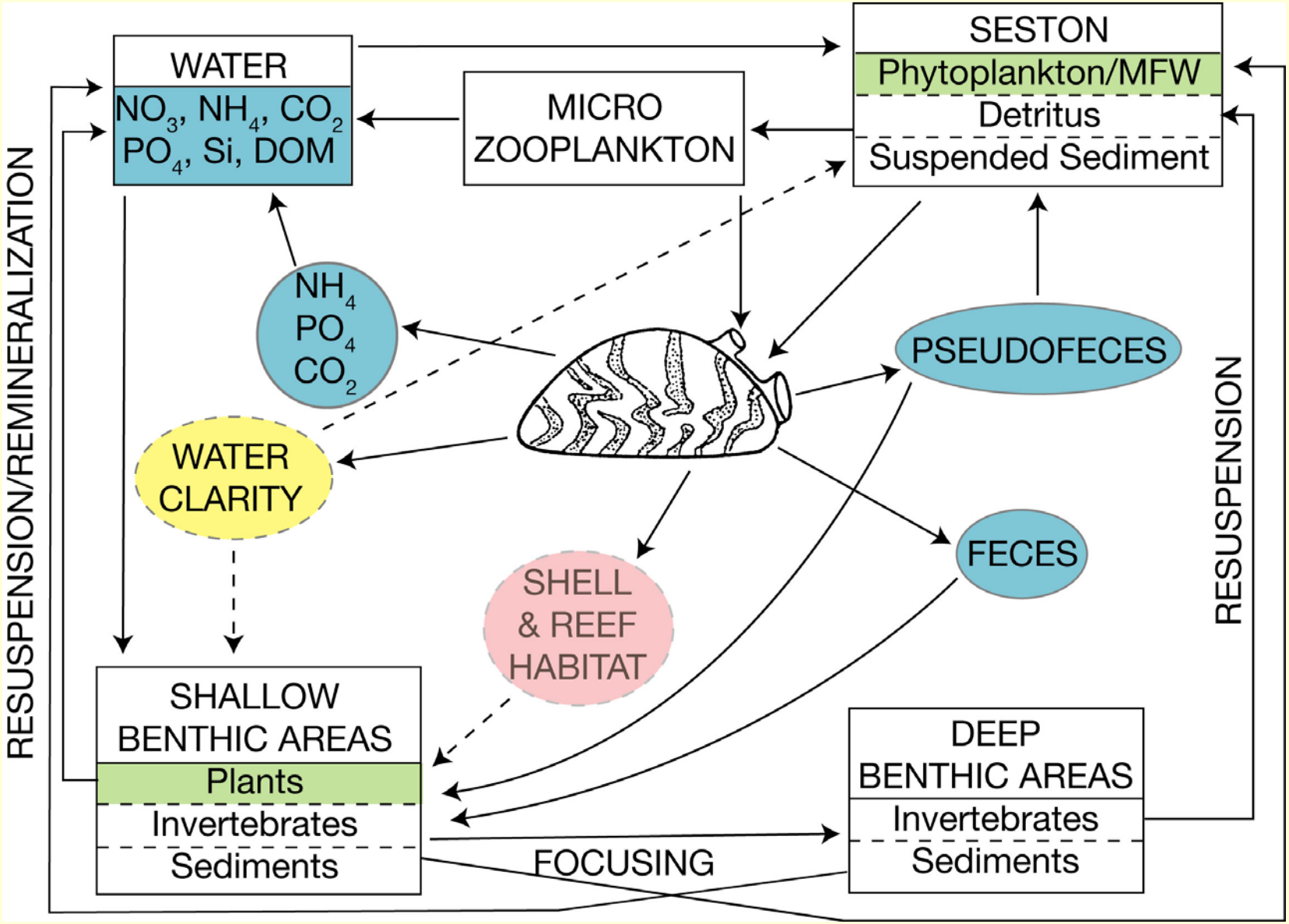
Flos-aquae morph from Gilkey Lake



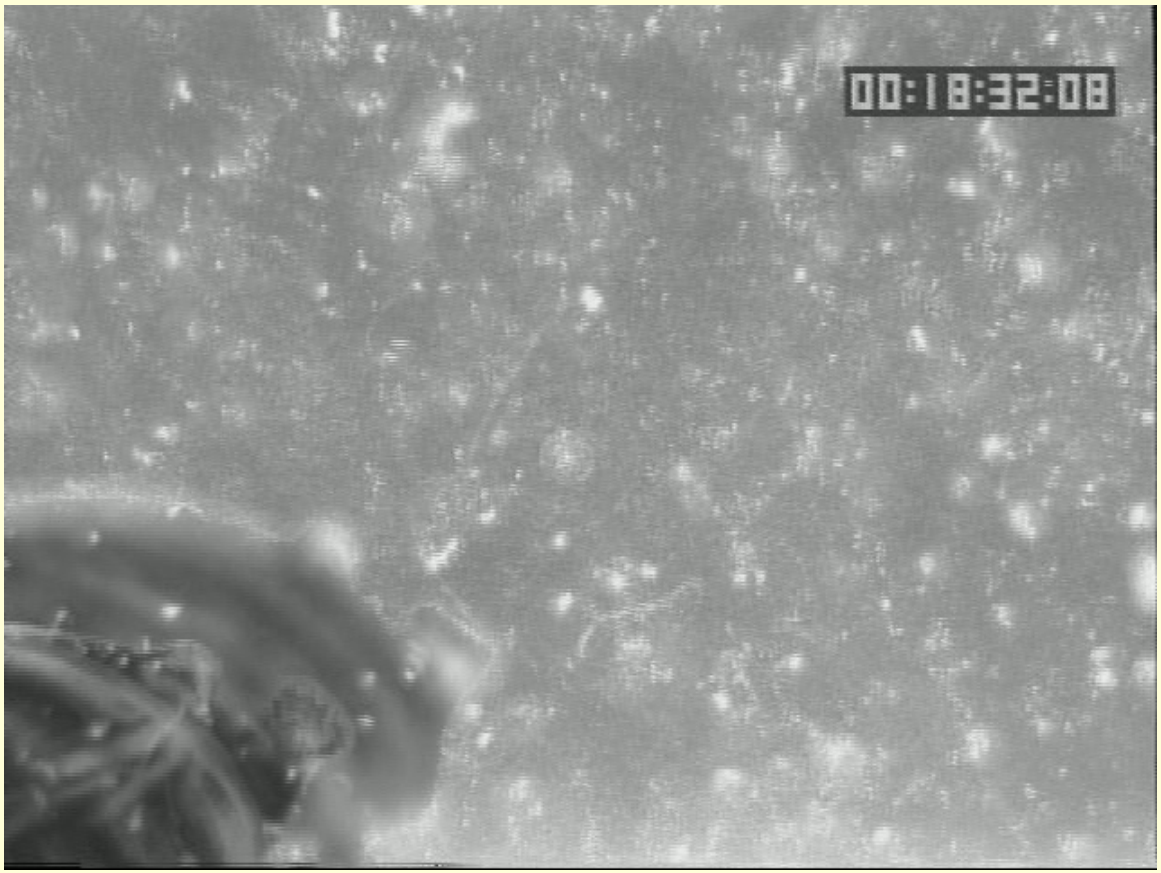
Aeruginosa morph from Hudson Lake



What zebra & quagga mussels do



The Beginning of the story:
Mussels and Lake Erie *Microcystis* bloom of September 1995, Hatchery Bay



The selective rejection paradigm: large toxic colonies are rejected while small algae are ingested (Vanderploeg et al. 2001)

Original paradigm details

- Abundant dreissenids clear a significant fraction of the water column per day
- Large toxic (or unpalatable) *Microcystis* are easily sorted from smaller phytoplankton and rejected as pseudofeces
- Pseudofeces are loosely aggregated with *Microcystis* returned to water column
- Nutrients from “processed” algae returned to water column to “feed” *Microcystis*

