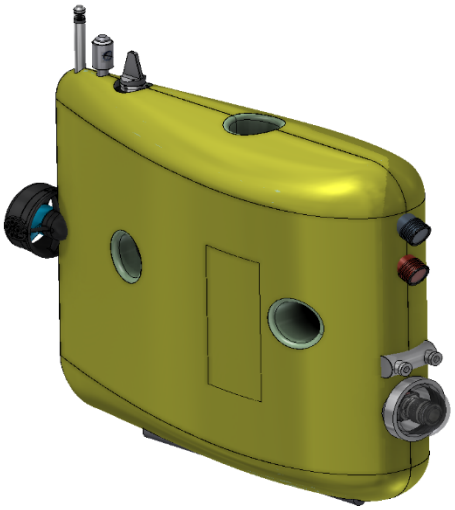
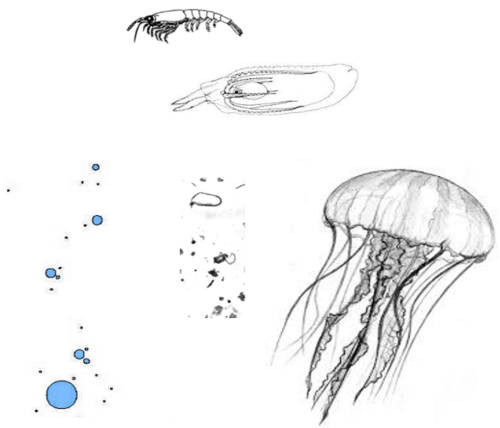
Mesobot: a New Autonomous Robot for Midwater Research and Exploration





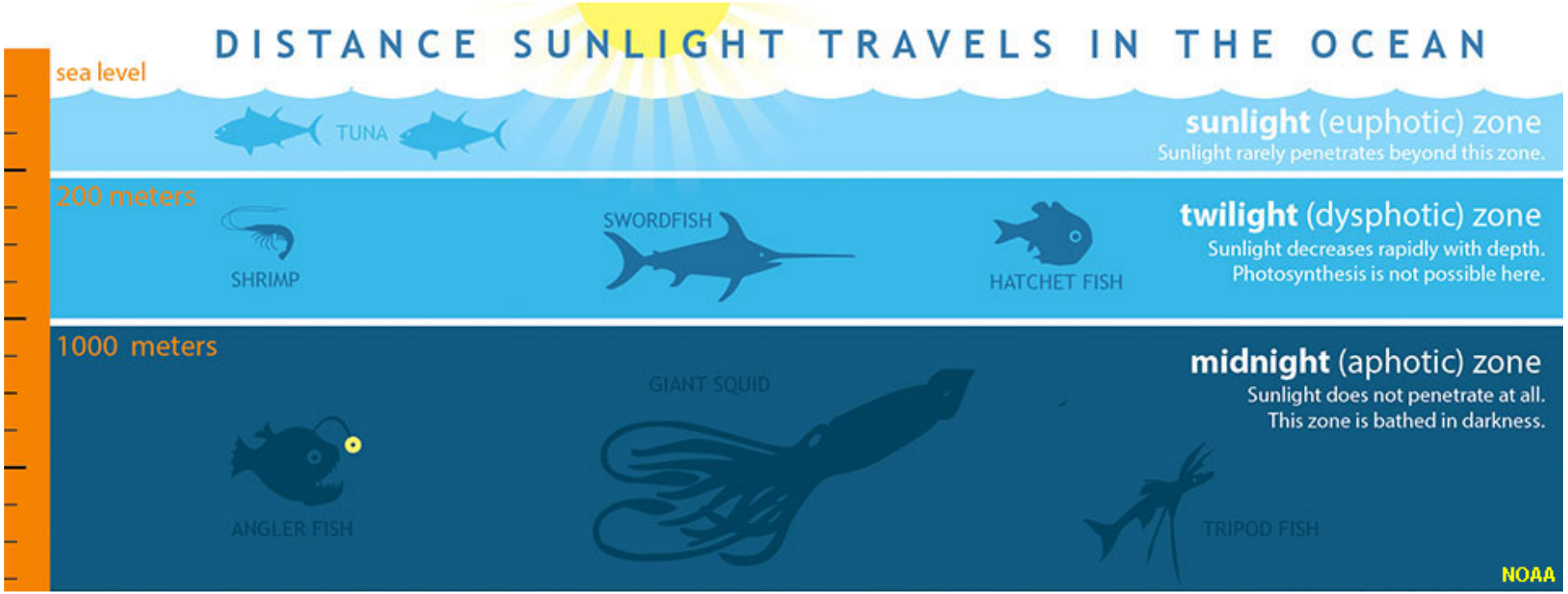
Dana R. Yoerger
Annette F. Govindarajan
Peter H. Wiebe
Joel K. Llopiz
Chris R. German
WHOI

