Population dynamics and restoration ecology of anadromous river herring

Mystic River Science Initiative Forum – April 30, 2019

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Collaborators

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Connecticut DEEP
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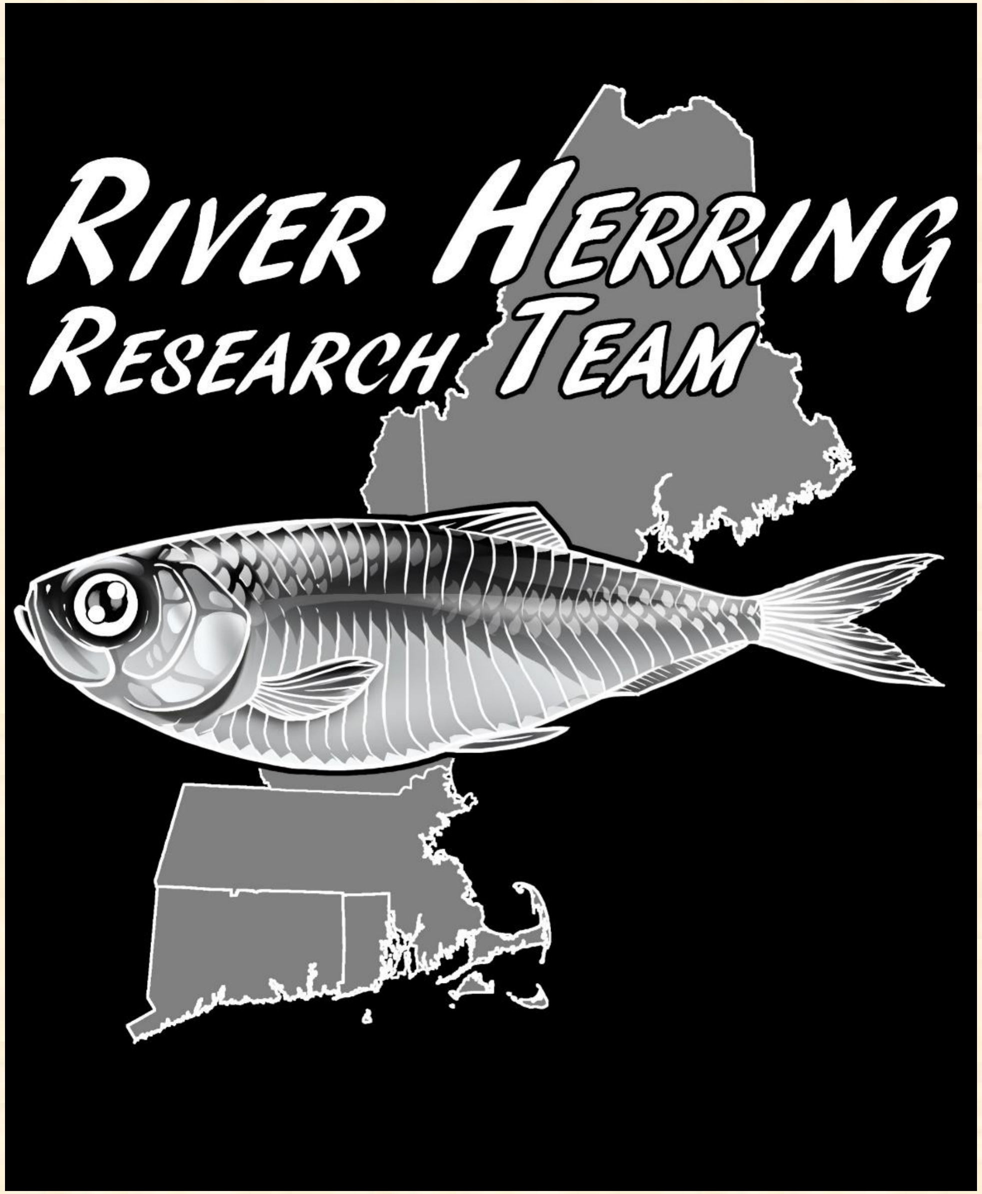
Maine DMR
Mystic River Watershed Association
Various Conservation Commissions

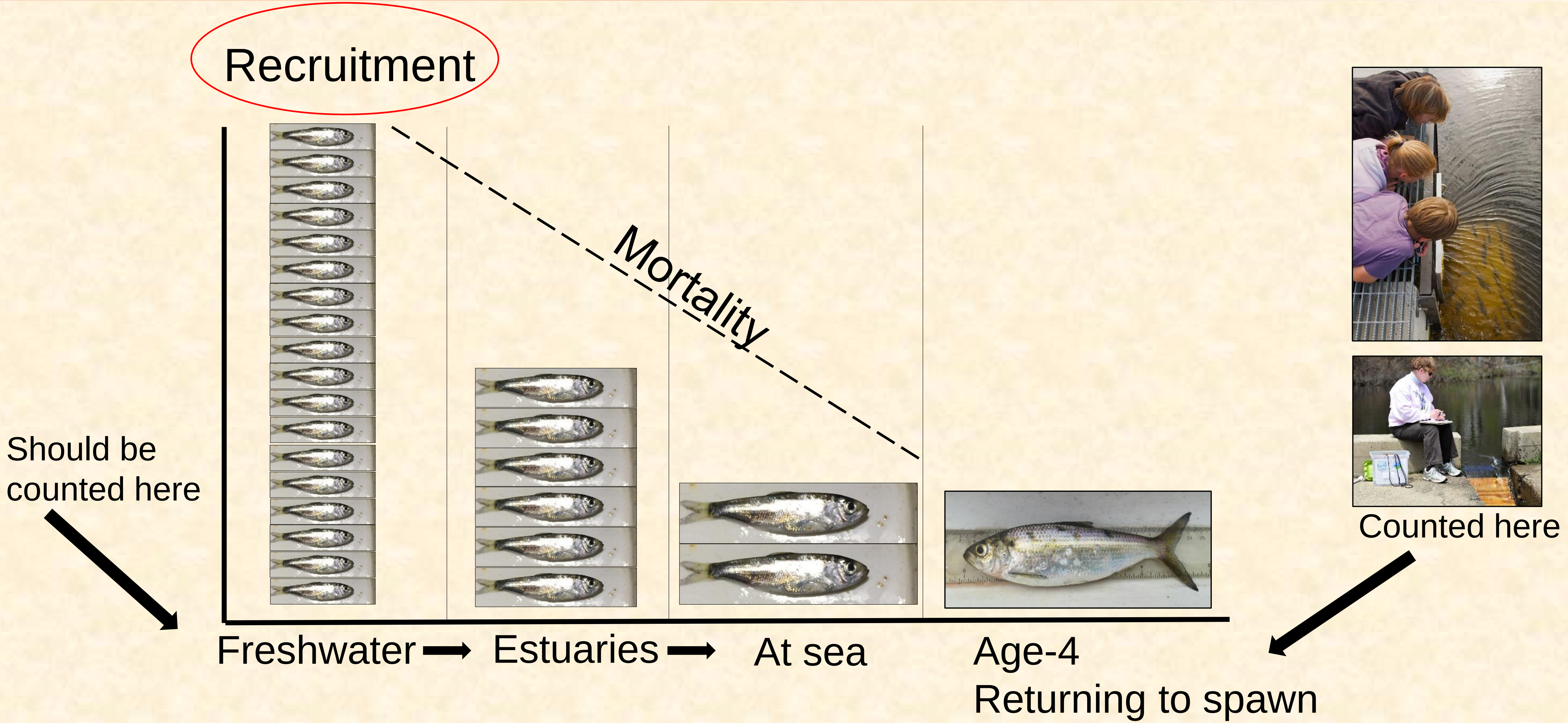


Population Data From Adult Run Counts

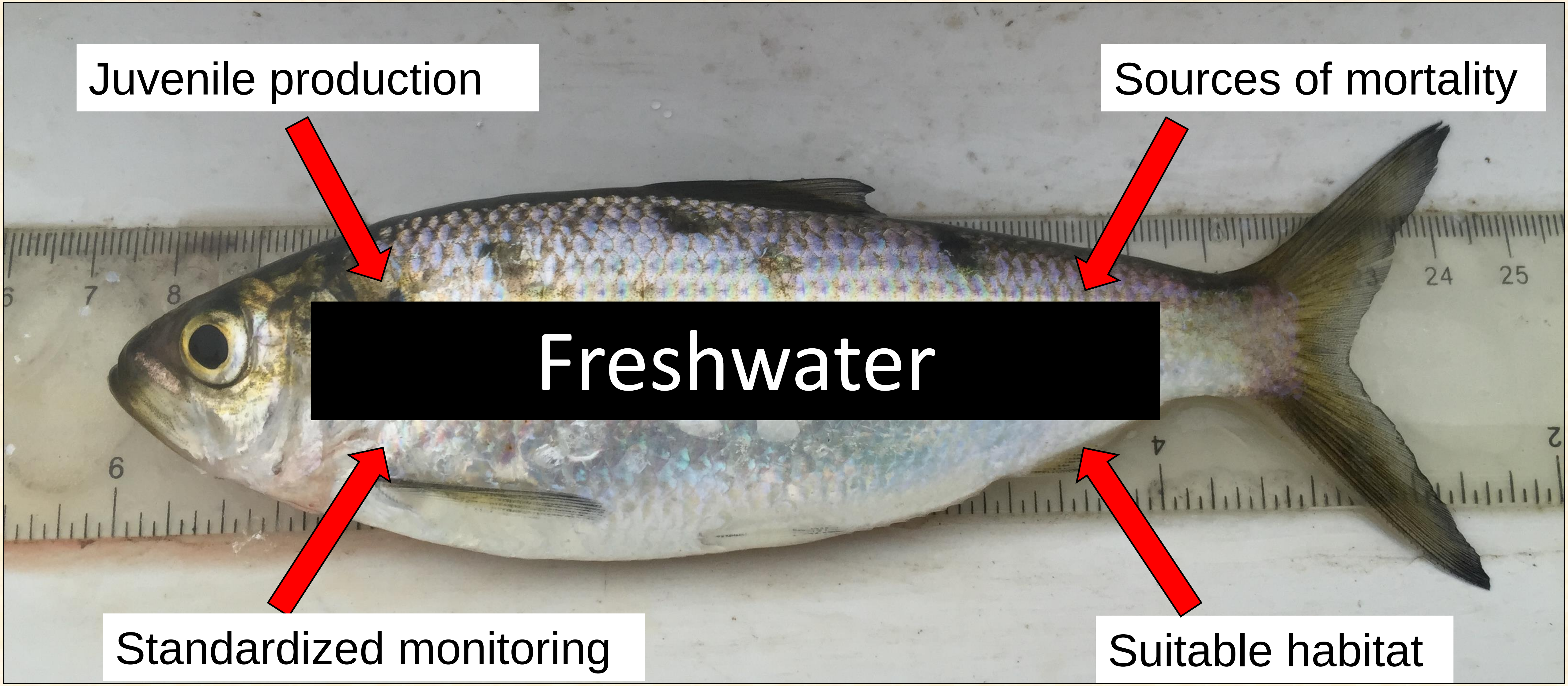
- Monitored a number of ways:
  - Electronic
  - Video
  - Citizen science

- Providing data on:
  - Number of adults returning annually
  - Timing of returns
  - Adult size/age structure

How Many Fish Are There Initially?



