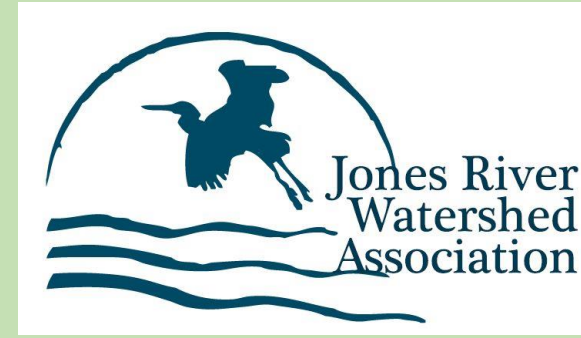
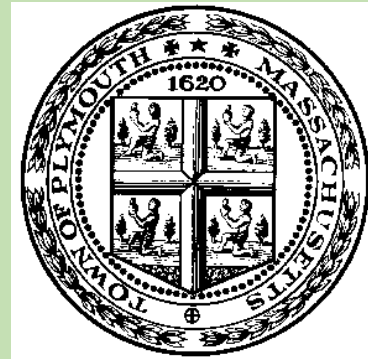


Environmental DNA (eDNA)

What eDNA can do for you, and how you can begin utilizing this powerful tool within your watershed





James Garner - PhD Student at UMass Amherst
 Co-advised by: Michelle Staudinger and Adrian Jordaan



Photo Credit: Jimmy Powell

My Background

- Previously worked with the Massachusetts Division of Marine Fisheries (MA DMF) as a Biological Fisheries Technician



My Background



- 1st year of PhD – I worked part time as the Ecology Program Director for the Jones River Watershed Association (where eDNA projects began)

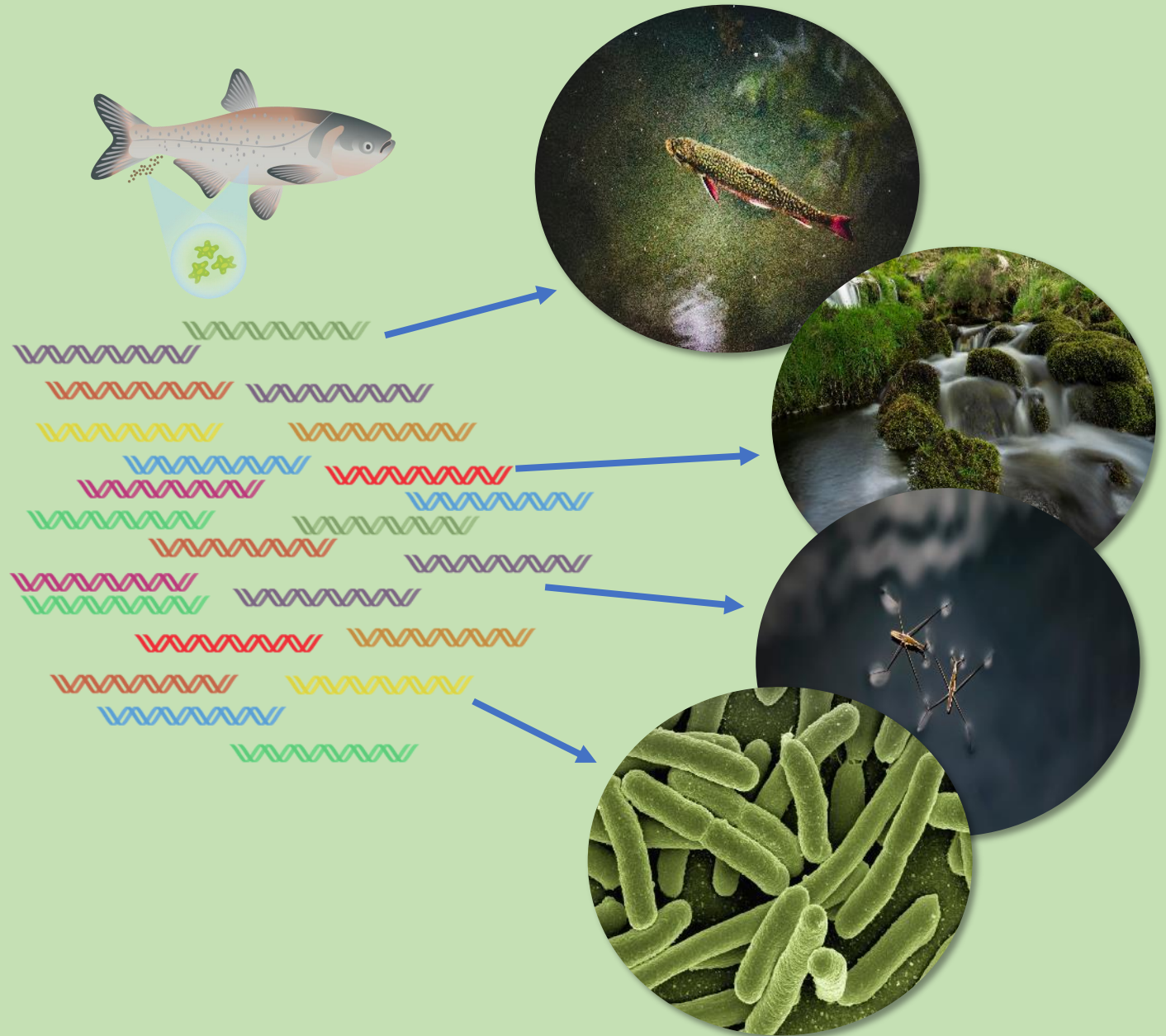


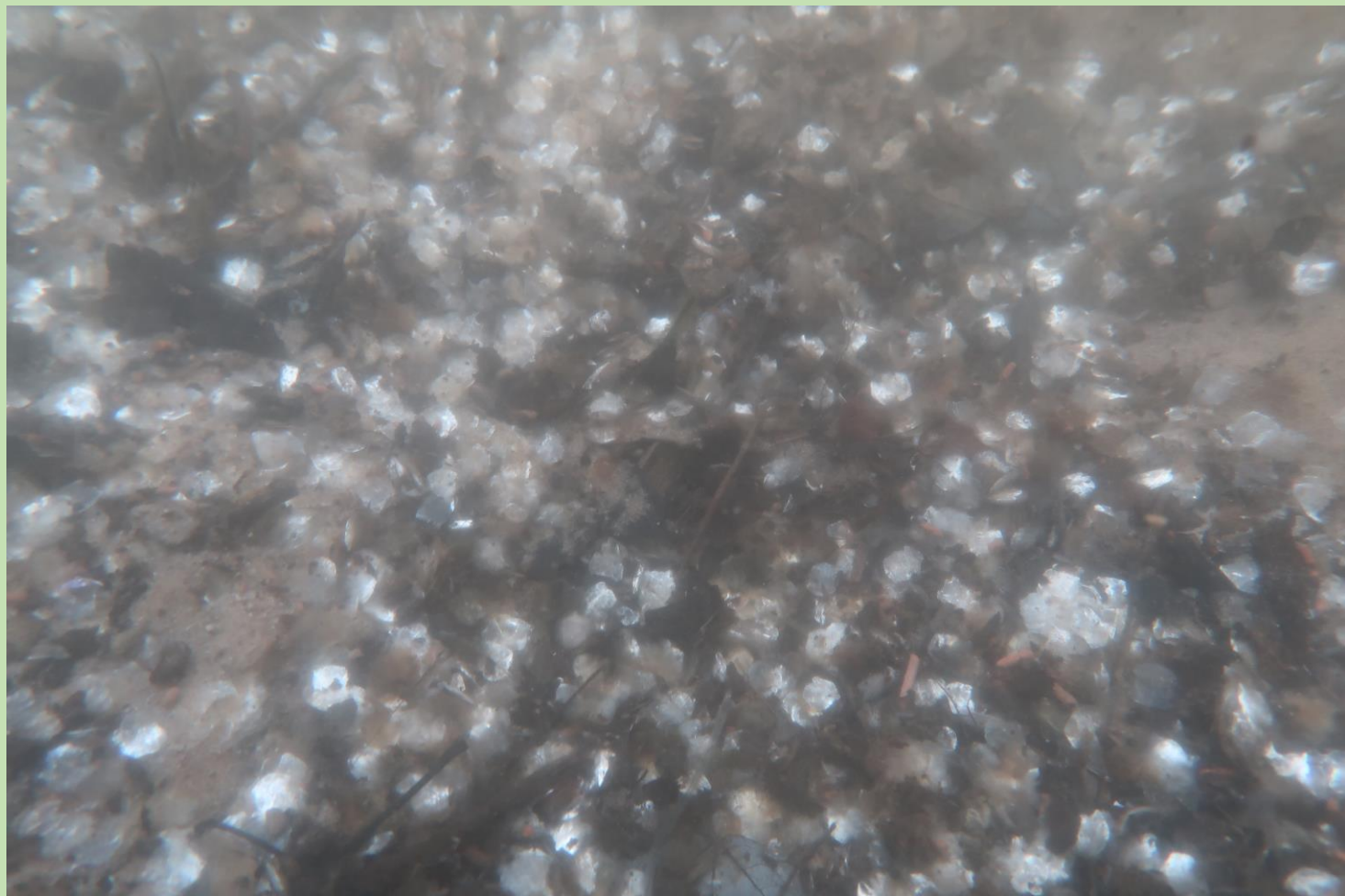
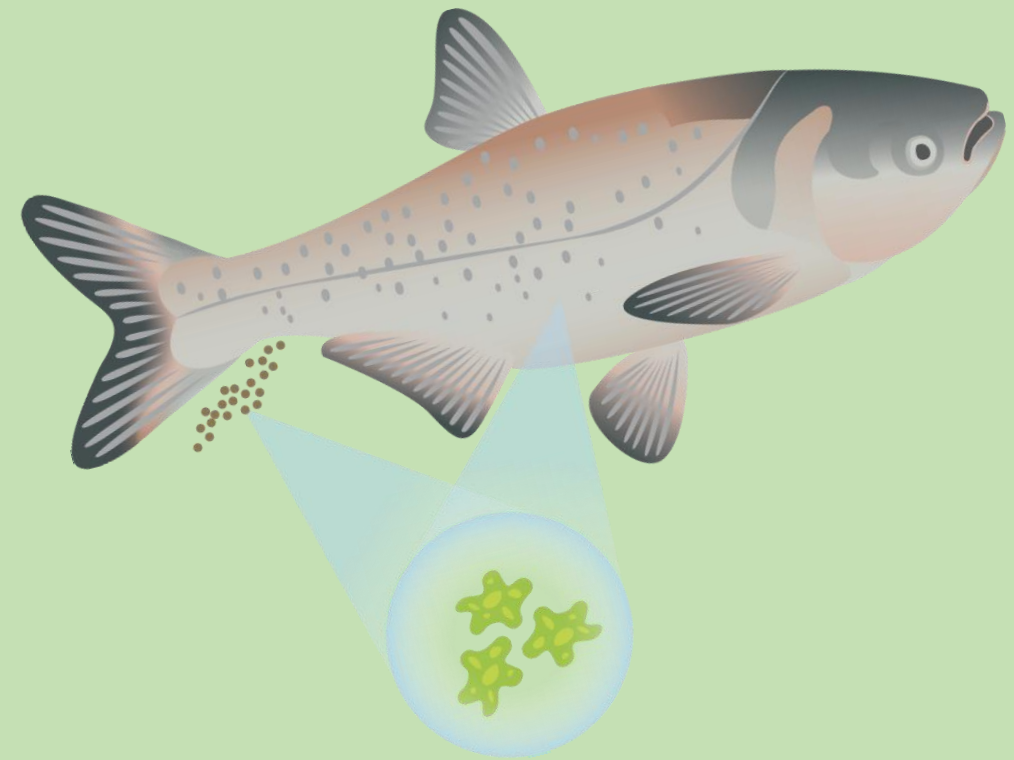
What IS eDNA?

What IS eDNA?

- DNA sourced from environmental samples, rather than directly from an organism

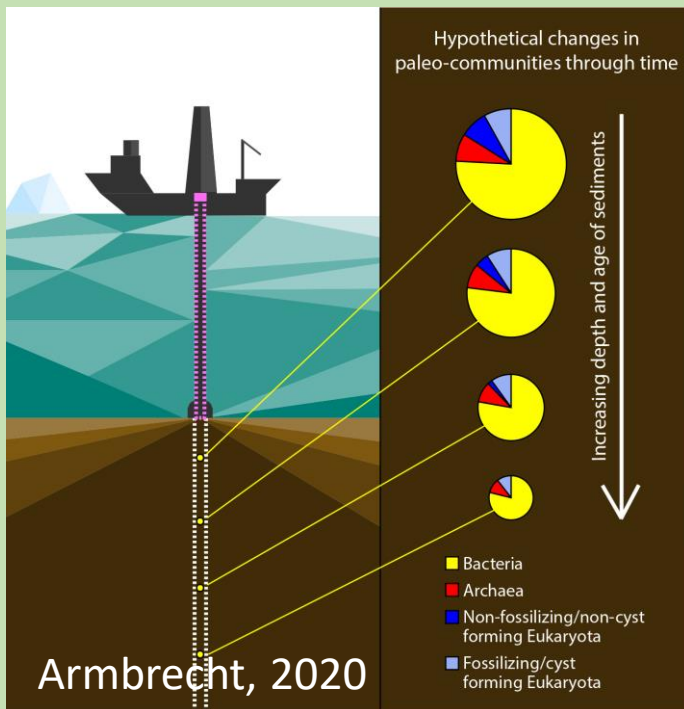
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- examples: soil
 - (Ancient DNA)



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What IS eDNA?

