

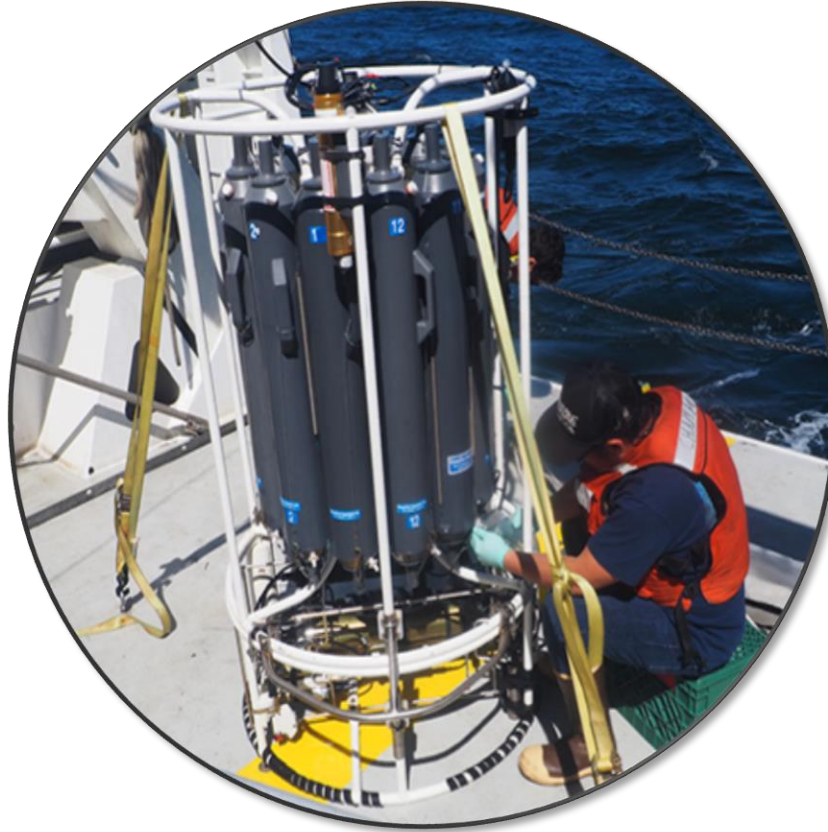
FIDO: A new type of autonomous sampling instrument for 'omics studies

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eDNA analyses start with sample collection



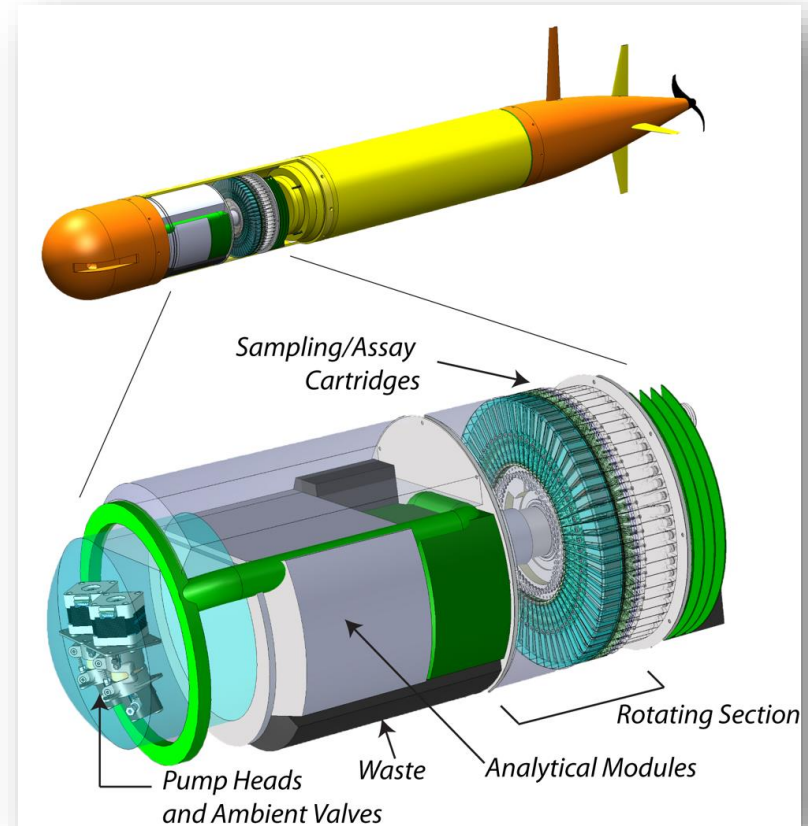
In the quest for answers, this is boring...