Data Gaps


Juvenile production
Sources of mortality
Freshwater
Standardized monitoring
Suitable habitat

Research Objectives

Population Dynamics

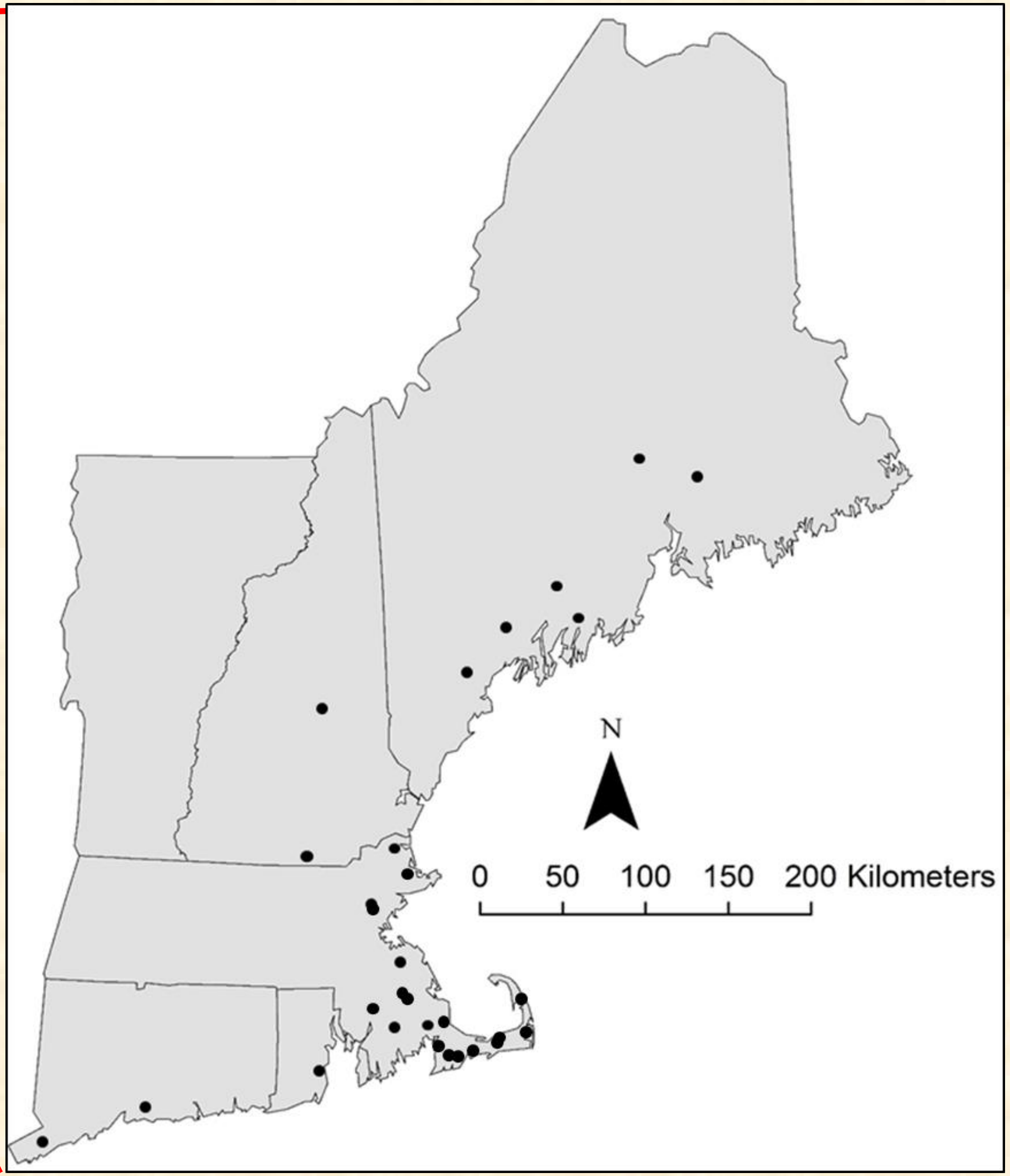
1. Investigate juvenile density, growth, and mortality in FW lakes
   - -Explore variability among lakes and from year-year
   - -Examine abiotic/biotic factors influencing productivity
2. Evaluate relationship between adult counts and juvenile densities

Restoration Ecology

1. Evaluate response to restored habitats
   - -Magnitude and timing of recovery
   - -Comparisons to natural runs
2. Model habitat suitability for prioritizing habitat restoration

Study Lakes

- 2014–2018
- Sampled 32 coastal lakes
- 5 lakes sampled all years
- Estimate of adults
- Stocked & natural runs



Fish Sampling Methods

100’ X 15’ 1/16” mesh

- 5–10 hauls/**night**
- June, July, August
- Random sampling
- Enumerated all herring
- 30/haul for age & growth


USGS

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North American Journal of Fisheries Management

Article

Precision and Relative Effectiveness of a Purse Seine for Sampling Age-0 River Herring in Lakes

Matthew T. Devine, Allison H. Roy, Andrew R. Whiteley, Benjamin I. Gahagan, Michael P. Armstrong, Adrian Jordaan

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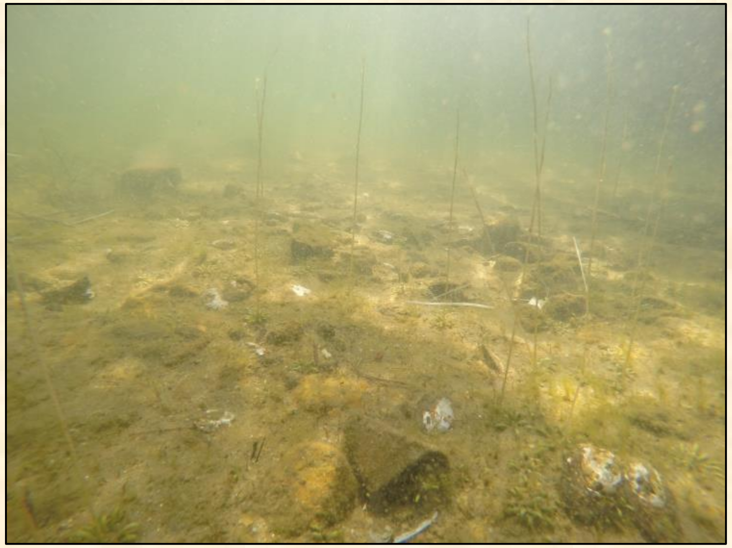
Habitat Quantity and Quality

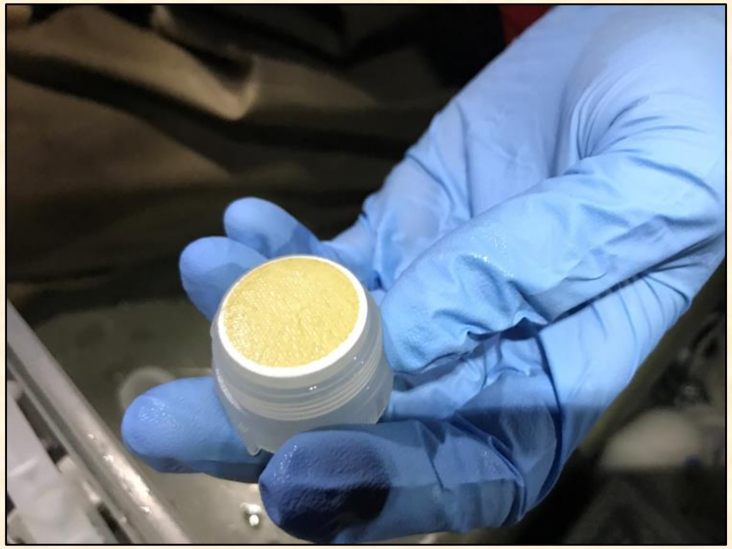
<u>Quantity</u>

- Surface area
- Depth
- Shoreline distance

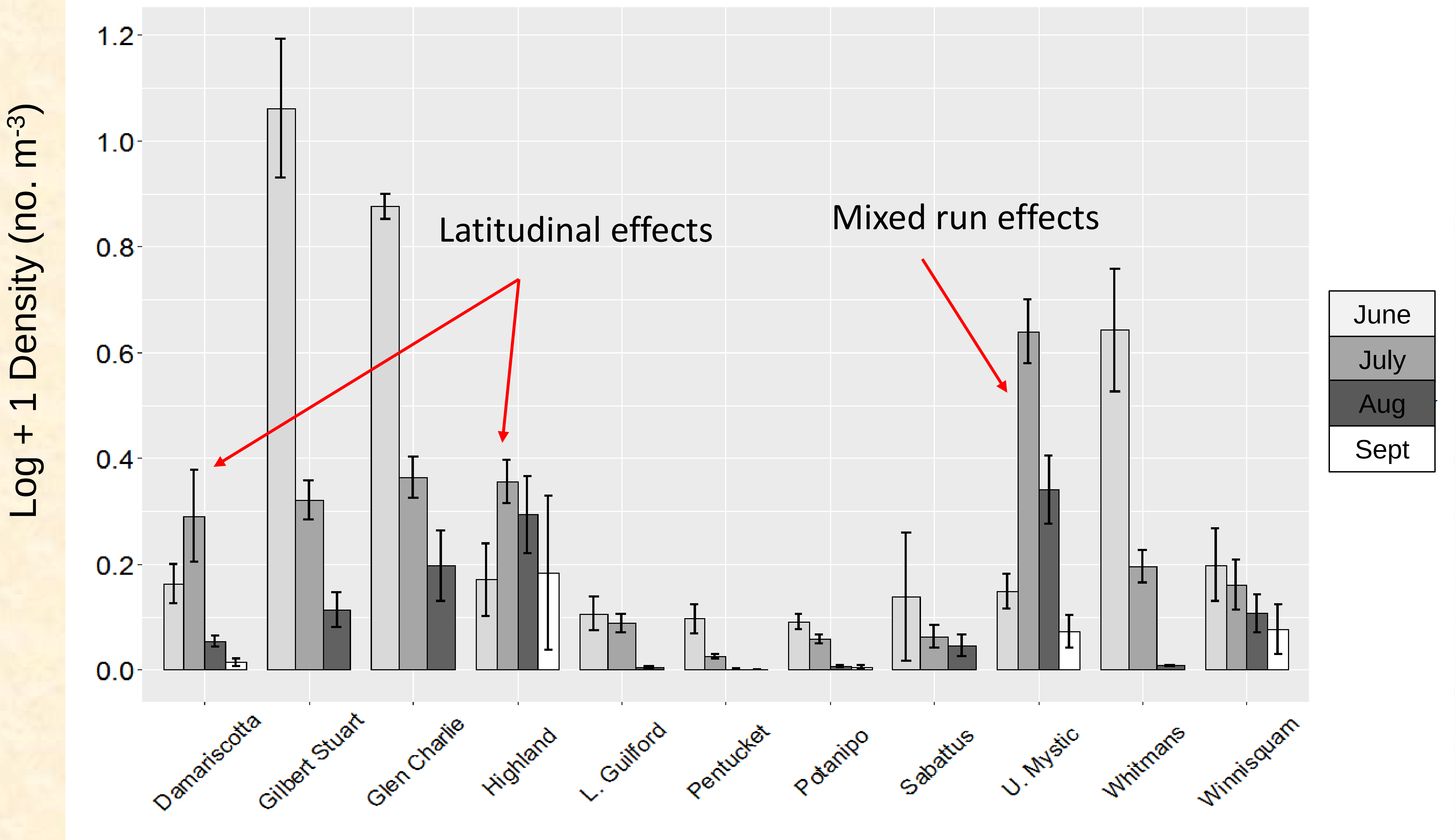
<u>Quality</u>

- Phosphorous
- Nitrogen
- Dissolved Organic Carbon
- Chlorophyll-a
- Temperature
- Dissolved Oxygen
- Secchi depth
- Zooplankton



