EyeRIS (Remote Imaging System):

A three-dimensional, high-resolution, remote/autonomous particle and flow imaging instrument

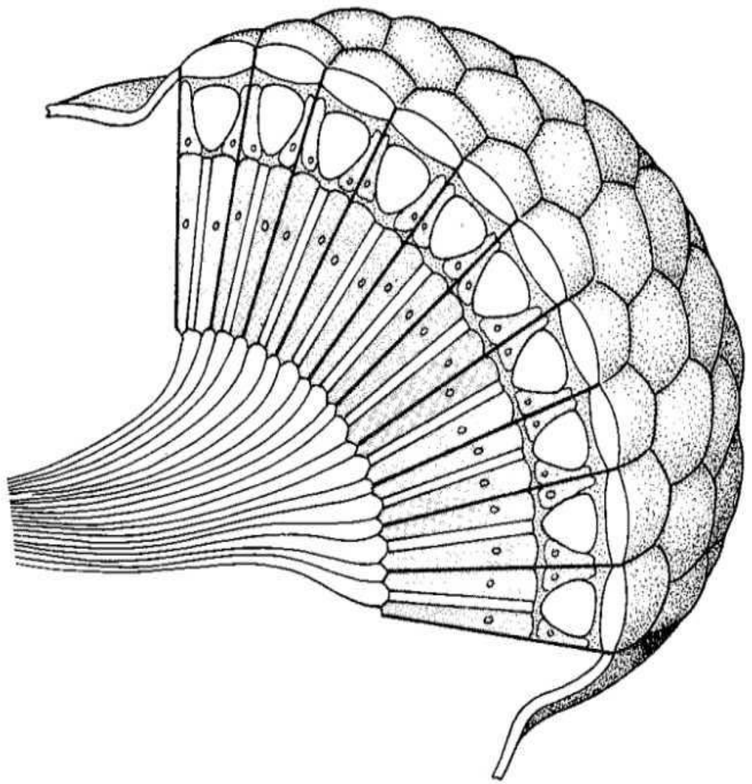
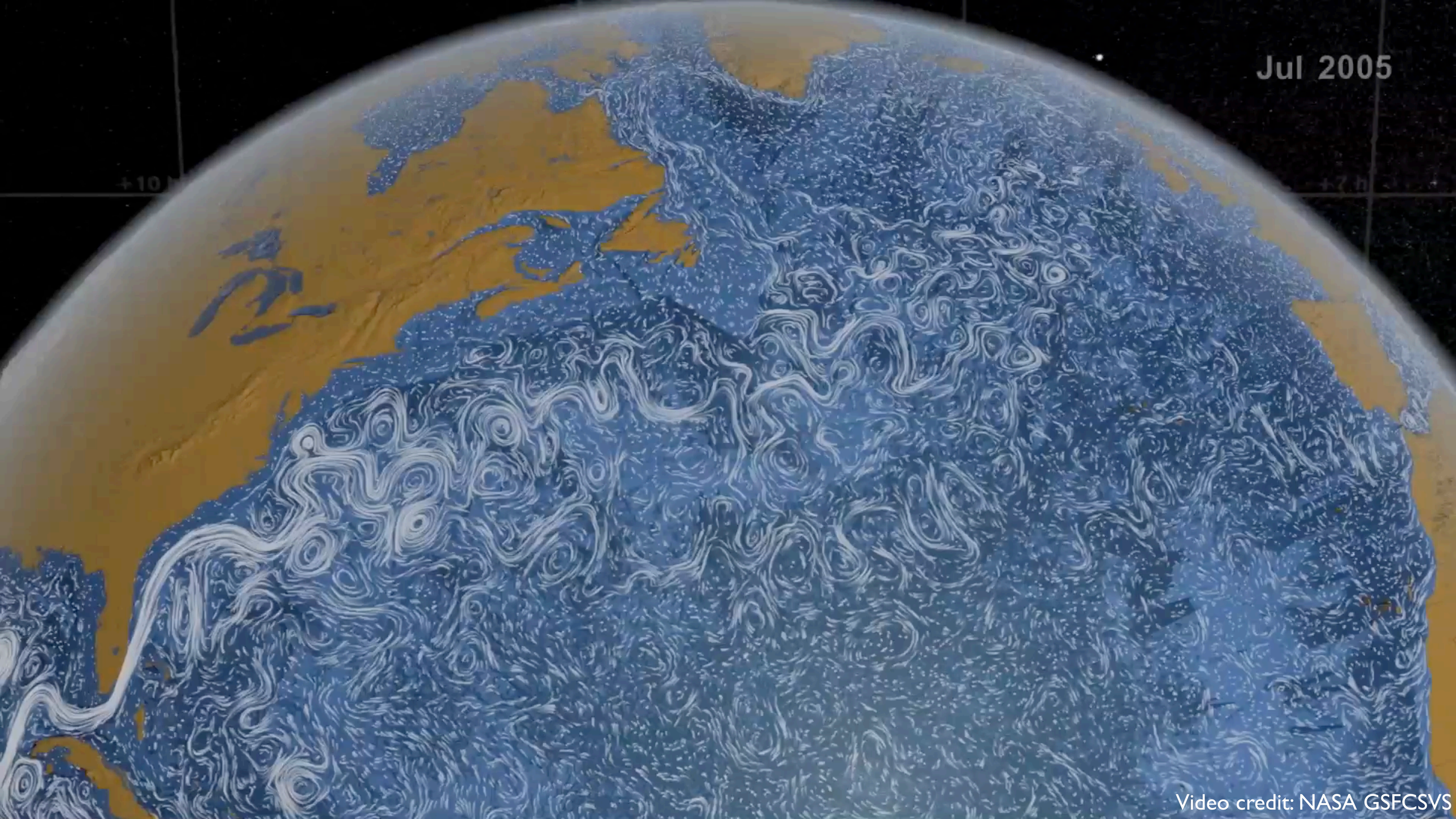
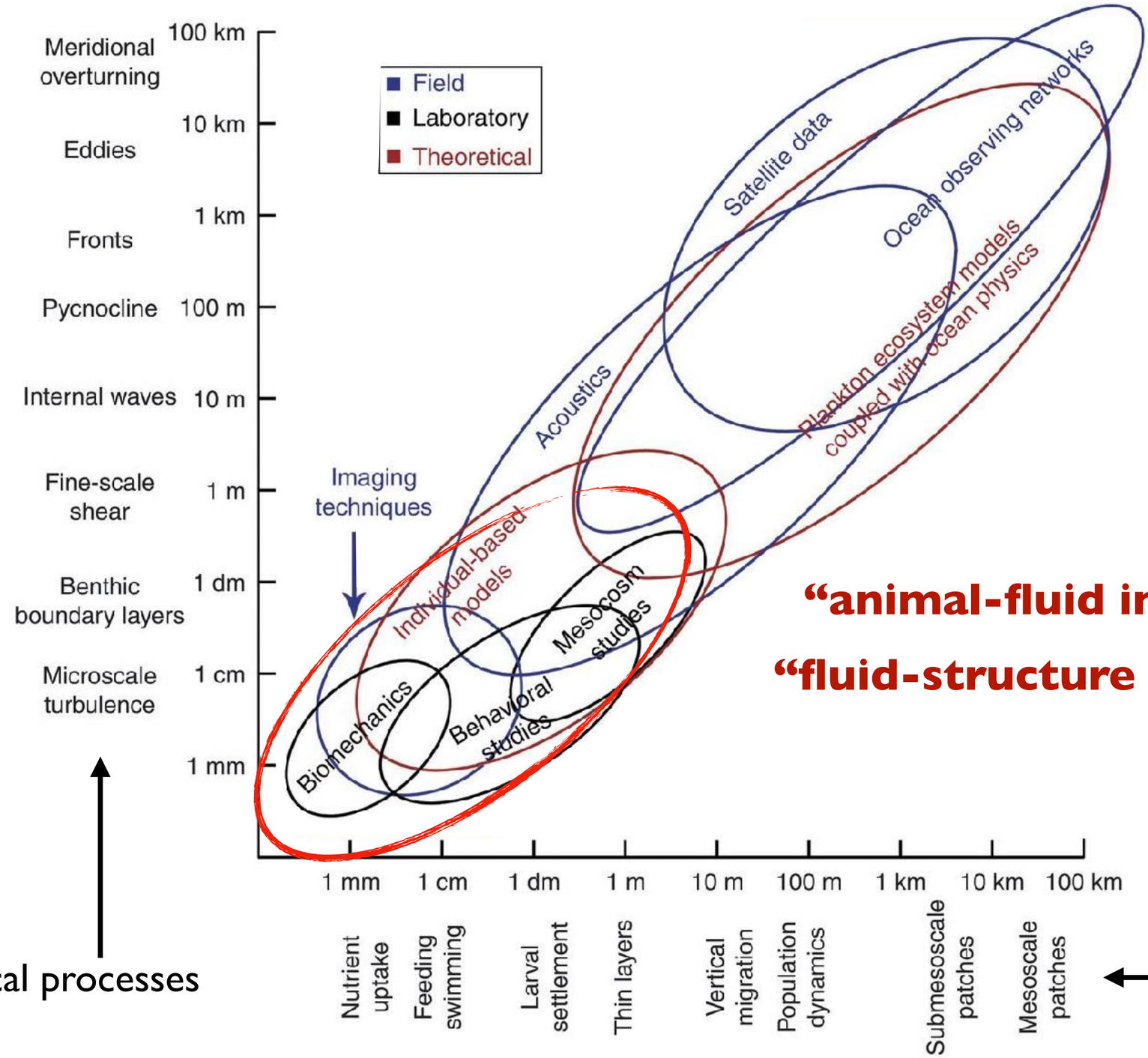