Environmental Sample Processor

2nd Generation ESP



3rd Generation ESP



Specific design requirements:
Submerged or Autonomous Vehicle Deployments with *in situ* analysis

Sampling robots have enabled robust science

Ottesen, E.A., et al. Metatranscriptomic analysis of autonomously collected and preserved marine bacterioplankton. **2011**. ISME Journal 5: 1881-1895

The **ISME** Journal
Multidisciplinary Journal of Microbial Ecology

Saito, M.A., et al. Examination of microbial proteome preservation techniques applicable to autonomous environmental sample collection. **2011**. Frontiers in Aquatic Microbiology. 2: 215.

Nowinski, B., et al. Microdiversity and temporal dynamics of marine bacterial dimethylsulfoniopropionate genes. **2019**. Environmental Microbiology 21(5): 1687-1701.

Yamahara, K., et al. *In situ* autonomous acquisition and preservation of marine environmental DNA using an autonomous underwater vehicle. **2019**. Frontiers in Marine Science. 6:373.

Den Uyl, P., et al. Lake Erie field trials to advance autonomous monitoring of cyanobacterial harmful algal blooms. **2022**. Frontiers in Marine Science. 9:1021952.

Sepulveda, A.J., et al. Robotic environmental DNA bio-surveillance of freshwater health. **2020**. Scientific Reports 10:14389.

Zhang, Y., et al. A system of coordinated autonomous robots for Lagrangian studies of microbes in the oceanic deep chlorophyll maximum. **2021**. Science Robotics 6: eabb9138.

Truelove, N.K., et al. Expanding the temporal and spatial scales of environmental DNA research with autonomous sampling. **2022**. Environmental DNA. 4: 972-984.

Preston, C., et al. Autonomous eDNA collection using an uncrewed surface vessel over a 4200-km transect of the eastern Pacific Ocean. **2023**. Environmental DNA, 6, e468.

Zhang, Y., et al. Using a long-range autonomous underwater vehicle to find and sample harmful algal blooms in Lake Erie. **2024**. Lim. & Ocean, Methods. Science. 9:1021952.

frontiers
in Microbiology

frontiers
in Marine Science

Science
Robotics

AAAS

environmental
microbiology

nature

SCIENTIFIC
REPORTS

Environmental DNA

Open Access

Dedicated to the study and use of environmental DNA for basic and applied sciences

LIMNOLOGY AND OCEANOGRAPHY

Methods

ASLO

Association for the Sciences of
Limnology and Oceanography



High Frequency or Long Term sampling

USGS -- repeated deployments in 2018, 2019, 2021, 2022

NOAA -- Scott Creek



Carter's Bridge (Yellowstone R.)



