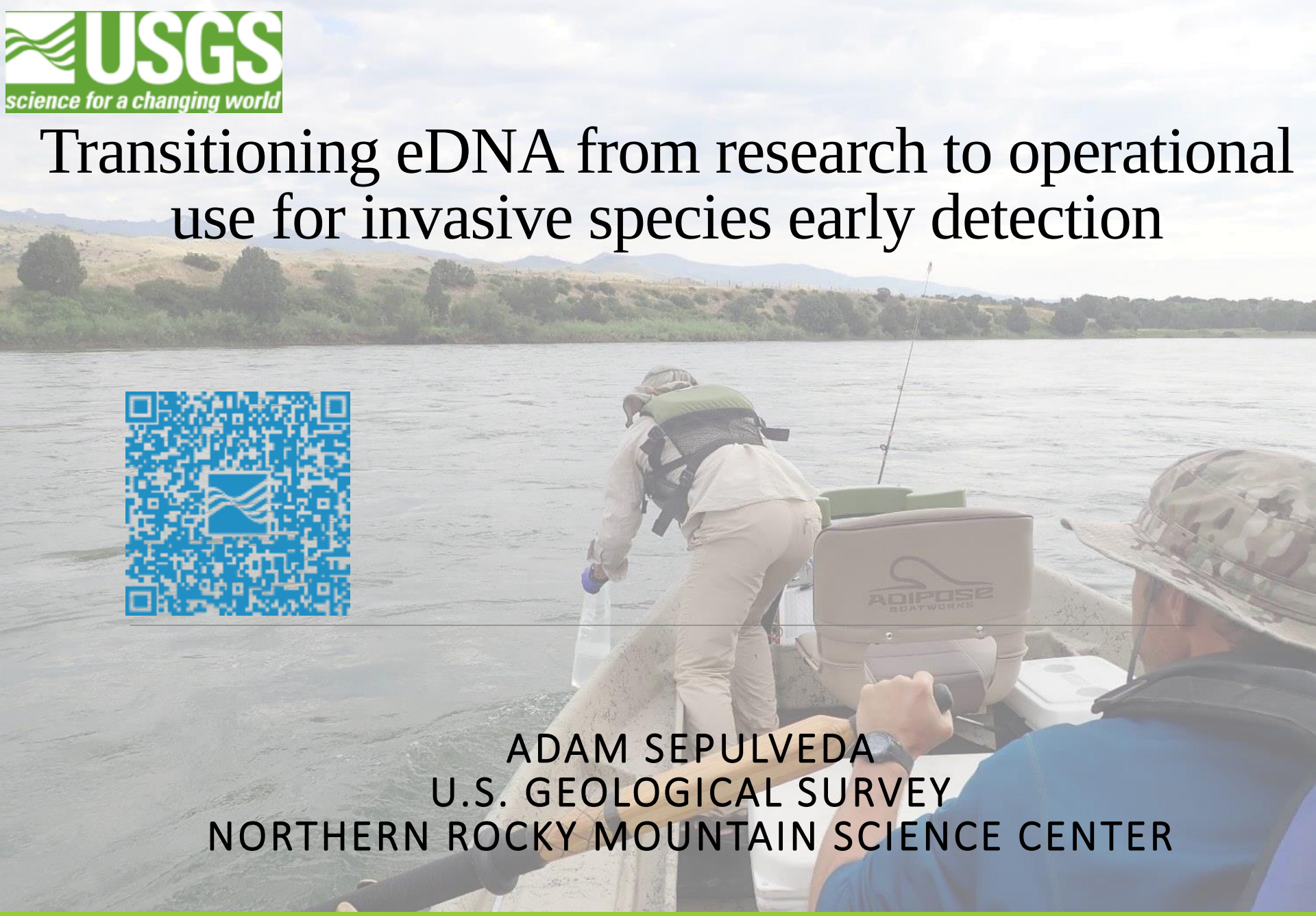
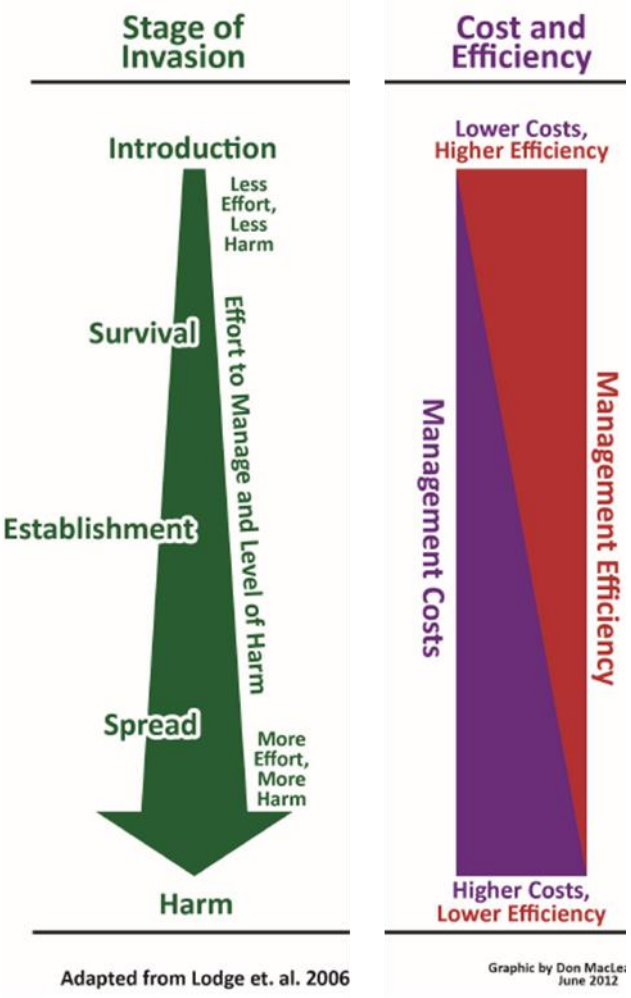
Transitioning eDNA from research to operational use for invasive species early detection



