



First MBARI...

MBARI is a non-profit oceanographic research institute founded in 1987 by David Packard. We're located in Moss Landing, California, at the edge of the Monterey Bay submarine canyon - one of the deepest underwater canyons on the west coast. This unique location provides us with immediate access to diverse marine environments from shallow coastal waters to the deep sea, making it an ideal natural

laboratory for developing and testing ocean technology.

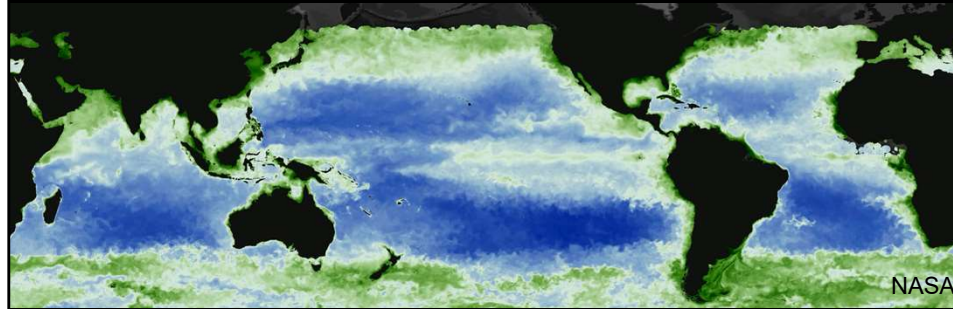
At MBARI, our approach is fundamentally collaborative - we bring together engineers and scientists to develop technology that answers important questions about our oceans. This visualization shows the kind of interconnected ecosystem monitoring we envision - from surface vessels to autonomous underwater vehicles, all working together to understand aquatic biodiversity. One important piece of this interconnected monitoring system is environmental DNA.

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There is a constant planet wide exchange between the ocean and atmosphere.

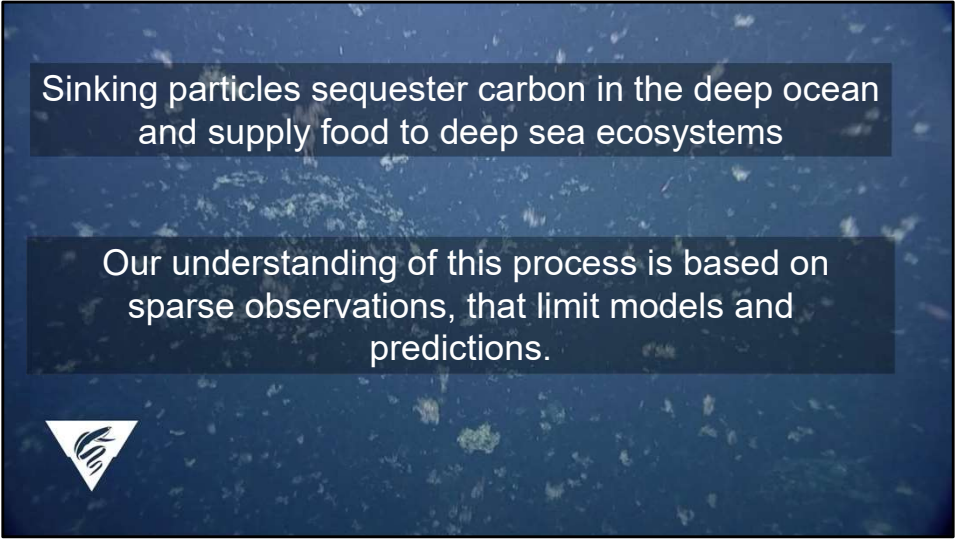


Phytoplankton absorb atmospheric CO₂ and generate most of the organic carbon feeding deep sea ecosystems

2010-01-01

Chlorophyll (mg/m³)

A horizontal color scale bar ranging from 0.01 to 25 mg/m³. The colors transition from dark blue at the low end, through light blue, green, and yellow, to dark green at the high end.



Sinking particles sequester carbon in the deep ocean
and supply food to deep sea ecosystems

Our understanding of this process is based on
sparse observations, that limit models and
predictions.



Second Ocean Carbon...

Constant planet wide exchange between the Ocean and the atmosphere primarily driven by phytoplankton.

The Measurement Challenge: What Information Do We Need?