Bruce H. Robison
Kakani Katija
MBARI

Steve M. Rock
Stanford

John "Chip" Breier
UTRGV

The Mesopelagic or “Twilight Zone”



- A huge volume ~1/4 of the ocean’s volume
- Teaming with diverse and often bizarre life
- Critical to the global carbon cycle
- Large scale industrial harvesting is underway and unregulated

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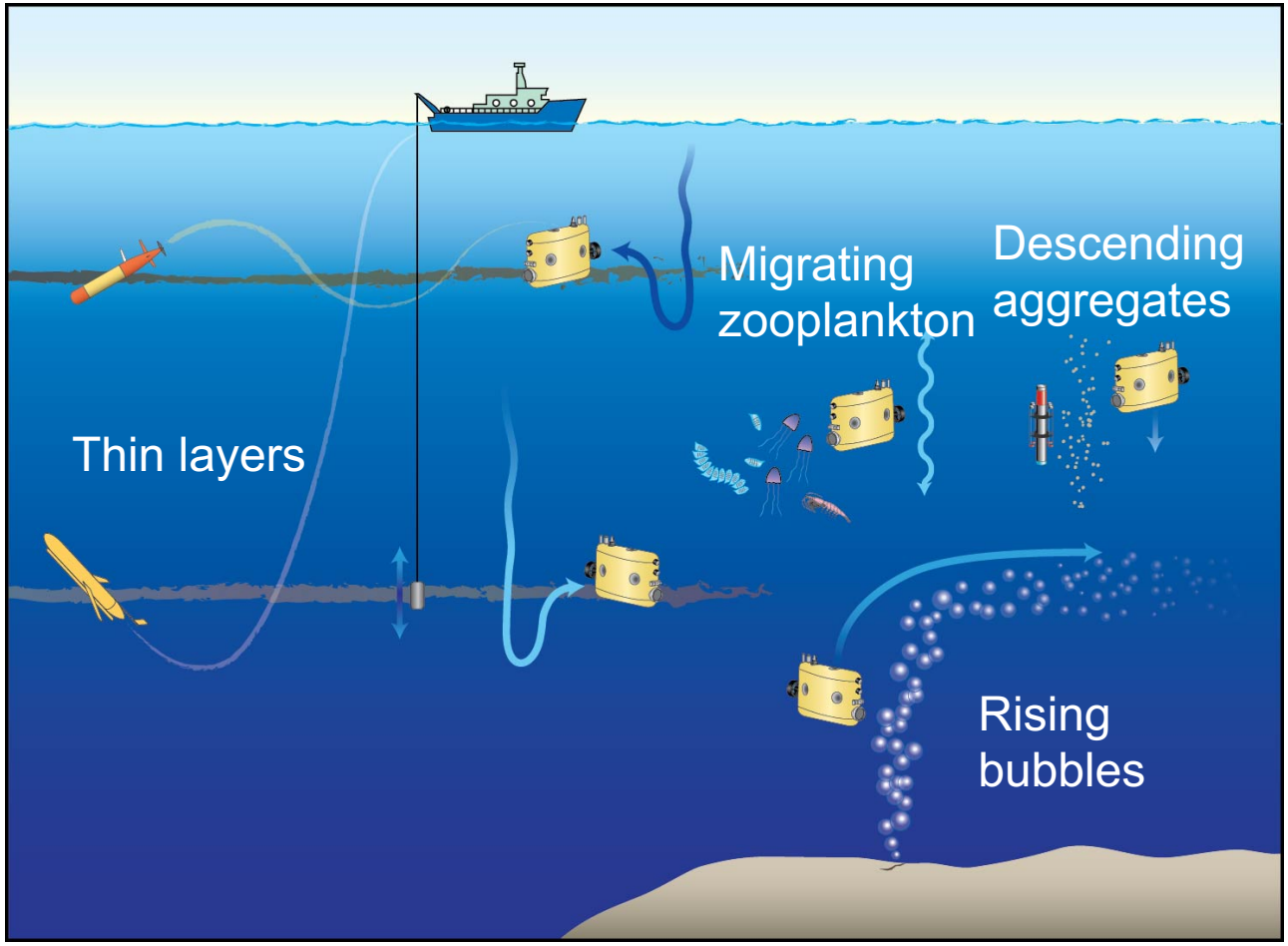
Mesobot: part of an integrated approach to studying the midwater