ADAM SEPULVEDA
U.S. GEOLOGICAL SURVEY
NORTHERN ROCKY MOUNTAIN SCIENCE CENTER



Early Detection → Rapid Response (EDRR) saves money, reduces negative effects

USGS

Early detection monitoring

95% prob detecting in 1 sample when rare

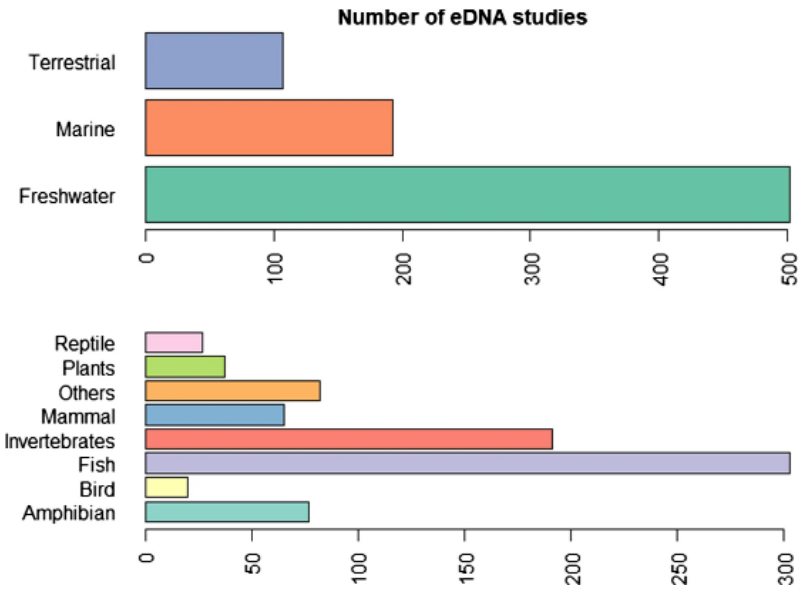
74 – 149 plankton tow samples

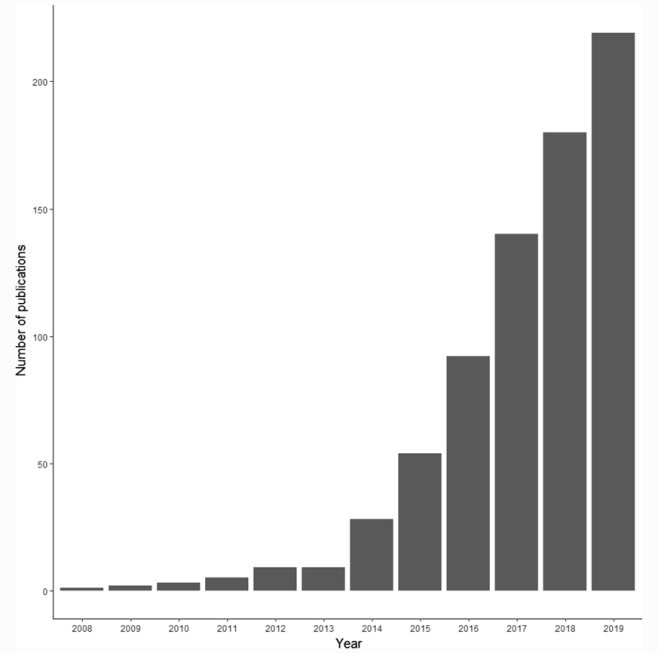
2-30 eDNA samples

Winder M, Sepulveda AJ, Hoegh A (2022) An initial assessment of plankton tow detection probabilities for dreissenid mussels in the western United States. Management of Biological Invasions 13(4): 659–678

Sepulveda AJ, Amberg JJ, Hanson E (2019) Using environmental DNA to extend the window of early detection for dreissenid mussels. Management of Biological Invasions 10(2): 342–358

eDNA has matured





Beng, K.C., Corlett, R.T. Applications of environmental DNA (eDNA) in ecology and conservation: opportunities, challenges and prospects. *Biodivers Conserv* **29**, 2089–2121 (2020). https://doi.org/10.1007/s10531-020-01980-0