Forecasting Implications

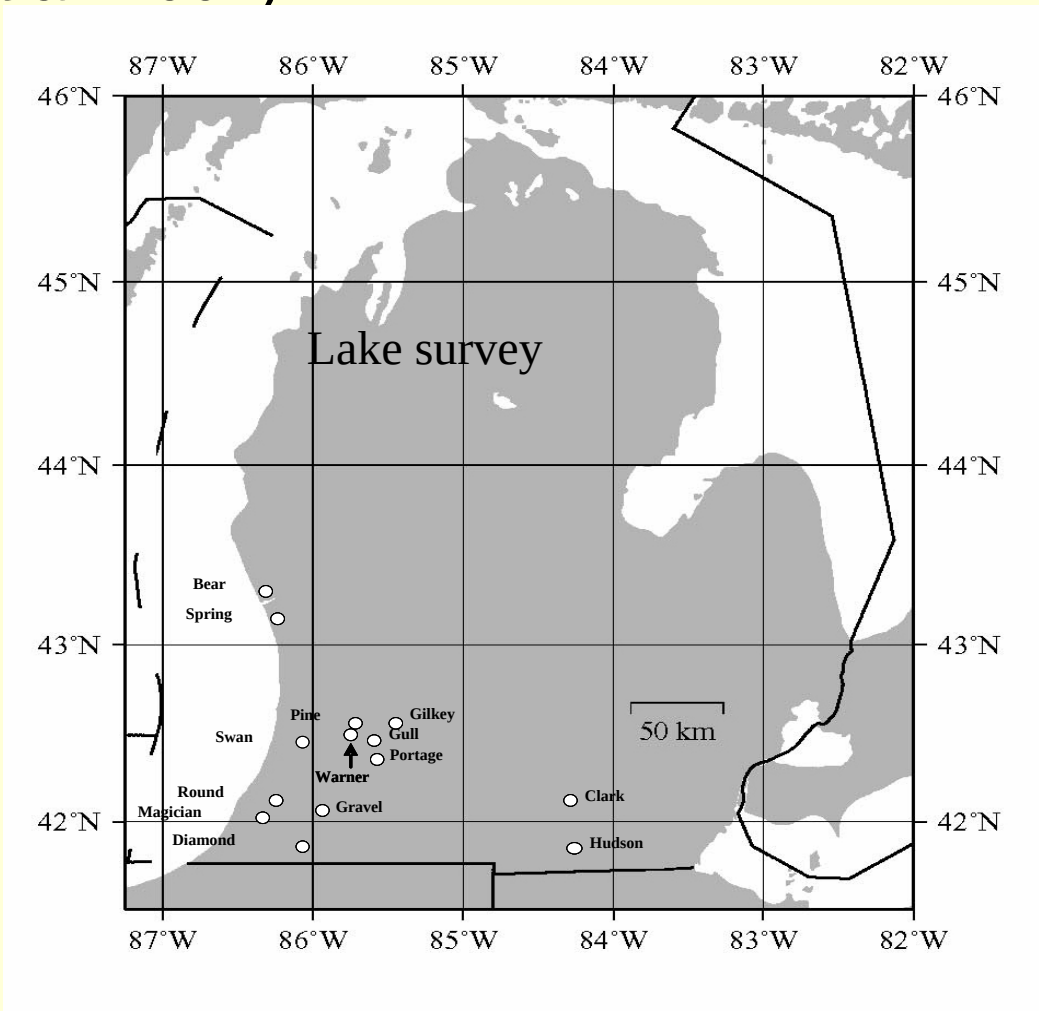
- Zebra mussels likely promoted *Microcystis* blooms
- Therefore, blooms and toxicity cannot be predicted in usual way
- Understanding of mussel/bloom mechanisms are necessary for prediction

Counter evidence

- Many laboratory strains of *Microcystis* are readily ingested
- No effects of mussels were seen in (hypereutrophic) Dutch Lakes

More evidence and puzzling results

Microcystis increased in low TP lakes (<25 µg L^{-1}), but not in high TP lakes (>25 µg L^{-1}) invaded by zebra mussels (Raikow et al. 2004)



More evidence and puzzling results

Microcystis decreased in Gull Lake mesocosms with mussels at TP<10 µg L^{-1} but increased at TP > 10 µg L^{-1} (Sarnelle et al. 2005)

Forecasting Implication

There is a nutrient/trophic gradient interaction

A few hypotheses:

- Grazing and nutrient excretion interaction—a nutrient stoichiometry story?
- Strains vary among lakes of different eutrophy?
- Grazing not important at high TP concentrations?
- Mussels produce infochemicals that induce large toxic colonies and infochemical concentration varies with TP concentration