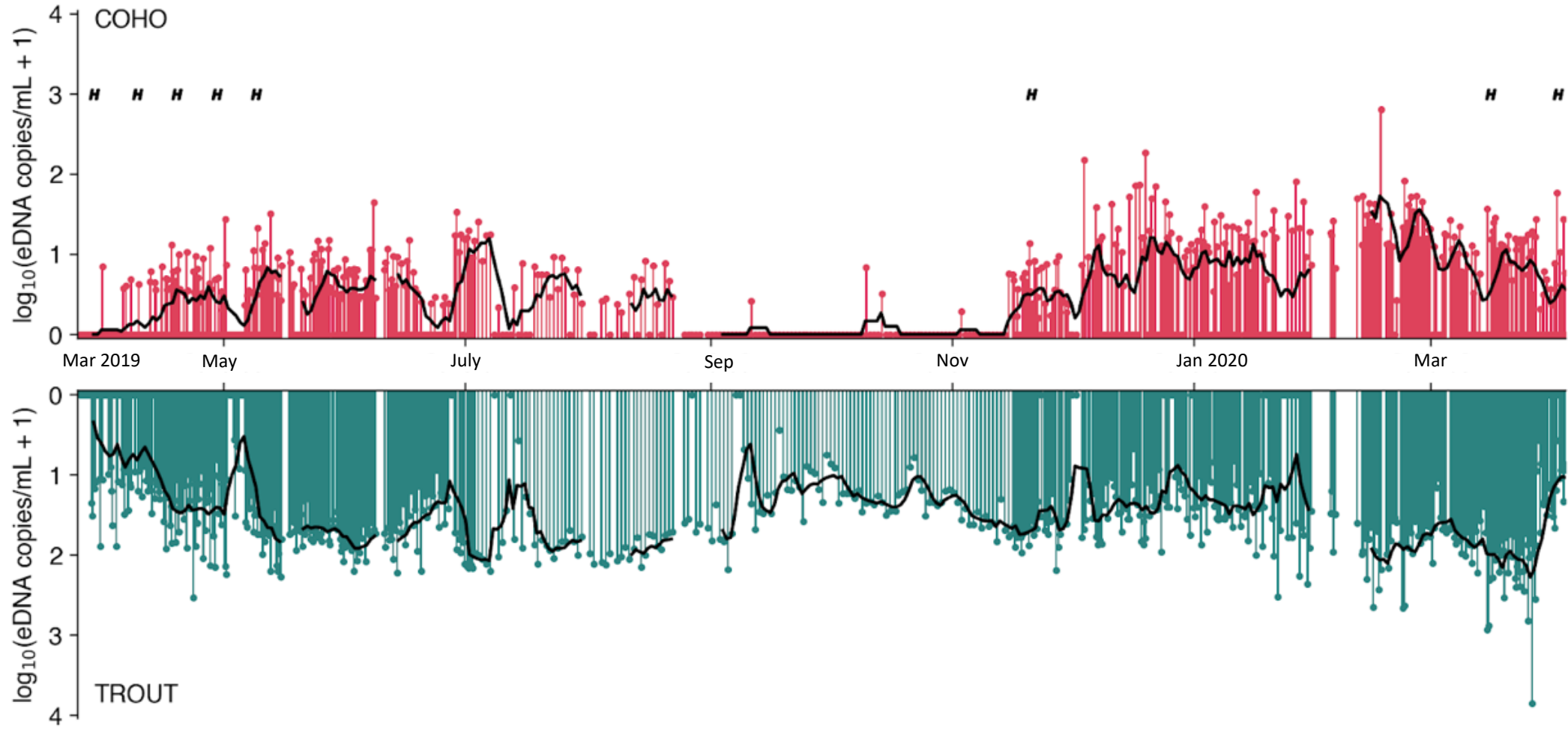
Corwin Springs (Yellowstone R.)



Scott Creek (Santa Cruz)