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- examples: soil, water, air, honey!
- Like a genetic NOSE for a given environment



What can eDNA tell us?

- For a given TIME and PLACE, an eDNA sample can give us data about:

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 - Relative abundance*

* Technique for calculating relative abundance is still being refined and requires calibration to other established techniques

Potential Applications and Outcomes of eDNA Monitoring

Application	Outcome

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Detecting species presence	Rare or endangered species confirmation



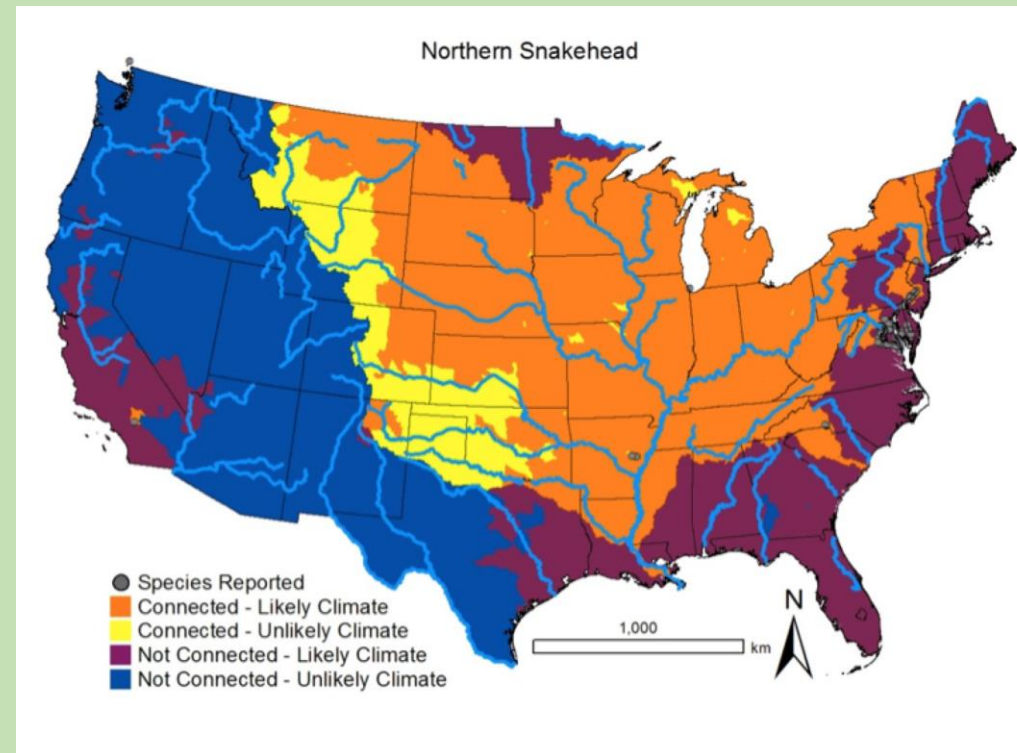
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Photo Credit: Jimmy Powell – JRWA SmugMug

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Biodiversity/community structure assessment	Establish a modern eDNA biodiversity baselines
	Understanding ecosystem response to restoration or climate adaptation action
Estimates of species density/abundance	Provide a low-cost supplement or alternative to other methods

Incorporating eDNA into a work plan

The eDNA workflow has four basic steps:

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- This is a perfect step to get communities and citizen scientists involved with a project!



Aman, J., Kinnison PhD, M. T., Holmes, V., & Gottsegen, C. (2020). Developing Cost Effective Monitoring for Rainbow Smelt Using eDNA.



Incorporating eDNA into a work plan

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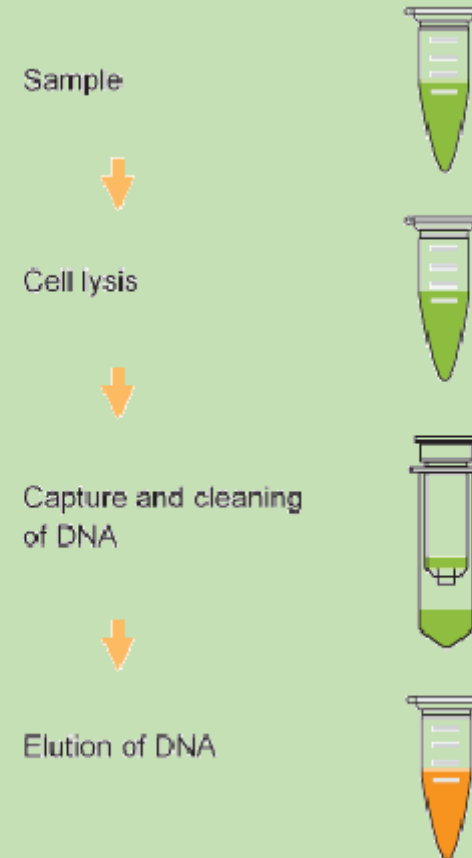


Photo Credit: Jimmy Powell

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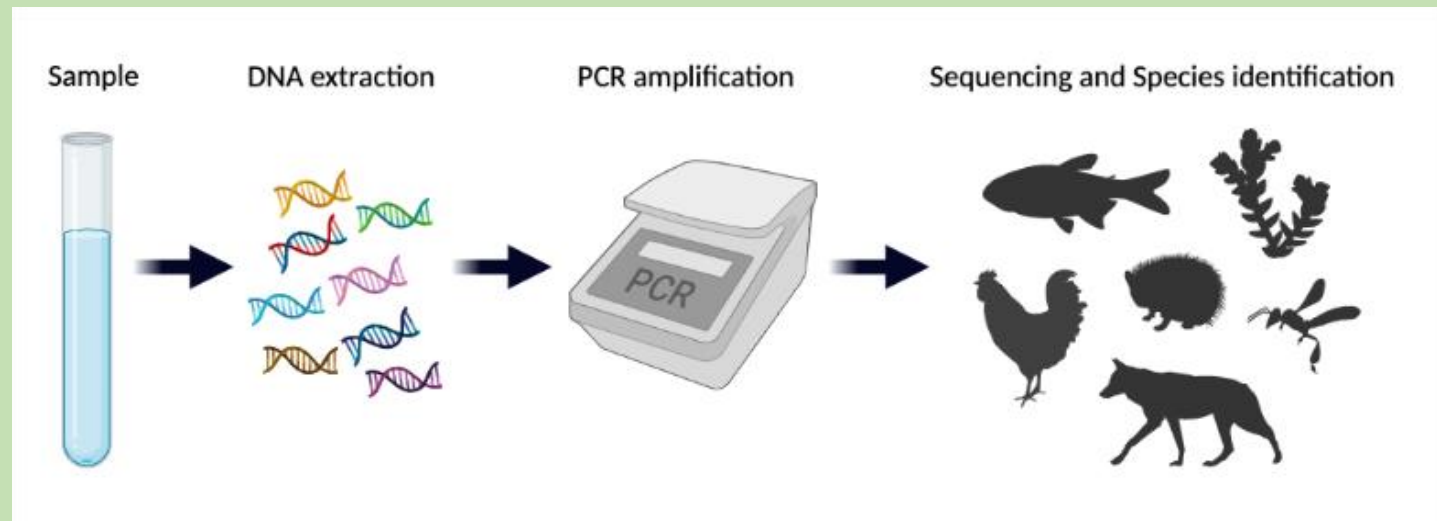
- Collection
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- Filtration
- Extraction



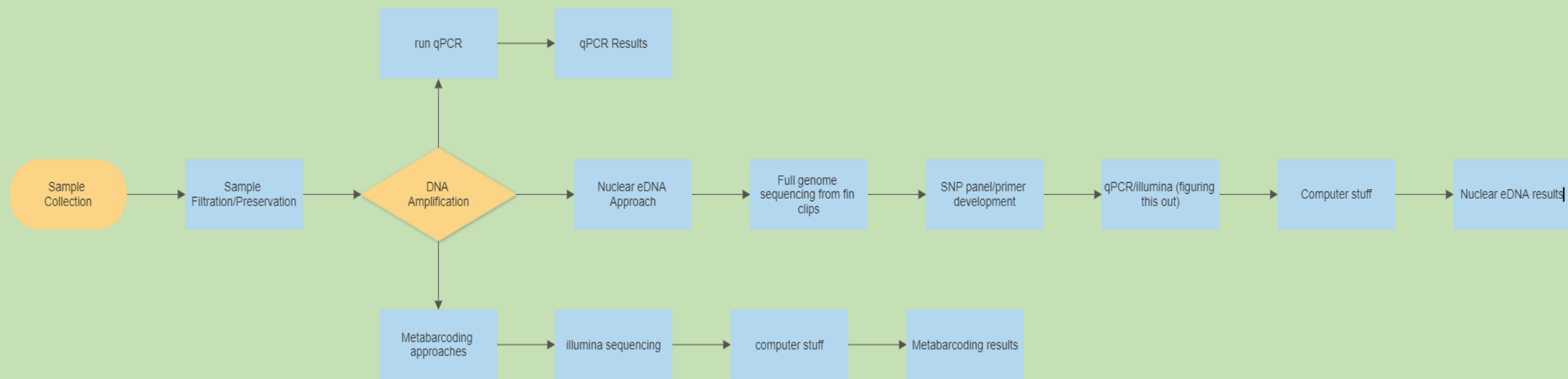
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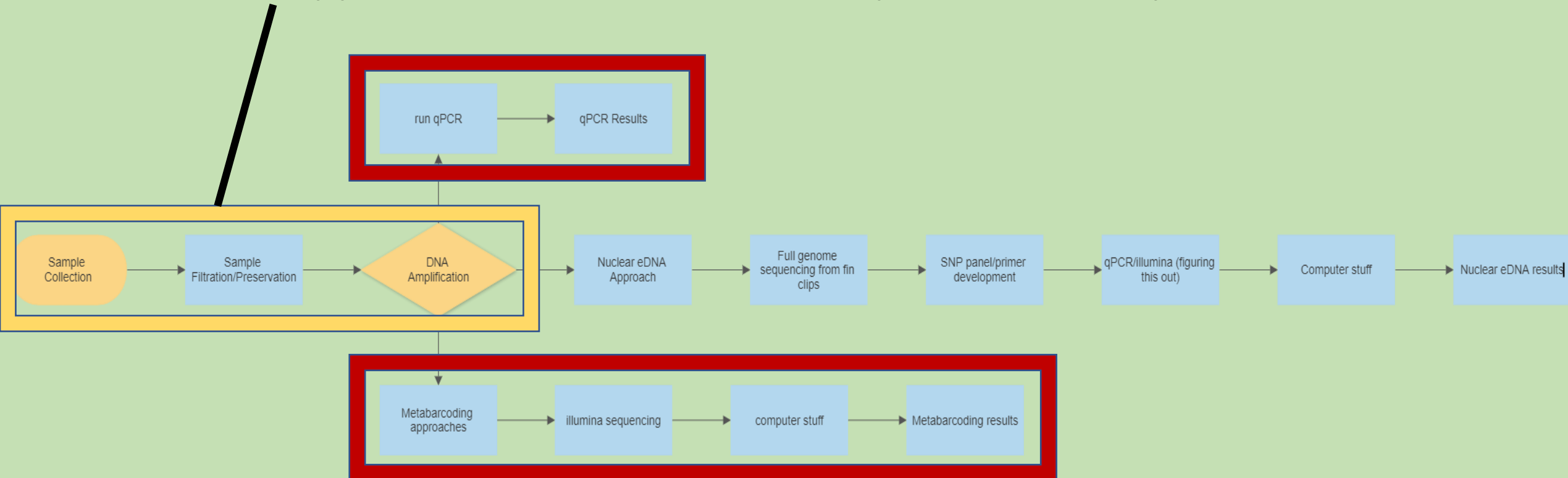


The two types of eDNA approaches I use:



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For both approaches, the first THREE steps are (basically) the same



Two common eDNA approaches:

Single species monitoring

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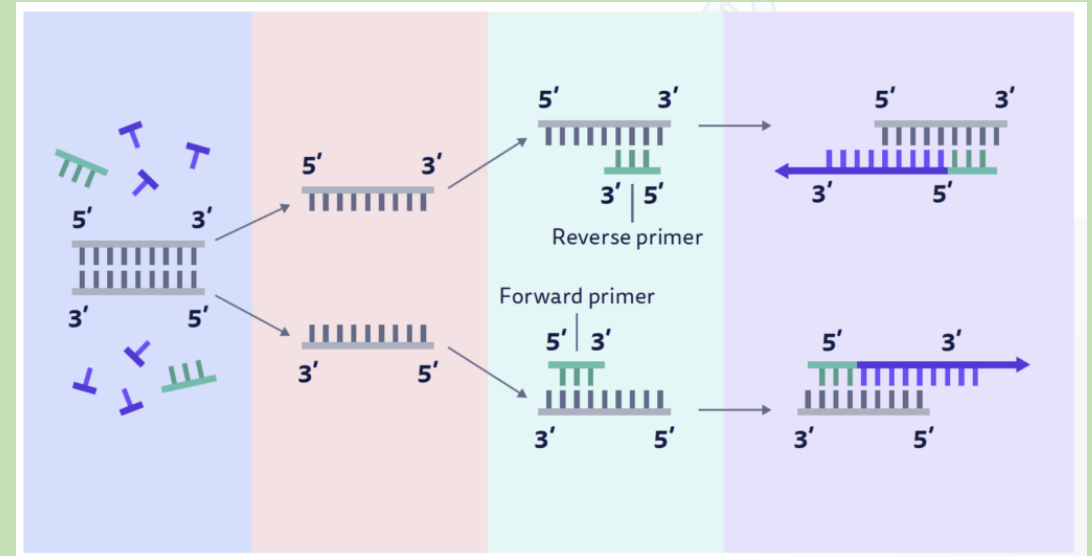
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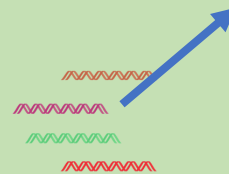
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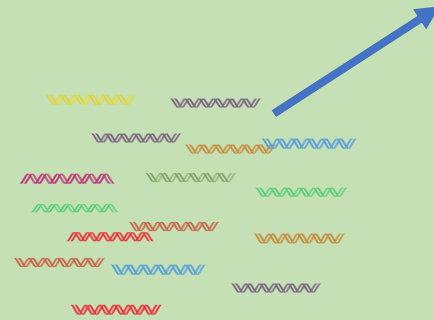
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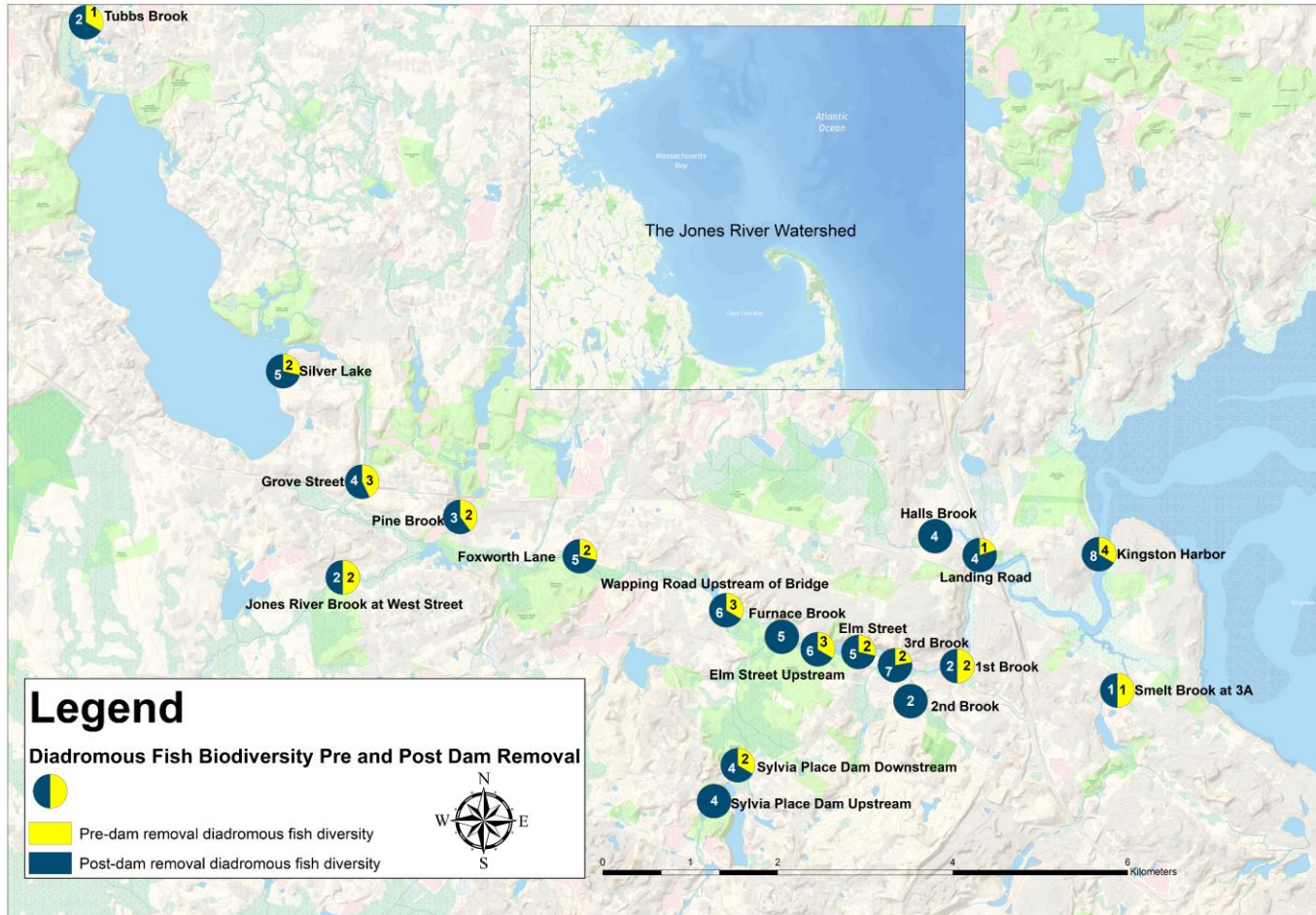
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1	METABARCODING DATA	sb	lr	hb	1b	2b	3b
4	American eel	1	1	1	1	0	1
5	american shad	0	0	0	0	0	0
6	Atlantic tomcod	0	0	0	0	0	0
7	blueback herring	0	1	0	0	0	1
8	brook trout	0	0	0	1	0	1
9	hickory shad	0	0	0	0	0	0
10	rainbow smelt	0	1	0	0	0	0
11	sea lamprey	0	0	0	0	0	1
12	striped sea-bass	0	0	0	0	0	0
13	white perch	0	0	0	0	0	0
14	Atlantic herring	0	0	0	0	0	0
15	Atlantic silverside	0	0	0	0	0	0
16	fourspine stickleback	0	0	0	0	0	0
17	grubby sculpin	0	0	0	0	0	0
18	haddock	0	0	0	0	0	0
19	menhaden	0	0	0	0	0	0
20	mummichog	0	0	1	0	0	0
21	ninespine stickleback	0	0	0	0	0	0
22	rock gunnel	0	0	0	0	0	0
23	sheepshead minnow	0	0	1	0	0	0
24	striped killifish	0	0	0	0	0	0
25	winter flounder	0	0	0	0	0	0
26	black crappie	0	0	0	0	0	0
27	black crappie or rock bass	1	1	1	1	0	1
28	bluegill sunfish	1	1	1	1	0	1
29	brown bullhead	0	1	0	0	0	0
30	chain pickerel	1	1	1	1	0	1

Diadromous Fish Species Diversity Pre and Post Mainstem Dam Removal



What can eDNA tell us?

- Species presence
- Biodiversity
- Estimates of abundance (calibrated)

What can eDNA tell us?

- Consider what your data is telling you compared to other traditional monitoring techniques
 - What are some other traditional ways we monitor aquatic life?

What can eDNA tell us?



- A good way to think about eDNA is to consider EXACTLY what your data is telling you compared to other traditional monitoring techniques
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Electrofishing surveys

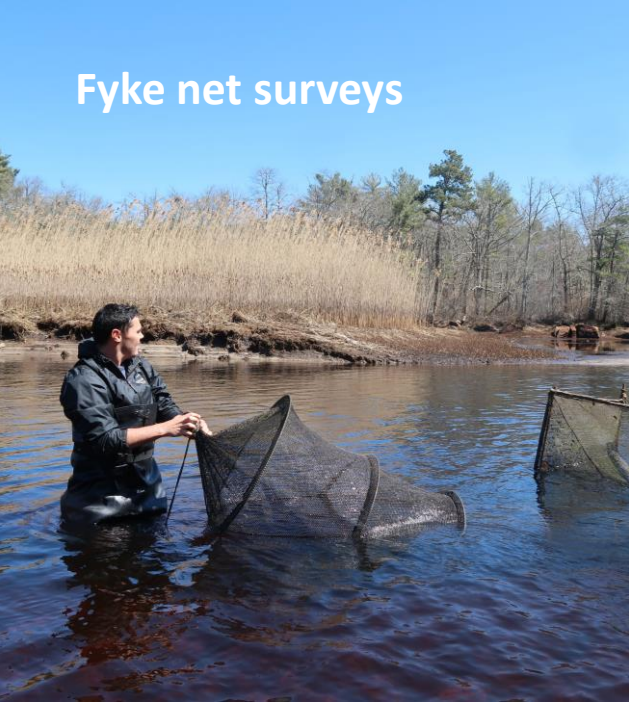


Volunteer river herring counts

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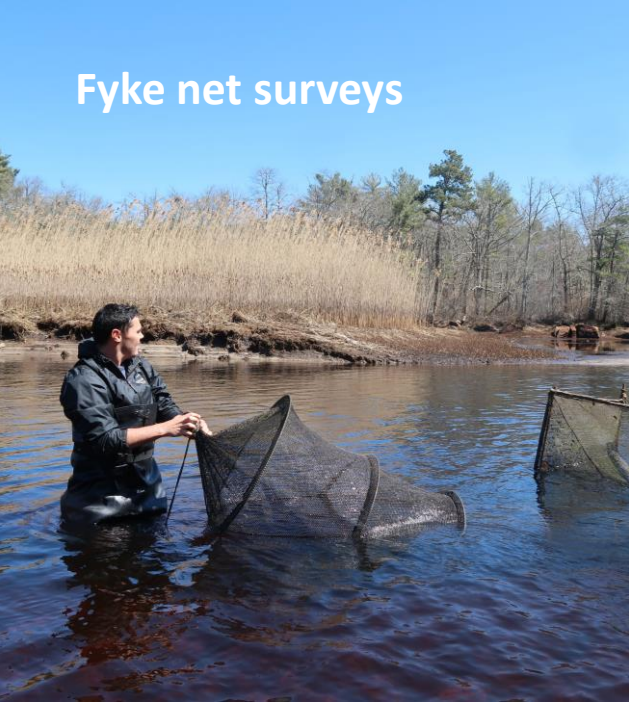
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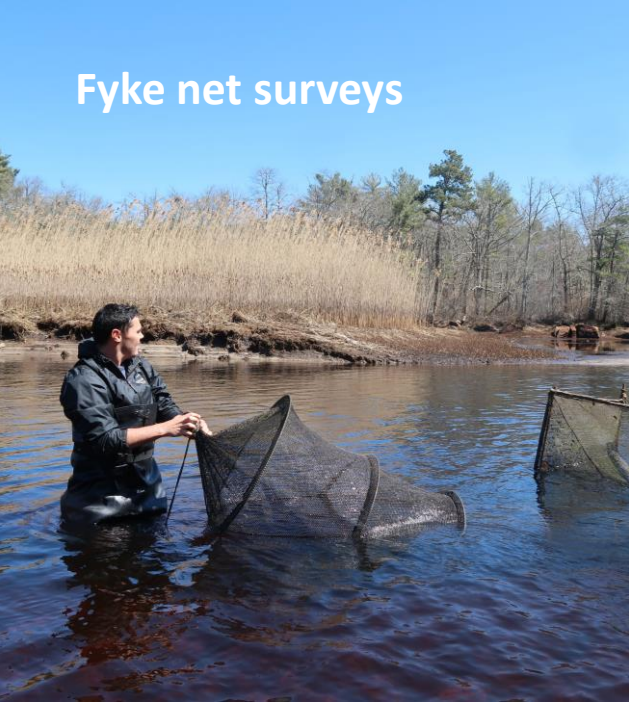
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Things eDNA can't tell you