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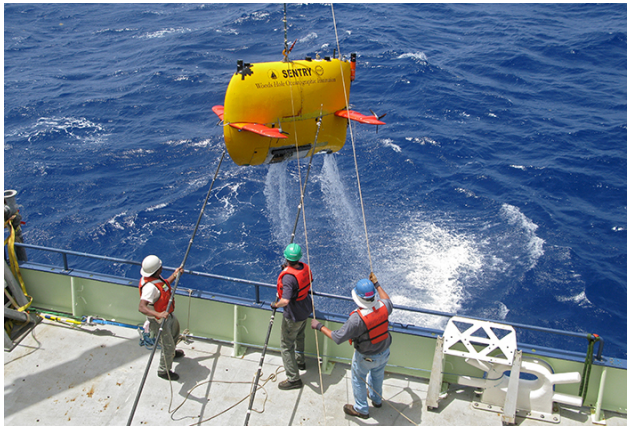
The Mesobot Team

- Woods Hole Oceanographic Institution (WHOI)
- Monterey Bay Aquarium Research Institute (MBARI)
- Stanford University
- University of Texas Rio Grande Valley

Mesobot's AUV and ROV Ancestors

Long-Range AUV (MBARI)

Sentry Autonomous Underwater Vehicle (AUV)



I2MAP (MBARI)

ROV Ventana (MBARI)

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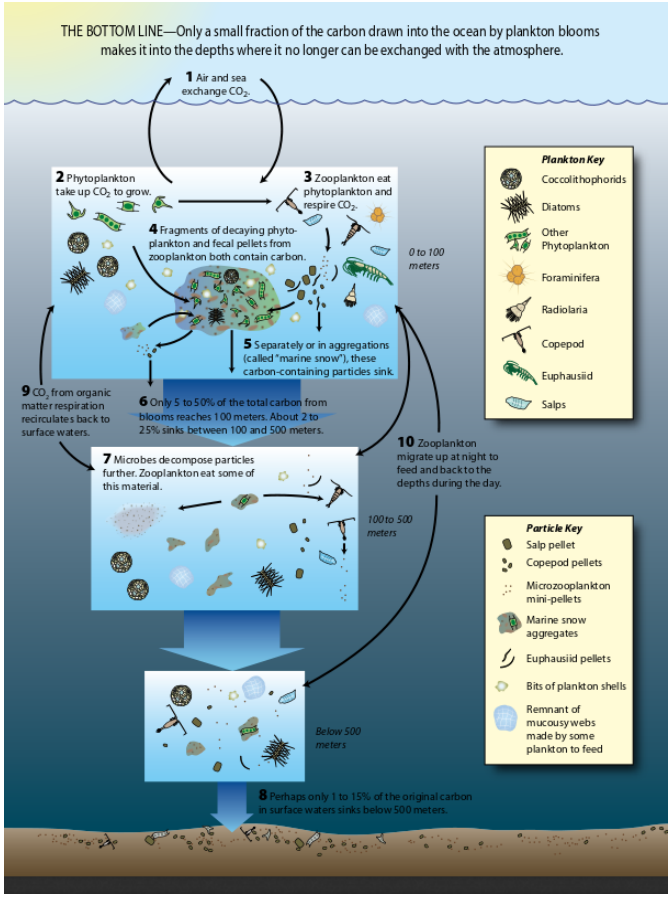
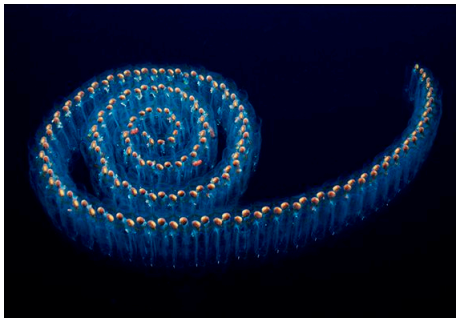
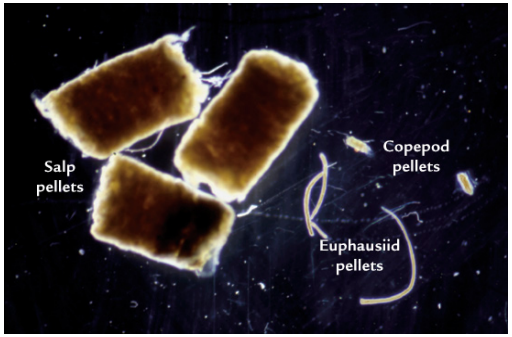
Mesobot: studying the carbon cycle



Salps: voracious feeders and poopers!