Scott Creek Salmonid eDNA concentrations

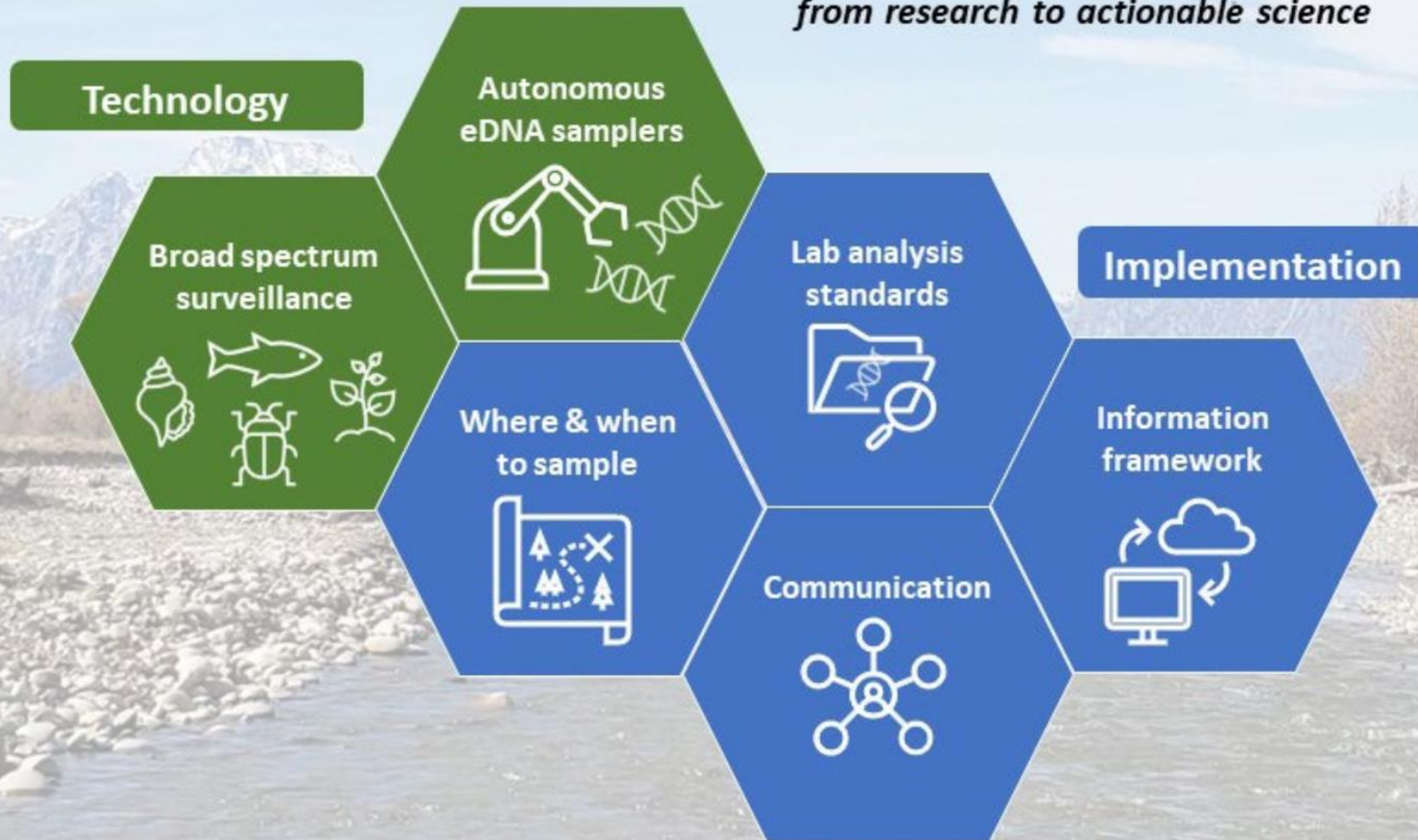


Searcy et al., *Environmental DNA*, 2022
(DOI: 10.1002/edn3.293)

READI-Net

Rapid eDNA Assessment and Deployment Initiative & Network

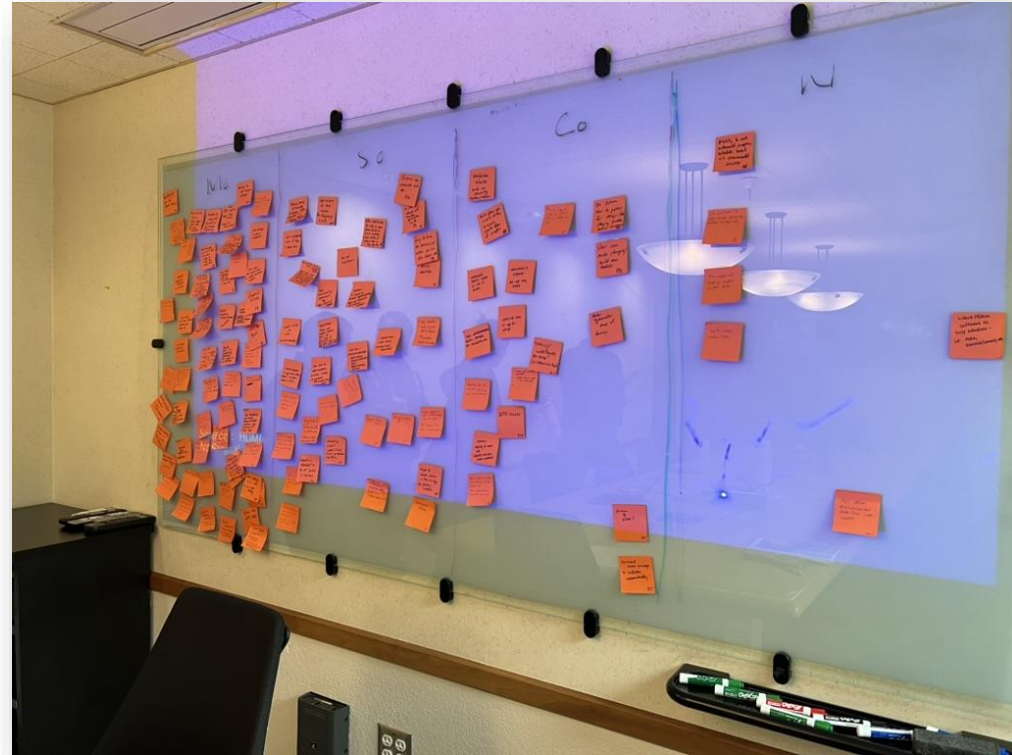
*transitioning eDNA biomonitoring
from research to actionable science*