- Particle size distribution (μm)
- Sinking speeds (m/day)
- Particle identity (biological source)
- Flux rates ($\text{particles m}^{-2} \text{ day}^{-1}$)
- Temporal patterns (hourly to seasonal)



The image shows a row of 11 sediment traps, each labeled with a number from 1 to 11. A large red arrow points down to the 9th trap. To the right of the traps is a 3x3 grid of micrographs labeled a through i, showing various types of particles, including organic matter, mineral grains, and biological structures. The MBARI logo is at the bottom left of the slide.

Clearly this an interesting an impactful process to study, but what does that look like?

List measurements...

High resolution

Dynamic

Specific

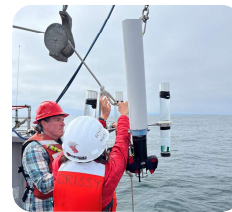
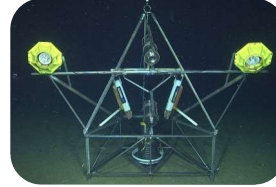
Measurements of individual particles

Bulk measurements of transport

All sustained in perpetuity

That is a lot...

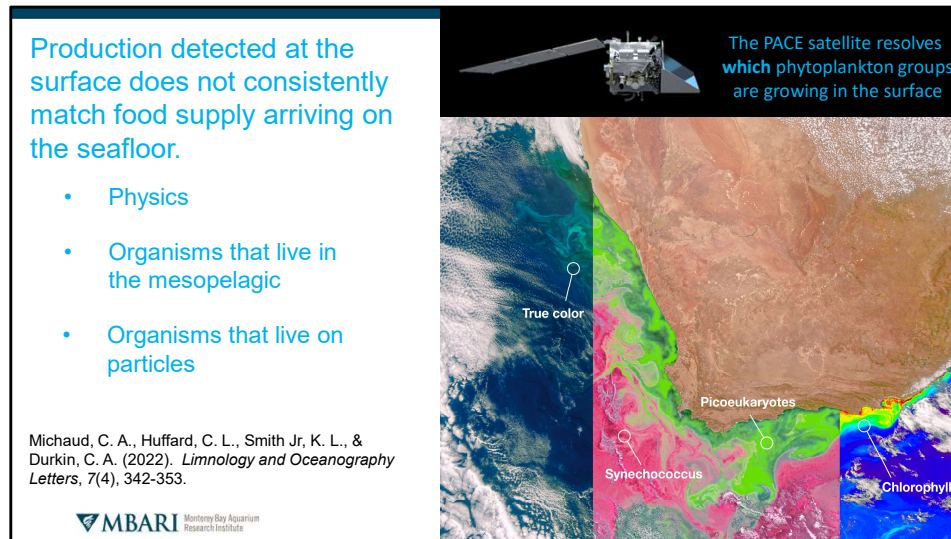
The Measurement Challenge: How do we collect it, what is missing?



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So what does that look like?

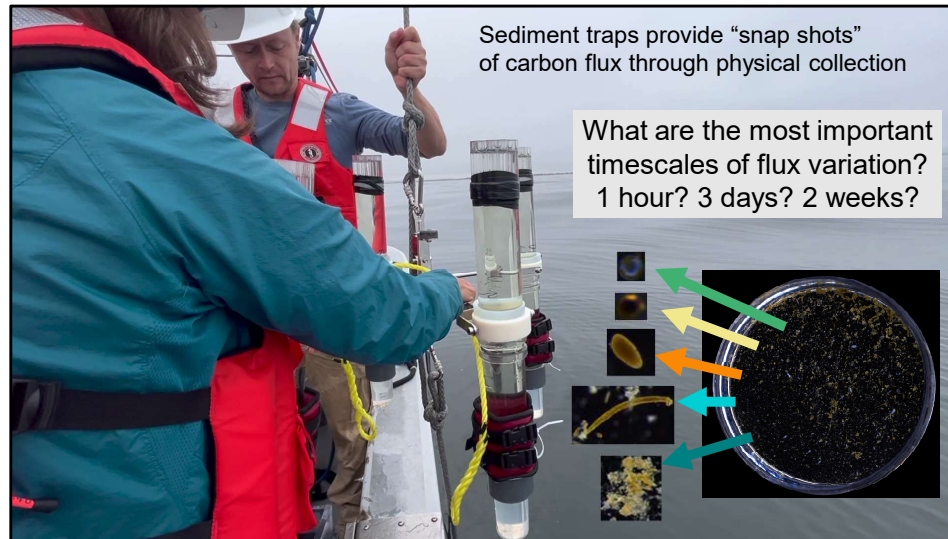
Lots of different instrumentation



Remote sensing, new and very powerful. PACE Launched in 2024 provides a global perspective and can resolve surface phytoplankton into groups.