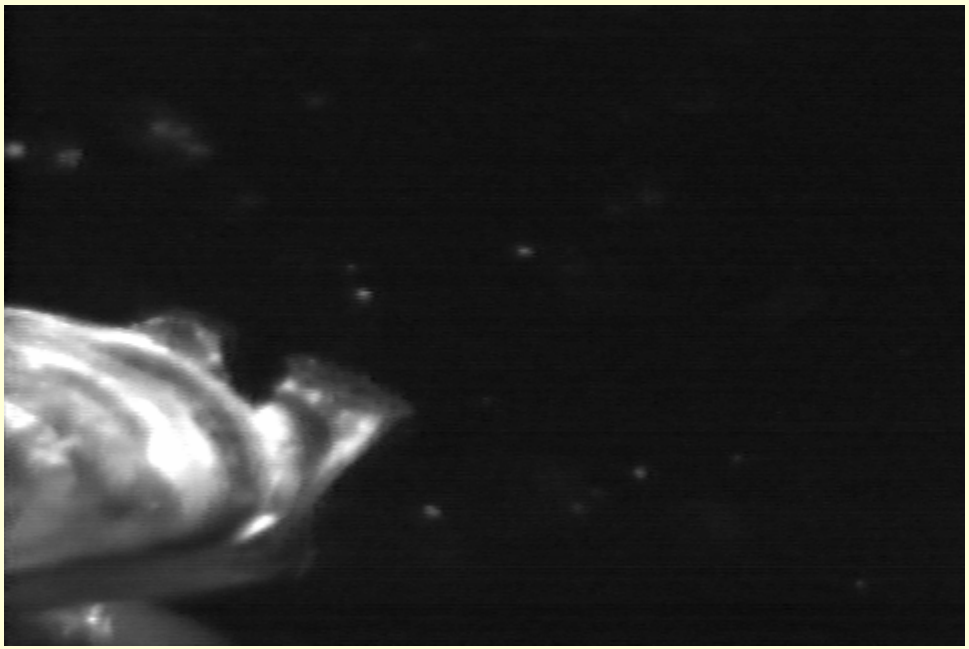
What we did

- We looked at the possibility of mussel infochemicals inducing defense response
- We did more work with natural seston
- We looked at the strain question—what factors induce rejection

Some recent results emphasizing:

- Importance of working with recently isolated cultures or natural seston
- There is more than one reason for rejection

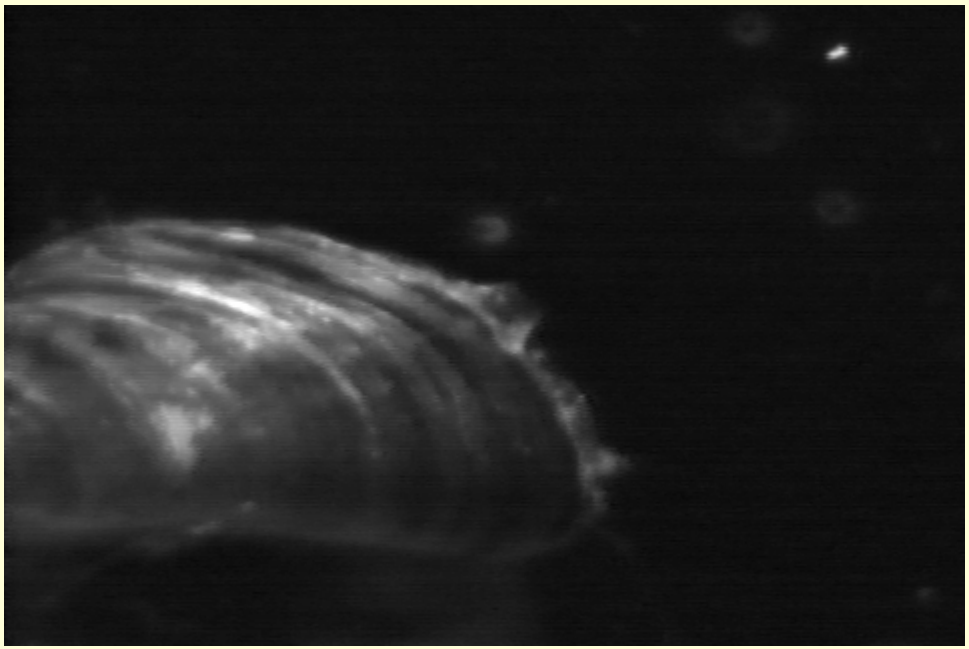
Bear Lake (mussels present) *Microcystis* strain — much feeding on smaller size fraction



Enthusiastic captures and forceful rejections

Fraction	Initial chl (µg/L)	Microcystin / chl	F_A (mL/cm^2/h)
>53µm	1.56	0.202	-7.26
<53µm	2.42		64.91
Total	3.97		29.23