eDNA application increasing

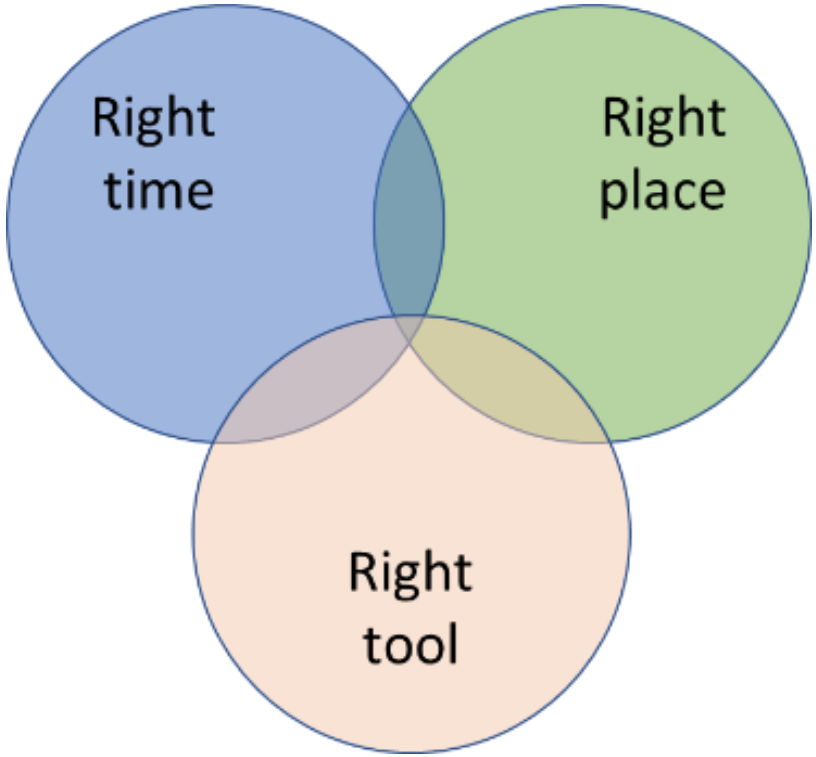
Federal register

- 23+ entries
- Snail darter
  - acceptable use of eDNA to determine distribution
  - eDNA detections contributed to delisting decision

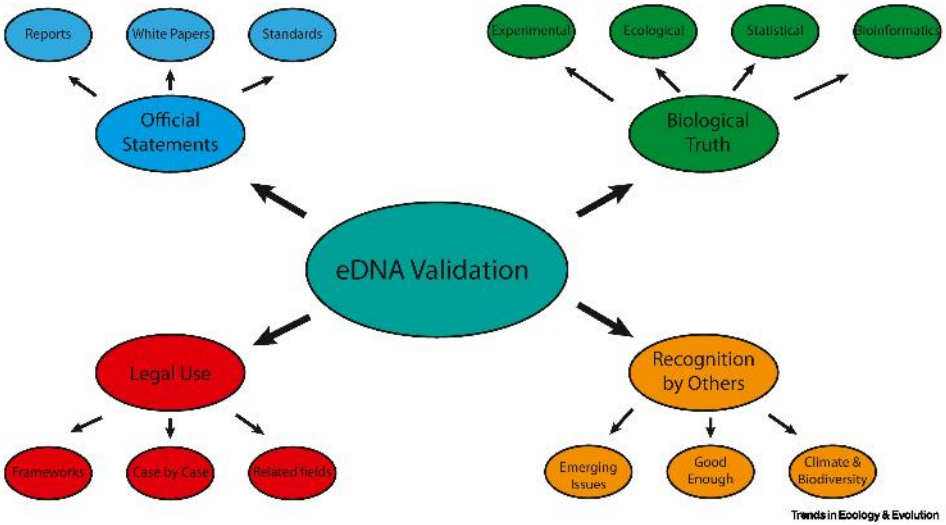
Agency	Parent Agency	Application	Locations/programs
National Invasive Species Council (NISC)	Interior (with membership made up of multiple cabinet-level agencies)	Invasive species	2022 framework for using eDNA,[27] white paper,[28] technical report[29]
United States Geological Survey (USGS)	Interior	Invasive species, ecosystem recovery (Elwha River recovery post-dam removal)[30]	Great Lakes, Yellowstone National Park, Florida Everglades[31]
Bureau of Offshore Energy Management (BOEM)	Interior	Environmental Impact Statement (EIS)	Offshore energy leasing[32]
Fish and Wildlife Service (FWS)	Interior	Invasive species, Endangered species	Aquatic Nuisance Species Task Force (ANS Task Force) Aquatic eDNAtlas Project[33]
National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NOAA NMFS)	Commerce	Invasive species, nearshore fish assessments,[34] public outreach	Aquatic Nuisance Species Task Force (ANS Task Force) Aquatic eDNA Atlas Project,[35] NOAA's Atlantic Laboratory video series on eDNA,[36] NOAA's Fisheries Strategic Initiative to use eDNA libraries,[37] offshore energy leasing with BOEM.
Forest Service (USFS)	Agriculture	Invasive and endangered species	National Genomics Center for Wildlife and Fish Conservation, eDNA Atlas, the Range-Wide Bull Trout eDNA Project,[38] Hiawatha National Forest[39]
Environmental Protection Agency (EPA)	N/A	Water quality	EPA Region 3 in collaboration with West Virginia, Maryland and Pennsylvania[40]

Laschever, Eric, et al. "The next generation of environmental monitoring: Environmental DNA in agency practice." *Columbia Journal of Environmental Law* 48.S (2023): 51-51.