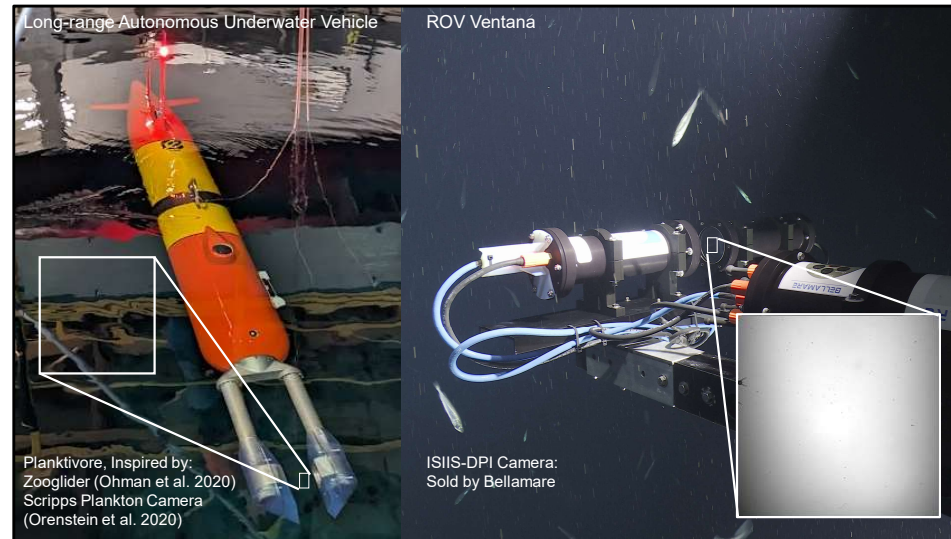
Why do we need all this stuff if we have satellites?

Not specific enough, lacks in water perspective. Much of the dynamics we are interested in studying happen below the surface.



Instrumentation that can take bulk measurements can only do so in snapshots.

Microscope imagery of trap samples reasonably estimates carbon flux and quantifies the ecological source, but oh my god this is time consuming and requires very specific training.



Take the microscope into the ocean... Remotely and autonomously

Off the shelf and custom...

SINKER: Requirements

Identify particle types from 50–5000 μm

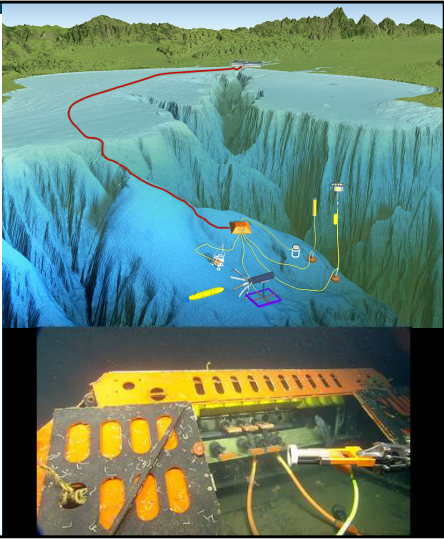
Assign particle sinking speeds

Accurately quantify their fluxes

All of this...

In situ, persistently for up to a year with
a real time connection back to shore

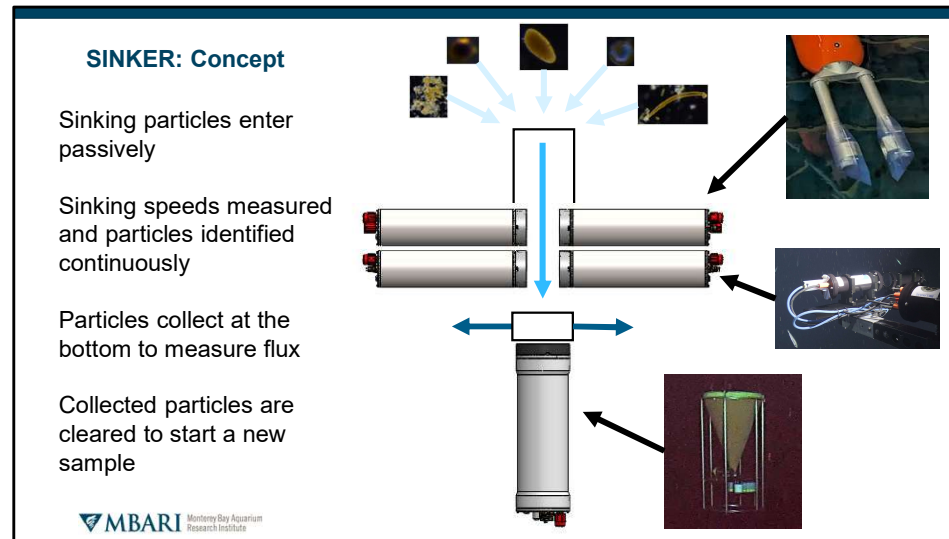
 Monterey Bay Aquarium
Research Institute