Image credit: D G Mackean


Jul 2005
Video credit: NASA GSFCSVS



"animal-fluid interactions"

"fluid-structure interactions"

Physical processes

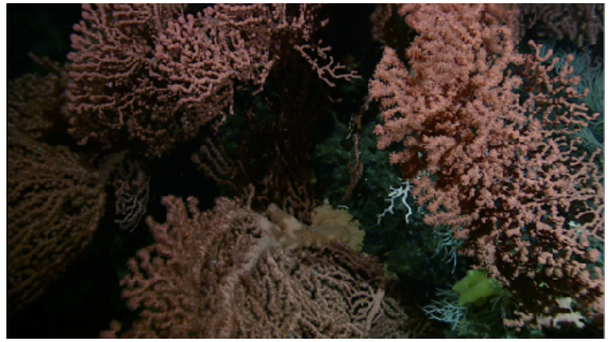
Biological processes

Sutherland, et al. (2012)

Potential science targets for in situ optical measurements of animal-fluid interactions

Midwater animal ecomechanics

Quantify feeding and predation interactions
Estimate energy expenditure and carbon flux

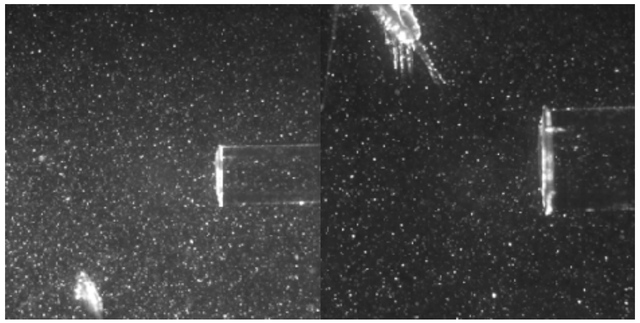


Health of deep sea benthic communities (coral and sponges)

Quantify boundary layer flow
Estimate filtration rates and nutrient/carbon flux
Identify passive mechanisms for feeding in high flows

