“Pond-to-Sea” Pilot Study of Cyanobacteria and Juvenile Herring, Cape Cod

River Herring Network Annual Meeting
November 1, 2023
Orleans Town Hall

Jo Ann Muramoto, Ph.D.

MassBays Regional Coordinator, Cape Cod

Association to Preserve Cape Cod

482 Main Street, Dennis, MA 02638

Sign at Santuit Pond, 2021

APCC Association to Preserve Cape Cod

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- Town of Brewster Alewife Committee
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Trophic Interactions between Anadromous Juvenile Alewife (*Alosa pseudoharengus*) and Cyanobacterial Populations in a Shallow Mesotrophic Pond

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Goals and Questions

1) **Explore possible links between cyanobacteria and river herring declines.**
2) **Work with scientists to understand effects of cyanobacteria on river herring and their spawning habitat.**
3) **Monitor cyanobacteria and cyanotoxin transport along herring runs from spawning ponds to the sea (i.e., "pond-to-sea transects").**
   a) **Are cyanobacteria and cyanotoxins present in the freshwater aquatic system for the entire juvenile Alosa life history period?**
   b) **Do juvenile river herring accumulate cyanotoxins, and if so, does it affect their condition?**
   c) **Is there physical transport of cyanotoxins in stream flow?**
   d) **Is there biological transport of cyanotoxins in juvenile herring migrating from ponds to the sea?**
   e) **Are concentrations of cyanotoxins in fish tissue and/or water occurring at environmentally relevant concentrations?**

4) Do river herring run size estimates provide any insights to potential effects of cyanobacteria?

Monitoring Locations and Years

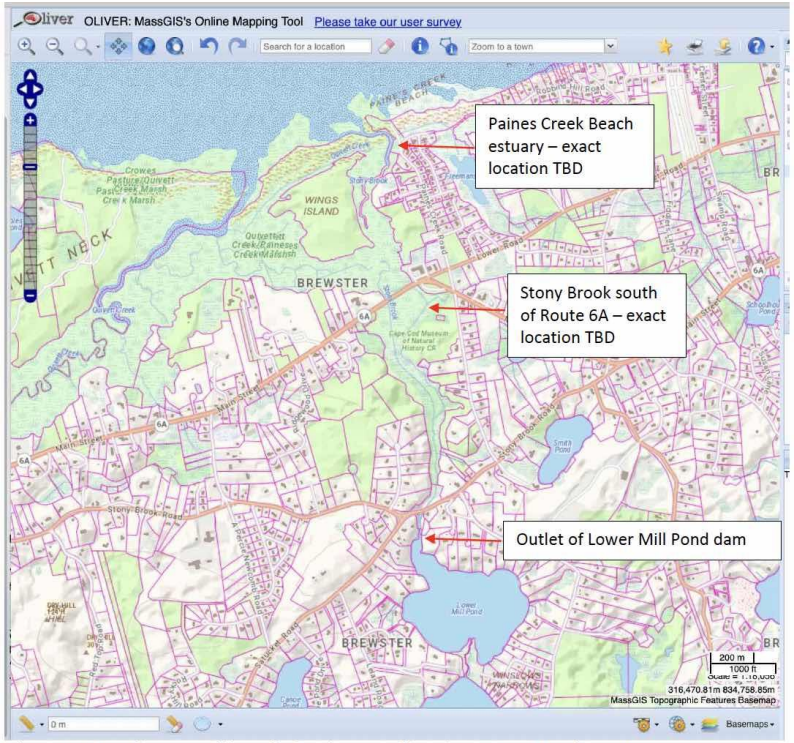


Figure 1. Map of proposed juvenile herring sampling sites, Stony Brook run, Brewster.