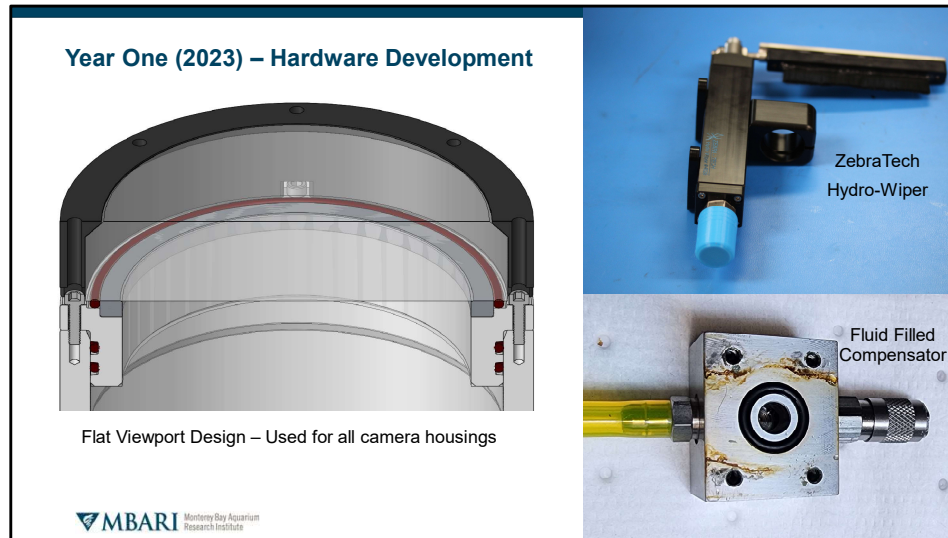
Opportunity to innovate

Here we saw an opportunity to create a new instrument that combines many of the capabilities of the systems we already use in a way that takes advantage of existing MBARI infrastructure for persistent presence.

The SINKing Ecology Robot (SINKER) was designed to... requirements



So what does that actually look like?



Engineering Challenges:
Flat view ports
Wiping system

Year One (2023) – Hardware Development



Lots of pressure vessels!



Design Tasks:
3X Camera systems
Battery system

March 2024 – Reality Check

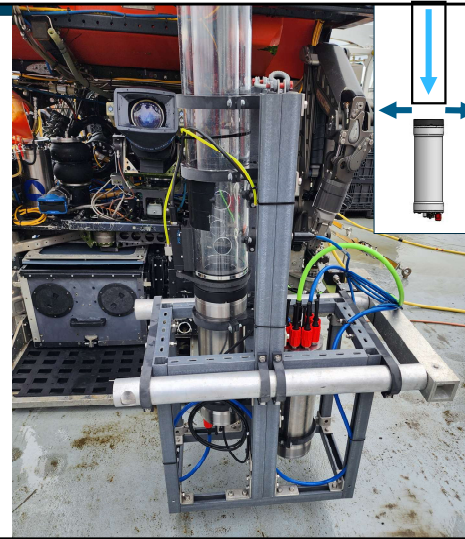
The goal was to test the sediment camera system at depth and evaluate the following...