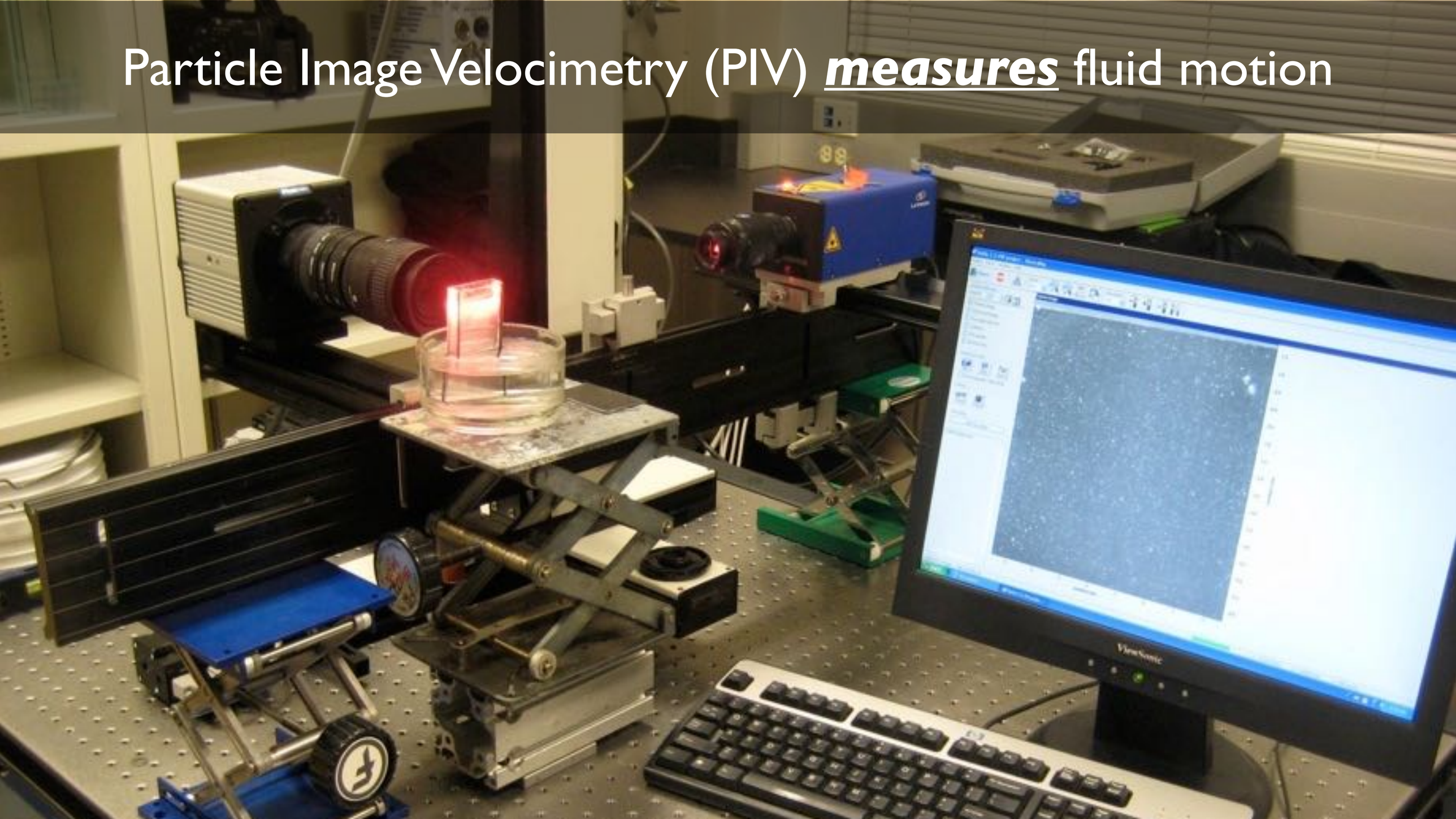
Linking food webs to mechanosensing

Quantify hydromechanical signals
Understand role hydrodynamics plays in predation and ecology of marine organisms