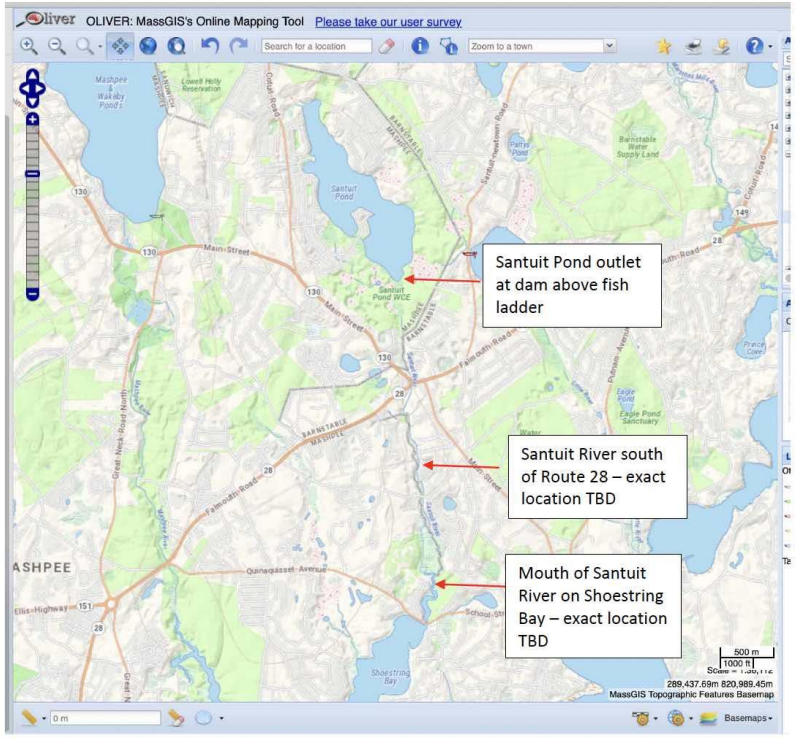


Figure 2. Map of proposed juvenile herring sampling sites, Santuit Pond run, Mashpee.

2019: Lower Mill Pond, Brewster (Leland et al, 2020).

2021: Lower Mill Pond, Stony Brook, and Paines Creek estuary (APCC 2021 study with N. Leland).

2021: Santuit Pond and Santuit River, Mashpee. (APCC 2021 study with N. Leland).

Do Juvenile Herring Accumulate Cyanotoxins? If So, Are They Affected?

Table – Cyanotoxin concentrations in juvenile herring. From Leland et al 2020 and unpublished results by Leland, 2021 APCC study.

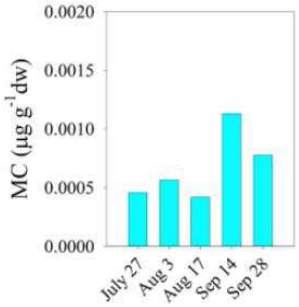
Date and Pond	Average Microcystin concentration in fish tissue, μg/g dw	Average BMAA concentration in fish tissue, μg/g dw)	Average Anatoxin concentration in fish tissue, μg/g dw	Fish condition (Fulton Condition Index) where slope of weight:length ratio of 3 or better is good
2019 Lower Mill Pond	0.003 *	4.49**	0.08	3.1 (good)
2021 Lower Mill Pond	0.0006	4.51	0.00002	3.1 (good)
2021 Santuit Pond	0.001	4.81	0.00001	2.5 (degraded)

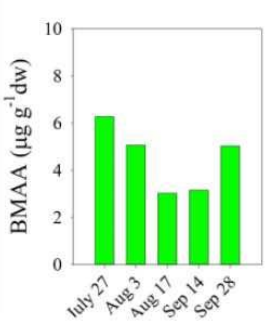
* Potential transfer to consumer is 0.0012 μg of MC

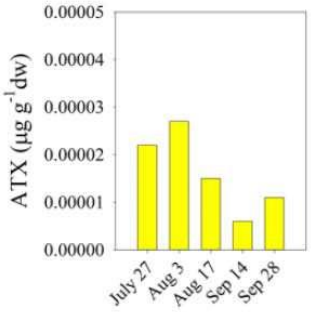
**Potential transfer to consumer is 1.85 μg of BMAA.

