

# From the Charles River to Half-Earth, ClassACT Symposium 1 June 2023

## Part 1: The Charles River and Boston Harbor, Then and Now

Jesse Ausubel ('73) and Mark Stoeckle ('74) assisted by Elizabeth Munnell ('73)

### Charles River Then:

#### 8 May 1972: Rat Race Reaches River as Riff-Raff Race Rafts

Harvard Crimson NO WRITER ATTRIBUTED

...eight hardy entrants paddled, puffed, swam and spun their way down the Charles in the second annual Adams House classic.

The City of Dorchester and the Canoe Cuy, full size catamaran-type warships, left all other contenders in the lurch. Canoe Cuy was the winner, but two first place awards were made, owing to a dispute about class conflict.

Both Water Bedlam (skippered by **Tinker Lindsay, Tad Paul, and Lisa Noll**) and Delta Queen (manned by **Henry Hardy and Terry Valenzuela**) ended upside down. The crew of Water Bedlam was compensated for their pains by walking off with the "**Cholera Cup**," awarded to the first contestant to fall in the Charles, and live.

**Sarah Groves and Dixie Brown** won the "I hope nobody recognizes me award" for worst constructed craft. **David Little and Bill Burke** won the "PT 109 Award" for best design for speed that lost anyway. The "Carpenter Center Award" for most creative craft went to **Robert Livingston** and his bag filled with balloons.

**7 August 1996** Gov Bill Weld takes unannounced dive into Charles River after signing rivers protection bill.

AP photo.



**Now: 15 July 2013** For first time in more than five decades, Boston's Charles River deemed clean enough for a swim. ...

<https://www.planetizen.com/node/64166>



# Cleaning the Waters and Sediments of Boston Harbor

Posted on *March 26, 2020* Written by *Rob Moir, Ph.D.*

*No Comments*

This article was written by Spring Intern Kaitlyn Carpenter.

## Boston Harbor

Boston Harbor was once called the dirtiest water in America. Raw sewage, runoff of the streets, heavy metals, and excess nutrients were found in the waters. This caused all sorts of problems for the people of Boston's health and safety. With the MWRA implementing Deer Island Sewage Treatment Plant, thanks to ratepayers, Boston Harbor is now known as, "A Great American Jewel." Harbor waters are cleaner with people enjoying beaches and recreating.



1994 sludge disposal stopped going into harbor.  
1997 full primary treatment implemented at Deer Island  
2000 full secondary treatment implemented  
2011 Combined Sewer Outflow Storage to protect after heavy rains implemented



Now, if clean...What **vertebrates** live in and around Charles River and Boston Harbor?  
Survey with new genomic technique: environmental DNA (eDNA), loose DNA found in water

- 21 JANUARY 2023 and 30 APRIL 2023
  - COLLECT 500 ML WATER AT 5 SITES



Betsy & Jesse



Mark



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# Short DNA sequences or “Barcodes” identify species

Colored stripes  
represent **thymine**  
**cytosine** **adenine**  
guanine nucleotides