Volunteer river herring counts



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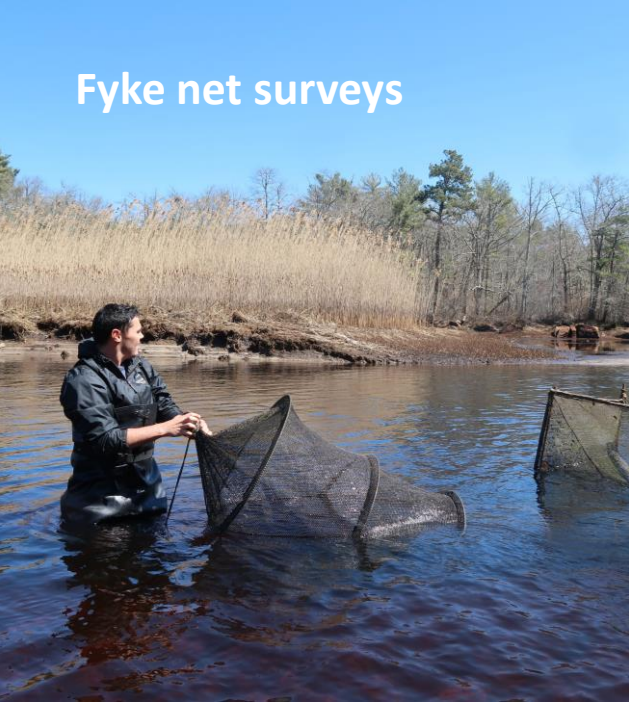
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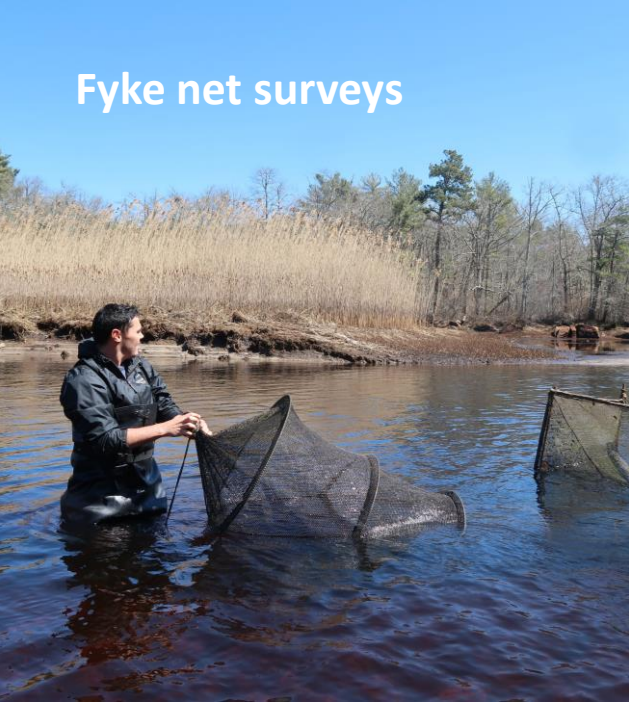
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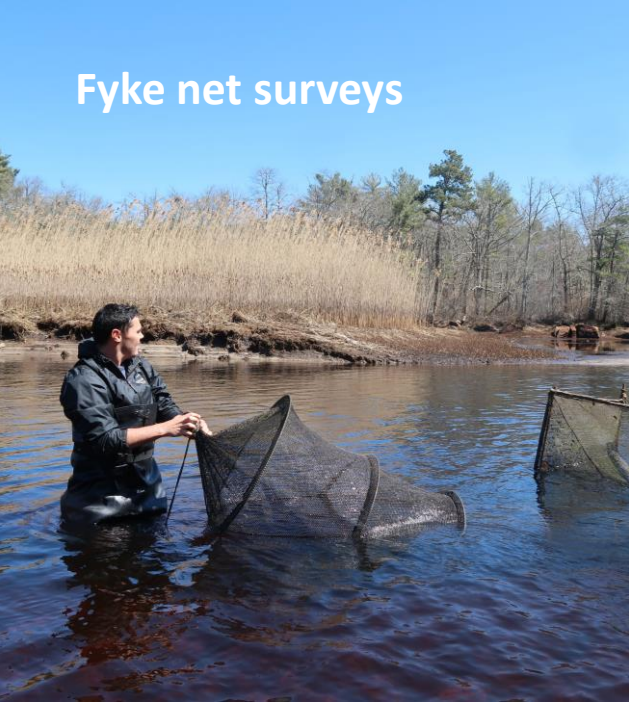
Things eDNA can't tell you

- Absolute abundance
- Age and Growth structure for fish populations
- What life stage your DNA signal came from (yet)

Volunteer river herring counts



Fyke net surveys



Electrofishing surveys

Volunteer river herring counts



eDNA is a SUPPLEMENT to ongoing monitoring practices, not a replacement.

Strengths/Weaknesses

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Pros:

- Cost effective
- Less upfront effort
- More accessible than traditional ecological monitoring
- Non-invasive/destructive
- Rare, shy, and cryptic species detection
- Field constantly being refined
- Novel applications emerging regularly

Strengths/Weaknesses

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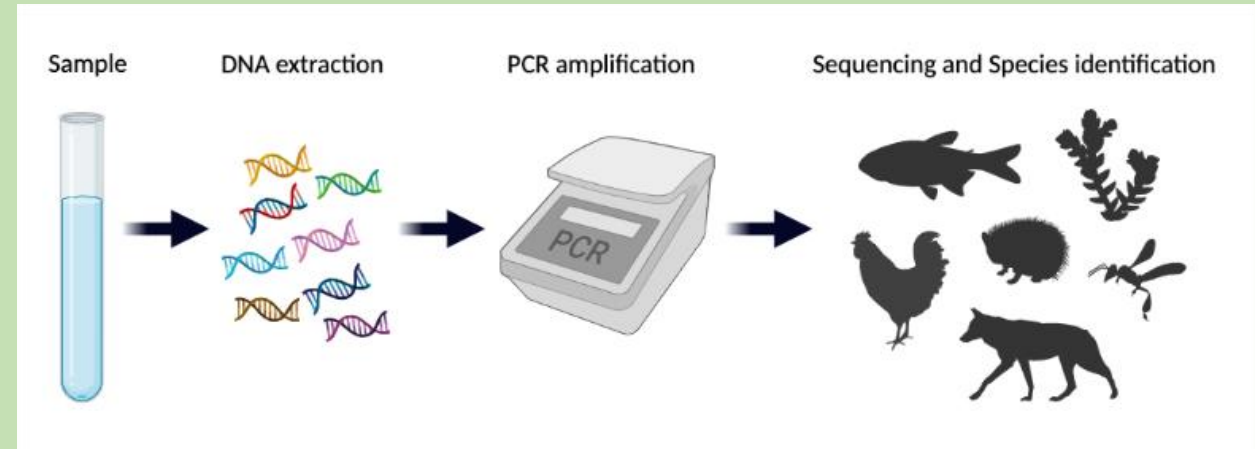
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Cons:

- False positives/negatives common
- Controversial (abundance estimates)
- Barrier to entry for downstream analyses (after sample collection/filtration) extremely high
- Still a new field requiring refinement

Known biases

eDNA monitoring techniques have limits and sampling biases.



The importance of calibration

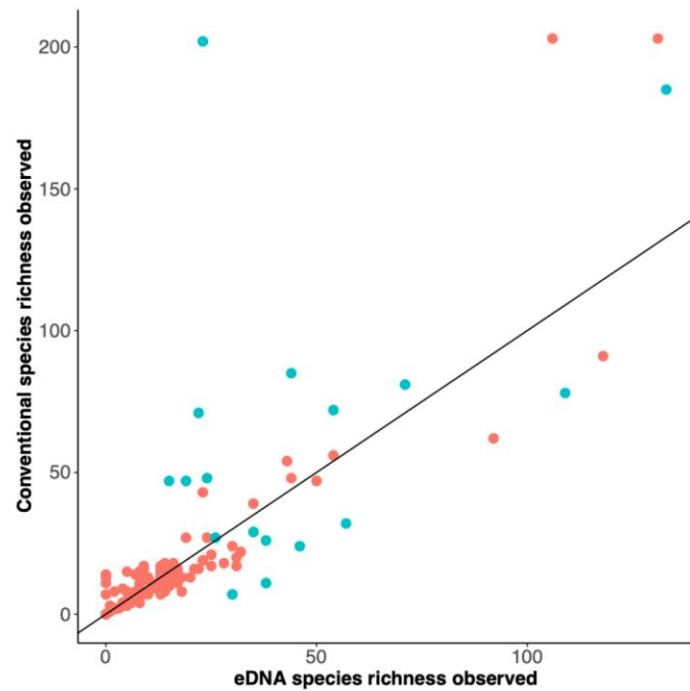
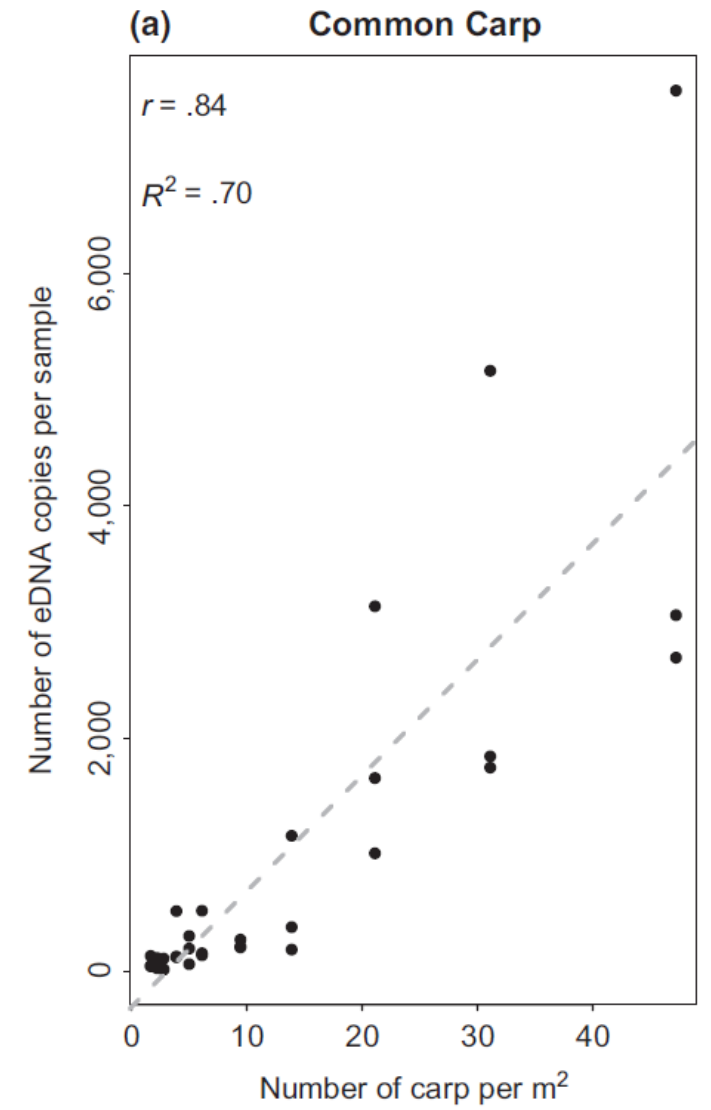


Figure SF8. Correlation between species richness observations from conventional surveys and eDNA metabarcoding for freshwater (red, n=104) and marine systems (blue, n=17). The line represents a 1:1 relationship.



One more time...

eDNA monitoring techniques are not meant to REPLACE other monitoring strategies, but to ENHANCE ongoing monitoring efforts

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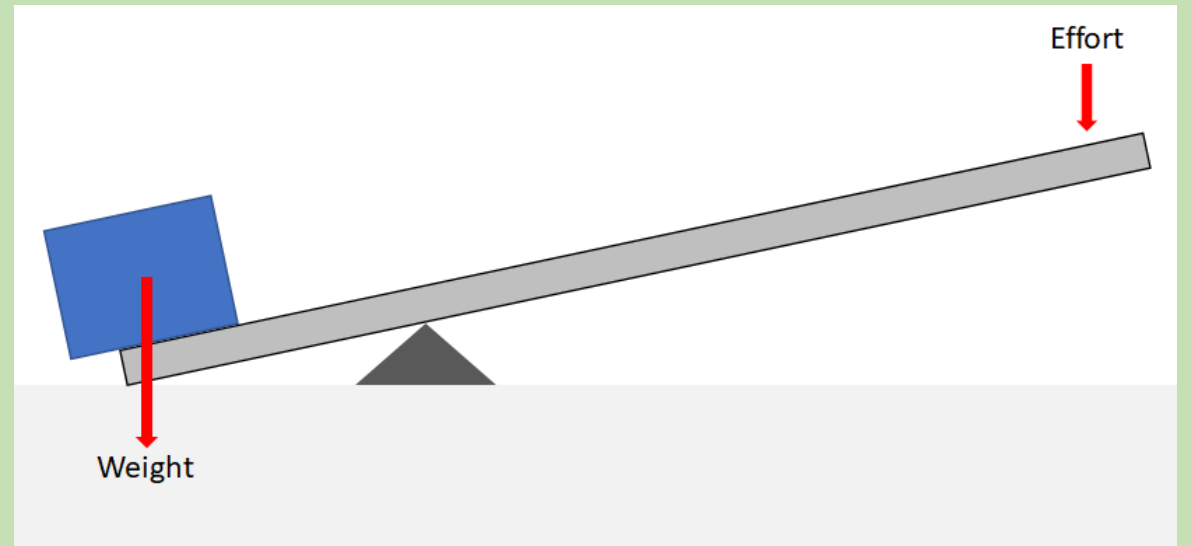
or

eDNA monitoring techniques are not meant to REPLACE other monitoring strategies, but to ENHANCE ongoing monitoring efforts

or

Provide an accessible and affordable starting point for watershed, biodiversity, and species monitoring efforts