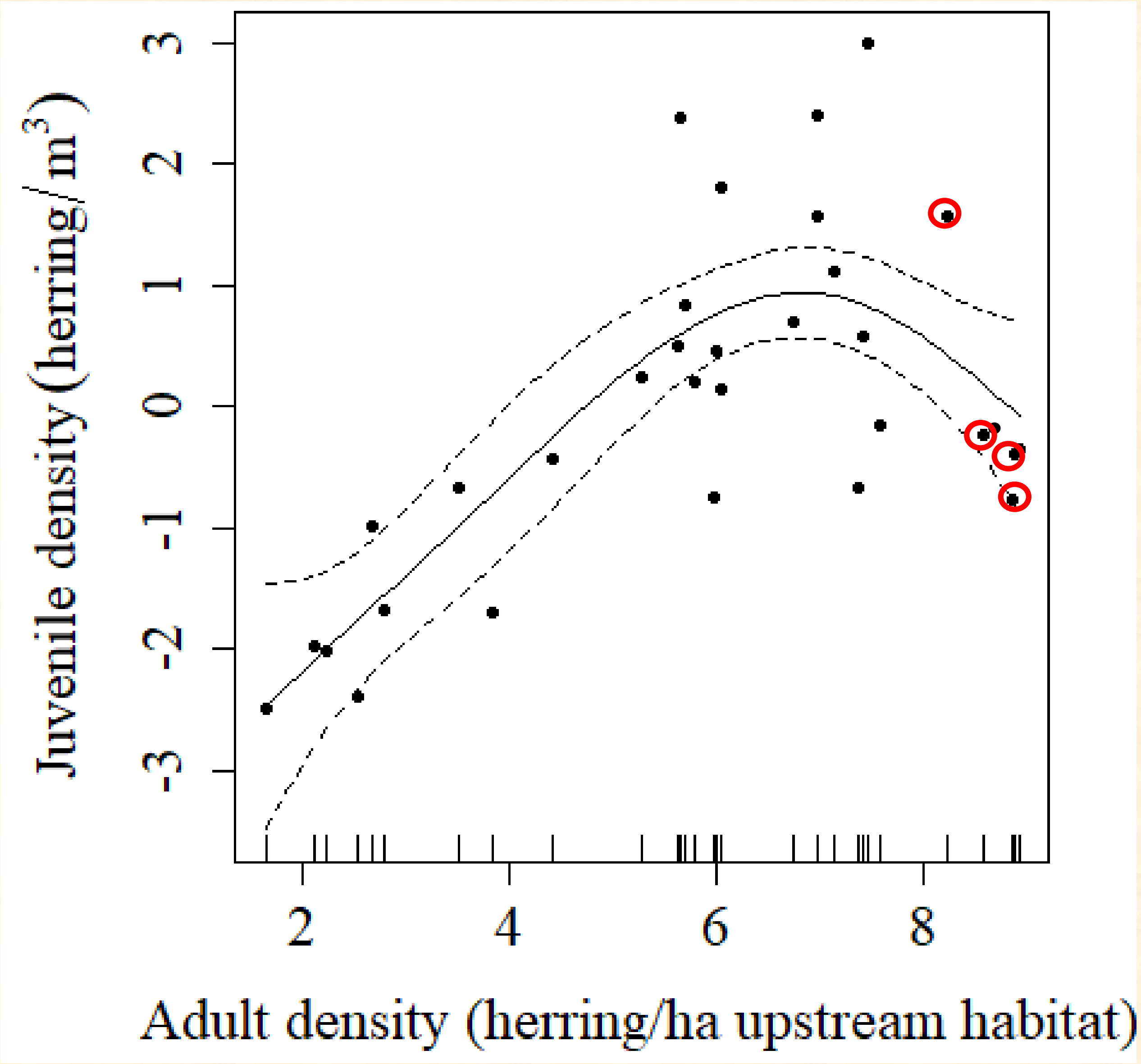


Density: Variation Within and Among Lakes

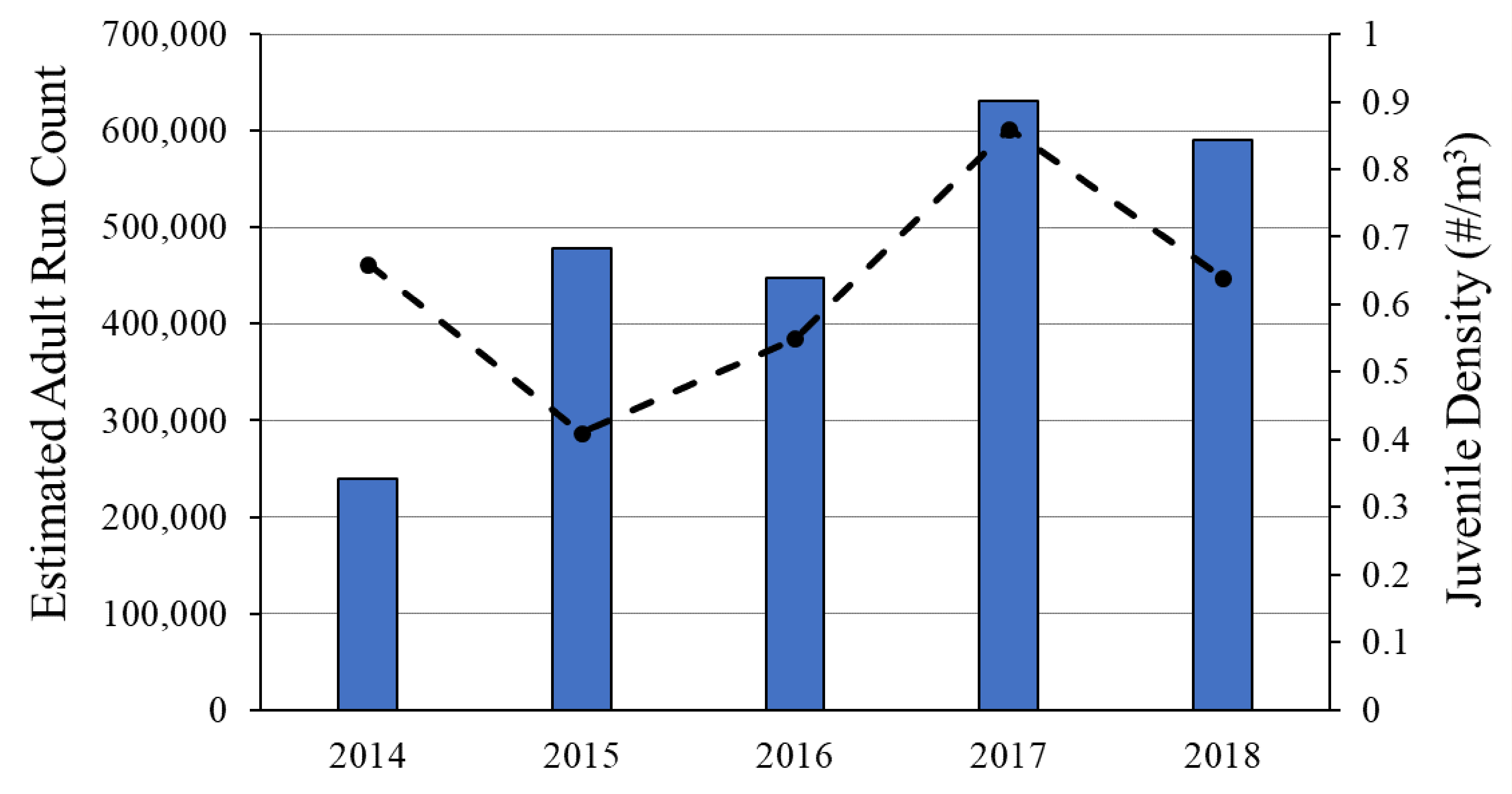


Density-Dependent Recruitment

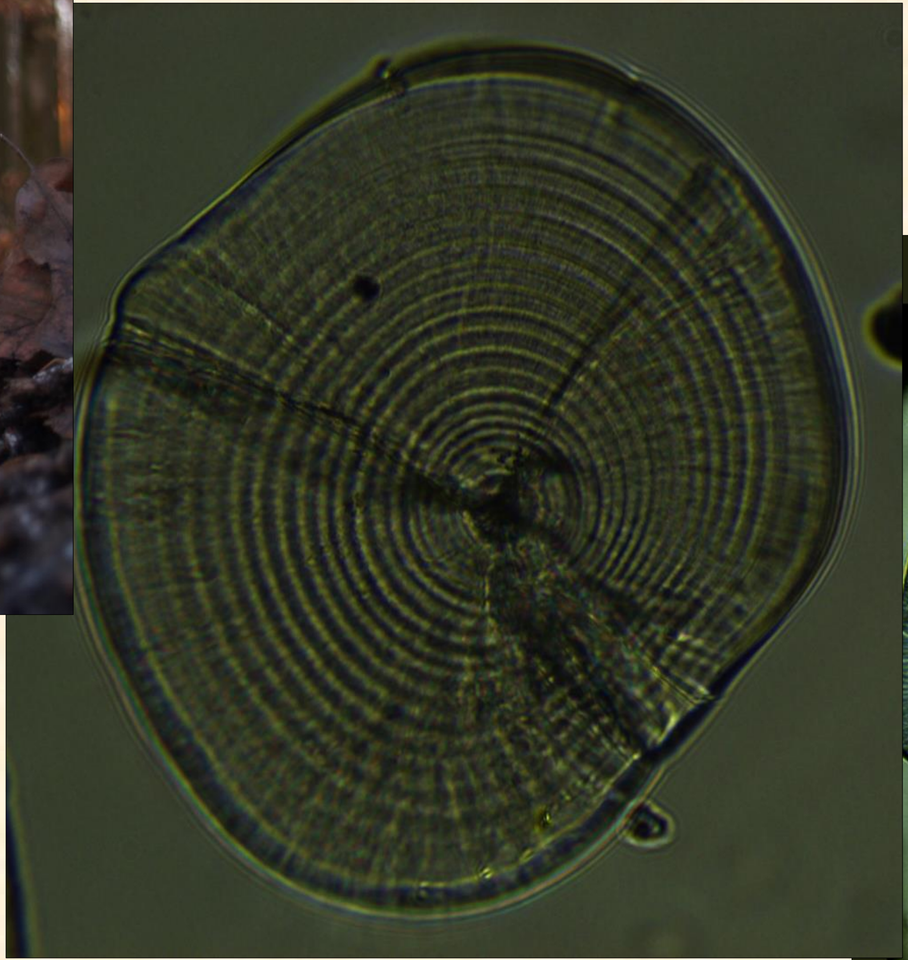
- Largely influenced by # of adults
    - 64% deviance explained (GAM)
- Non-linear
- Uncertainty at high densities
- Decline in production (1k/ha)