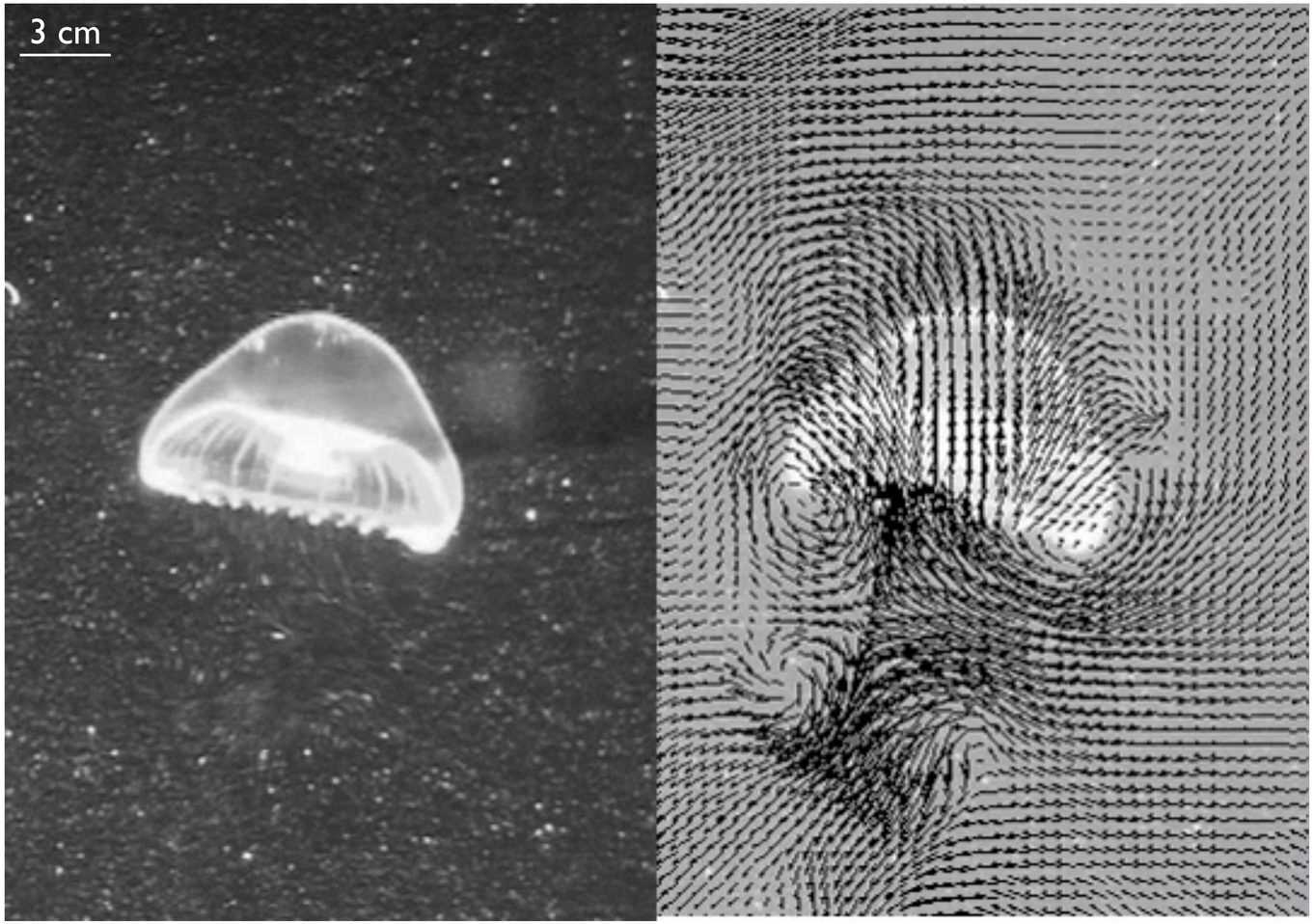


Animal-fluid interactions in the ocean:
Lessons learned from *DeepPIV*

Particle Image Velocimetry (PIV) ***measures*** fluid motion



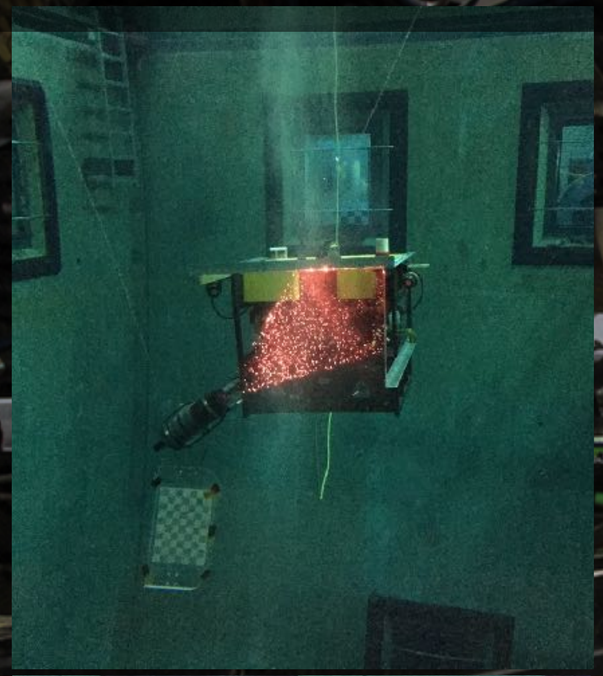
Representative PIV results: Particle displacements to flow velocity



(Left): Raw particle images of free-swimming *Aequorea victoria* used for PIV processing and animal kinematics investigations. (Right) Velocity fields from the PIV analysis.

Katija et al., Mar. Ecol. Prog. Ser. (2011)

DeepPIV on MBARI's ROV *Doc Ricketts* on board R/V *Western Flyer* (Summer 2017)