eDNA monitoring is a “Force Multiplier” for other monitoring efforts



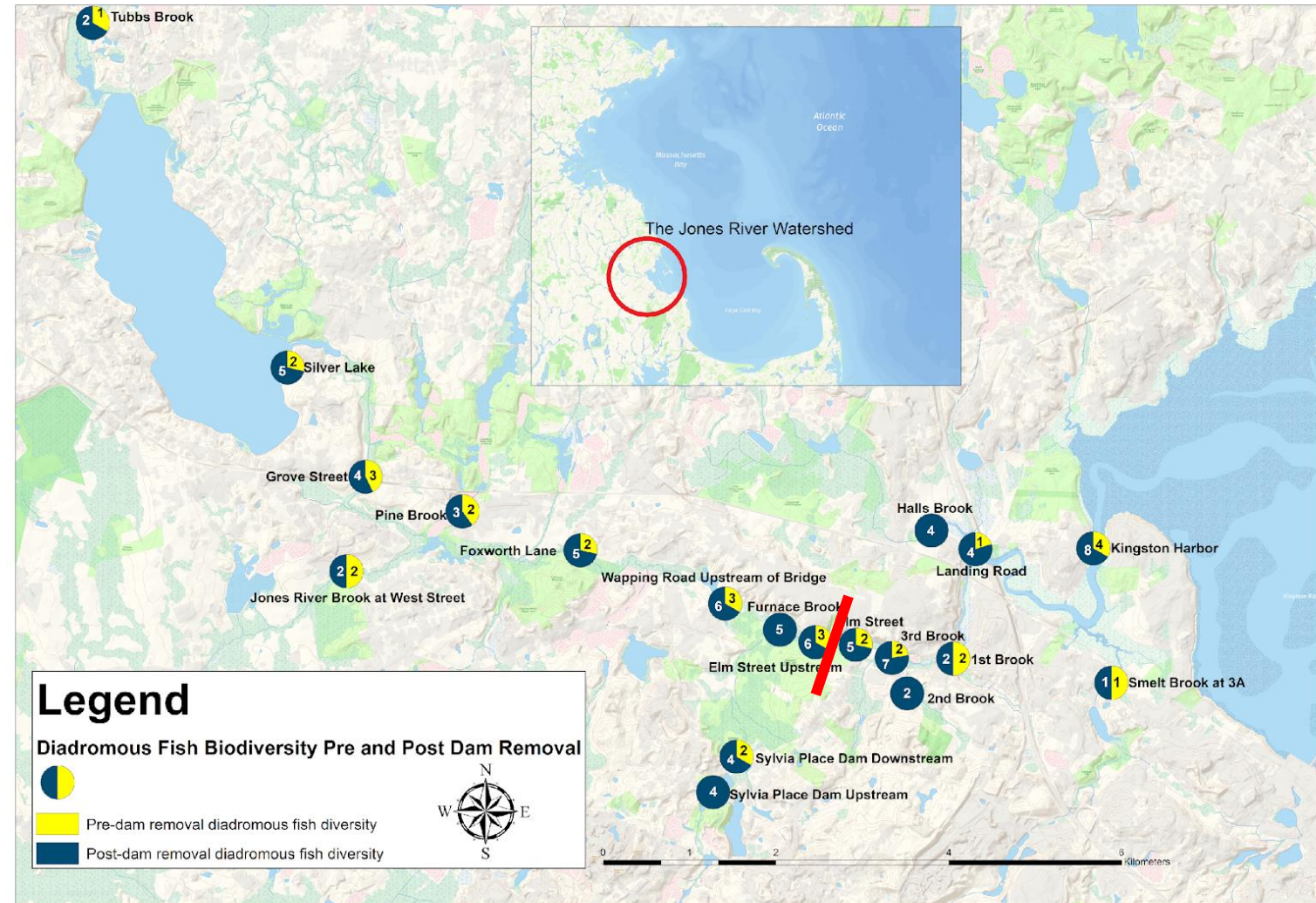
Potential Applications for River Herring Management and Restoration

Potential Applications for River Herring Management and Restoration

Determining IF your restoration/adaptation action met its intended goals

- Pre/post dam removal monitoring through time
- Pre/post fishway installation monitoring, etc.

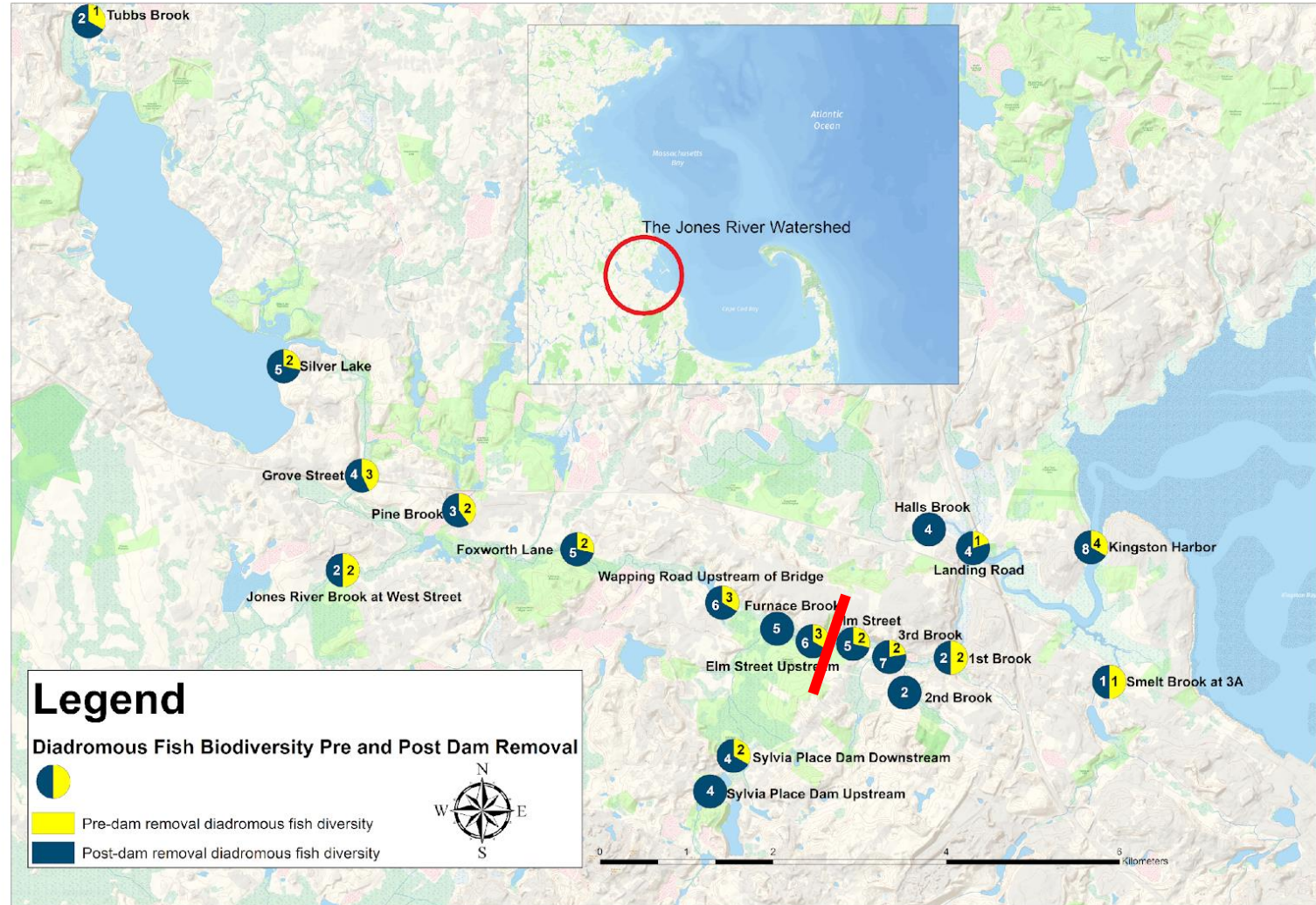
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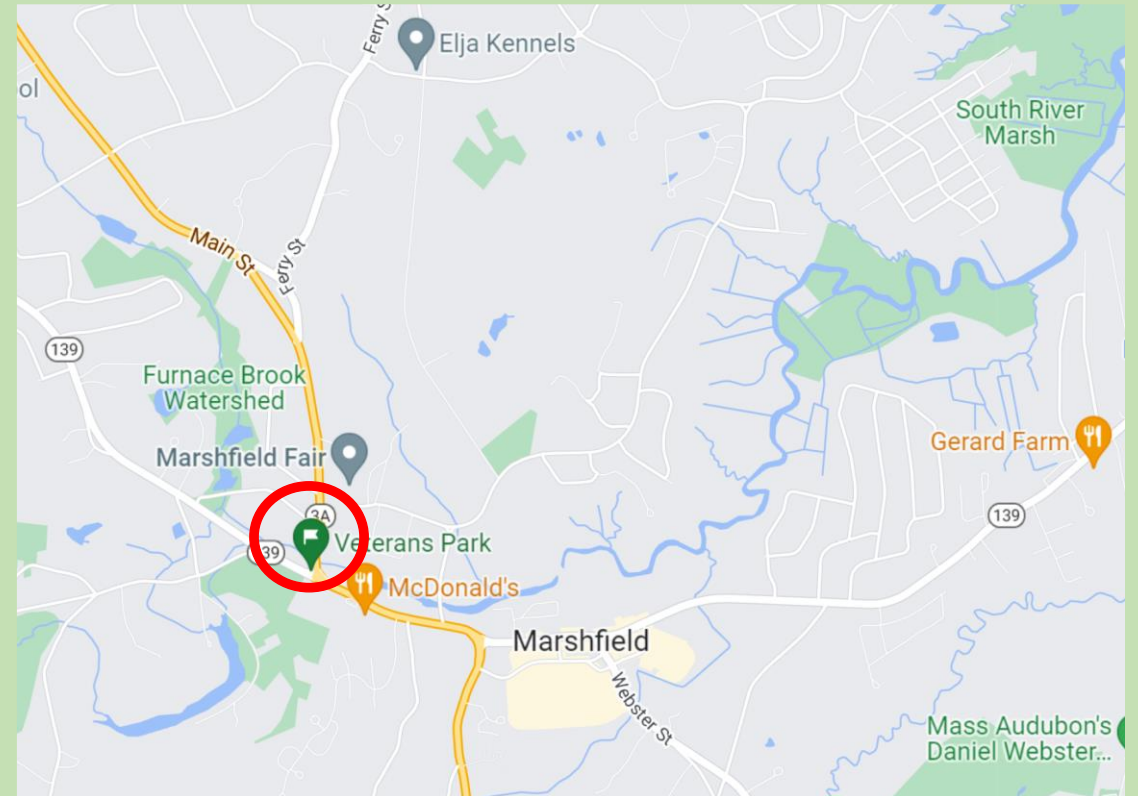
Determining how far upstream river herring are making it into your watershed

Diadromous Fish Species Diversity Pre and Post Mainstem Dam Removal



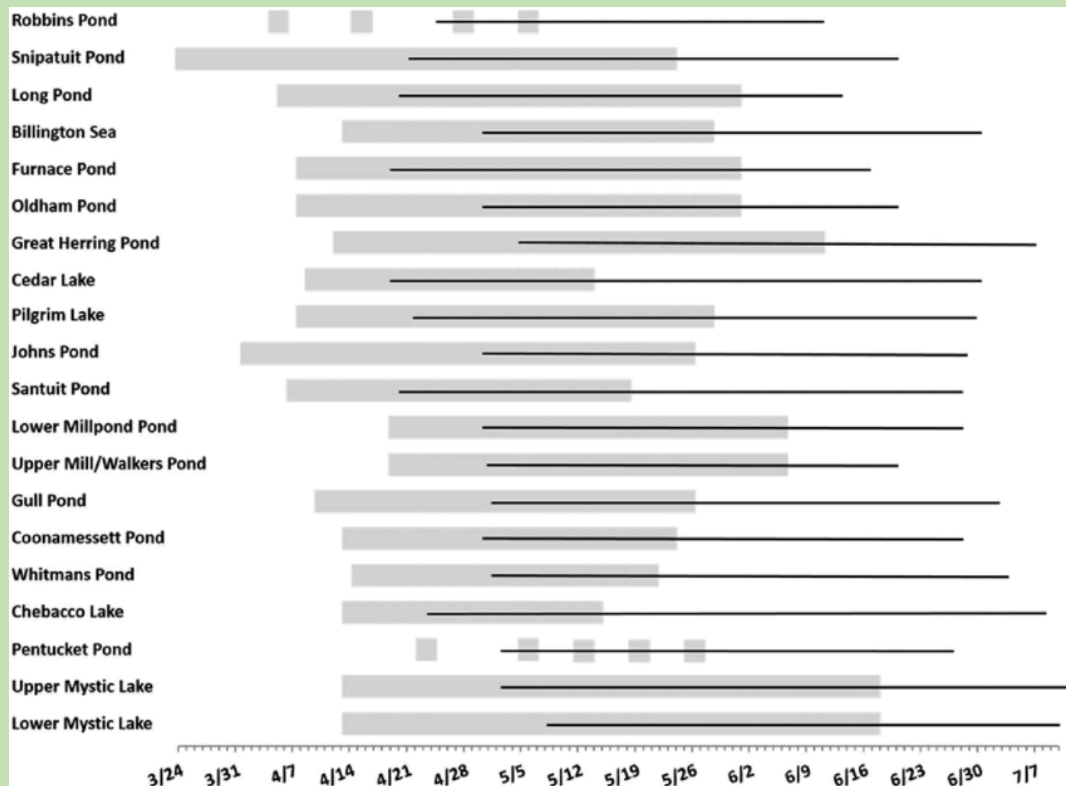
Potential Applications for River Herring Management and Restoration

Whether or not river herring are making it upstream of fish ladders



Potential Applications for River Herring Management and Restoration

When EXACTLY river herring are arriving to your watershed, how long they stay, and when they have all left (sampling through time)

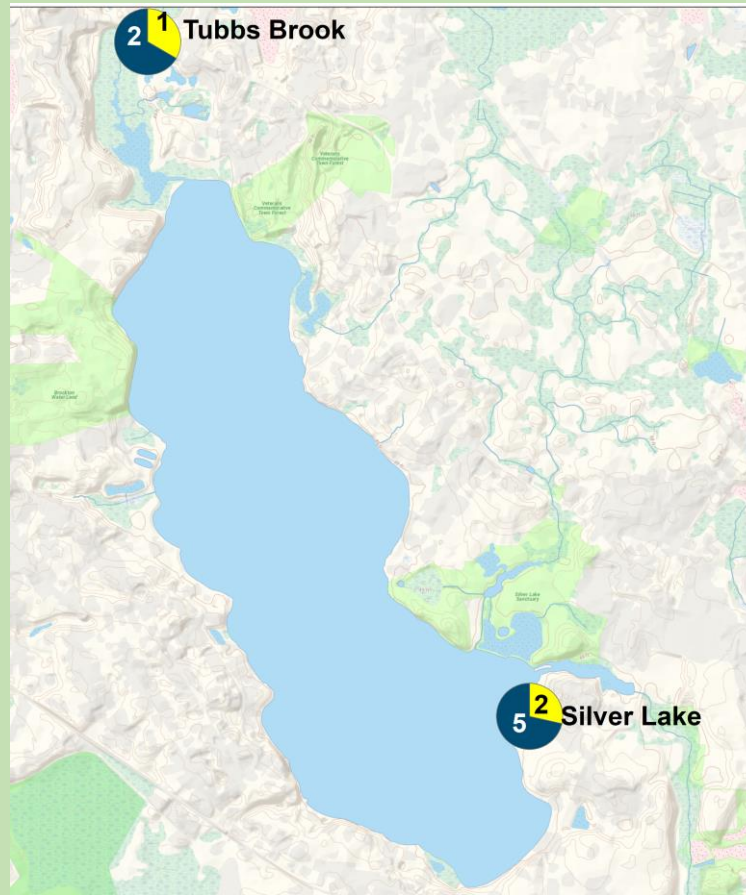


Rosset, J., Roy, A. H., Gahagan, B. I., Whiteley, A. R., Armstrong, M. P., Sheppard, J. J., & Jordaan, A. (2017). Temporal patterns of migration and spawning of river herring in coastal Massachusetts. *Transactions of the American Fisheries Society*, 146(6), 1101-1114.

