Fishing for DNA in the Hudson

Meeting point: entrance to Little Island, 13th St and West St, 9:00am, Thursday 3 Nov 2022

Jesse H. Ausubel, The Rockefeller University

Abstract: Sieving “eDNA” from the water has enabled discoveries about life in the Hudson River and New York Harbor. Findings span dolphins and sturgeon as well as seafood served in New York City restaurants.

Special thanks to Dr. Mark Y. Stoeckle

https://phe.rockefeller.edu/barcode/blog/nycnj-aquatic-vertebrate-edna-project/
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.

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

Tube anemone  Pelagic snail  Ambereye shrimp  Arctic Sea star
Marine environmental DNA (eDNA): A relatively low-cost, low-impact technology for detecting ocean animals

- Fish and other animals leave DNA traces in water
  No capture needed!
- Analyzing these traces can reveal what lives where
Could we collect DNA without collecting specimens or tissue?

Collecting fish

Collecting water
Why? Potential eDNA applications enables ecosystem-based management

- Monitor aquatic vertebrate distribution and abundance
- E.g., to detect invasive or endangered species
- Potentially cheaper, gentler, more widely applicable than traditional methods

Monitoring
- Fishing
- Aquaculture
- Extraction
- Energy
- Shipping
- Weather/Climate
- Conservation
- Restoration

Research/Exploration
Fishing for DNA: the steps

1. Collect water samples
2. Filter to concentrate
3. Extract DNA
4. Amplify target (mtDNA 12S 110 bp)
5. Sequence
6. Match to library

Illumina MiSeq
A lab from eBay on a dining room table (already feasible ~2010)

Heating block, thermal cycler, microcentrifuge, vortex mixer, electrophoresis unit, pipettors

~$5000
Reference library: most Northeast area fish species have relevant ("12S") sequences in GenBank database

*including ref seqs for 102/107 (95%) species ranked abundant/common

Current 12S coverage
NJ State Checklist
(Able 1992)
240/341 species (70%)

INCLUDES

New ref seqs since 2017 from MURU initiative
85 species
The start: *City Fish* - NYC Central Park eDNA survey

*Iman Nassef*

*Iman Nassef*

*Iman Nassef*

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*Iman Nassef*

The Loch

Harlem Meer

The Pool

*sampling sites summer 2015*

*Alden Liang*
A dozen species in ¼ cup of water

- Analyze 6.33 ng DNA (roughly 60 mL H₂O); 7 x 10^4 reads
- Detected 7 species of fish, also mammals, birds

Fish images NYS DEC

**Fish**

- Black crappie
- Golden shiner
- Brown bullhead
- Largemouth bass
- Banded killifish
- Bluegill
- Pumpkinseed

**Mammals, birds**

(Note lower scale)

- Raccoon
- Songbird
- Mallard
- Norway rat
- Dog
- Human

The Loch

103rd & CPW
eDNA detected most species found by traditional methods, plus some not found

vs. Electrofishing

vs. Seining

NYSDEC Meer, Pool Surveys, 2008-2015

2013 Bioblitz, Harlem Meer, The Pool
eDNA vs traditional methods

- 7 of top 10 species same by seining, eDNA

Seining top 10 species
  (#individuals)

- weakfish
- Atlantic tomcod
- Hogchoker

eDNA top 10 species
  (#reads)

- tautog
- white perch
- goby
- cunner
- American eel
- oyster toadfish
- striped bass
- bay anchovy
- Herning (Alosa spp)
- Atlantic menhaden

- Seining data from 2013 Long River Survey, Hudson River Monitoring Program
  (thanks to Keith Dunton for sharing survey reports)
- Long River Survey Hudson only, NYC to Albany
Verification: NY Aquarium tanks

About 1/10 total DNA vs natural samples (water strongly filtered)
Tropical Reef tank (10 known species)
Walrus tank (only walrus)
Penguin tank (5 fish sp, penguin, gull)
Shark tank (sand tiger shark)
Where are fish eDNAs in NYC?

• 10 sites, 23 1 liter samples, Aug-Nov 2015
  • Fish eDNA all sites
  • 29 species
  • Average 9 species/site

Subsequently Gowanus Canal, Coney Island…now working in Raritan Bay
Under the George Washington Bridge

Location: Ft. Washington Park, Manhattan
Date: November 6, 2015  Sample: 100 mL

Aquatic vertebrate eDNA

<table>
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<tr>
<th>Species</th>
<th>Percent AV reads</th>
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<td>SHAD</td>
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- Atlantic menhaden
- Shad (Alosa sp.)
- Oyster toadfish
- American eel
- Striped bass
- Tautog
Salt marsh at top of Manhattan: mostly salt marsh minnow eDNA

NYC/NJ Aquatic Vertebrate eDNA Project
Sample no. 26
Location: Spuyten Duyvil Creek, Manhattan
Date: October 18, 2015  Volume analyzed: 1 liter