Courtesy of Adam Sepulveda - USGS

READI-Net

READI-Net Kickoff meeting – March 1-2, 2023



Must have, Should have, Could have or Won't have
Prioritization

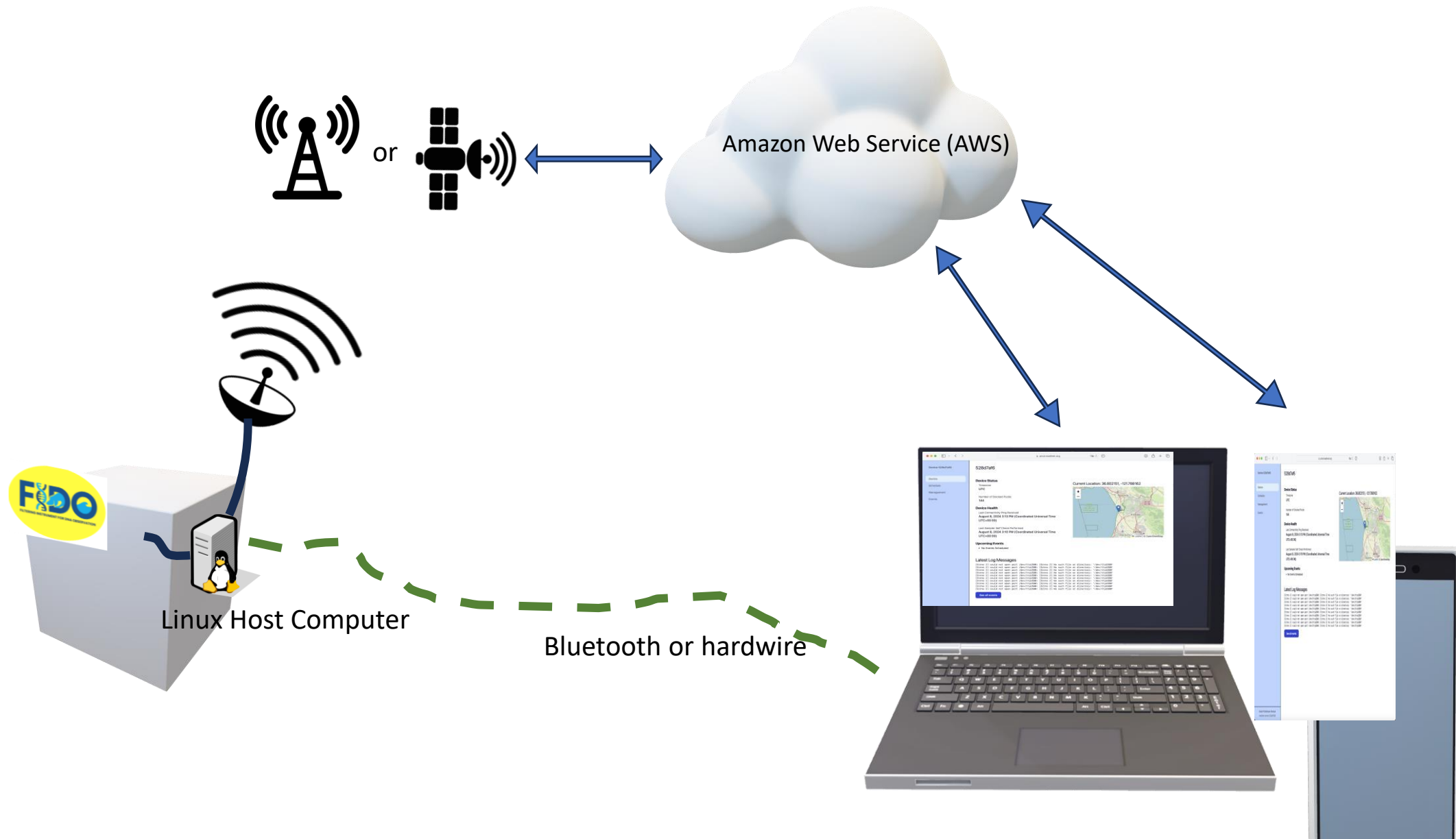
FIDO: Filtering Instrument for DNA Observations

- 144 samples – 47mm Membranes
- Liquid preservation & decontamination
- Remote Command & Control GUI
 - Wifi, Cellular and Satellite
- Sample metadata encoding
- Simple servicing and replenishment



...simple, simplicity, simpleness, straightforward...