Works for fragments,  
look-alikes, different life stages

From COI gene  
mitochondrial DNA,  
also other genes,  
e.g., 12s, 16s



Tube anemone



Pelagic snail



Ambereye shrimp



Arctic Sea star

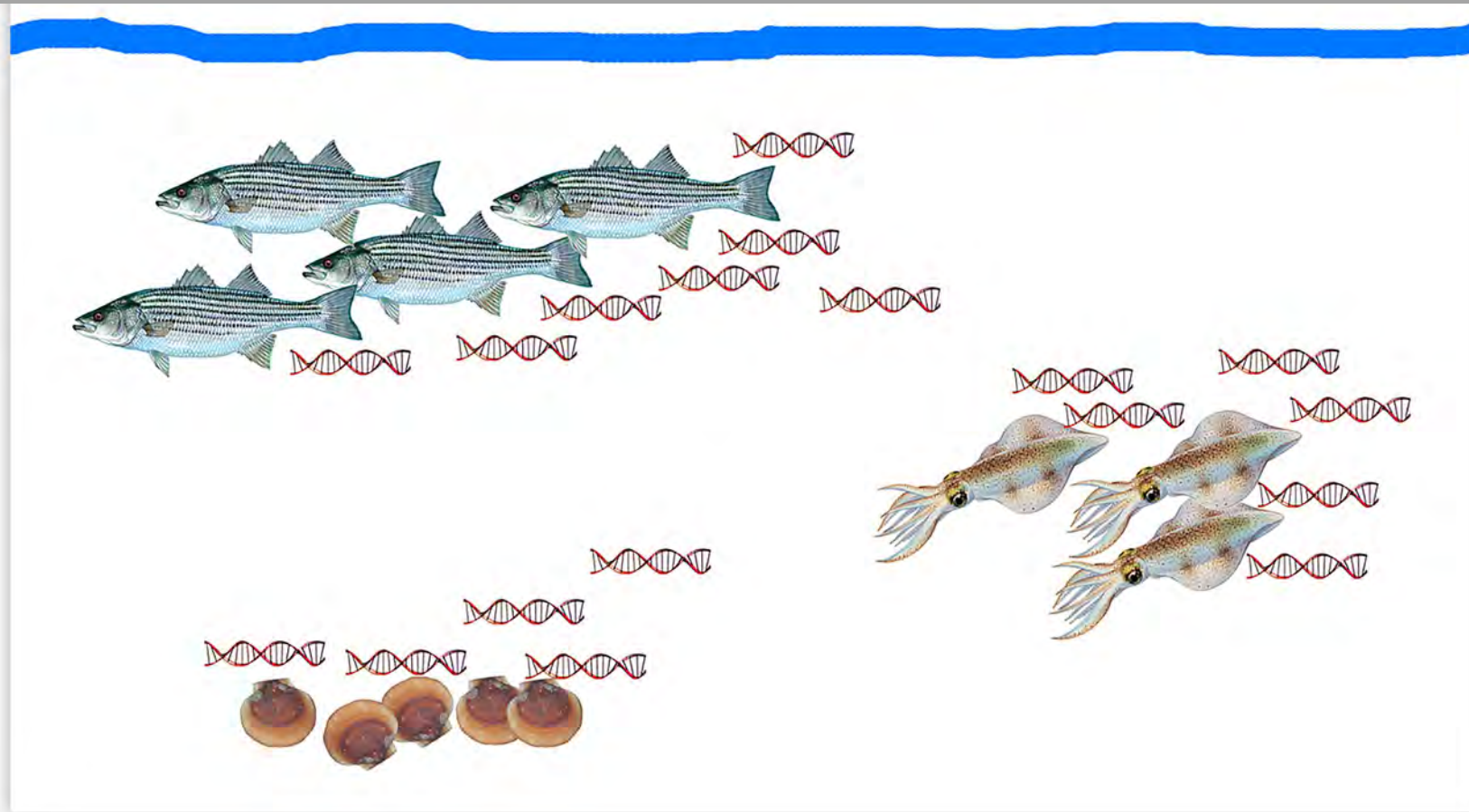
*Barcodes: Stoeckle*  
*Images: Clarke-Hopcroft,*  
*Hopcroft, Bluhm, Iken*



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Aquatic environmental DNA (eDNA):  
Low-cost, low-impact technology for detecting aquatic animals & those nearby

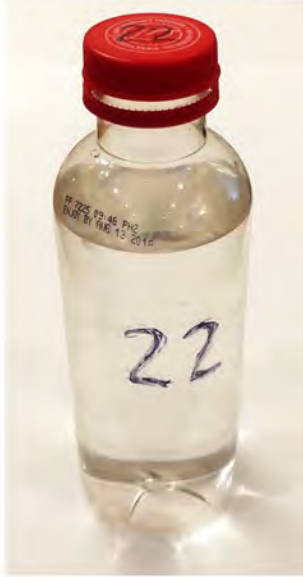


- Fish and other animals leave DNA traces in water  
No capture needed!
- Analyzing these traces can reveal what lives where



# Process for acquiring and analyzing eDNA

## Collect



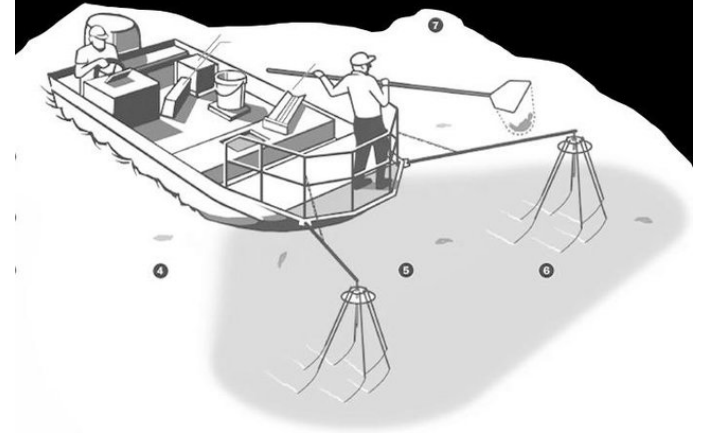
## Filter



## Purify DNA



Cf Electrofishing with a boom-boat which stuns fish with high-voltage direct current