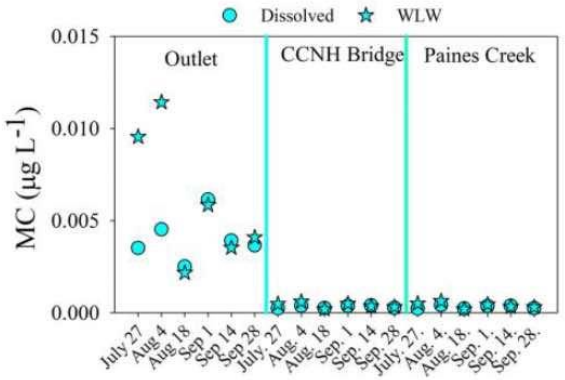
Are Cyanotoxins Present in Fish Tissue and Water?

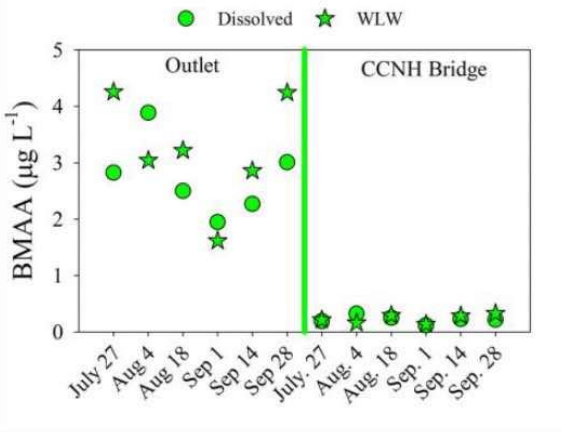
Cyanotoxins accumulated in juvenile Alosa pseudoharengus
and moved downstream via physical (water column) and biological (fish tissue) transport