Problem 1
Early detection hard, even for eDNA



Problem 2
eDNA not always trusted



Hajibabaei 2022
https://doi.org/10.1016/j.tree.2022.06.015

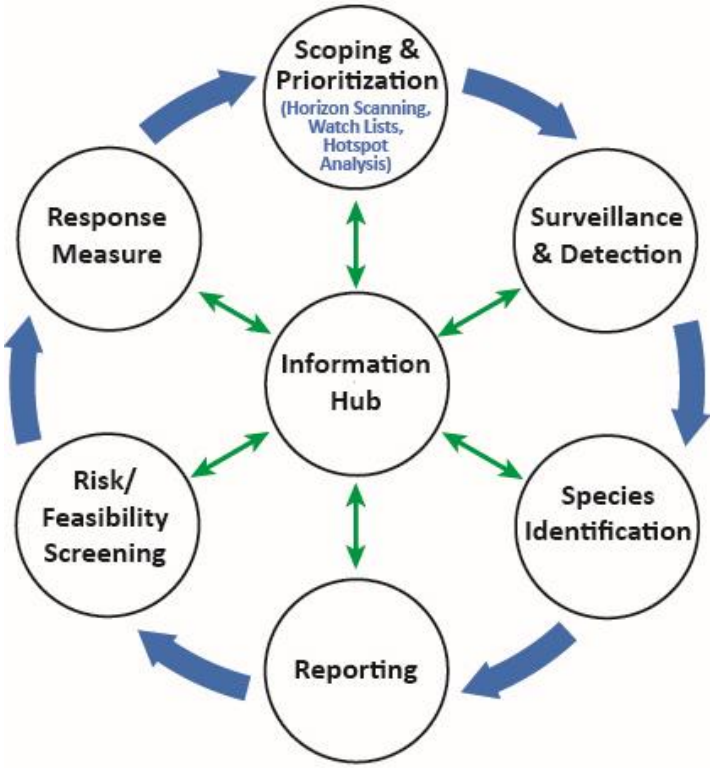
Figure 1. eDNA Science Panel, left to right: Karen Vargas, Robert Bajno, John Darling, Jim Snider, Jon Amberg, and Caren Goldberg.

How to learn to stop worrying and love environmental DNA monitoring

John A. Darling*
National Exposure Research Laboratory, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711, USA
*darling.john@epa.gov

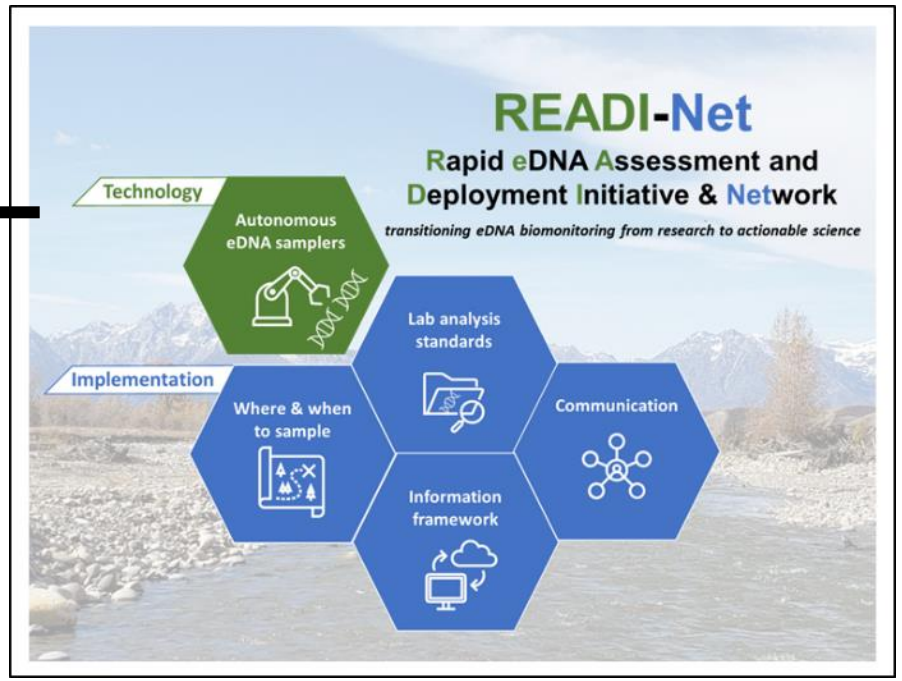
Solutions

USA EARLY DETECTION RAPID RESPONSE FRAMEWORK



Adapted from Reaser et al 2020. The early detection of and rapid response (EDRR) to invasives. Graphic by Don MacLean, U.S. Fish and Wildlife Service