## Sequence DNA



## Match "reads" to genetic library

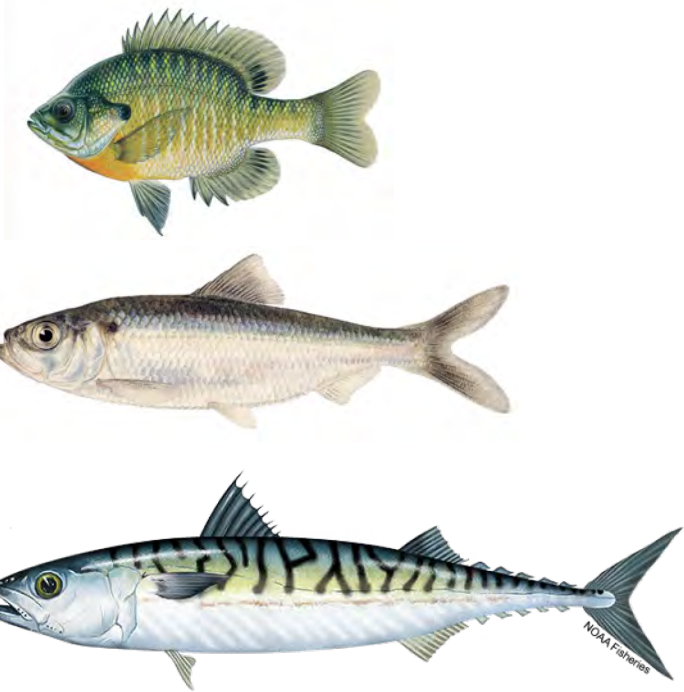



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# eDNA reveals diverse local wildlife

## FISH 52 species



  
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## BIRDS 26 species



## HERPS 9 species



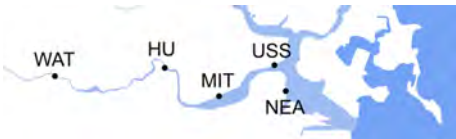
## MAMMALS 21 species





# FRESHWATER FISH (including migratory)

eDNA COPIES PER LITER  
5 sites, 28 sp



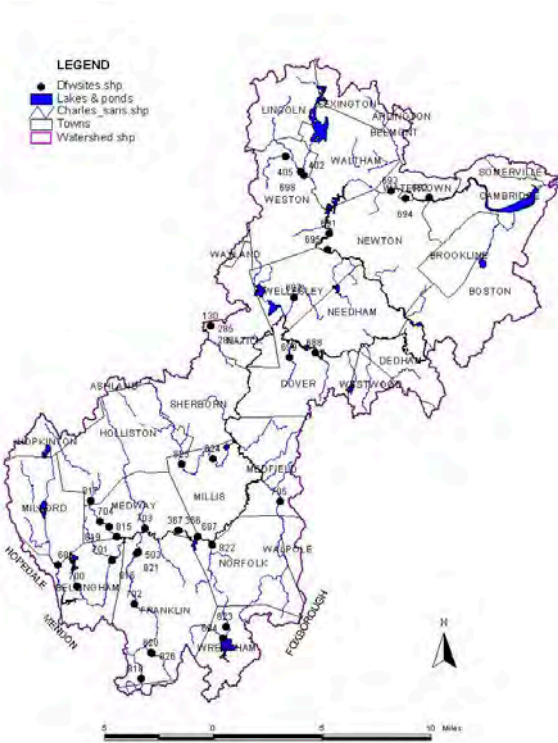
HABITAT	SPECIES ID	SUM COPIES	LIBRARY									
			980-200r1 30A1 A May 2003-2	980-200r1 30A1 S May 2003-2	982-200r1 30A1 A May 2003-2	982-200r1 30A1 S May 2003-2	981-200r1 30A1 A May 2003-2	981-200r1 30A1 S May 2003-2	979-200r1 30A1 A May 2003-2	979-200r1 30A1 S May 2003-2	983-200r1 30A1 A May 2003-2	983-200r1 30A1 S May 2003-2
FRESH	White sucker	19548										
FRESH	Bluegill	9889										
FRESH	Pumpkinseed	9434										
FRESH	Spottail shiner99	7316										
FRESH	Common carp	7287										
FRESH	Red breast sunfish	4148										
FRESH	Yellow perch	3909										
FRESH	Largemouth bass	2823										
FRESH	Black crappie	1812										
FRESH	Yellow bullhead	1256										
FRESH	Golden shiner	1128										
FRESH	Banded killifish	1063										
FRESH	Grass or chain pickerel	639										
FRESH	Goldfish	461										
FRESH	Smallmouth bass	339										
FRESH	Brown bullhead	243										
FRESH	Darter sp96	241										
FRESH	Brown bullhead99	226										
FRESH	Rainbow trout, other Oncorh	17										
FRESH	White bass	8										
BOTH	Alewife, river herrings	486946										
BOTH	Striped bass	5220										
BOTH	American gizzard shad	5106										
BOTH	White perch	3919										
BOTH	Mummichog	2451										
BOTH	American eel	1548										
BOTH	White catfish	790										
BOTH	Rainbow smelt	382										