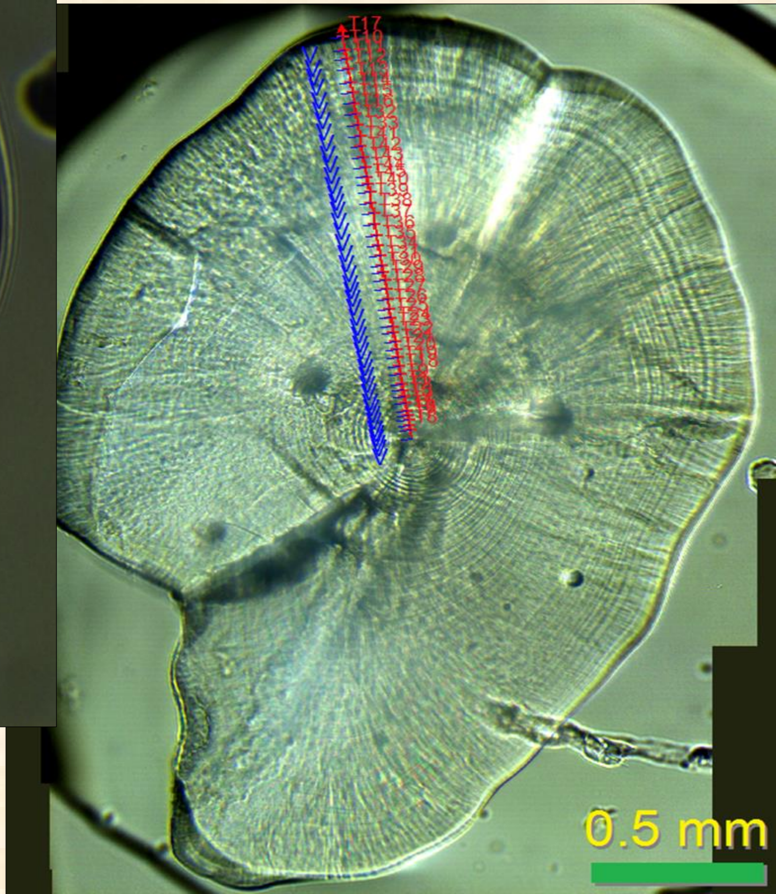


Upper Mystic Lake

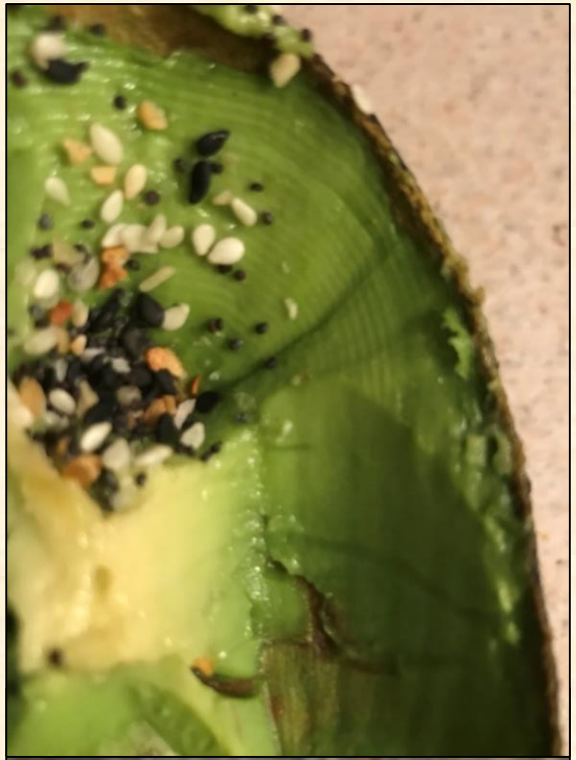


Otoliths Provide Growth History

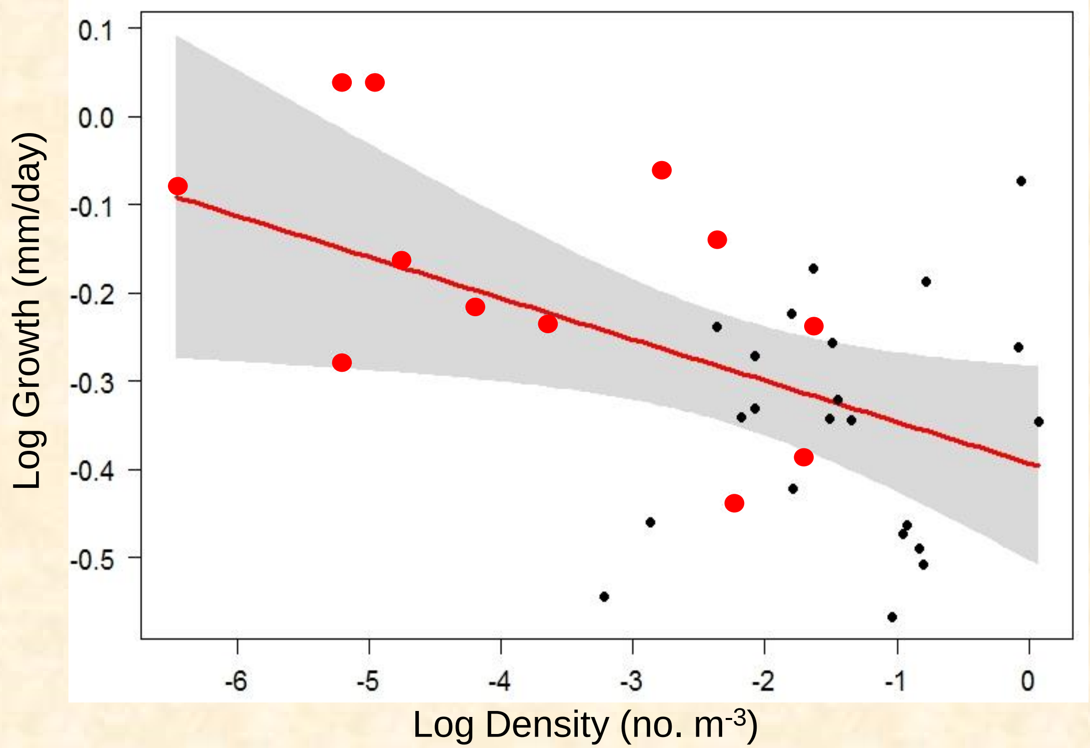




Otoliths on the Mind



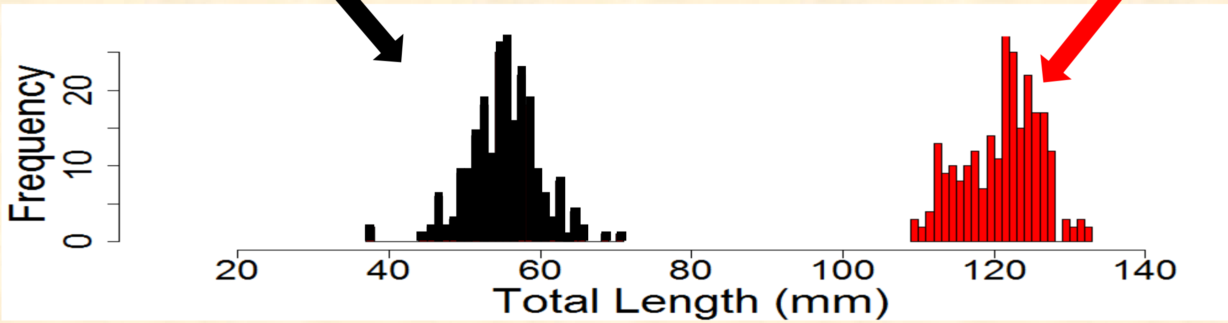
Density-Dependent Individual Growth



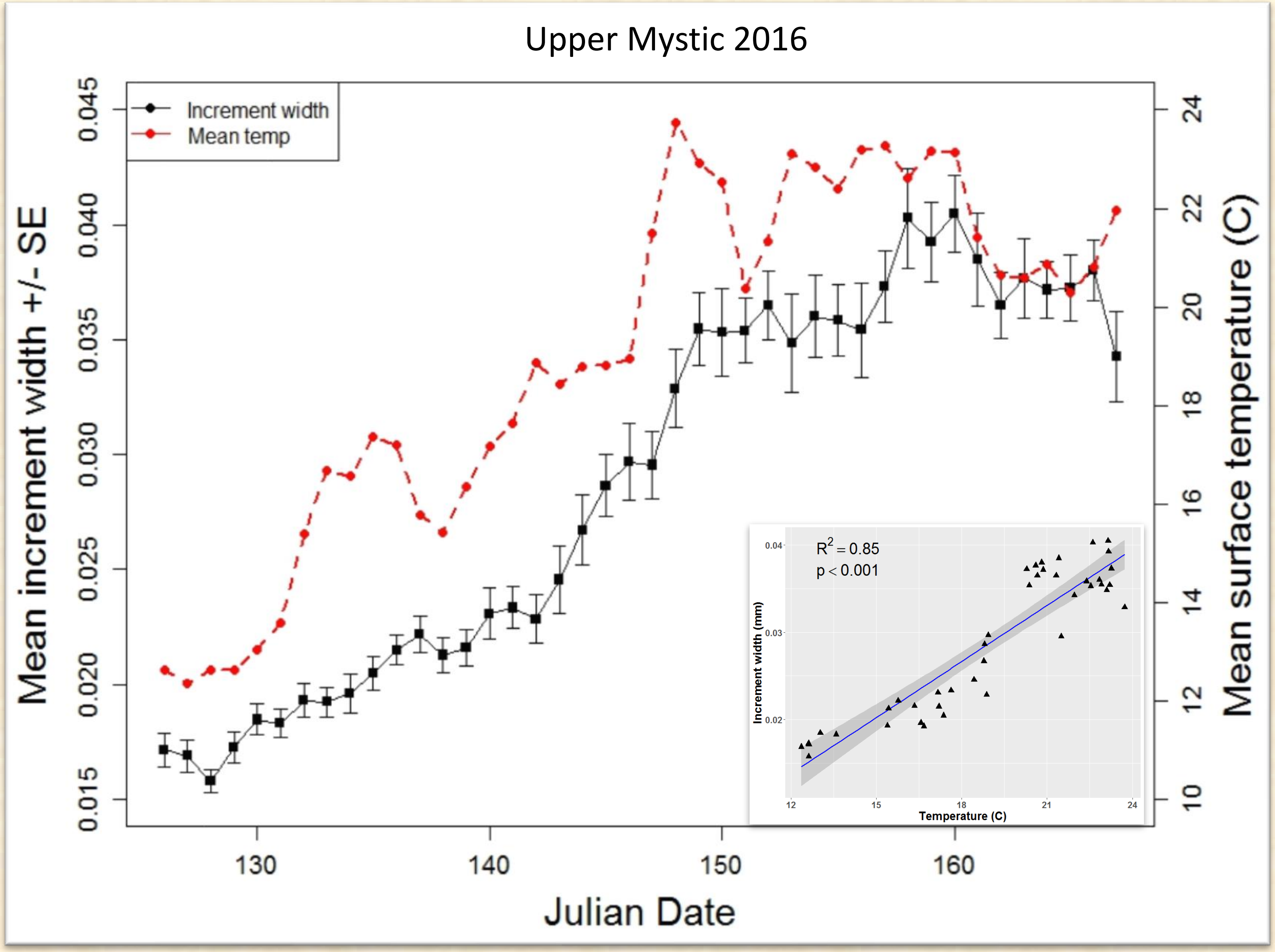
- Growth negatively related to density
- Leads to variation in size-at-age