Flow effects around the instrument

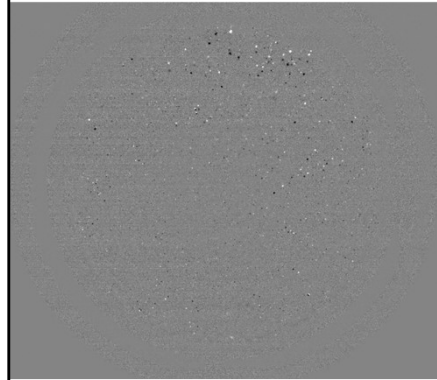
Particle resolution

Flux measurement capabilities

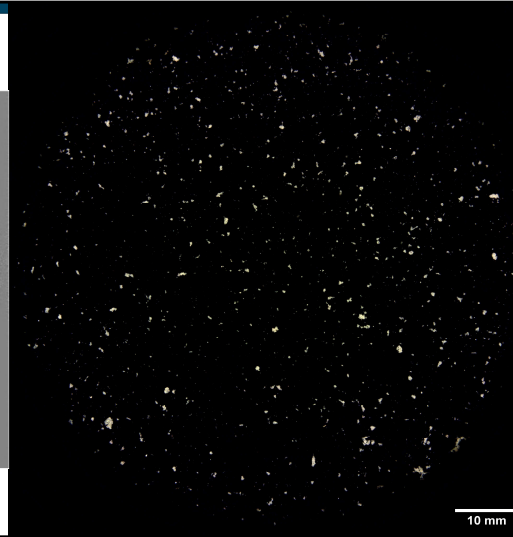
Cleaning system

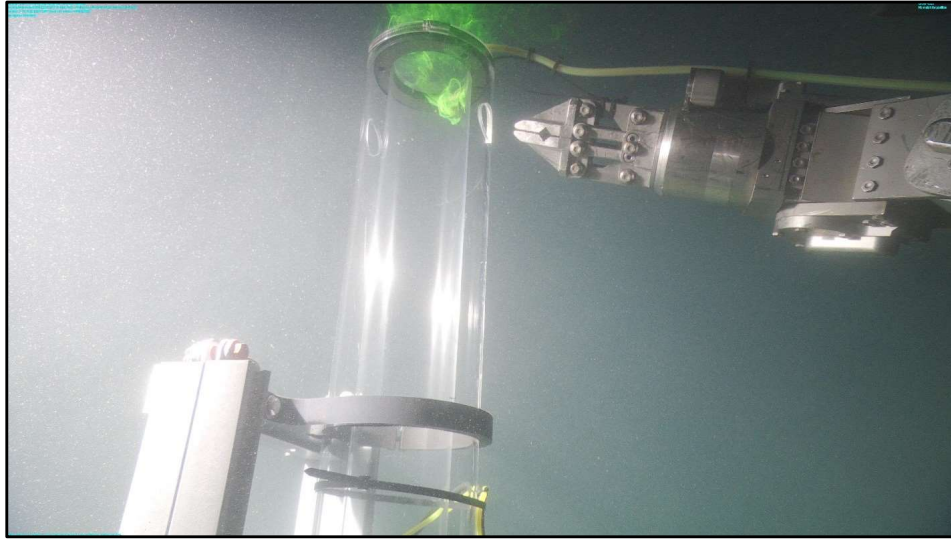


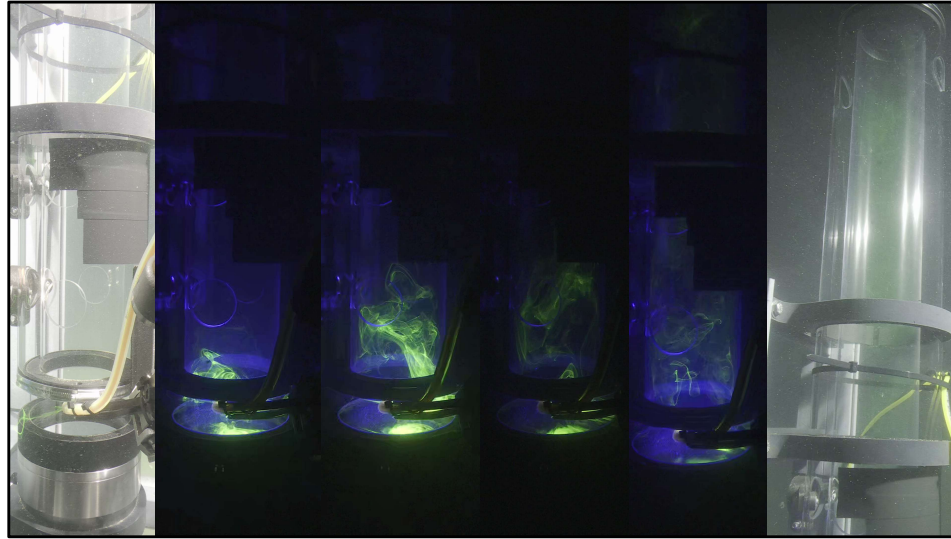
March 2024 – Reality Check



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March 2024 – Lessons Learned

Dive 1:

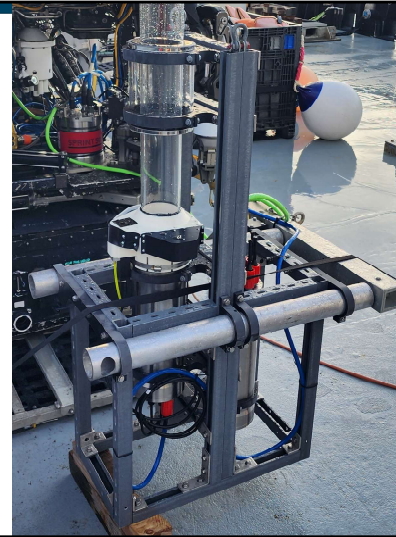
Fully shrouded the base of the collection tube and enclosed the wiper.