SITE	JANUARY					APRIL					TAP
	WAT	HU	MIT	USS	NEA	WAT	HU	MIT	USS	NEA	
LIBRARY	F	F	F	S	S	F	F	F	S	S	T
LOCAL SPECIES	16	22	20	14	24	18	22	16	22	24	0

Electrofishing survey 2000-2003  
28 sites, 25 sp

Table 4-3. Charles River Watershed Fish Sampling Results 2000-2003

Fish Species	Macrohabitat Classification <sup>(1)</sup>	Mainstem Count	Tributary Count	Total Count	Relative Abundance
Bluegill	MHG	545	316	861	25.9%
Redfin Pickerel 1	MHG	6	376	382	11.5%
Largemouth Bass	MHG	140	216	356	10.7%
American Eel	MHG	298	24	322	9.7%
Redbreast Sunfish	MHG	207	85	292	8.8%
Pumpkinseed	MHG	92	139	231	7.0%
Yellow Perch	MHG	145	16	161	4.8%
Golden Shiner	MHG	90	44	134	4.0%
Yellow Bullhead	MHG	33	80	113	3.4%
Chain Pickerel 1	MHG	19	57	76	2.3%
White Sucker	FD	22	52	74	2.2%
Brown Bullhead	MHG	4	63	67	2.0%
White Perch	MHG	55	3	58	1.7%
Common Carp	MHG	51	0	51	1.5%
Black Crappie	MHG	48	1	49	1.5%
Brown Trout	FS	1	32	33	1.0%
Smallmouth Bass	MHG	14	0	14	0.4%
Creek Chubsucker	FS	0	12	12	0.4%
Brook Trout	FS	0	10	10	0.3%
Banded Sunfish	MHG	0	7	7	0.2%
White catfish	MHG	6	0	6	0.2%
Blueback Herring 2	FD	5	0	5	0.2%
Swamp Darter	MHG	0	3	3	0.1%
Rainbow Trout	FS	2	0	2	0.1%
Hy. Bluegill/Pumpkinseed	MHG	0	1	1	0.0%
Blacknosed Dace	FS	0	0	0	0.0%
Fallfish	FS	0	0	0	0.0%
Spottail Shiner	MHG	0	0	0	0.0%



Yellow = also detected by eDNA



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Black square = eDNA detected