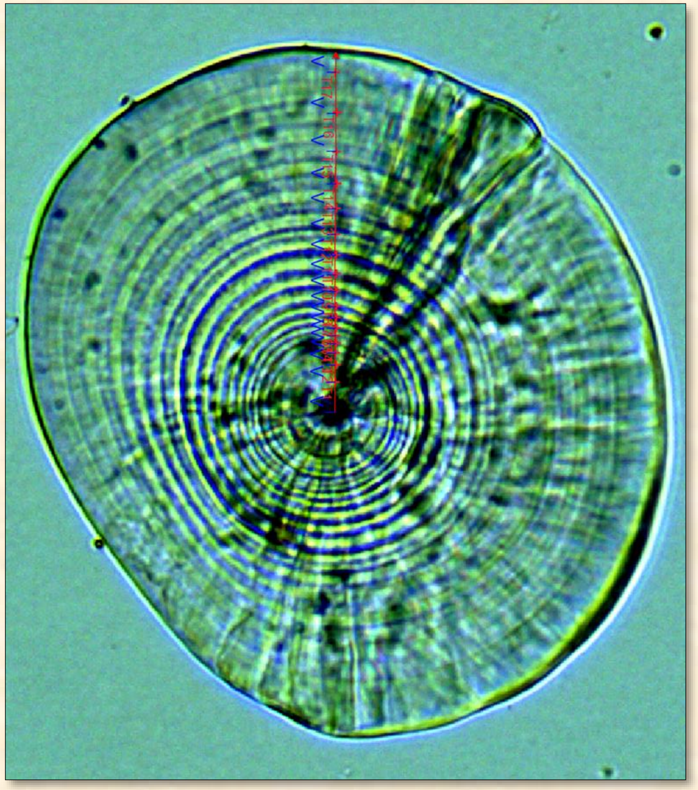
August 2015

August 2015



Daily Growth Related to Temperature





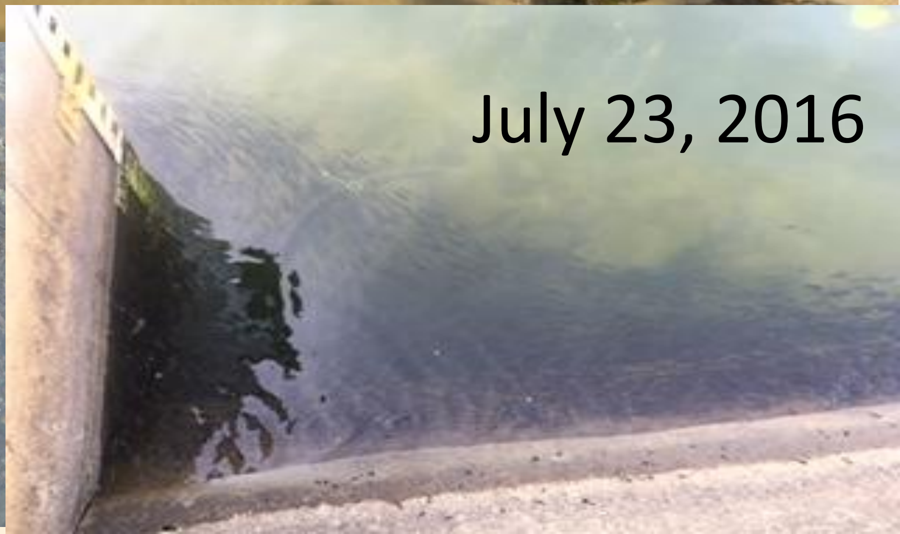
Grow Fast, Leave Early: Recipe for Survival?

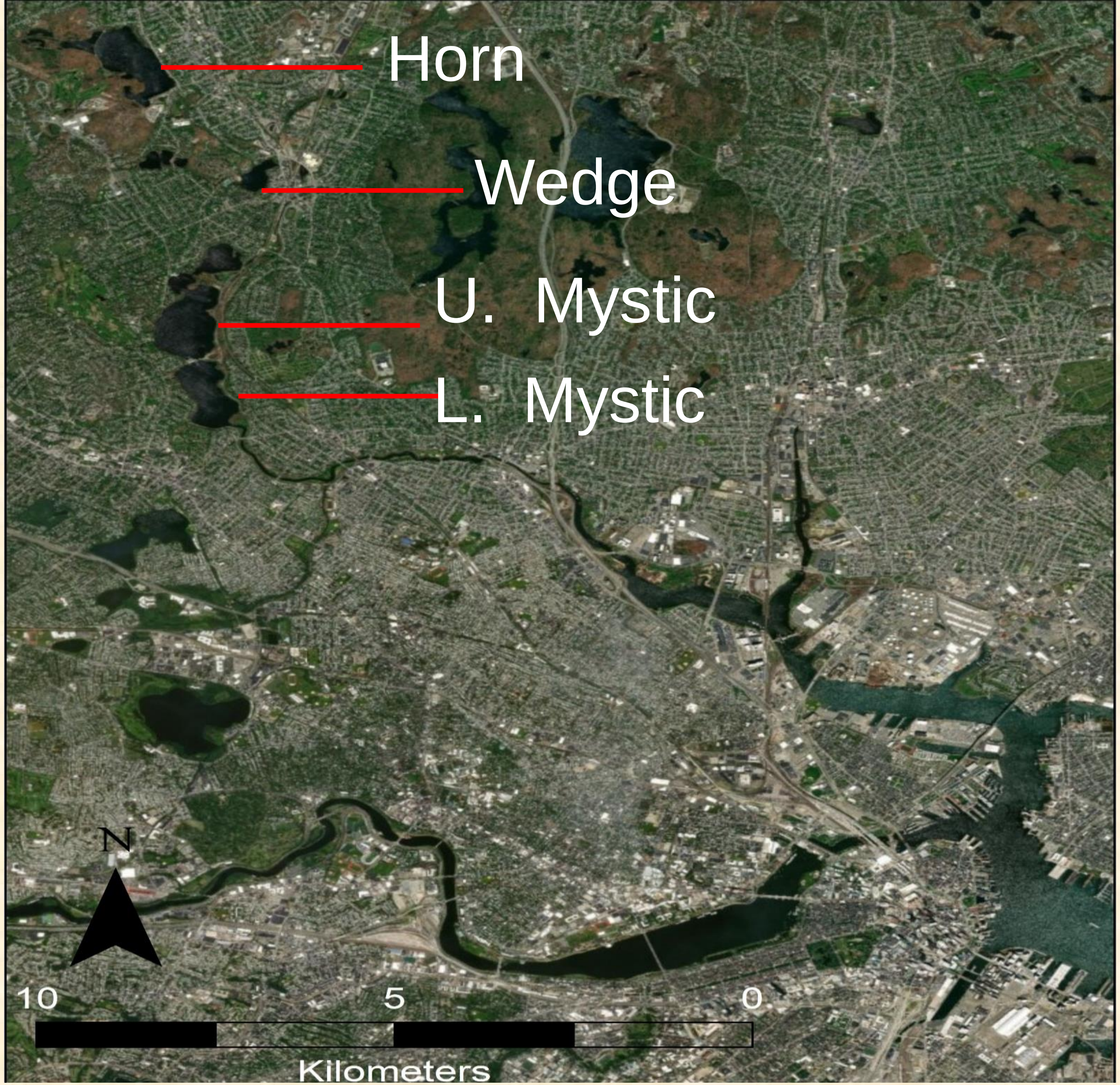
Consequences of Stranded in Lakes

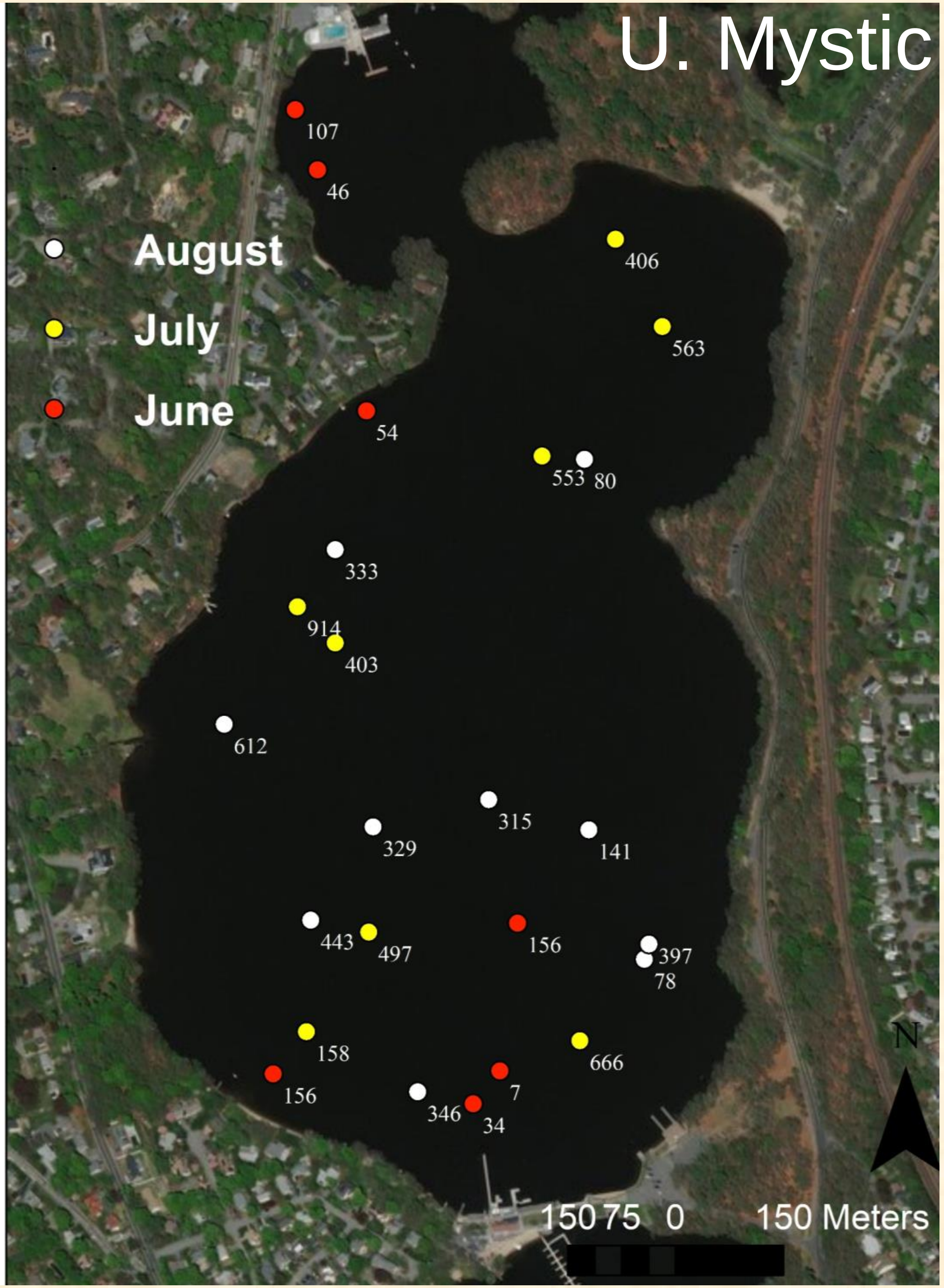
- Increased competition
- Slower growth rates
- Thermal stressors
- Altered diet (less preferable items)
- Limited nutrient flux