This totally failed to stabilize collected particles, and the wiping system failed

Dive 2:

Removed wiping system and sealed the base of the collection tube.

Totally resolved particle issues!



Our ship schedule gave us a second dive two weeks later to reattempt a deployment. With the time we had, we rapidly reconfigured the instrument to better shroud the base of the collection tube with a fully enclosed but unsealed wiper.

Since we were not totally confident that this would be sufficient, we planned our test dive at a shallow site that would allow us to recover and modify the instrument. This ended up being a very good choice, because none of the changes we made were effective, and the wiper failed halfway through the dive.

We recovered, removed everything, and sealed the base of the tube completely using rubber tape. This time when we started seeing particles, everything that hit the collection plate stayed still despite ROV movement and turbulence from the vehicles' thrusters.

This dive showed us without a doubt that we needed to fully seal the sinking column, and raised concerns about the wiping system.

July 2024 – System Redesign

Spectre Performance SPE-9775 4" Flex Boot, Black

Visit the Spectre Store
4.5 ★★★★★ (172) | Search this page

Price: **\$44.99** **FREE** Returns

Buy more, save more

2 units	6 units: Lowest price
-4% \$86.56	-7% \$251.58
\$43.28/unit	\$41.93/unit

Additional shipping fees may apply for items fulfilled directly by selling partners.

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- EPDM/TPE rubber
- Durable design
- Available in black
- Not recommended for turbo-charged and super-charged engines

[See more product details](#)

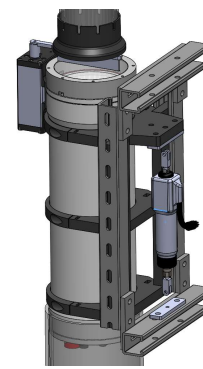
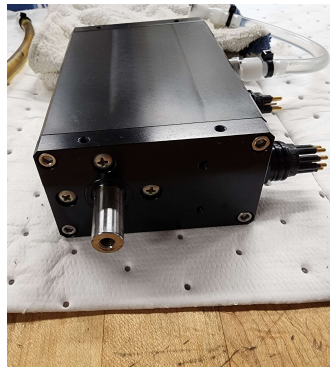
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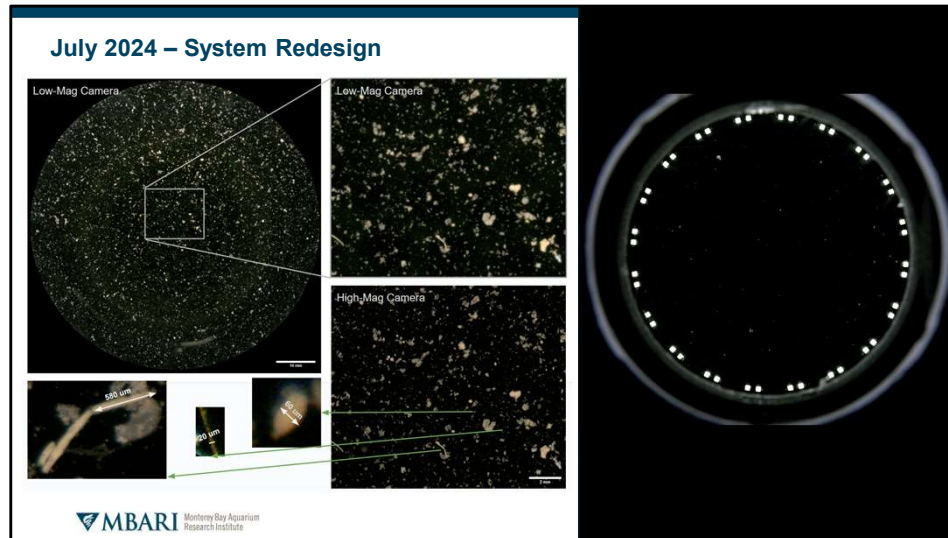
Over the next week, we came up with a simple and effective way to make and break a seal at the base of the collection tube using a small linear actuator and an after market car part.