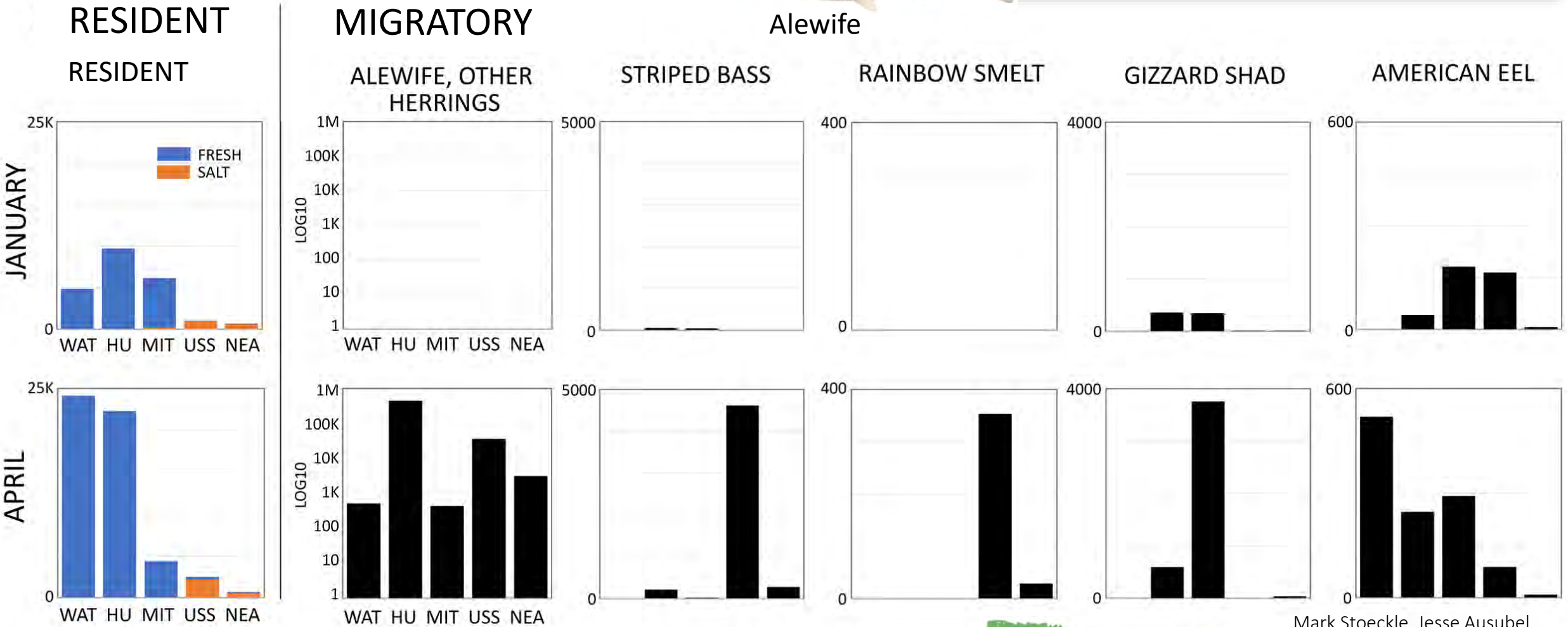


# FISH: RESIDENT, MIGRATORY

eDNA copies/liter



Alewife



MAMMALS

SPECIES ID	SUM COPIES	COLLECTION DATE									
		JANUARY					APRIL				
		WAT	HU	MIT	USS	NEA	WAT	HU	MIT	USS	NEA
Norway rat	37272	F	F	F	S	S	F	F	F	S	S
Eastern cottontail	21111										
American beaver	7432										
Gray squirrel	4699										
New England cottontail	3896										
Muskrat	2558										
Deer mouse	2090										
Northern short-tailed shrew	1135										
Raccoon	1106										
Meadow vole	713										
Long-tailed weasel	168										
White tailed deer	150										
Opossum	86										
Eastern chipmunk	85										
Star-nosed mole	65										
Striped skunk	24										
Vole sp Microtus sp	19										
Fisher	18										
River otter	17										
Red fox	13										
Sea lion	10										