Challenges to Emigration

- Drought
- Lake drawdowns
- Low flow events



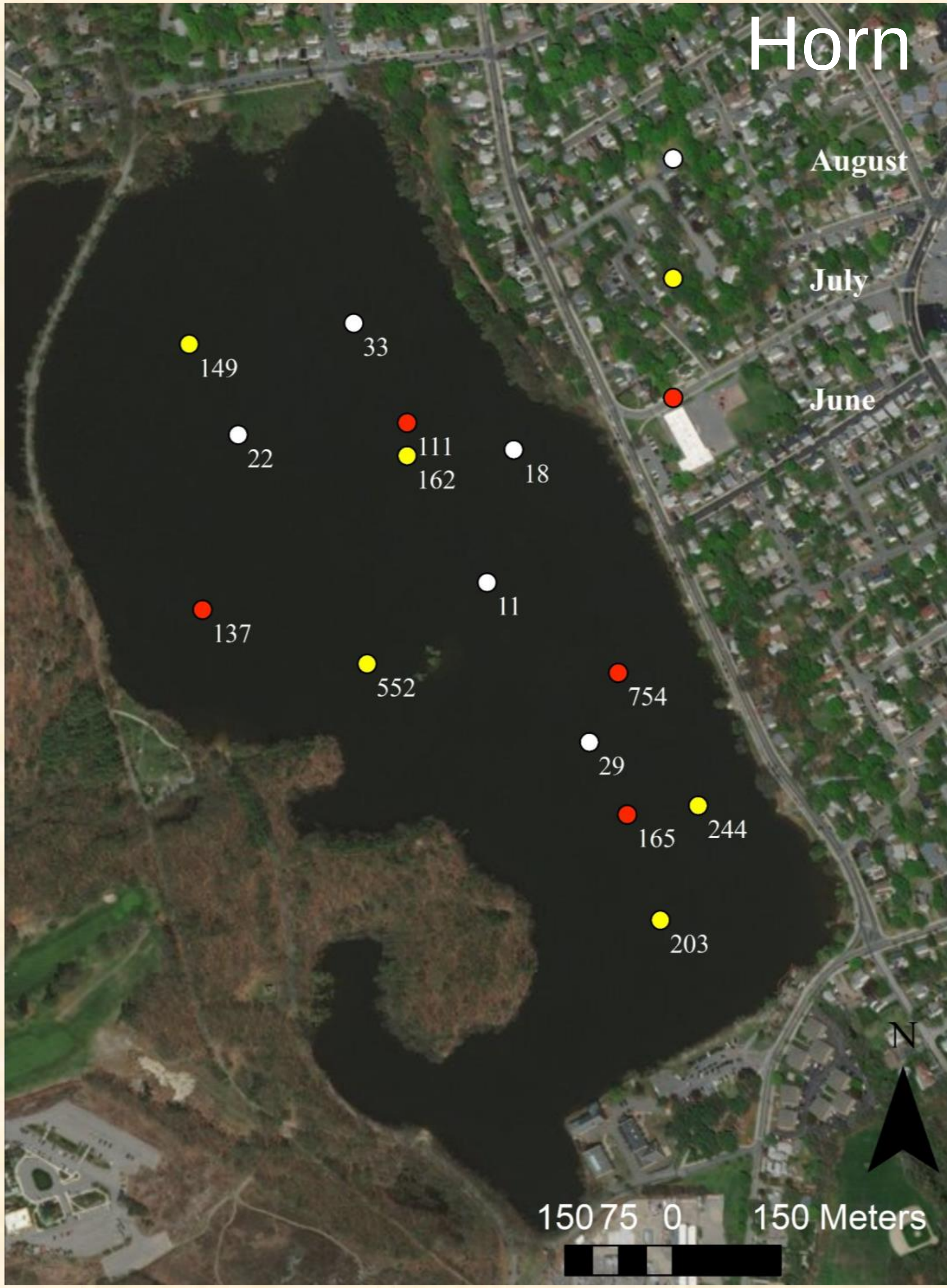

Horn
Wedge
U. Mystic
L. Mystic
N
10
5
0
Kilometers



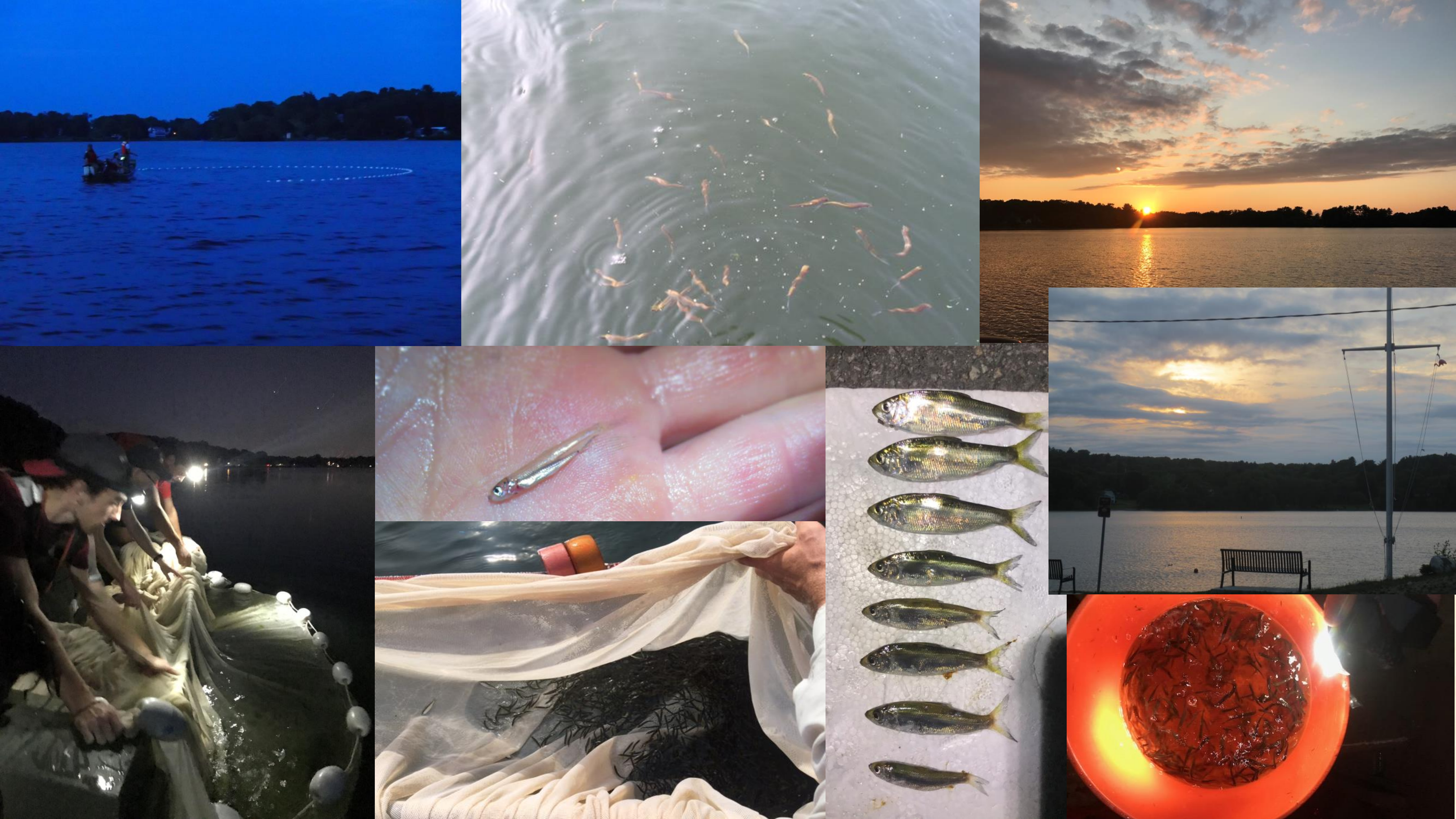
Average
 # herring/haul

U. Mystic
June: 80
July: 520
Aug: 307

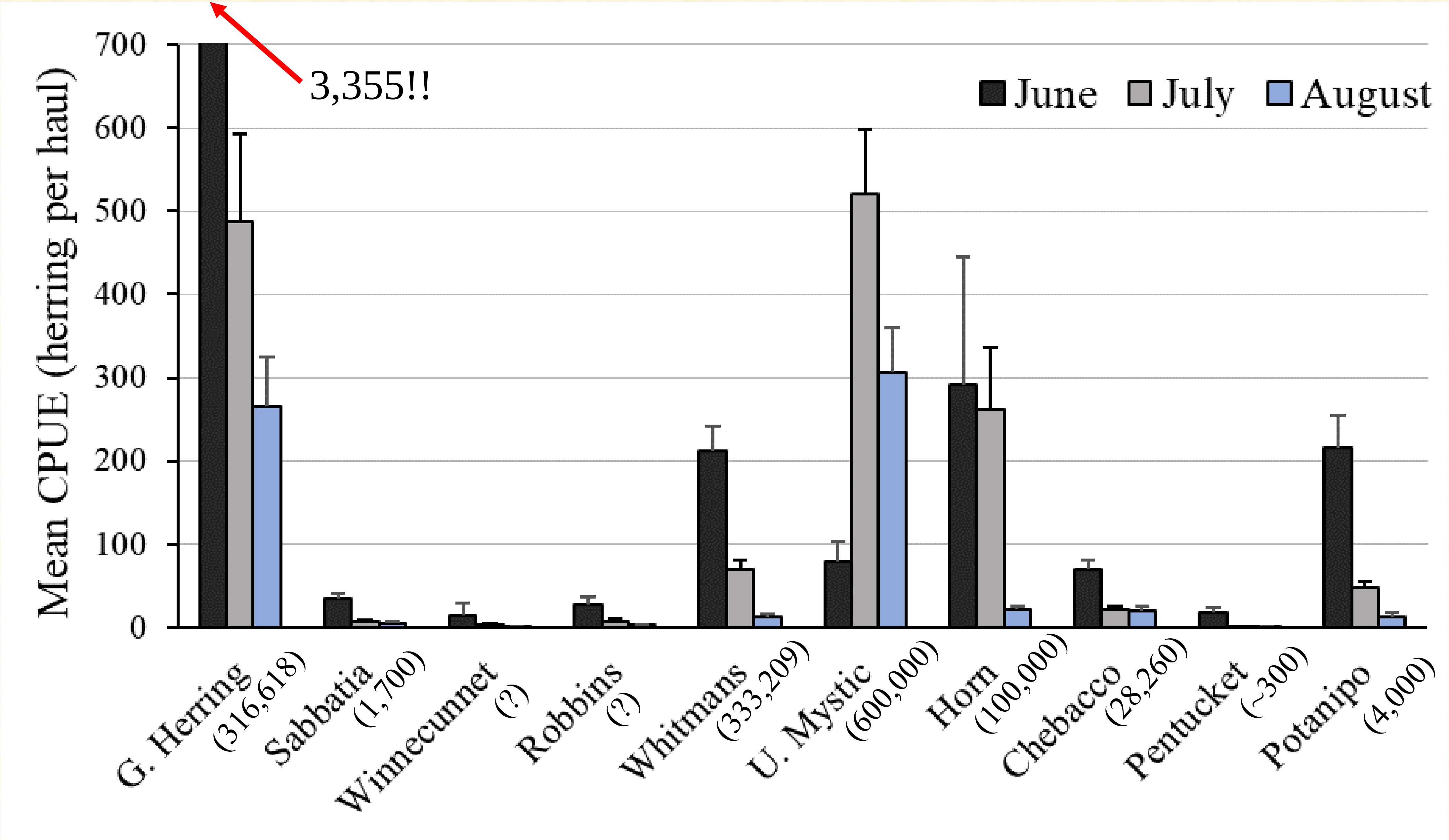
Horn
June: 292
July: 262
Aug: 23



Documented successful spawning & reproduction in first year!!!