Potential Applications for River Herring Management and Restoration

If river herring are entering your watershed from other locations

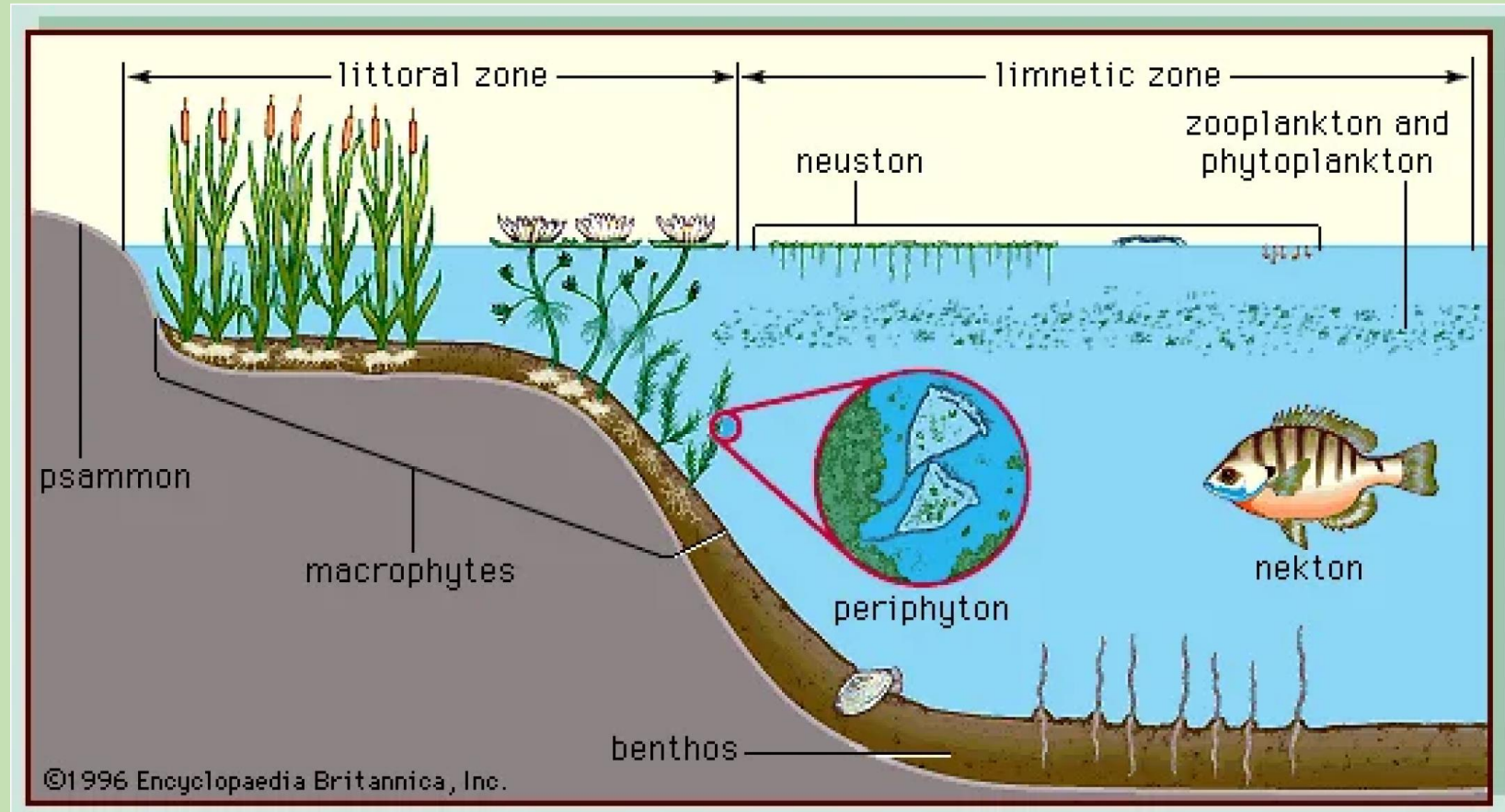
- other inlet streams to a headwater pond, for example



Potential Applications for River Herring Management and Restoration

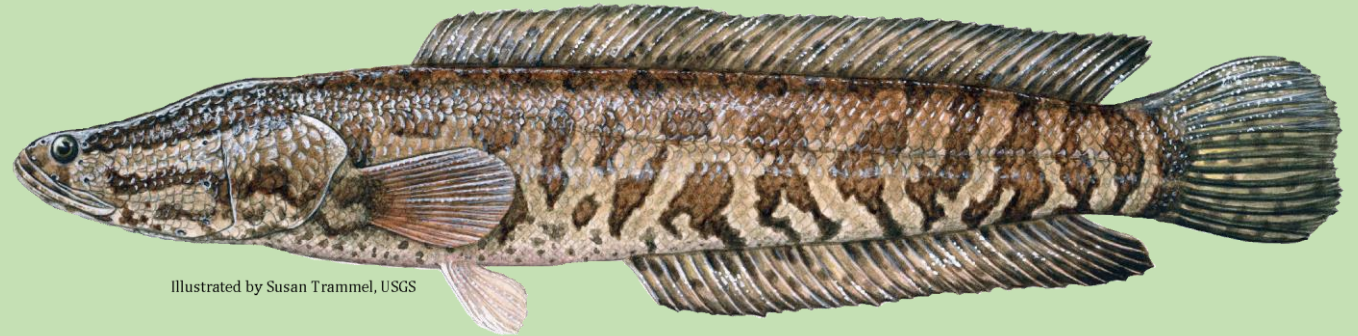
Biodiversity and community structure of:

- Prey species
- Habitat/plant community structure
- Aquatic pathogens
- Freshwater competitors



Potential Applications for River Herring Management and Restoration

Invasive Species introductions



Illustrated by Susan Trammel, USGS



Potential Applications for River Herring Management and Restoration

Provide low-cost biological evidence for permitting



Things to consider:

Implementing eDNA in your watershed

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- 1 species or many?
- Time series/sampling locations

You've collected water or filtered samples,
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- Ship frozen water samples or preserved (filtered) samples to a lab

Some New England based Labs you can work with:

University of Maine, Kinnison Lab

<https://umaine.edu/evoappslab/people/dr-michael-kinnison/>

UMaine eDNA website: <https://umaine.edu/edna/>

Contact:

Geneva York: geneva.york@maine.edu

University of New Hampshire, Hubbard Center for Genome Studies

<https://hcgs.unh.edu>

Contacts:

Krystalynne Morris: krystalynne.morris@unh.edu

Kelley Thomas: kelley.thomas@unh.edu

What's it going to cost me?

(shipping and handling not included)

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Biodiversity (Metabarcoding):

Roughly between \$2,000 and \$3,000 for 96 samples

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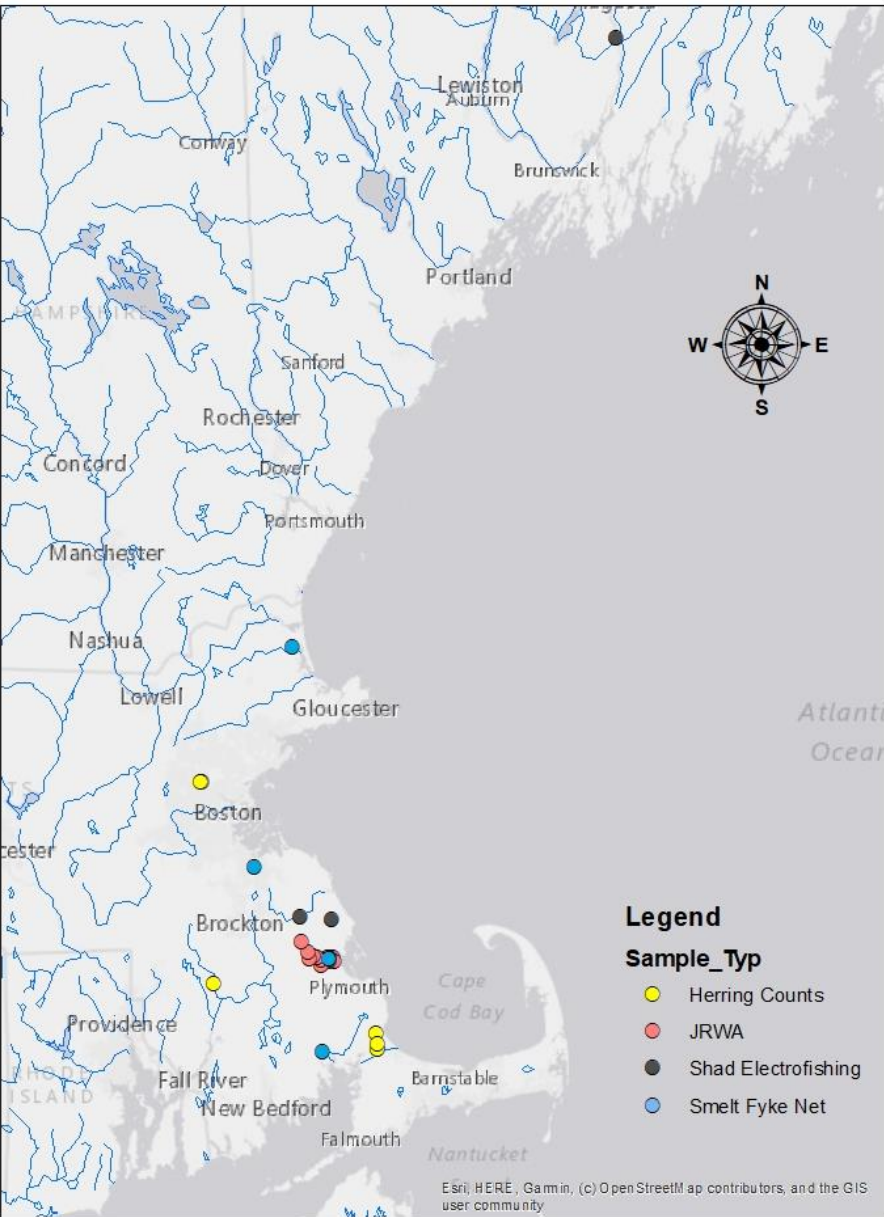
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Single Species (qPCR):