END-TO-END eDNA DETECTION PROGRAM

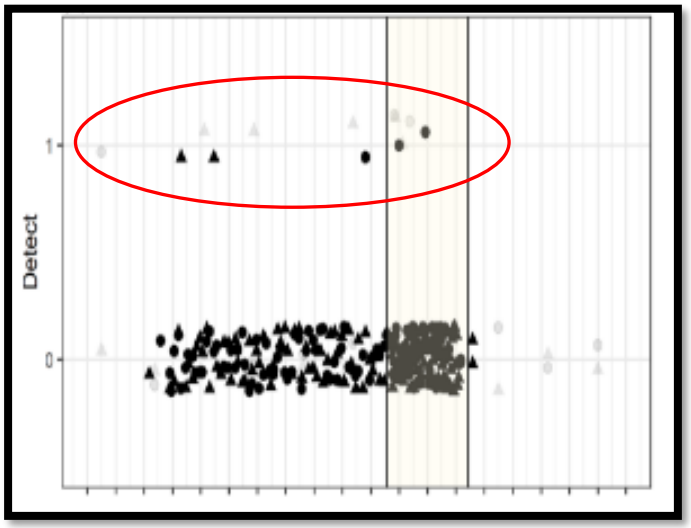


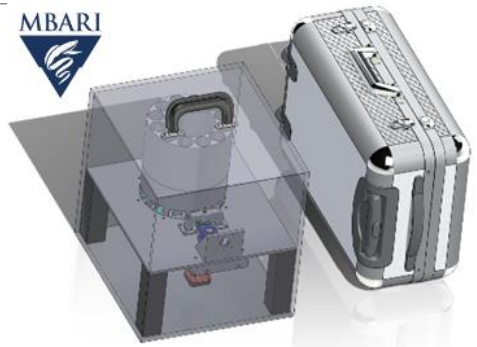
READI-Net

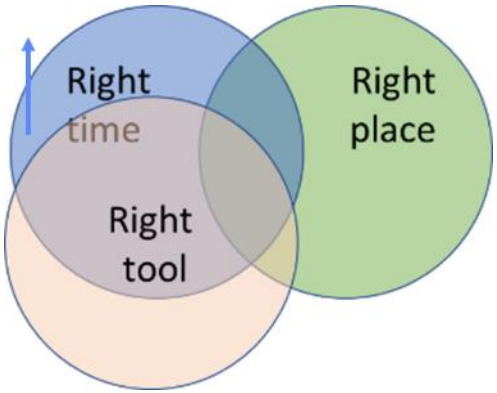
- Improve eDNA detection technology
- Improve trust in eDNA methods and results
- Reduce impacts and costs of invasive species

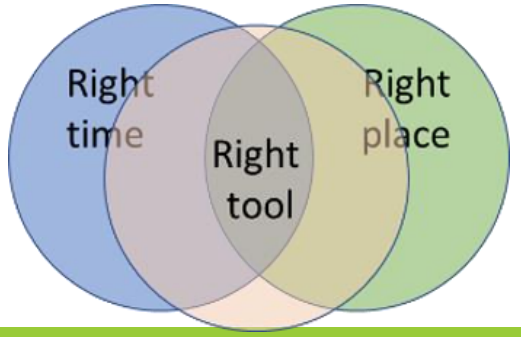
Autonomous eDNA samplers

Monterey Bay Aquarium Research Institute









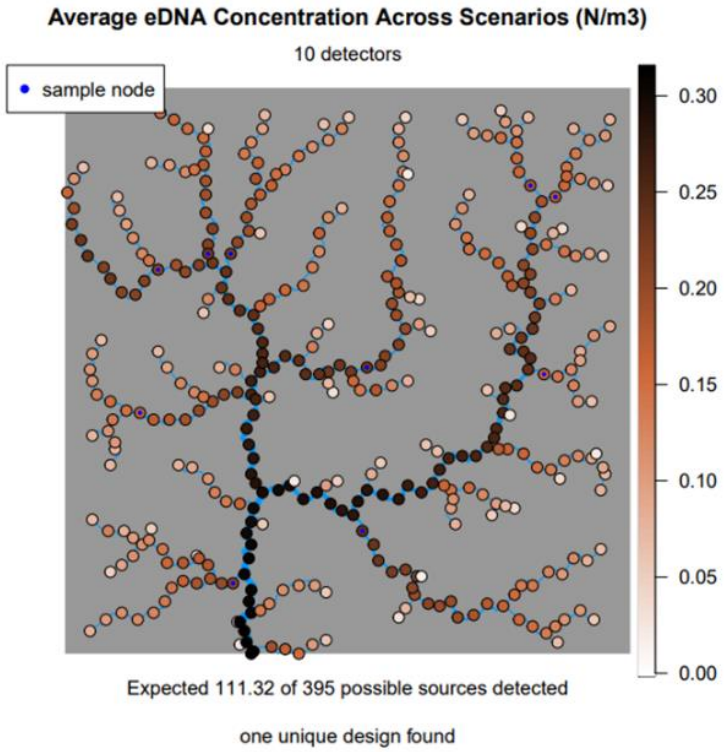
Sepulveda, Adam J., et al. "Robotic environmental DNA bio-surveillance of freshwater health." *Scientific Reports* 10.1 (2020): 1-8.

Where & when to sample

eDNA fate & transport models

- spatial configuration of auto- samplers
- sampling frequency

- improved information
  - detection probability
  - eDNA source location



Repeatable & reproducible results across READI-Net labs

READI-Net
Rapid eDNA Assessment and Deployment Initiative & Network

<u>Establish lab protocols and set lab performance baselines</u>

- 17 USA & CAN labs
- 4-phase intercalibration exercise
  - Increased complexity & realism with each phase

11:35 Caren Helbing & Katy Klymus

Information framework

Multi-Lab Information Management System

≈ Electronic Medical Records

- Data storage for every piece of data collected
- Advanced query capabilities

SQL Server

ArcGIS Enterprise Server

- Data control center
- Manage who has access to what

- Field and lab data collection
- Automated quality assurance for fewer mistakes

ArcGIS Survey123 & Excel Templates

ArcGIS Workflow Manager

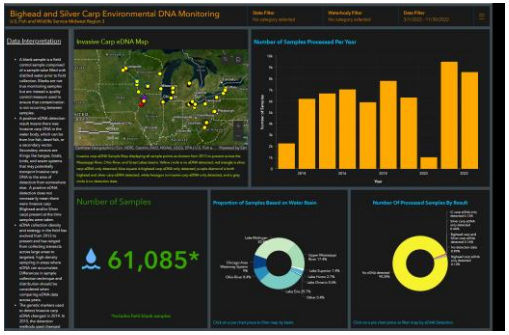
- Automate data flow and quality control
- Automate communication among labs