Descending fecal pellets sequester carbon

Oceanus, Vol46 No1 2008

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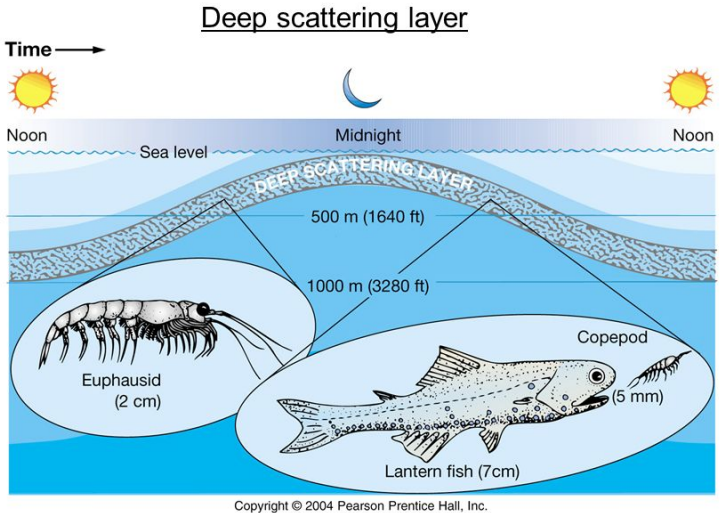
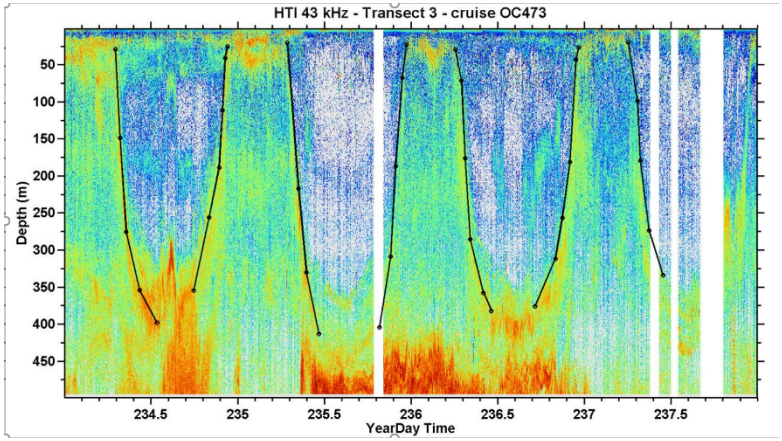
Diel Migration: The largest migration on Earth (by far)





- Migrating animals include fish, crustaceans, and salps
- Migrating animals feed at the surface, bringing organic carbon from the surface to deeper waters

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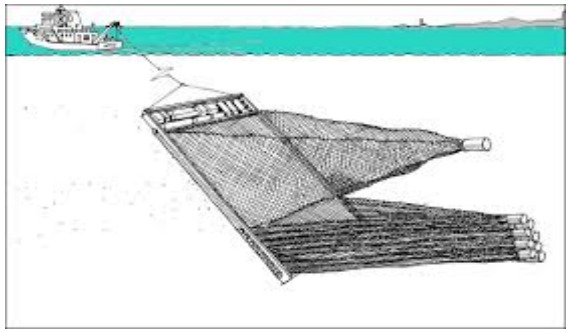
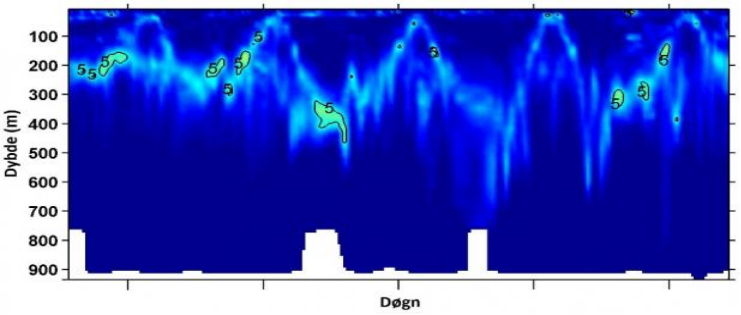
Existing tools for studying the mesopelagic zone