FIDO: internet control



FIDO: GUI Control

Device 528d7af6

Device

Schedule

Management

Events

Management

Sensor Management

Default Volume

1.0

Liters

Default Filter Porosity

0.5

µLiter

Scheduled Events

Enabled

Next Scheduled: February 13, 2025 5:30 AM (Coordinated Universal Time UTC+00:00)

Sensor Actions

Take Sample Now

Restock Sampler

Cancel Sample

Truncate Sampler

Decontaminate

Reset Sampler

Location

Latitude

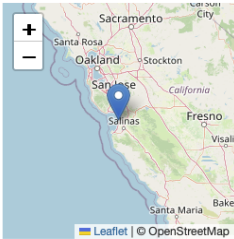
36.802151

Longitude

-121.788162

Notes

Internal notes



Device Management

Device Name

528d7af6

Device Timezone

UTC

Local WiFi SSID

readinet-528d7af6

Local WiFi Password

readinet

Uplink Internet

Uplink Type

WiFi/Hotspot

Uplink Wifi SSID

MBARI-Guest

Uplink WiFi Password

vampsqu1d

Remote Management

Adopted to Cloud Management

Adopt to New Organization

Rock Pi Software Version

readinet-server (02a9149)

Device 528d7af6

Device

Schedule

Management

Events

< today > UTC

Feb 9 – 15, 2025

day week month

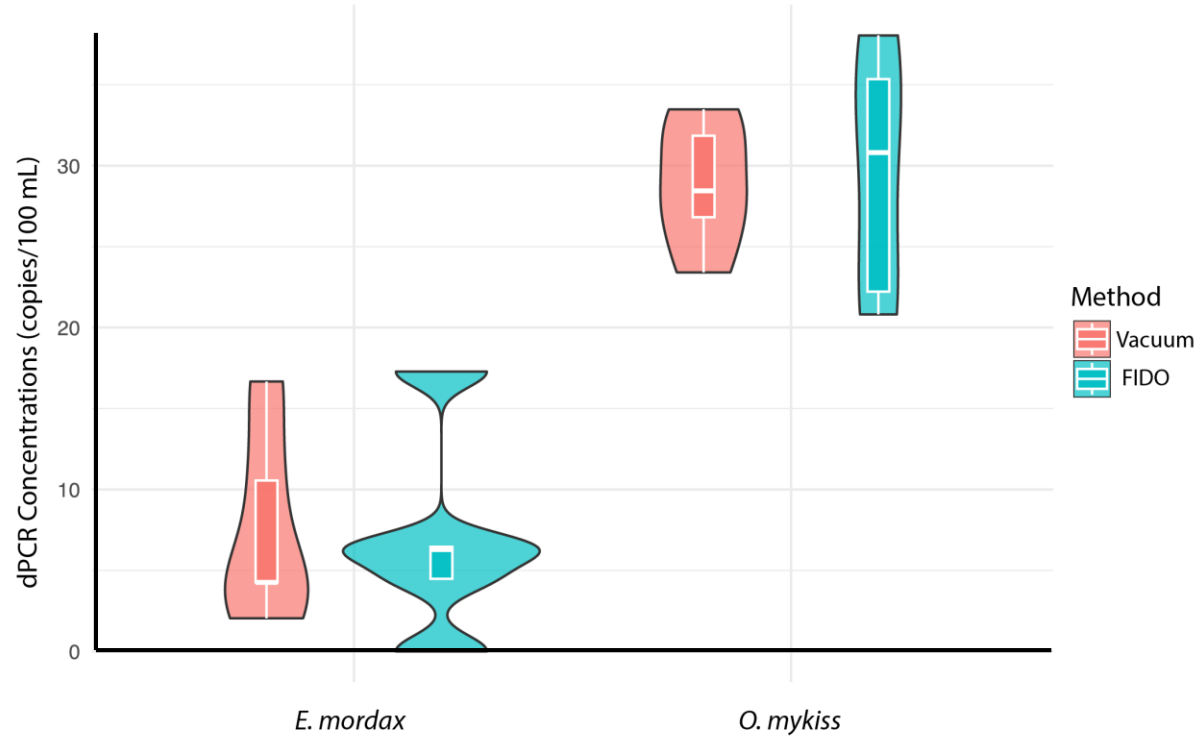
	Sun 2/9	Mon 2/10	Tue 2/11	Wed 2/12	Thu 2/13	Fri 2/14	Sat 2/15
3am							
4am							
5am							
6am						Scheduled Sample/Decon	Scheduled Sample/Decon
7am							
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Rock Pi Software Version