- Communication portal
- Provide access to all labs and limited access to public

ArcGIS Hub

ArcGIS Dashboards

- Summary overview of lab projects
- Real time reporting and query capability



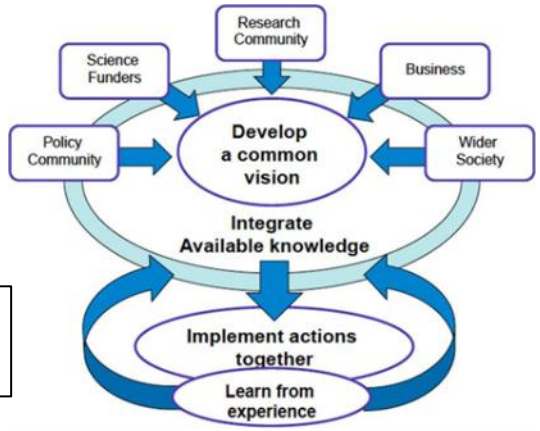
Tracking system to automate QA/QC, share workflows, and provide transparency to end-users

Communication

Shift attitudes, project uptake

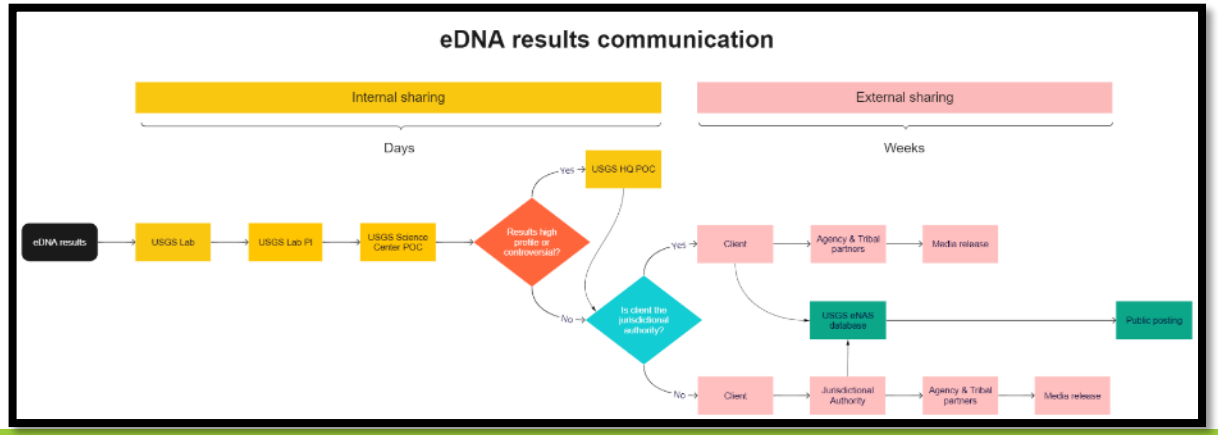
Partner engagement

Kaylin Clements
kclements@contractor.usgs.gov