July 2024 – System Redesign



 MBARI Monterey Bay Aquarium Research Institute

When we looked into the issue with the wiper motor, we found that the compensation fluid that we used doubles as an excellent solvent for grease and oil. Turns out it had totally stripped all the grease out of the gear box, causing it to seize. Fortunately we were able to find a larger oil compensated servo motor that we could drop in to replace the smaller motor.



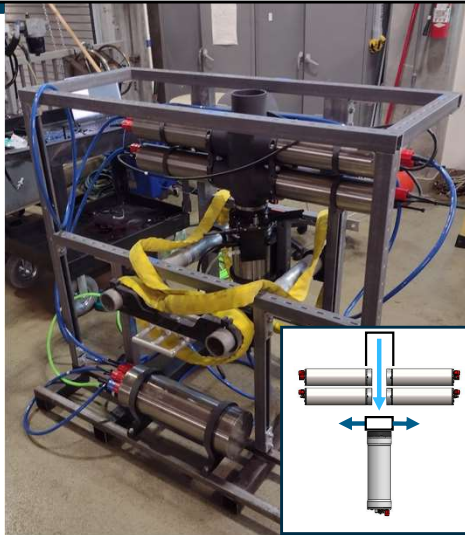
In July we were able to test this new configuration on ROV Ventana. The sealing and wiping system worked very well, giving us the confidence to move on with the construction of the rest of the instrument.

October 2024 – Full System Integration

The goal was to test the sinking camera systems at depth and evaluate the following...

Sinking speed measurements

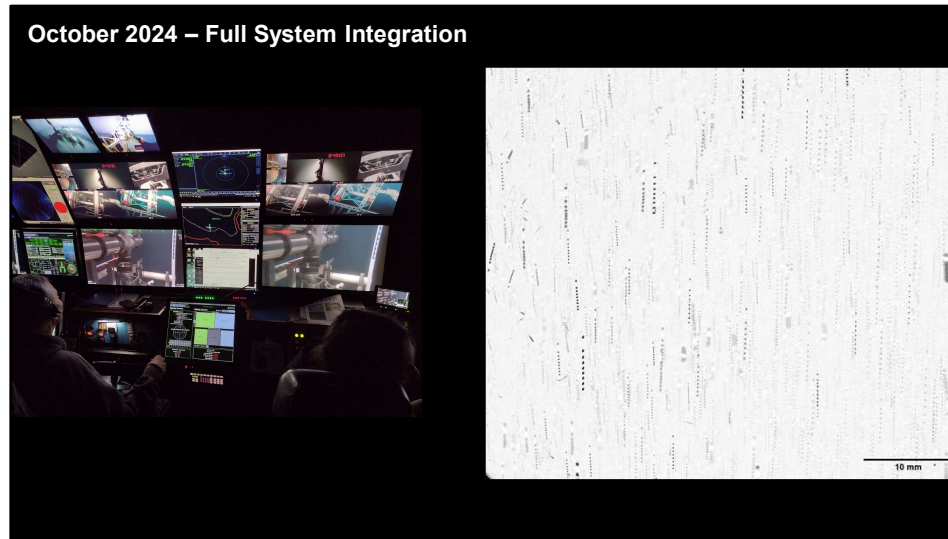
Cleaning system effect on measured particles in the upper camera systems



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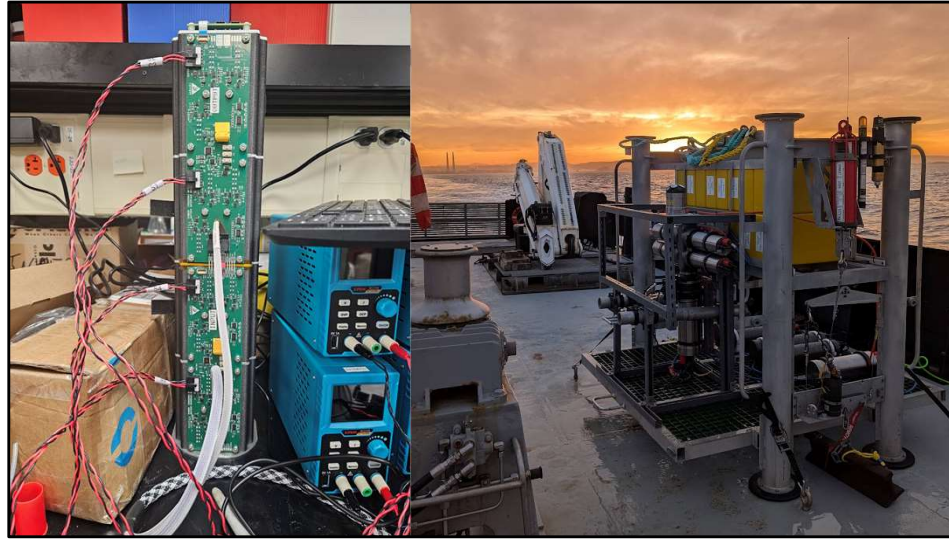
October 2024 – Full System Integration