Initial Results

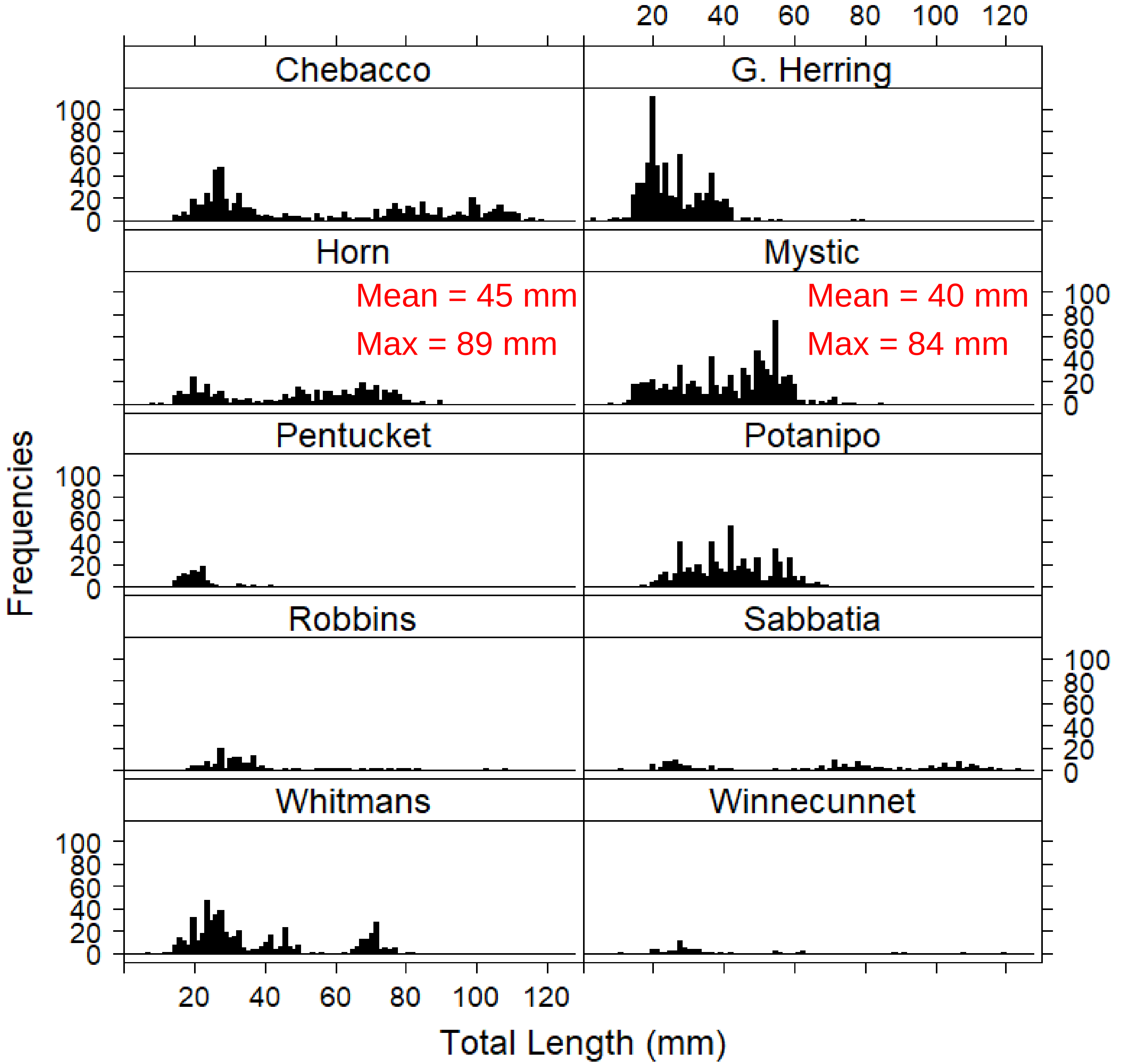


2018 Length Data

- Achieve larger sizes initially in restored sites relative to long-term sites

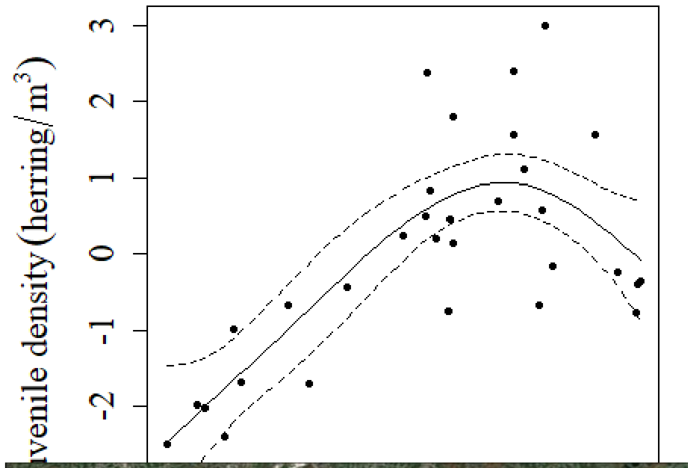
- Density-dependence

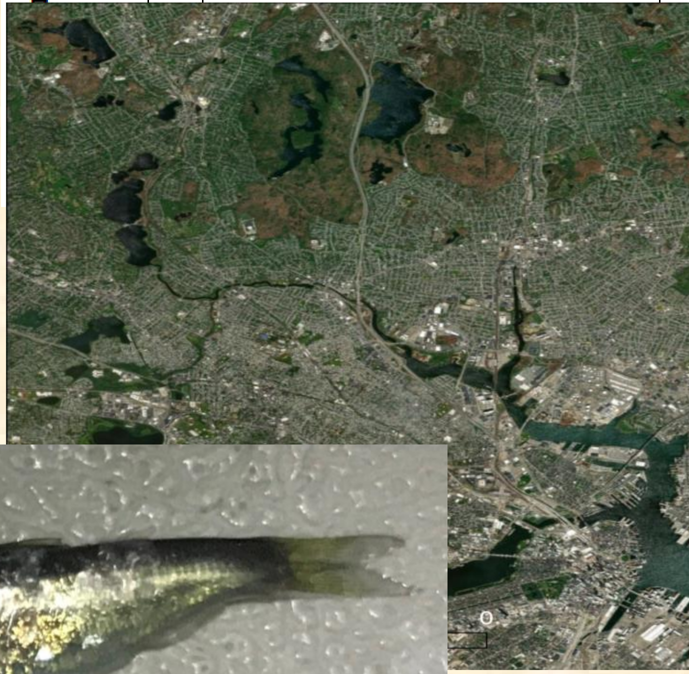
- Abundant zooplankton prey

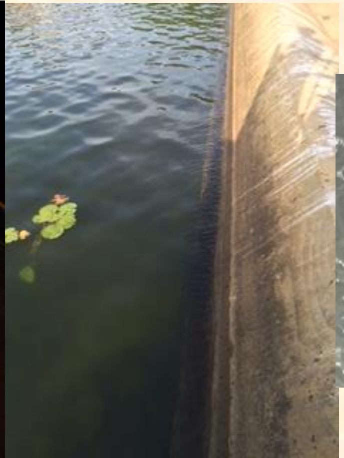


Management Implications

- Limits to any single restoration activity
  - -Models to help interpret expected productivity increases
- Prioritize increasing run size <u>AND</u> habitat area
  - -Mystic watershed a model example of success
- Water quality (temp, DOC) key to growth/survival
- Appropriate water levels essential for emigration







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Thank You

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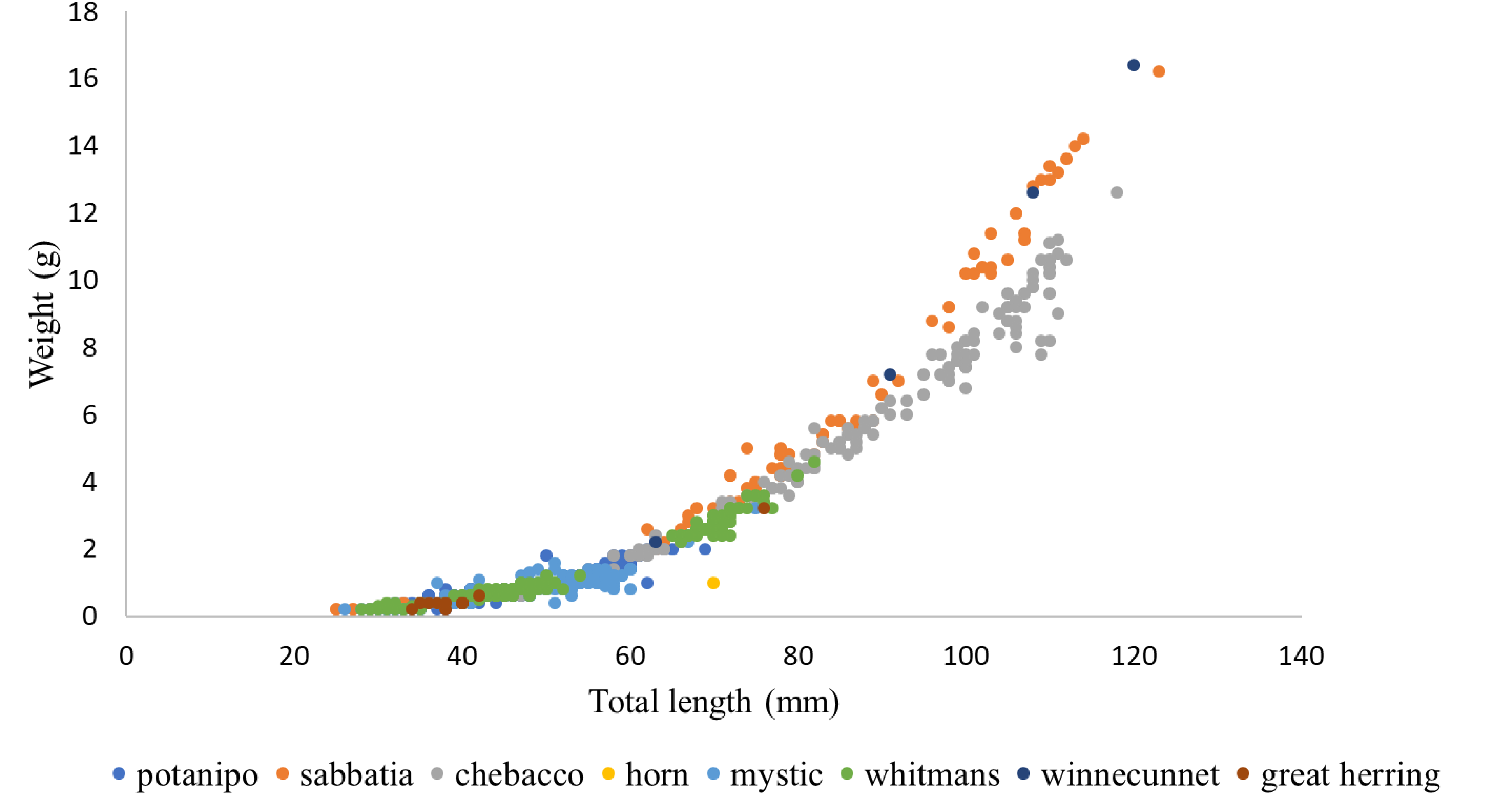
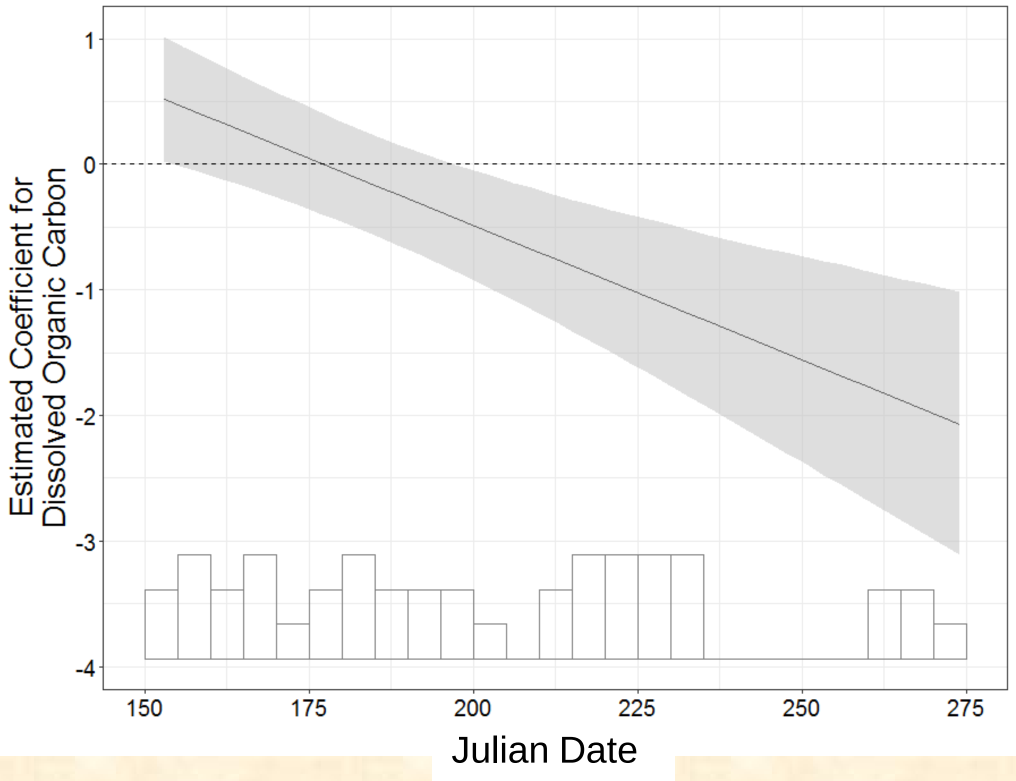