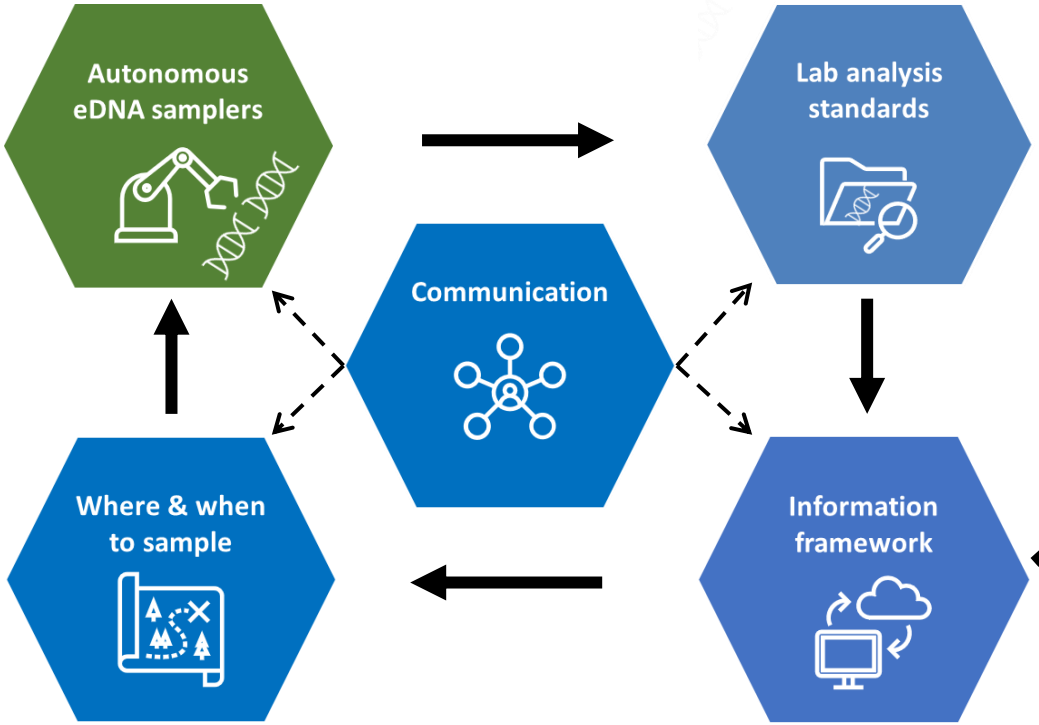


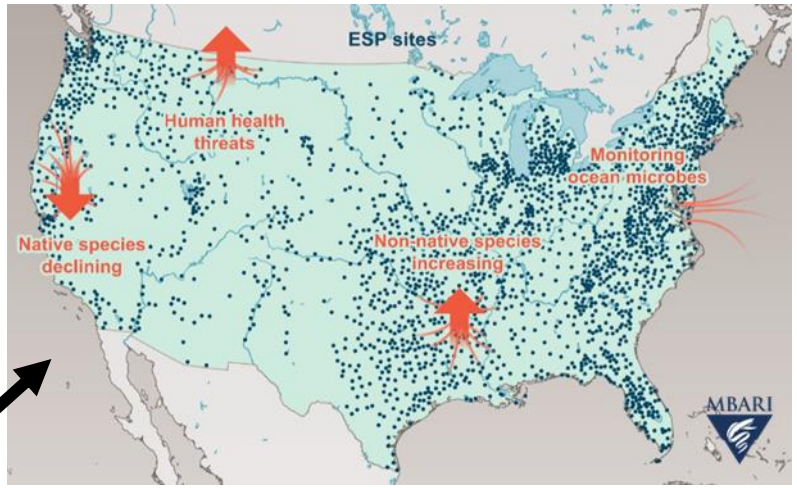
Squire 2014
https://doi.org/10.1186/1753-6561-9-S10-S2

Trust, transparency, no surprises



eDNA research to operation





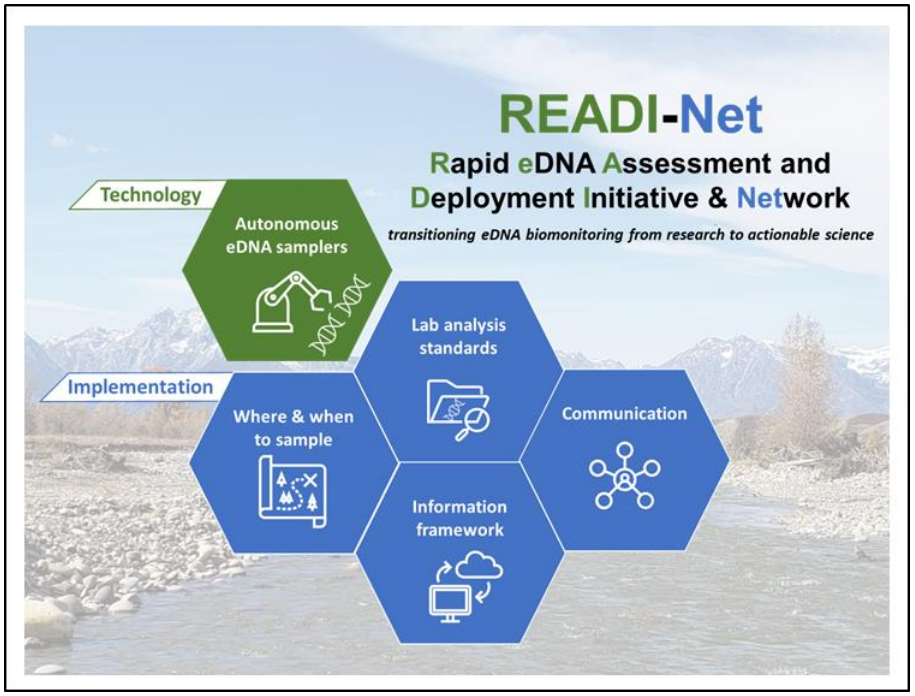
READI-Net

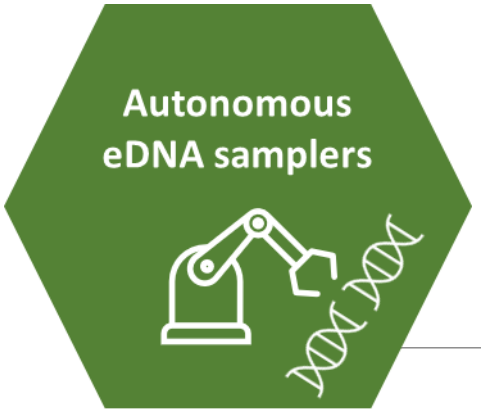
Rapid eDNA Assessment and Deployment Initiative & Network

Contact info

Adam Sepulveda: asepulveda@usgs.gov

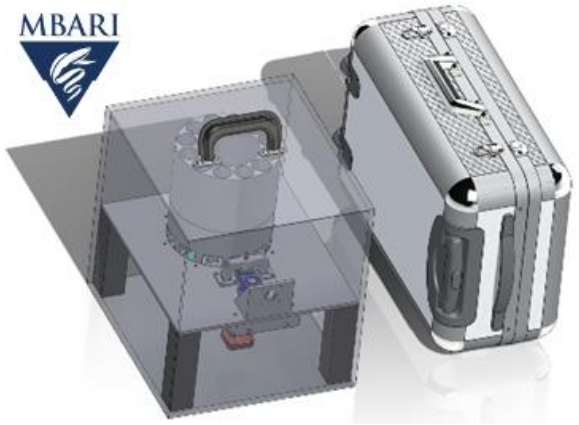
Kaylin Clements: kclements@contractor.usgs.gov