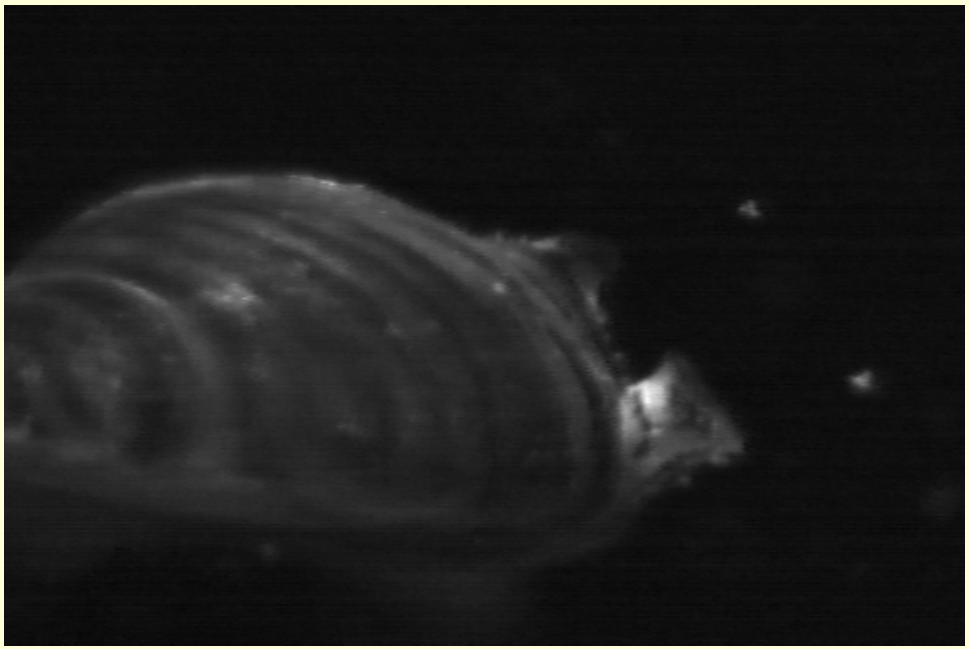
Gilkey Lake (no mussels present) strain — no feeding on any size category



Note symptoms of distress: siphon not fully open & weak expulsion response

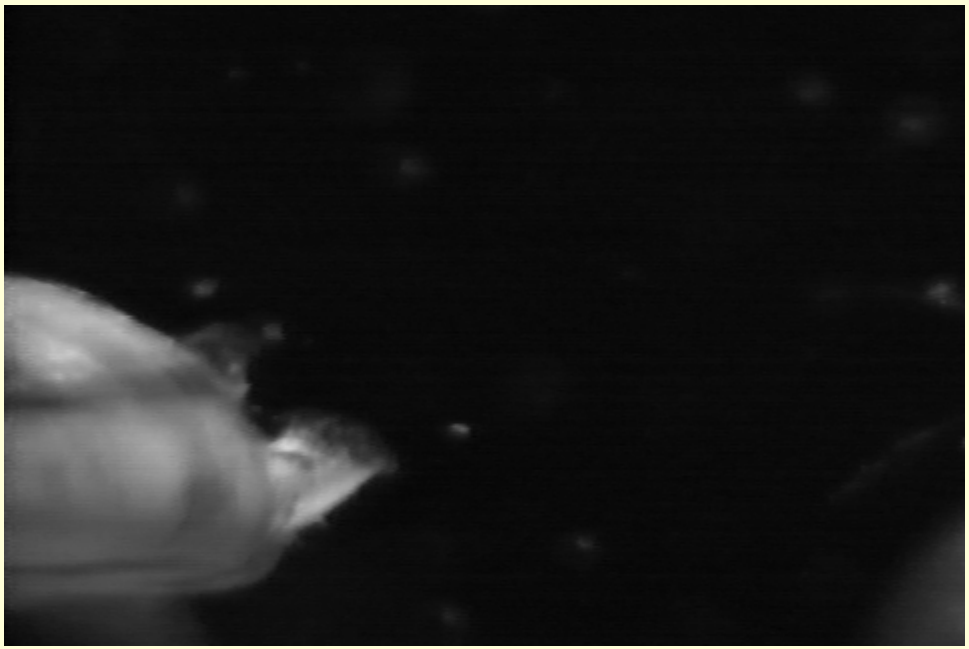
Fraction	Initial chl (µg/L)	Microcystin / chl	F_A (mL/cm^2/h)
>53µm	1.96	0.099	-10.53
<53µm	0.84		-1.90
Total	2.79		-8.20

Gilkey Lake strain plus *Cryptomonas*



Note rejection of individual colony as it enters siphon

Hudson (no mussels present) BD strain — non toxic, little ingested



Enthusiastic captures and forceful rejections

Fraction	Initial chl (µg/L)	Microcystin / chl	F_A (mL/cm^2/h)
>53µm	3.72	0.003	4.01
<53µm	0.01		-238.41
Total	3.73		1.61

Conclusions

- Mussels promote *Microcystis* in systems of low to moderate P concentration.
- Colony size (and mucilage) is a sufficient condition for rejection.
- *Microcystis* from invaded and not invaded lakes elicited rejection response.
- There is a toxicity response (not necessarily microcystin) in mussels that makes the rejection response more sensitive

Conclusions continued

- More work is necessary to explain the interaction among dreissenid mussels, *Microcystis* abundance, colony form and toxin concentration and eutrophy of the lake
- We can no longer work with *Microcystis* strains from commercial culture collections and expect to learn anything.