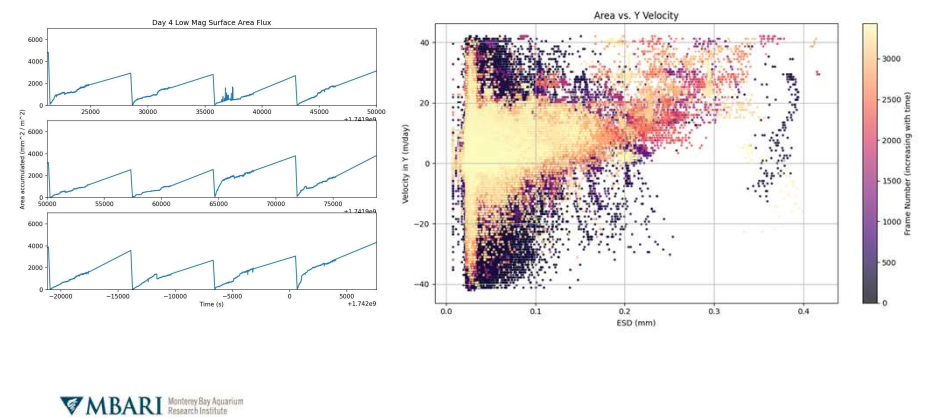
The view of the complete SINKER instrument from the ROV control room during October 9, 2024 test dive.

Visualizing sinking particles inside of the sinking column using the shadowgraph modality. A sequence of 10 consecutive frames recorded at 1 Hz is superimposed into one image to show the particle trajectories. The shadowgraph imaging geometry enables quantitative

measurements of particle size and velocity due to its orthographic projection of the imaged volume. Estimated sinking speeds from this set of images range from 8 to 80 m/day across the slowest and fastest moving particles in the image



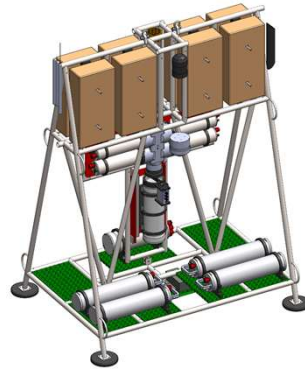
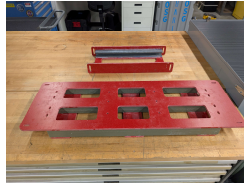
March 2025 – Autonomous Operations



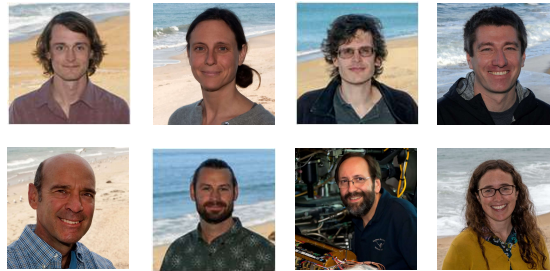
Individual 2-hour accumulation plots from day 4 of the deployment. At the start of each accumulation period, the wiper clears the port surface and resets the background flux estimate to 0. Accumulation is measured at 1 Hz for the first 5 minutes and then 1/10 Hz after for the first hour. At the end of the second hour, total accumulation is estimated for a final image before clearing the port restarts the cycle.

Scatter plot of sinking/rising speed (positive means sinking) as a function of particle size (horizontal) and time (color) during a 1-hour recording period. Smaller particles tend to follow fluid motion and are found to be sinking and rising during the earlier part of the recording period due to the column being unsealed for cleaning. After around 15 minutes, the flow settings and the majority of the particles are found to be sinking at rates between 5-40 m/day.

Current & Future Work – Lander Build & Cabled Deployments



Acknowledgments



This work wouldn't be possible without our fantastic team at MBARI and our partners at USGS. Special thanks to Adam Sepulveda for leading the READI-Net initiative. Funding came from the David and Lucile Packard Foundation and the USGS. Thank you for your attention, and I'm happy to take questions.