Fish eDNA

- Mummichog
- Atlantic silverside
- White perch
- Striped bass
eDNA in the East River

NYC/NJ Aquatic Vertebrate eDNA Project

Location: East River at 63rd ST, Manhattan

Date: October 30, 2015   Sample: 1 liter

Fish eDNA

- Atlantic menhaden
- Herring spp
- Black sea bass
- Striped bass
- Tautog
- American eel
- Bluefish
- Bay anchovy
- Oyster toadfish
- Atlantic silverside
- Mummichog
- Conger eel

No. reads (%)
A historically polluted Brooklyn canal

Gowanus Canal eDNA Project

Collection sites
- 1 liter samples
- July 2019

Fish eDNA
- analyzed by Illumina MiSeq
  12S metabarcoding

<table>
<thead>
<tr>
<th>Gowanus, NY Harbor</th>
<th>GOWANUS</th>
<th>TAP</th>
<th>NY HARBOR</th>
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<td>Striped bass</td>
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Alla Zeidyyeh, Mark Stoeckle, Program for the Human Environment, RockEDU SSRP, The Rockefeller University
eDNA finds sea life at NYC’s Coney Island

1. Atlantic menhaden
2. Tautog
3. Bluefish
4. Scup
5. Smooth dogfish
6. Bay anchovy
7. Windowpane flounder
8. Striped bass
9. Summer flounder
10. Atlantic silverside
11. Winter flounder
12. American butterfish
13. Smallmouth flounder
14. Cownose ray
15. Black sea bass
16. Bullnose ray
17. Clearnose skate
18. Northern sea robin
19. Weakfish
20. Striped sea robin
21. Conger eel
22. Drum species
23. Little or winter skate
24. Atlantic sand lance
25. Atlantic thread herring
26. American eel
27. Spot or black drum
28. Ray species 1
29. Northern stargazer
30. Oyster toadfish
31. Hake sp
32. Seaboard goby
33. Broad striped anchovy
34. Cunner

Marine mammal eDNAs

Bottlenose dolphin

Steeplechase Pier, Coney Island, NYC
1 liter weekly sampling, March 30 to August 3, 2017
The Bronx River, north of Botanical Garden, near grave of Miles Davis in Woodlawn Cemetery, 219th Street, 3 May 2016
Potential for broad biodiversity surveys, not only marine animals

- Electrofishing survey cancelled due to high water, current
- Water analyzed for eDNA: 500 mL

Species detected
- American eel
- Blacknose dace
- Common carp
- Darter (Etheostoma sp)
- Largemouth bass
- Mummichog
- Sunfish (Lepomis sp)
- White sucker
- Yellow bullhead
- Chipmunk
- Eastern cottontail rabbit
- Fowler’s/American toad
- Gray squirrel
- Meadow vole
- Northern short tailed shrew
- Norway rat
- Raccoon
- White-footed deer mouse
- 8 bird species

Compare to Bronx River survey April-Jul 2003 (13 survey days):
  6/10 fish species, plus 3 species not in survey

Thanks to Melissa Cohen, NYS DEC
Marine mammals return to City waters

Bottlenose dolphin-2016 detections
Hudson, East River 1/87 samples 4aug
Barnegat Light, NJ 4/16 samples 10apr,30may,16jul,31jul
• Precision: eDNA detects >40 marine fish species
• Most are seasonal
• Includes species at risk
Localization in space: bay fish eDNA in bay, ocean fish eDNA in ocean

- 12-mo shoreline sampling Barnegat Light, NJ

Top Ten Fish eDNAs

**Bay**
1. Mummichog
2. Atlantic silverside
3. Striped killifish
4. Four-spined stickleback
5. Sheepshead minnow
6. Killifish species
7. Atlantic menhaden
8. Naked goby
9. Northern pipefish
10. Oyster toadfish

**Ocean**
1. Atlantic menhaden
2. Bluefish
3. Striped bass
4. Bay anchovy
5. Tautog
6. Sand lance
7. Windowpane flounder
8. Drum species
9. Silver perch
10. Northern kingfish

- Top 10 frequently detected fish eDNAs
- 26 ocean/bay samples
- Apr 2017-March 2018
eDNA describes abundance as well as identifies species diversity. Amounts of eDNA correspond to weights of fish in net trawls.

- Reads, biomass roughly proportional over about 5 orders of magnitude.

August 2019

\[ R^2 = 0.74 \]

Trawl weight (LOG10)

Emission DNA reads (LOG10)

Stoeckle et al., ICES J Marine Sci 2021, 78, 293-304

New Jersey Trawl eDNA Initiative
Can sample adaptively, spontaneously, e.g., after storms, heat waves, pollution episodes
Information on species diversity & abundance from DNA in 1 liter of water comparable to information from 66 million liters trawled by a net.

66M liters fills football field above goal posts
New York Bight is full of marine life. Let’s be good stewards.

Thanks again to Mark Stoeckle!

Questions?