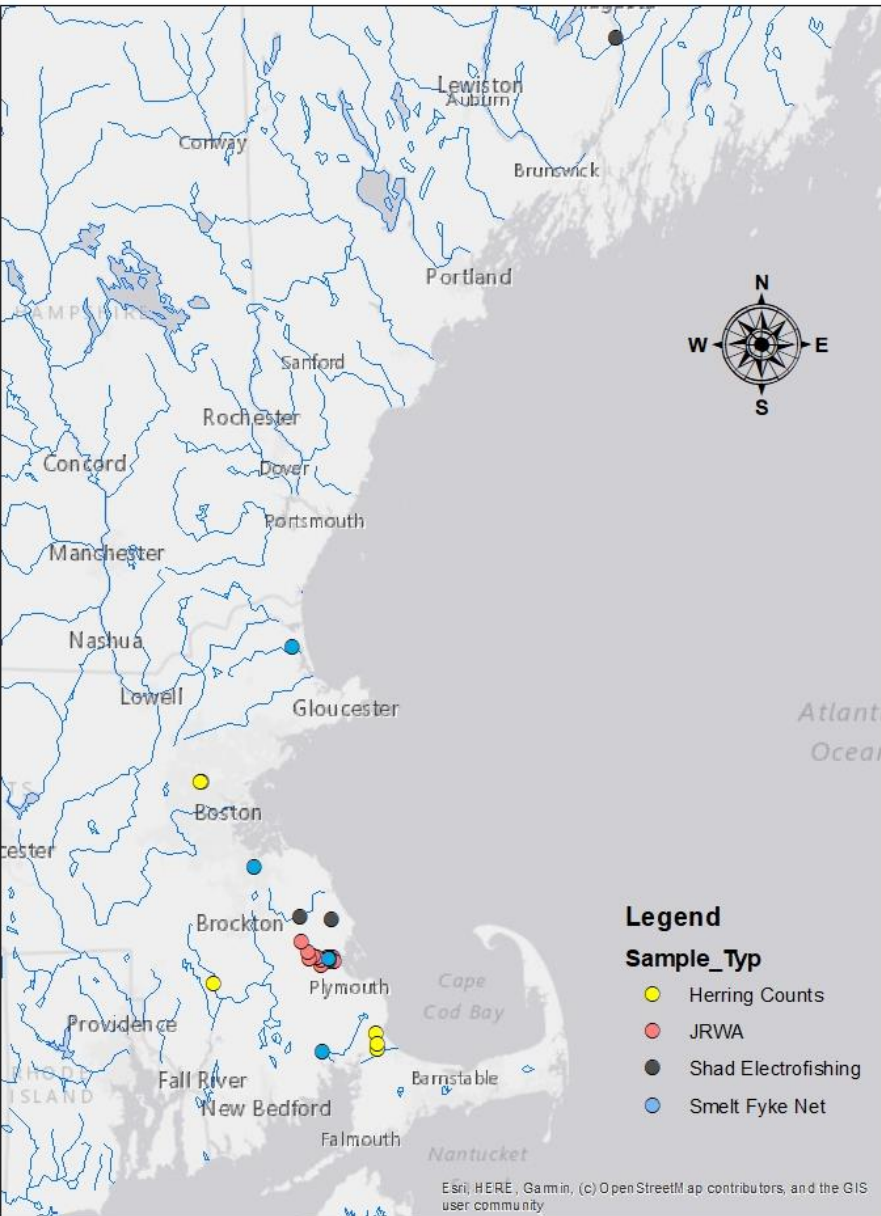
Less than \$20 per sample

New England eDNA Project Locations



Some of my ongoing work

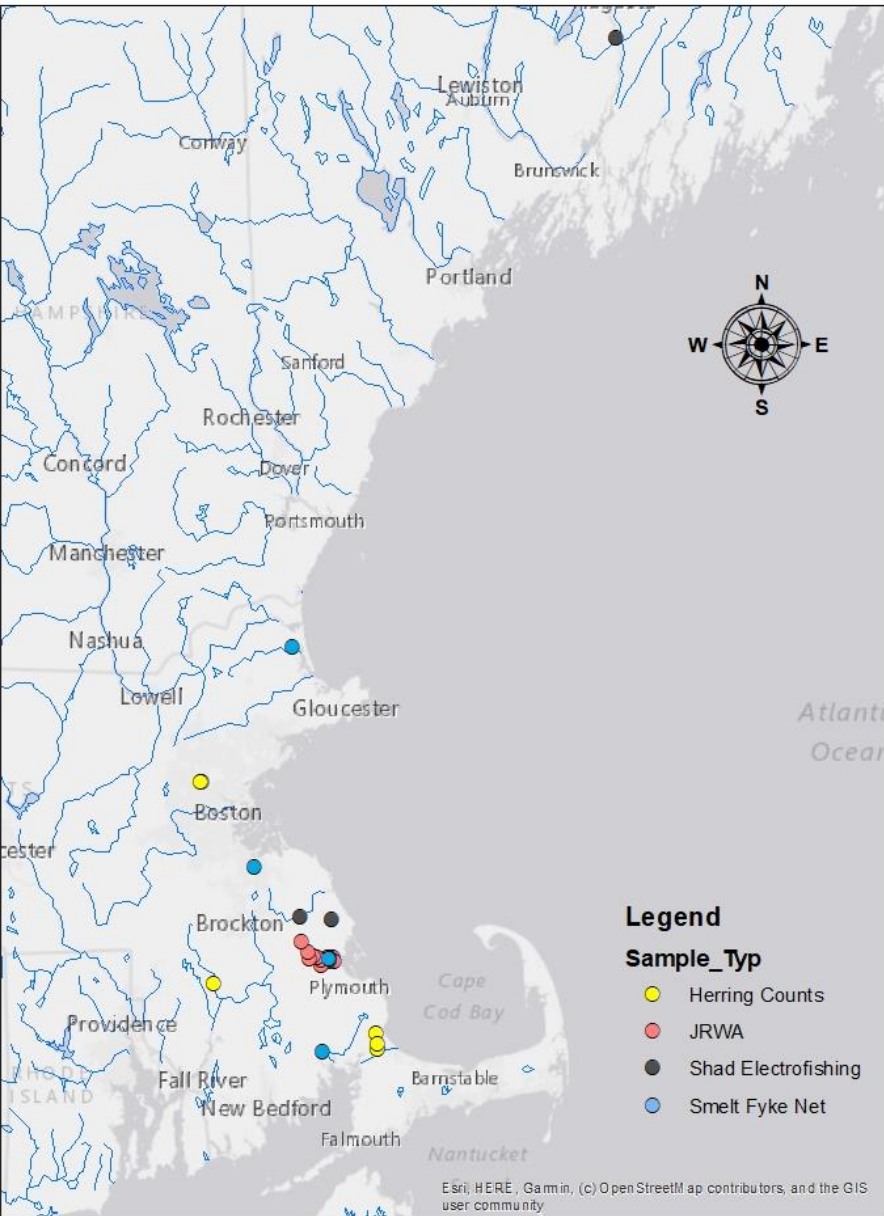
New England eDNA Project Locations



Some of my ongoing work

The Goal of my PhD research is to make eDNA tools and techniques more accessible, and to get them in the hands of the people, communities, and managers who can use them the most.

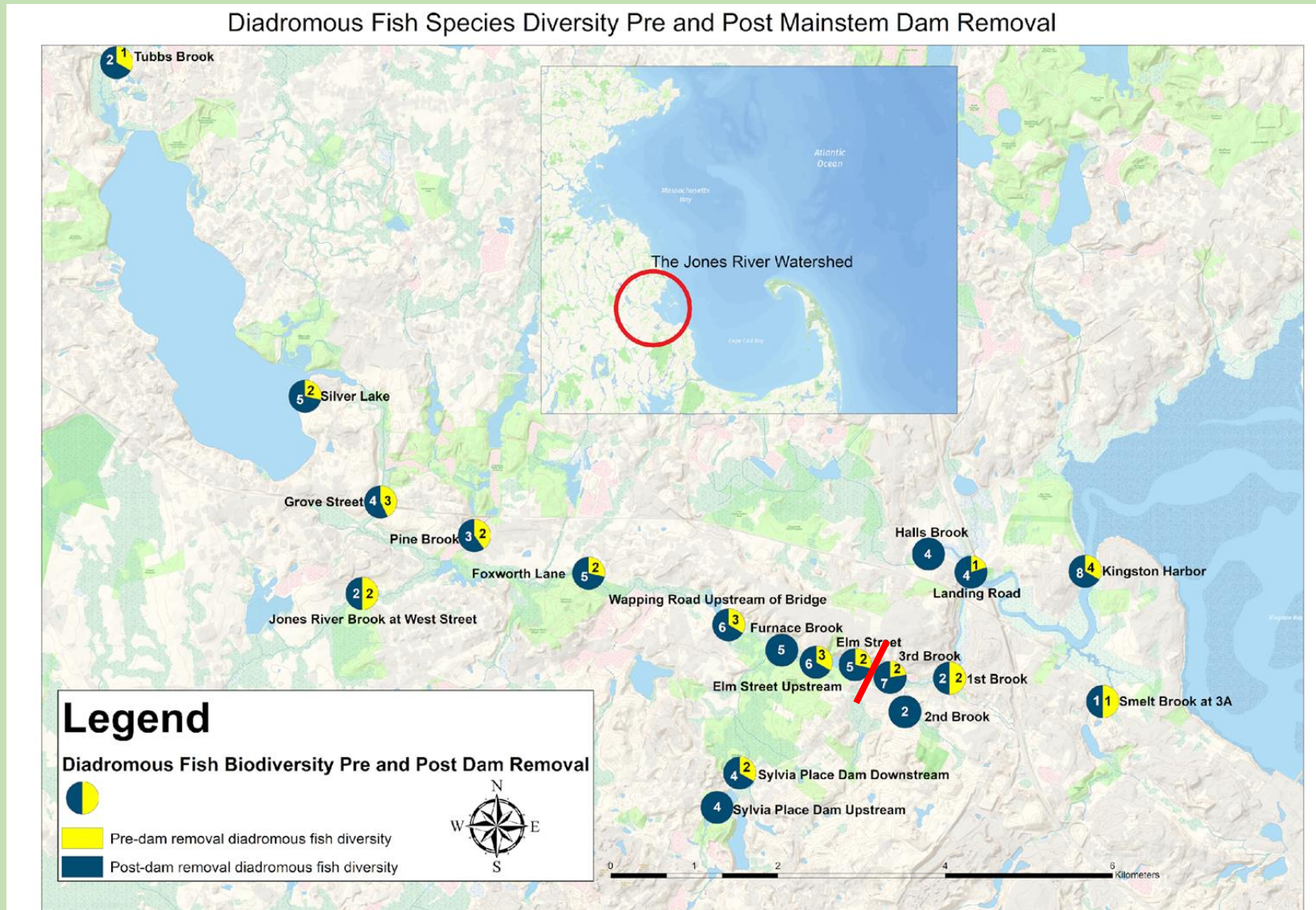
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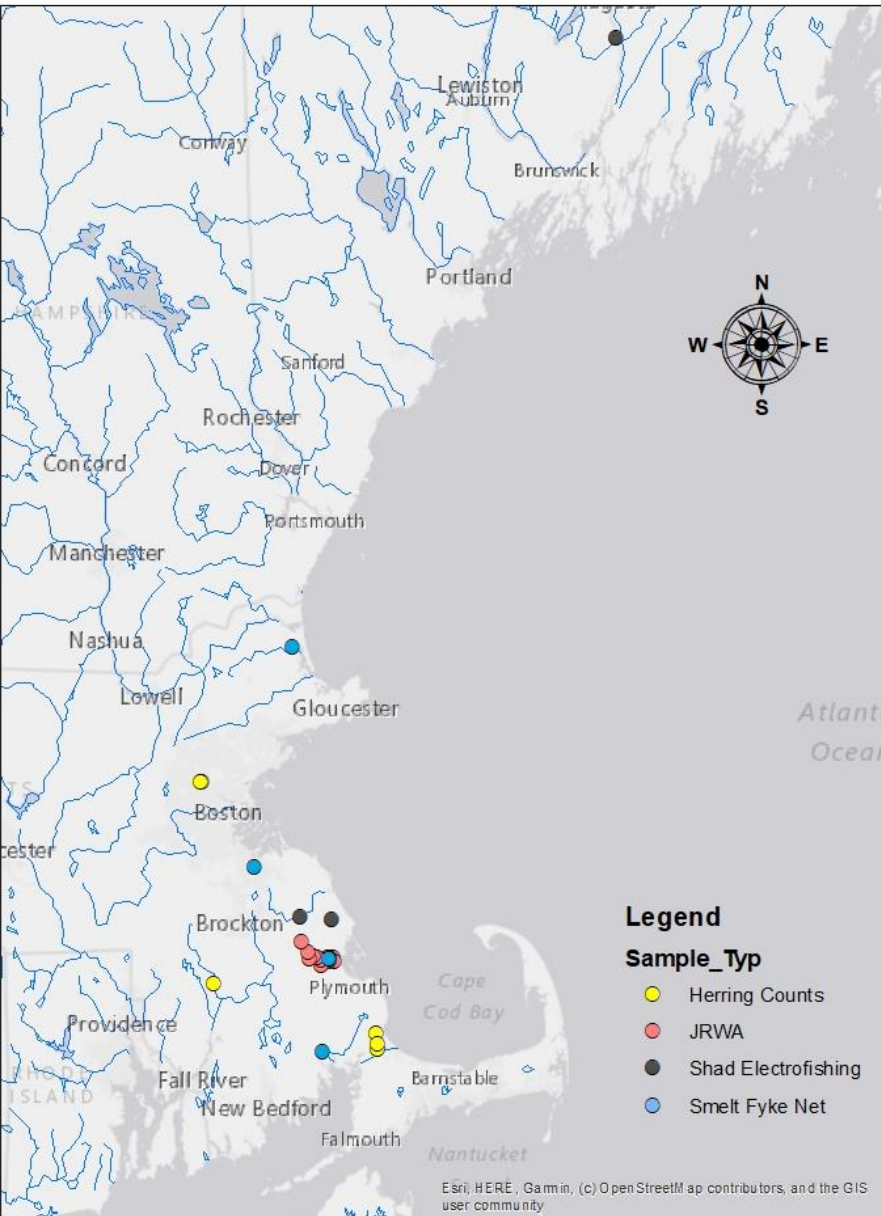
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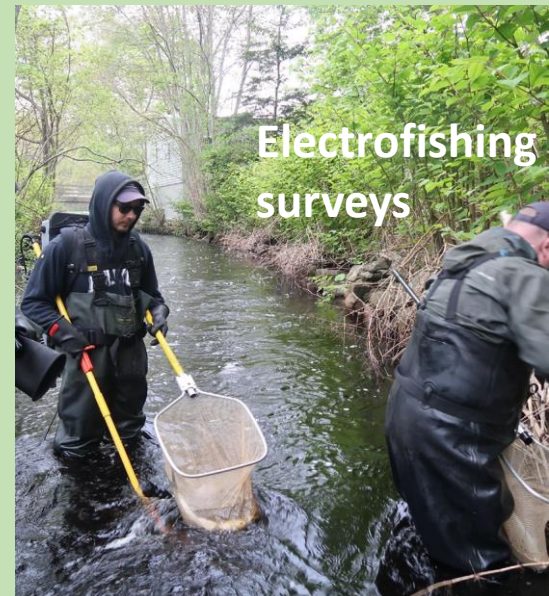
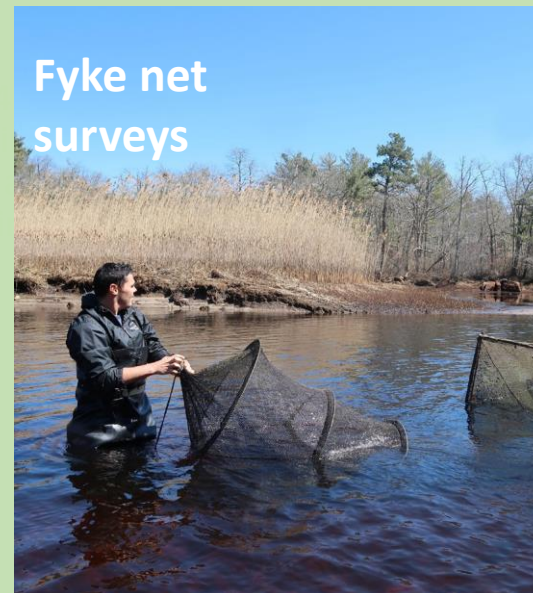