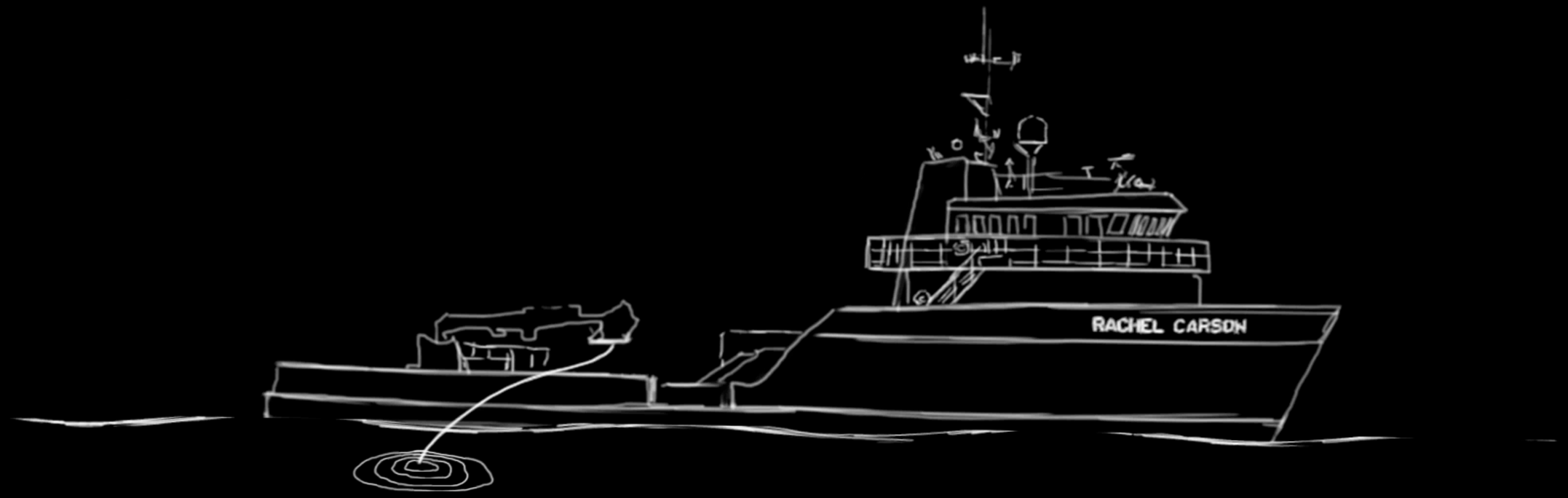


Particle/Dye Bladder

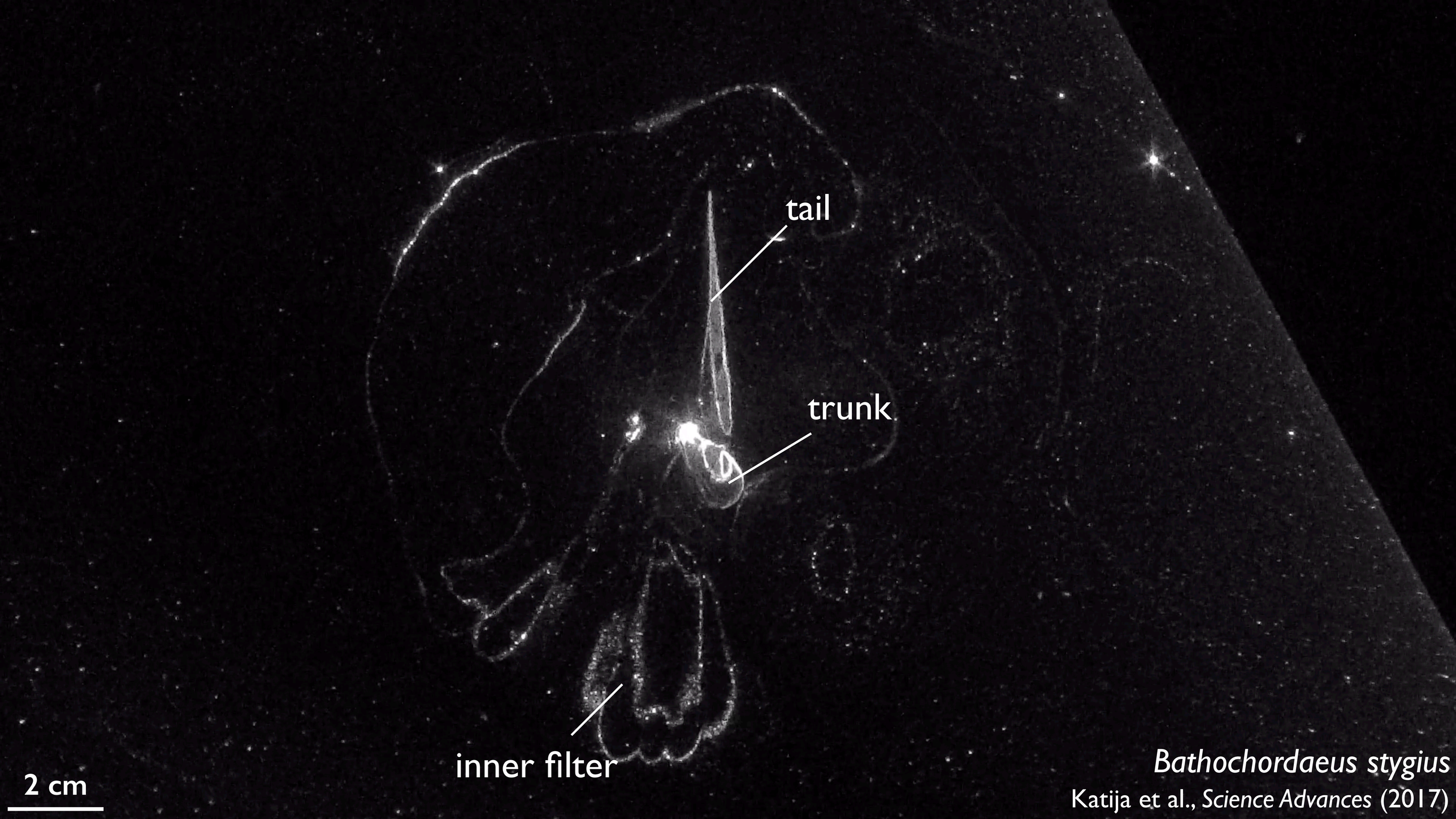
Particle/Dye Injector Tubing

Camera

Laser/ Optics



Animation credit: Kelly Lance, MBARI



Bathochordaeus stygius

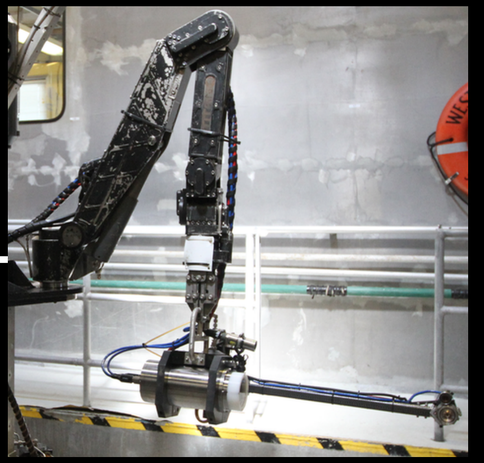
Katija et al., *Science Advances* (2017)