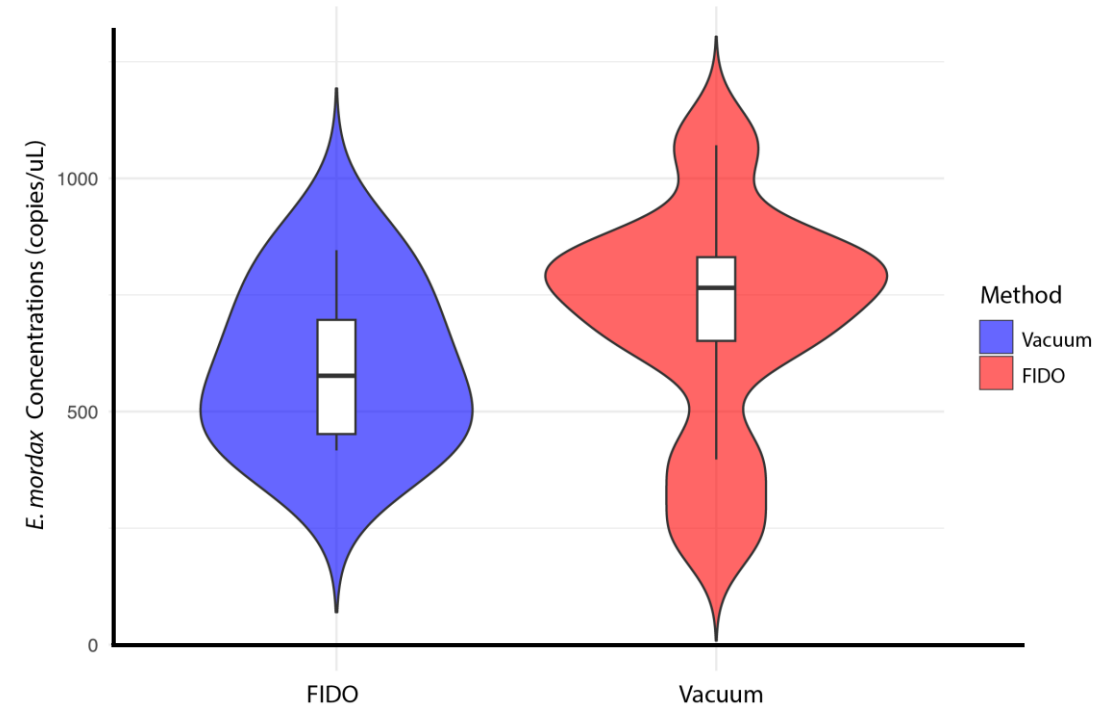
readinet-server (02a9149)