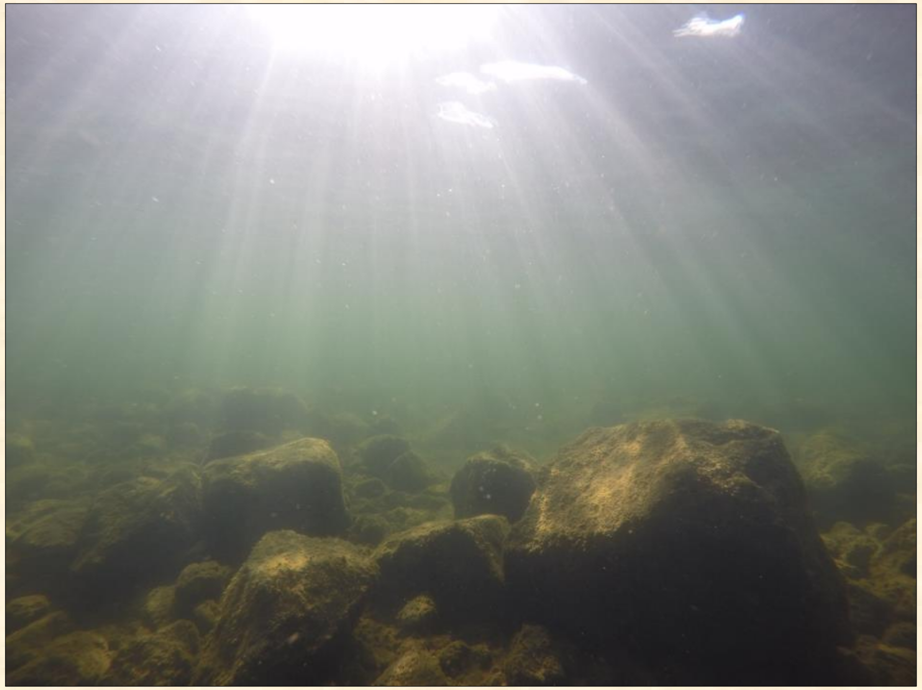
Weight (g)
0
2
4
6
8
10
12
14
16
18
Total length (mm)
0
20
40
60
80
100
120
140
potanipo
sabbatia
chebacco
horn
mystic
whitmans
winnecunnet
great herring

Negative Effects of Dissolved Organic Carbons



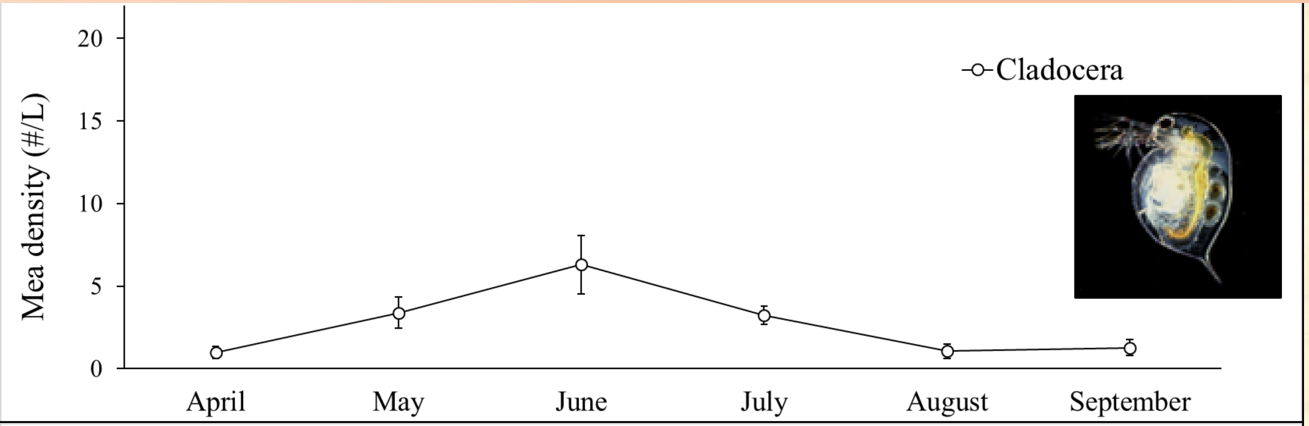
- Density negatively related to DOC
- "Browning" of water limits productivity
- Complex physical/biological effects

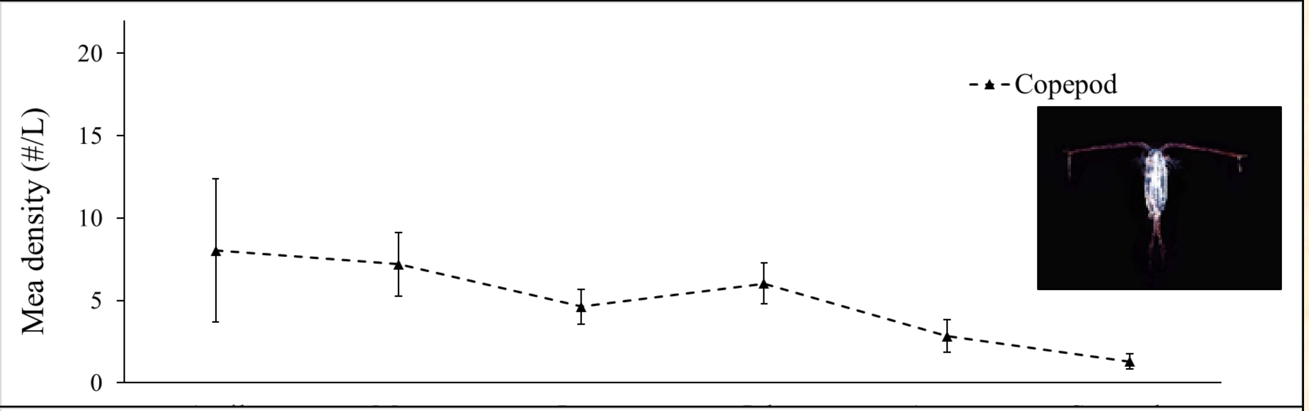
Karlsson et al. 2009 Finstad et al. 2014; Craig et al. 2017

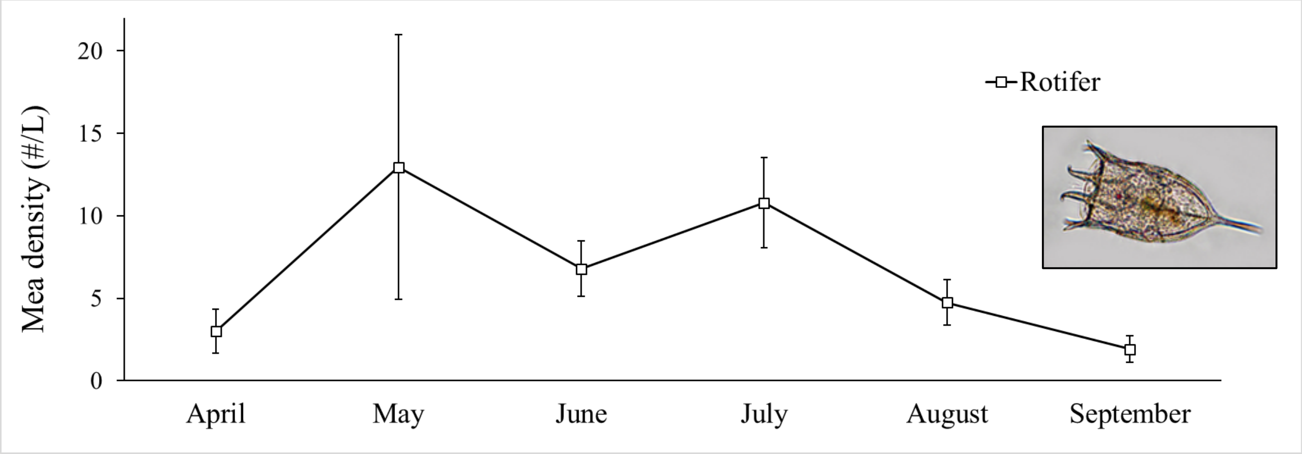


Candidate Models	k	AICc	ΔAICc	w_i	R^2
★DOC * Julian	6	153.31	0.00	0.94	0.76
Temp	4	160.52	7.21	0.03	0.30
Chl-a	4	161.51	8.26	0.02	0.34
DOC + Julian	4	162.33	9.02	0.01	0.23
Temp + Chl-a	5	163.24	9.82	0.01	0.33

Zooplankton Dynamics







- Larger bodied
- Preferred by herring
- Peak in June – then steady decline

- Common, small crustaceans
- More abundant than cladocerans
- General decline

- Most abundant/smallest order
- Largest variation across lakes
- Heavy predation by larvae

Study Lakes – Physical & Chemical Summary

Variable	Min	Max	Mean	Std. Dev
Area (ha)	8.01	1894	305.66	528.20
Mean depth (m)	1.50	15.20	4.78	3.48
Maximum depth (m)	1.80	53.10	10.07	9.26
Shoreline length (km)	1.38	64.69	10.58	13.82
Elevation (m)	-0.54	146.66	23.95	30.70
Surface temperature (°C)	17.66	28.74	24.16	2.46
Dissolved organic carbon (mg C l^{-1})	1.49	11.10	4.64	1.89
Secchi Depth (m)	0.20	5.80	1.86	1.02
Total phosphorous (µg P l^{-1})	0.61	71.50	25.11	14.71
Total nitrogen (mg N l^{-1})	0.12	1.86	0.50	0.33
Chlorophyll-a (µg l^{-1})	0.33	160.77	15.47	24.34