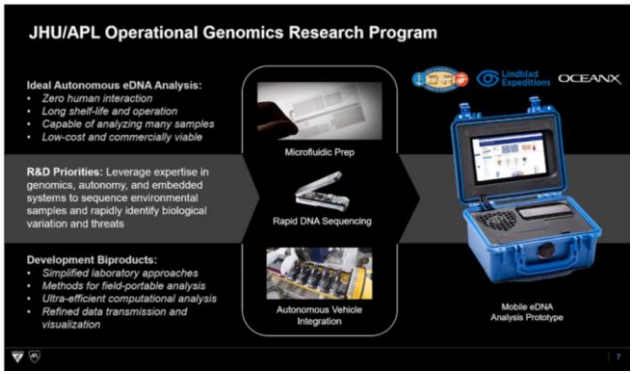


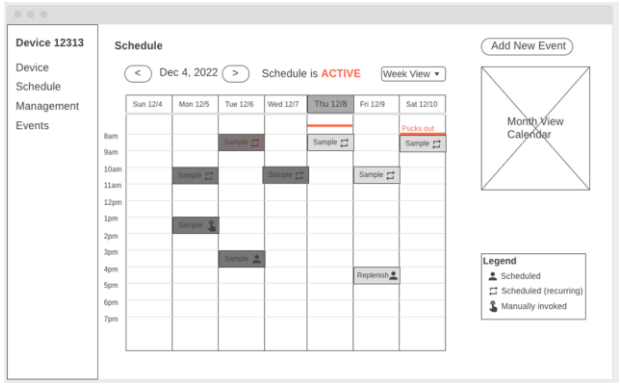
eDNA sampler
cheaper, robust, scalable

- Filter & preserve… not *in situ analysis*
- 144 samples
- 2-way communication
- Easy to use & maintain
- ~ 30 min to retrieve & resupply samples
- <u>Standardize field sampling</u>



In situ analysis alternatives



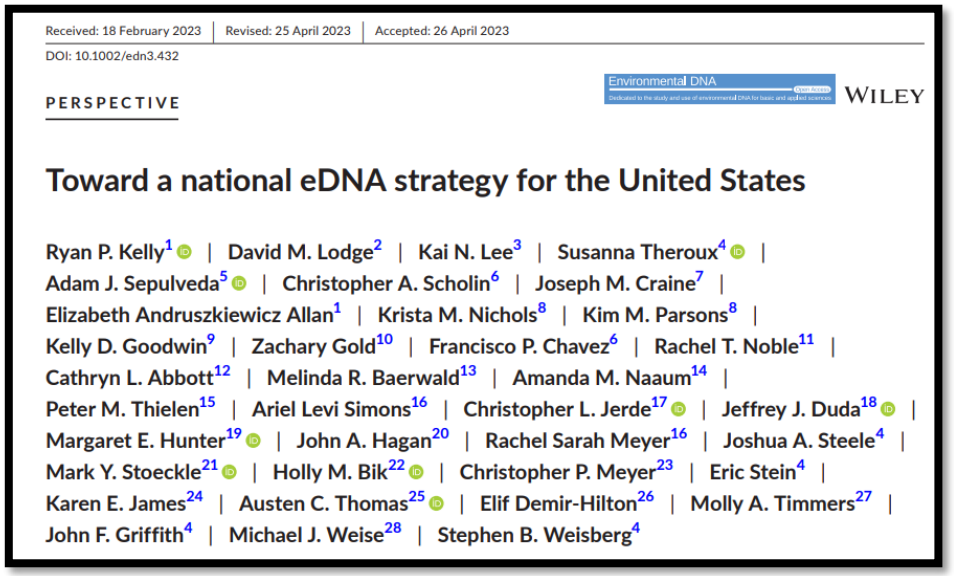


What are your thoughts?

- How can READI-Net add value / fill gaps in your program?
- What aspects of READI-Net are of most vs least use to you?
- What is still missing?
- How can we keep you informed?

eDNA normalization

- Call for National Strategy
- White House OSTP
  - National eDNA strategy for oceans & great lakes
- Consideration as ‘best available science’



Received: 18 February 2023 | Revised: 25 April 2023 | Accepted: 26 April 2023

DOI: 10.1002/edn3.432

PERSPECTIVE

Environmental DNA

WILEY

Toward a national eDNA strategy for the United States

Ryan P. Kelly[1] | David M. Lodge[2] | Kai N. Lee[3] | Susanna Theroux[4] | Adam J. Sepulveda[5] | Christopher A. Scholin[6] | Joseph M. Craine[7] | Elizabeth Andruszkiewicz Allan[1] | Krista M. Nichols[8] | Kim M. Parsons[8] | Kelly D. Goodwin[9] | Zachary Gold[10] | Francisco P. Chavez[6] | Rachel T. Noble[11] | Cathryn L. Abbott[12] | Melinda R. Baerwald[13] | Amanda M. Naaum[14] | Peter M. Thielen[15] | Ariel Levi Simons[16] | Christopher L. Jerde[17] | Jeffrey J. Duda[18] | Margaret E. Hunter[19] | John A. Hagan[20] | Rachel Sarah Meyer[16] | Joshua A. Steele[4] | Mark Y. Stoeckle[21] | Holly M. Bik[22] | Christopher P. Meyer[23] | Eric Stein[4] | Karen E. James[24] | Austen C. Thomas[25] | Elif Demir-Hilton[26] | Molly A. Timmers[27] | John F. Griffith[4] | Michael J. Weise[28] | Stephen B. Weisberg[4]