New England eDNA Project Locations

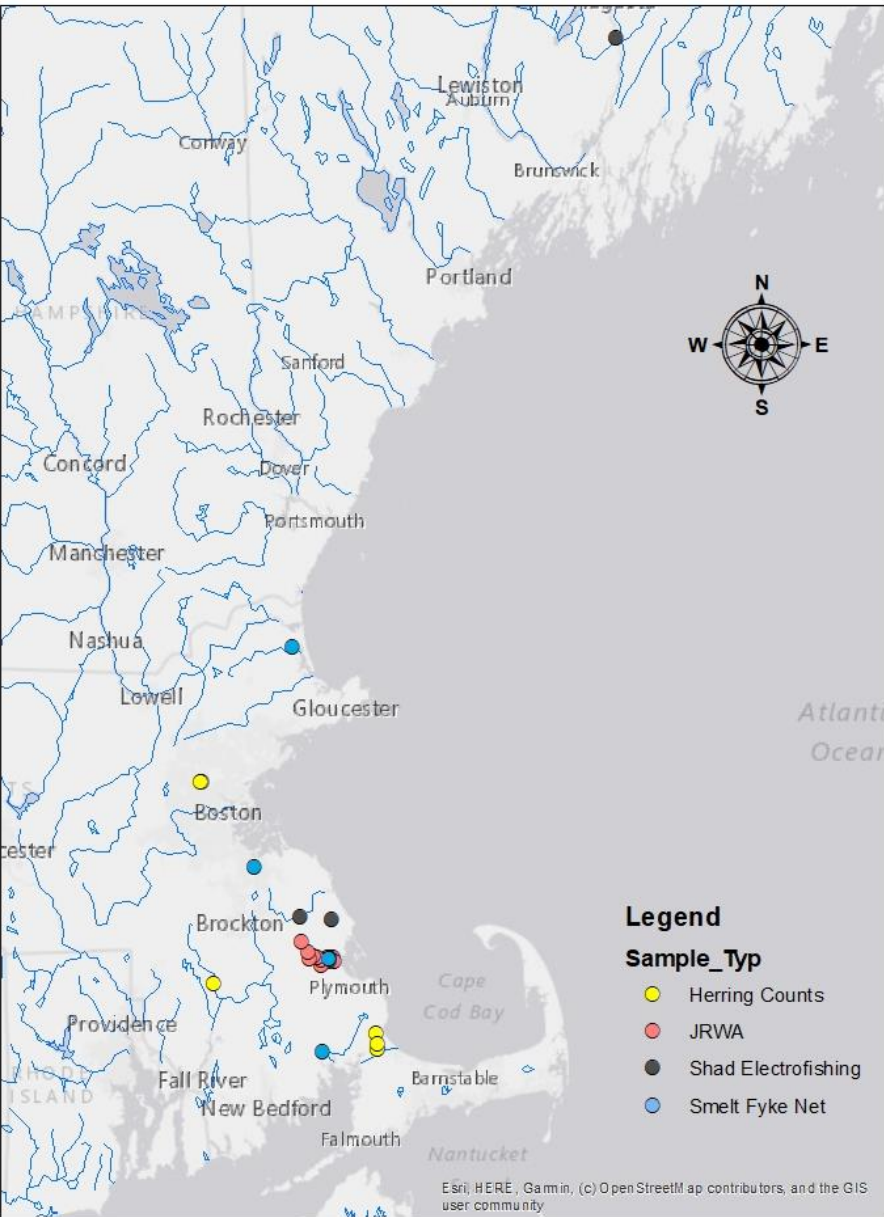


Some of my ongoing work

Project 2: Calibrating eDNA abundance metrics to established methods (electronic herring counters, fyke net surveys, purse seine surveys, and electrofishing surveys)



New England eDNA Project Locations



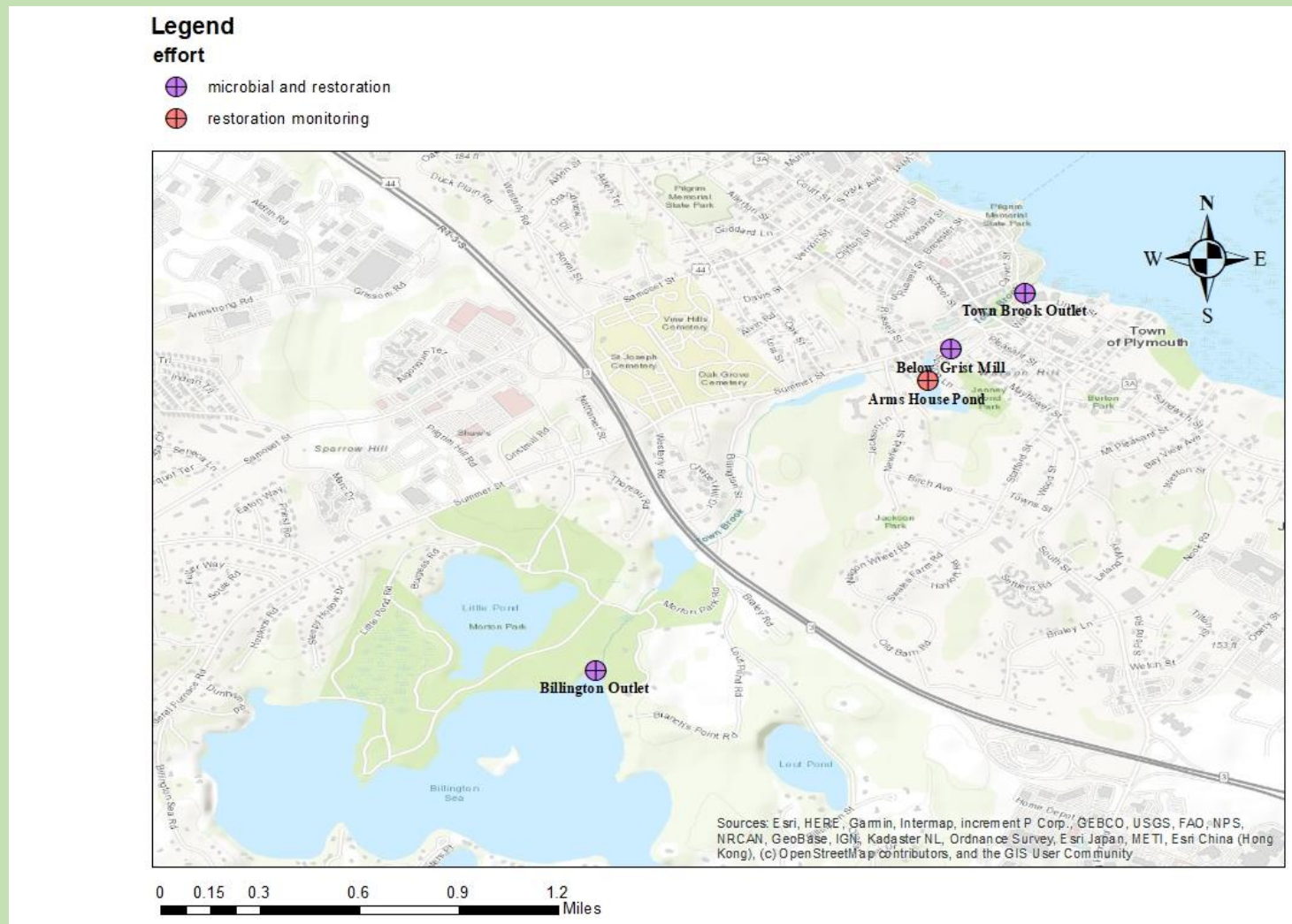
Some of my ongoing work

- Project 3: Detecting population (read; river) specific genetic signatures of American shad using eDNA techniques that are currently being developed

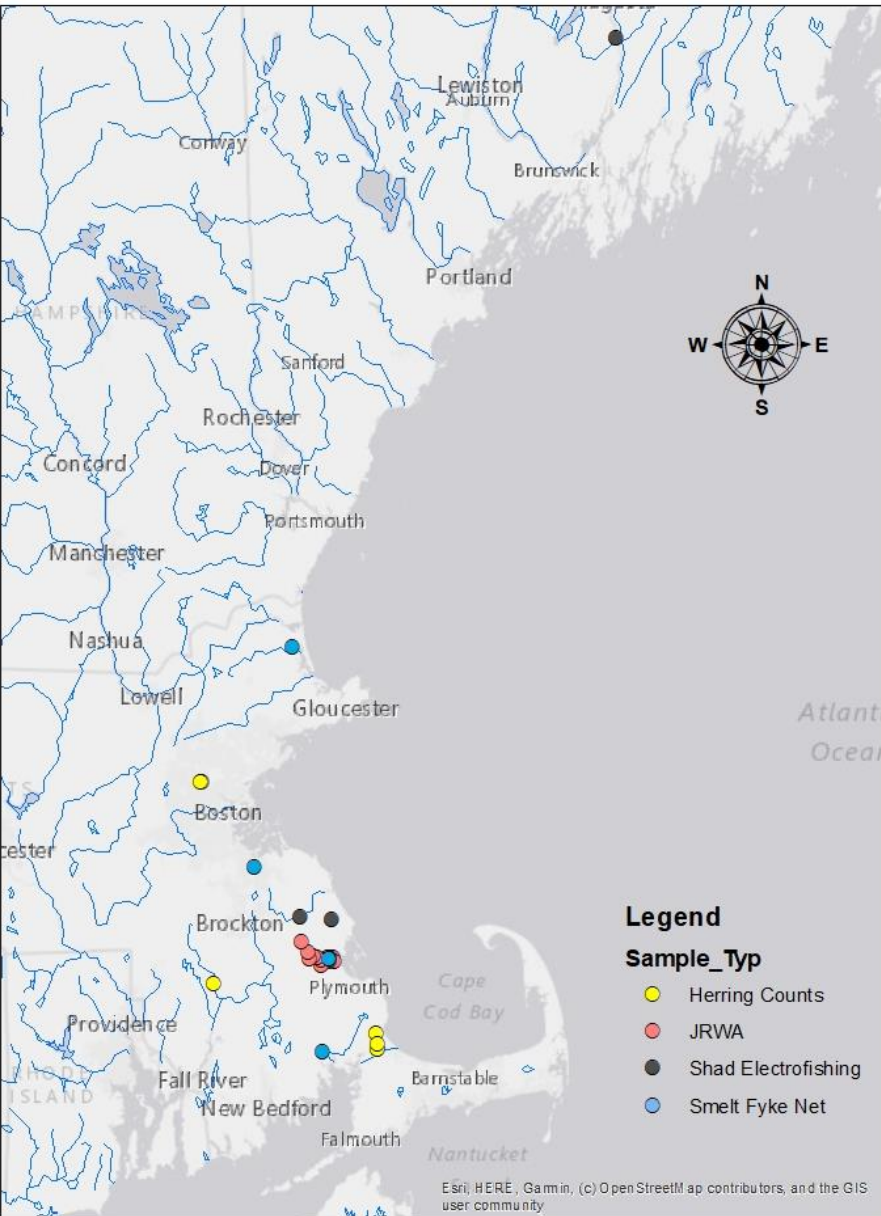
Project 4:

Developing a field deployable, affordable, equitable, and accessible eDNA biodiversity monitoring kit

Project being tested/validated in conjunction with the Town of Plymouth, MA in preparation for an upcoming dam bypass project



New England eDNA Project Locations



Some of my ongoing work

- Project 1: Using eDNA biodiversity methods to measure restoration action efficacy in a coastal New England watershed
- Project 2: Calibrating eDNA abundance metrics to established methods (electronic herring counters, fyke net surveys, purse seine surveys, and electrofishing surveys)
- Project 3: Detecting population (read; river) specific genetic signatures of American shad using eDNA techniques that are currently being developed
- Project 4: Validating/comparing novel eDNA biodiversity sequencing, filtration, and preservation techniques to develop a turn-key, field deployable biodiversity monitoring system

Resources and Literature

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Questions?

Thank you!!!

For references, contacts, or any questions, please don't hesitate to reach out!

Contact Information: JGGarner@umass.edu