DeepPIV Development Timeline

DeepPIV on MiniROV (v1.0)

Larvacean ecology

Benthic feeding ecology



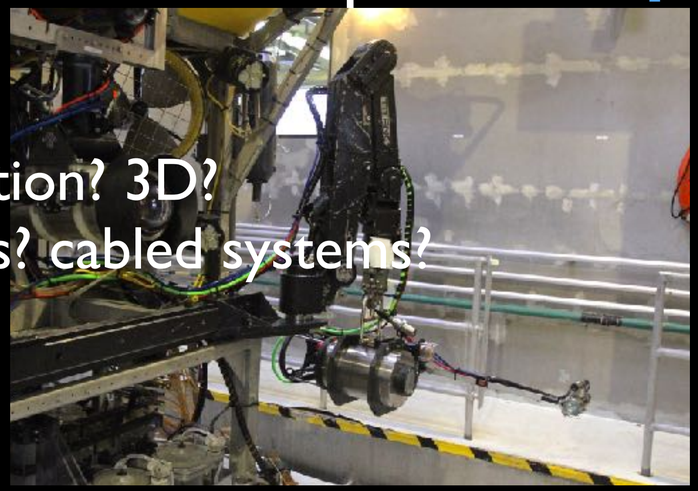
DeepPIV on Doc Ricketts (v3.0); final camera

2014 2015 2016 2017 2018 2019

>100 deployments

DeepPIV conceptual design

- miniaturization? duplication? 3D?
- payload for AUVs? floats? cabled systems?



DeepPIV on Doc Ricketts (v2.0)

DeepPIV on Ventana (v4.0); final laser

3D using plenoptic imaging

GORDON AND BETTY MOORE FOUNDATION

Fundamental Problem

To robustly inform *fluid-structure interactions* in the ocean:

1. Measure 3D particle distributions
2. Measure 3D surfaces
3. Achieve (1) and (2) *simultaneously*

temporally varying targets

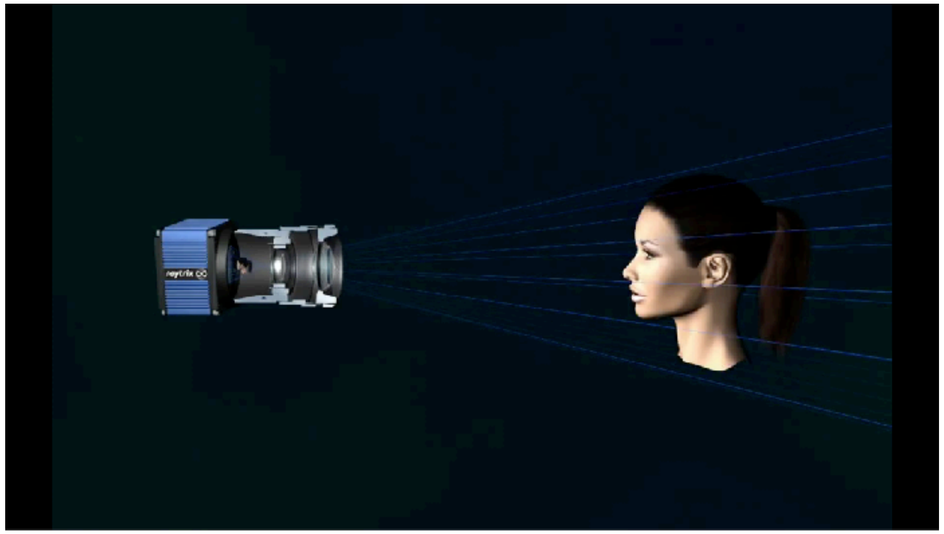
The Impact

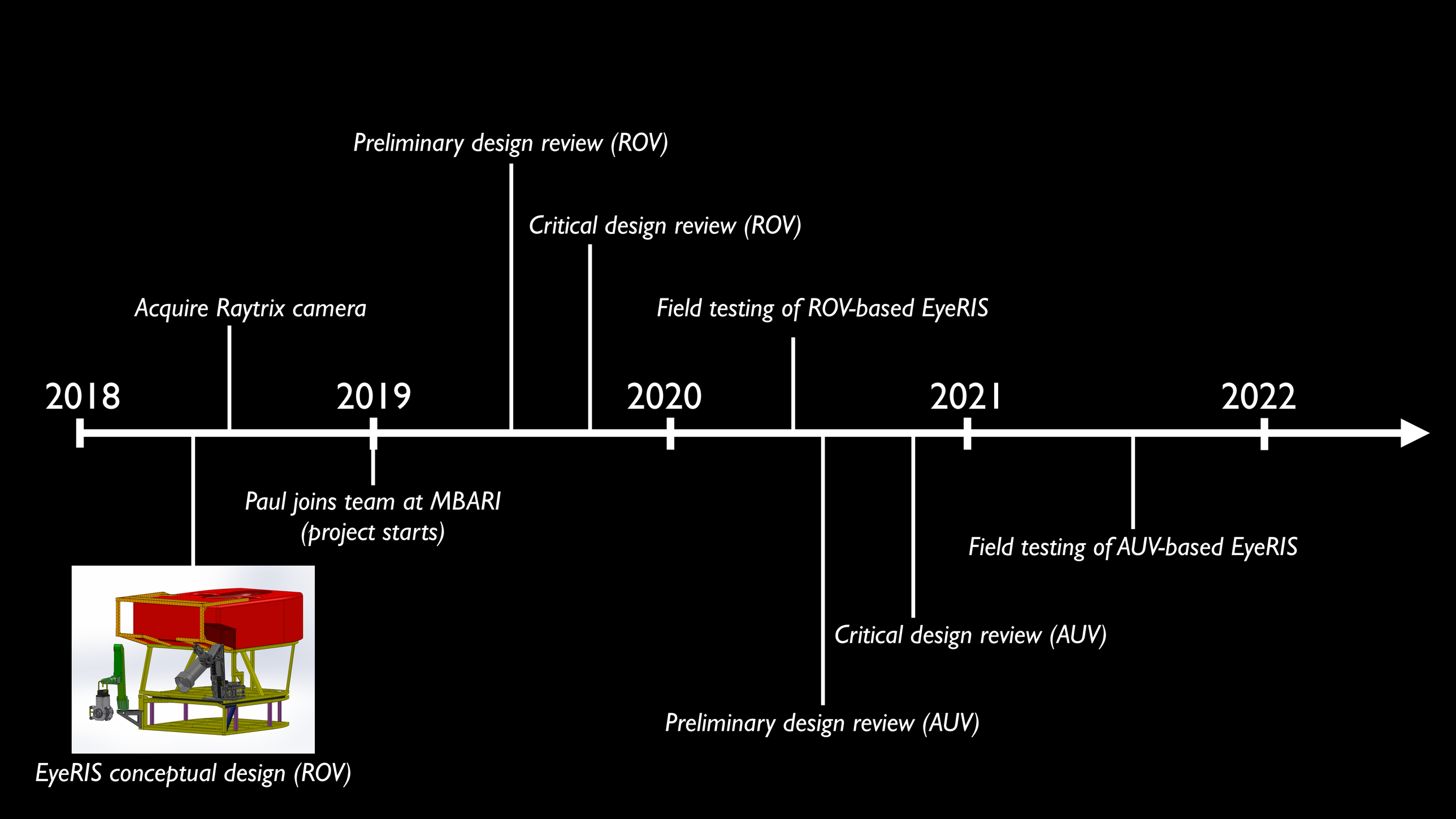
The proposed instrument would have a broad impact as novel measurements are of value to many areas, including:

- Resolving particle/aggregate fields and fluxes towards quantifying the global carbon budget
- Feeding ecology of midwater and benthic organisms
- Monitoring complex flows that impact health of coral reefs
- Understanding fine-scale turbulence throughout ocean's depths to inform mixing and biogeochemical models
- Quantifying diffuse versus hydrothermal vent flows
- Single-camera underwater tracking and observing platforms
- And more…

The Technology

- Plenoptic cameras: these have a micro-array of lenses that sit in front of the image sensor, enabling one camera to image many different focal planes from different perspectives simultaneously.




Preliminary design review (ROV)
Critical design review (ROV)
Acquire Raytrix camera
Field testing of ROV-based EyeRIS
2018
2019
2020
2021
2022
Paul joins team at MBARI
(project starts)
Field testing of AUV-based EyeRIS
Critical design review (AUV)
Preliminary design review (AUV)
EyeRIS conceptual design (ROV)

Proposed *EyeRIS* Project Timeline

	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Design ROV-based *EyeRIS*												
Build ROV-based *EyeRIS*												
Test ROV-based *EyeRIS* (test tank)												
Deploy *EyeRIS* on ROV *MiniROV*												
Design AUV-based *EyeRIS*												
Build AUV-based *EyeRIS*												
Test AUV-based *EyeRIS* (test tank)												
Deploy *EyeRIS* on *LRAUV*												
Disseminate efforts to community												