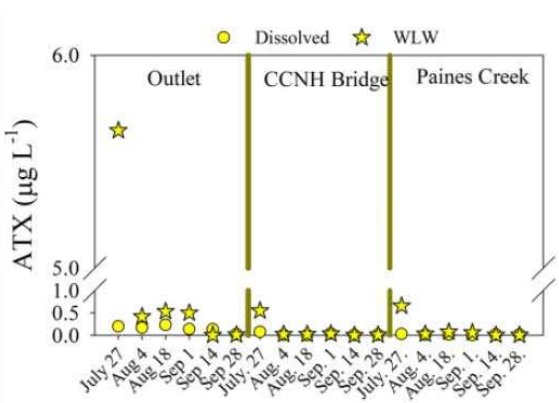






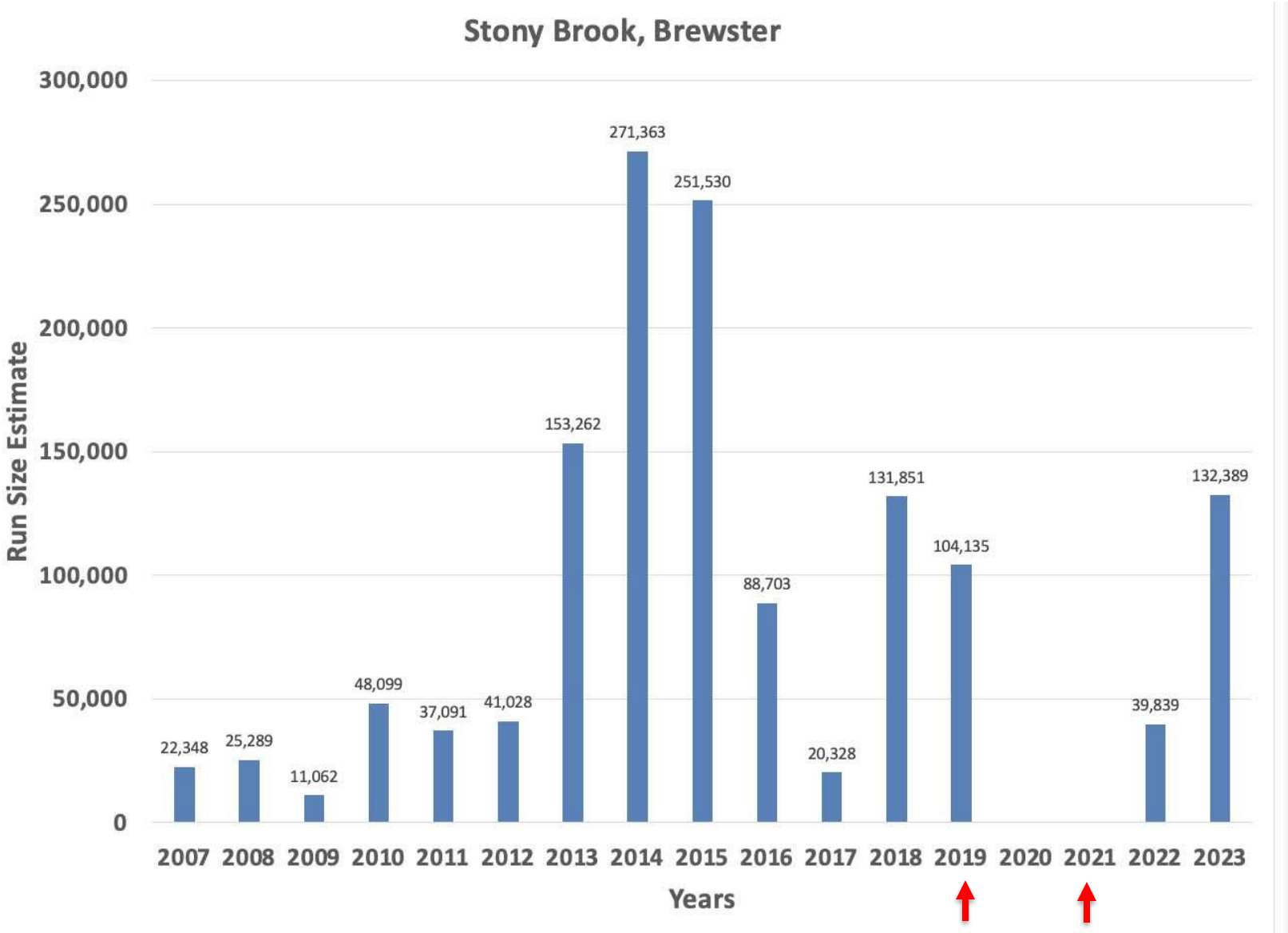


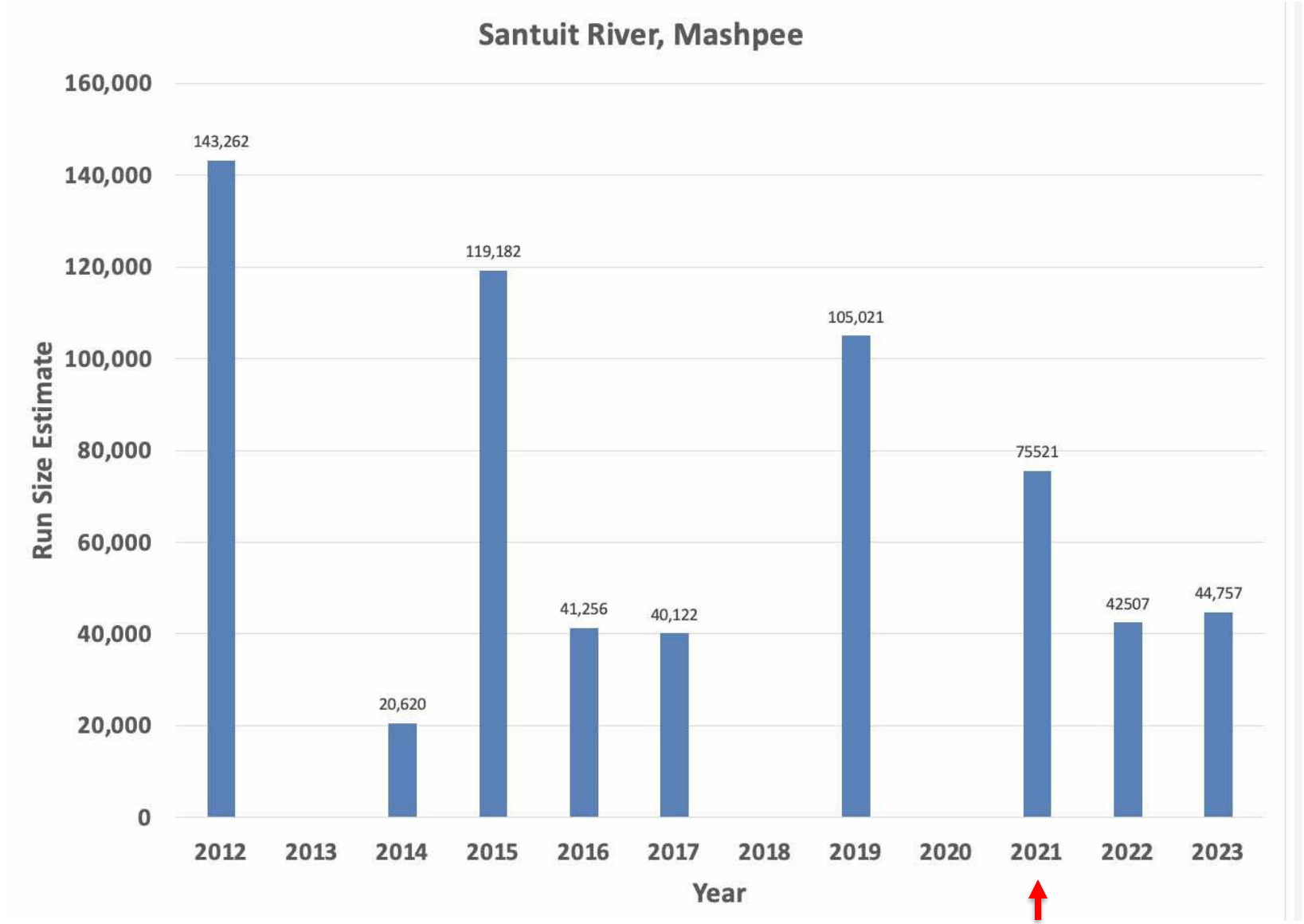




Bottom charts: 3 different cyanotoxins present at different locations in Stony Brook system, 2021

What do Herring Run Sizes tell us?




Santuit River, Mashpee
Run Size Estimate
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
143,262
20,620
119,182
41,256
40,122
105,021
75521
42507
44,757
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year

Conclusions

1) **Explore possible links between cyanobacteria and river herring population declines. More research is needed to understand if there are links.**

2) **Monitor cyanobacteria and cyanotoxin transport along herring runs from spawning ponds to the sea (i.e., "pond-to-sea transects"). This pilot looked at two transects.**

   a) **Are cyanobacteria and cyanotoxins (MC, BMAA and ATX) present in the aquatic system for the entire juvenile Alosa life history period? Yes for July-Oct.**

   b) **Do juvenile river herring accumulate cyanotoxins (Yes), and if so, does it affect their condition? (Not clear).**

   c) **Is there physical transport of cyanobacteria and cyanotoxins in stream flow? Yes.**

   d) **Is there biological transport in juvenile herring migrating from ponds to the sea? Yes.**

   e) **Are concentrations of cyanotoxins in fish tissue and/or water occurring at environmentally relevant concentrations? Toxin concentrations in water could affect some invertebrates.**

4) Do river herring run size estimates provide any insights to potential effects of cyanobacteria? Run sizes are likely affected by many factors. More targeted studies and controls are needed.

Questions for further research

1) These studies used the Fulton Condition Index (weight:length ratio) as a measure of fish condition. Is there a more specific indicator of fish health that can be related specifically to cyanotoxin in fish tissue?
2) By feeding on cyanobacteria, do juvenile herring serve as a control on cyanobacteria populations in ponds and lakes?
3) Do juvenile herring retain cyanotoxin in tissues as they mature in the sea, or is cyanotoxin eventually purged from tissues?
4) Do adult herring tissues contain cyanotoxin from their early days as juveniles feeding on cyanobacteria?
5) What are the food web implications if juvenile herring ingest and accumulate cyanotoxins?
6) How does pond water quality affect juvenile river herring?

For more information

Visit APCC's website at https://apcc.org/our-work/science/community-science/herring/ .

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