FIDO dPCR and qPCR Validations

dPCR Anchovy and Rainbow Trout

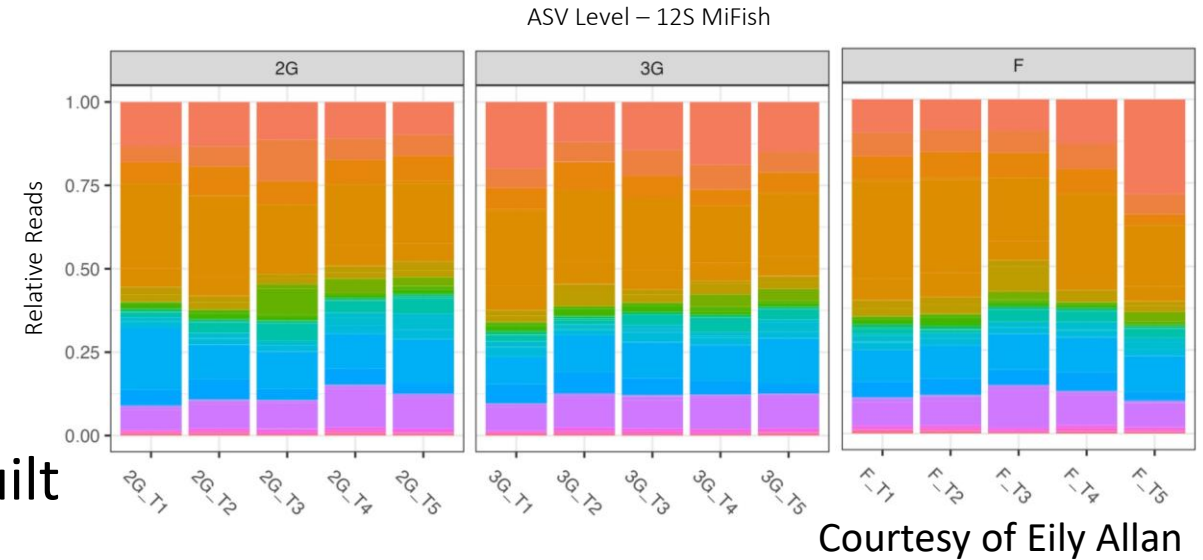


qPCR Anchovy

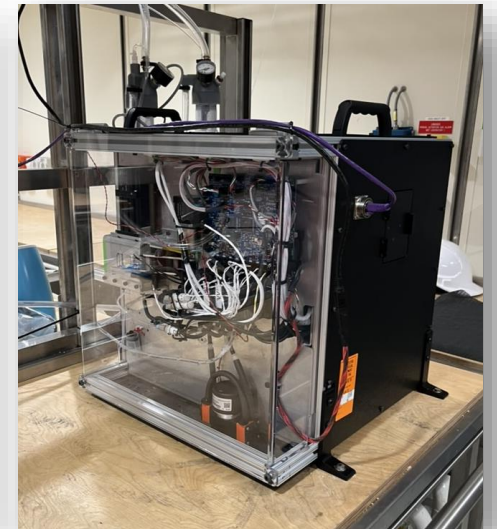


Next Steps

- Validation is continuing
 - qPCR and metabarcoding
- READi-net Implementation in 2025
 - 10 production units are currently being built
 - Looking to license to commercial vendor



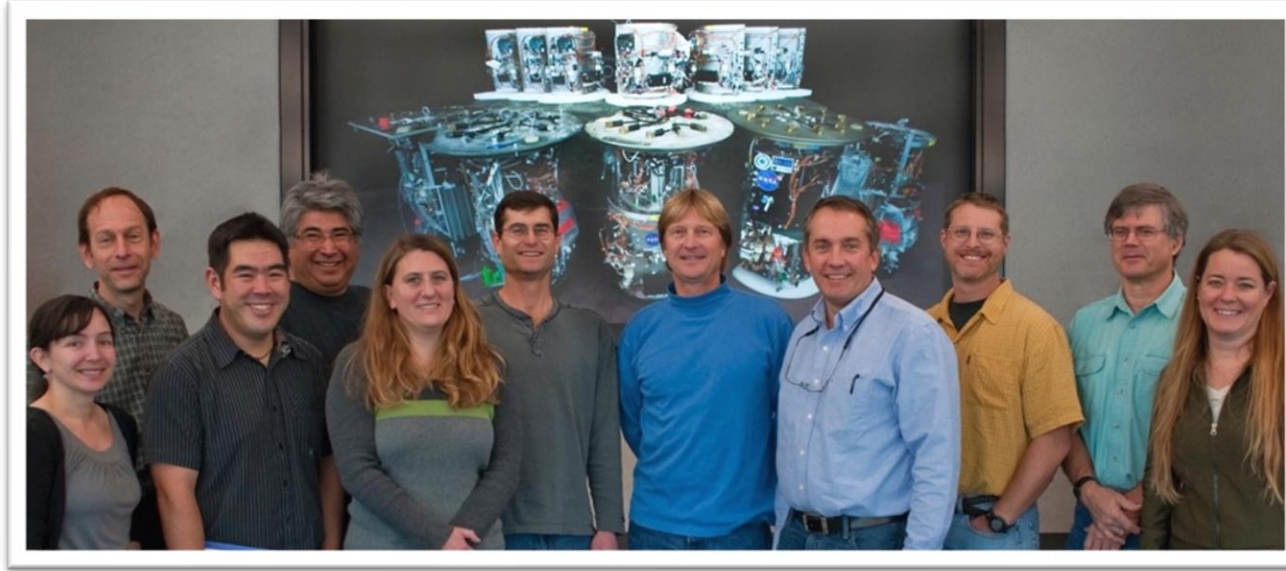
Integration on-board research vessels



Take-home message

- Use-cases should drive the instrument design.
 - There is no single BEST instrument for all use-cases.
 - Applications should be matched to appropriate instrumentation
- Validation is important!!
 - Proper validation builds confidence in data and reduces operational risks
- Large number of samples=good, but ‘kicks the can down the road’
 - Ideally, *in situ* processing alleviates laboratory bottleneck.

Acknowledgements



Adam Sepulveda