Black = eDNA detected



Norway rat



Short-tailed shrew



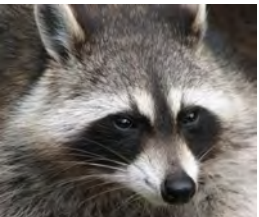
American beaver



Deer mouse



Eastern cotton-tail



Raccoon



Star-nosed mole



Long tailed weasel



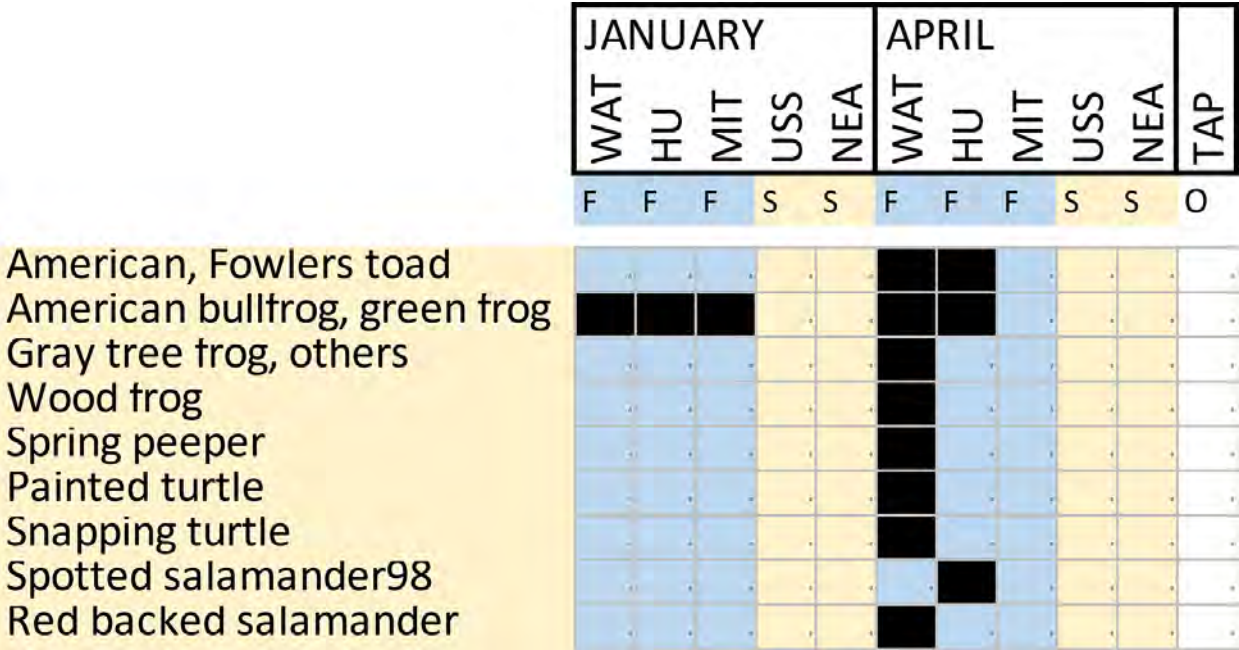
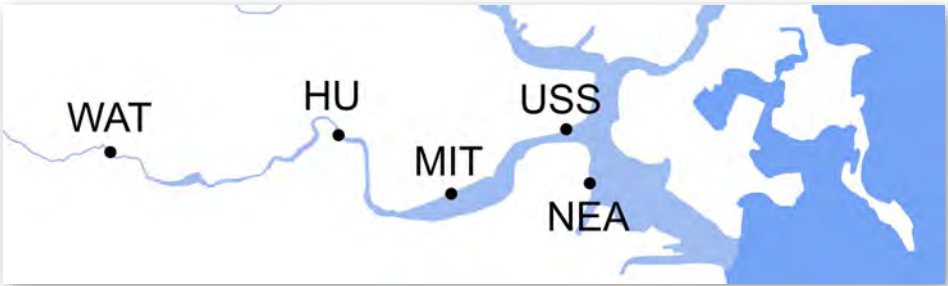
River otter



Fisher



# AMPHIBIANS, REPTILES



Black = eDNA detected



# Does improving the environment reward the effort and expense?

Front. Mar. Sci., December 2018 <https://doi.org/10.3389/fmars.2018.00478>

## Evaluating Boston Harbor Cleanup: An Ecosystem Valuation Approach

Di Jin<sup>1\*</sup>, Chris Watson<sup>2</sup>, Hauke Kite-Powell<sup>1</sup> and Paul Kirshen<sup>2</sup>

<sup>1</sup>Marine Policy Center, Woods Hole Oceanographic Institution, Woods Hole, MA, United States

<sup>2</sup>School for the Environment, University of Massachusetts Boston, Boston, MA, United States

We develop an economic evaluation of the Boston Harbor Cleanup, court-mandated in 1986, through comparison of cleanup costs and relevant ecosystem service values. Our results suggest that the ecosystems in the study area provide services to society with a capitalized value ranging from \$30 to \$100 billion. The \$4.7 billion cost of the Boston Harbor Cleanup is about 5–16% of the total asset value of ecosystem services.

7 October 2022

EPA Highlights Boston Harbor as a National Success Story to Celebrate the 50th Anniversary of the Clean Water Act

<https://www.epa.gov/newsreleases/epa-highlights-boston-harbor-national-success-story-celebrate-50th-anniversary-clean>



<https://youtu.be/Kye7QuBiLNc>



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From the Charles River to Half-Earth: Ecosystems can recover, and  
liquid biopsies allow affordable, frequent, reliable biodiversity surveys  
A little water tells a lot

#fish species by  
eDNA in 1 liter

≥

#fish species by  
trawl in 60 M liters



1 liter







Photos from 1973 Raft Race



Thanks to Mark and Betsy,  
and over to John