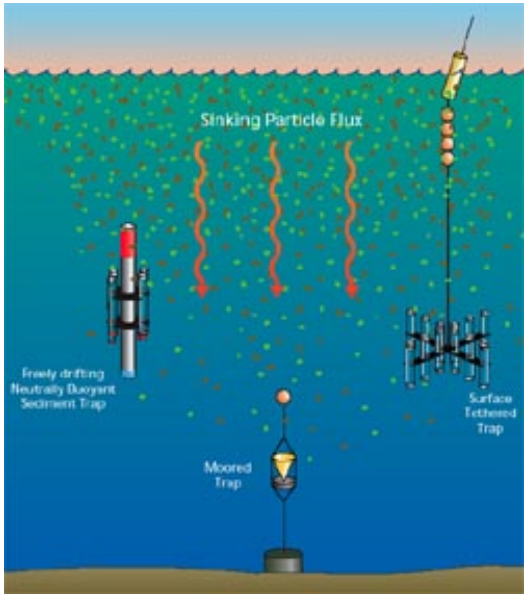


Net tows: MOCNESS (Wiebe)

Video Plankton Recorder (Davis)



Bioacoustics (Wiebe, Stanton, Lavery)



Sediment traps (Honjo, Buesseler, Price)

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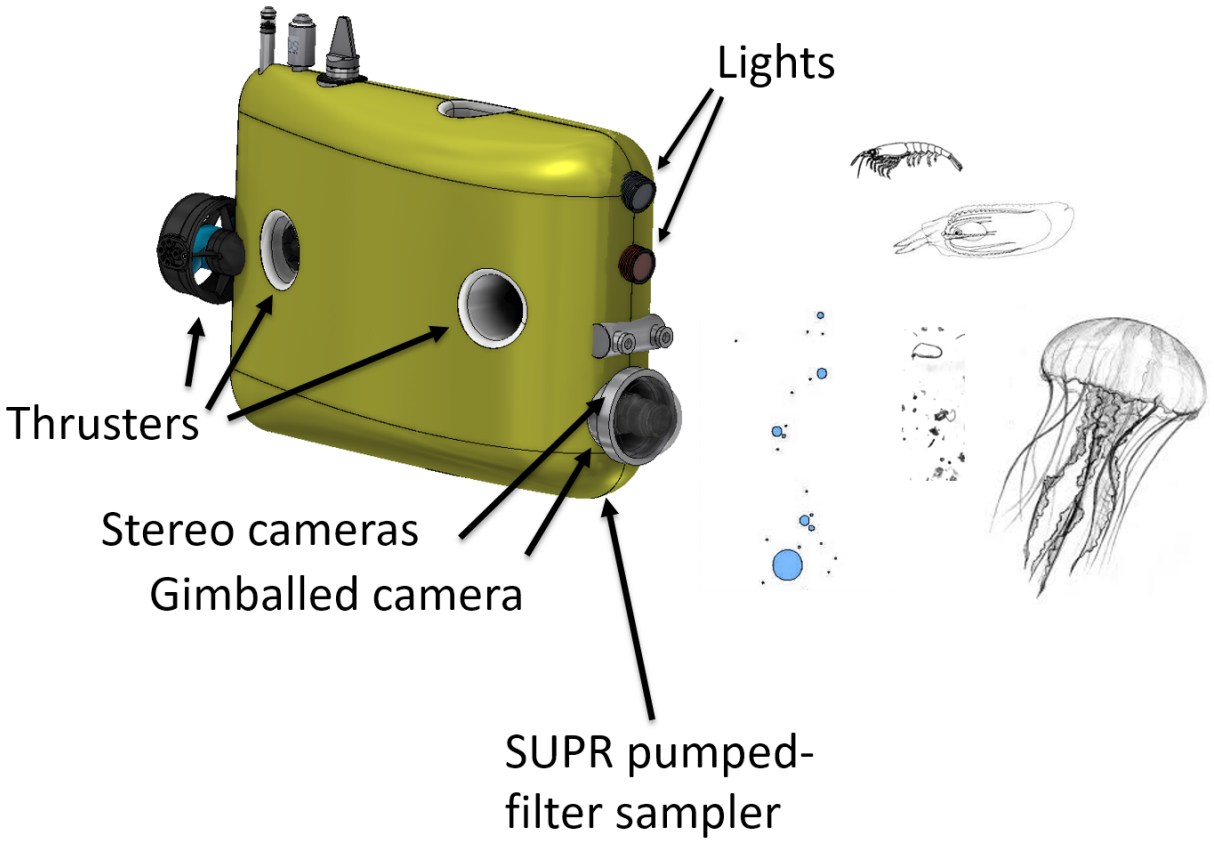
Mesobot: tracking and sampling midwater animals and particles



Other sensors

- CTD
- Optical backscatter
- O_2
- PAR

Goal: “Almost lagrangian”

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Stanford/MBARI jellyfish tracking using a tethered remotely operated vehicle

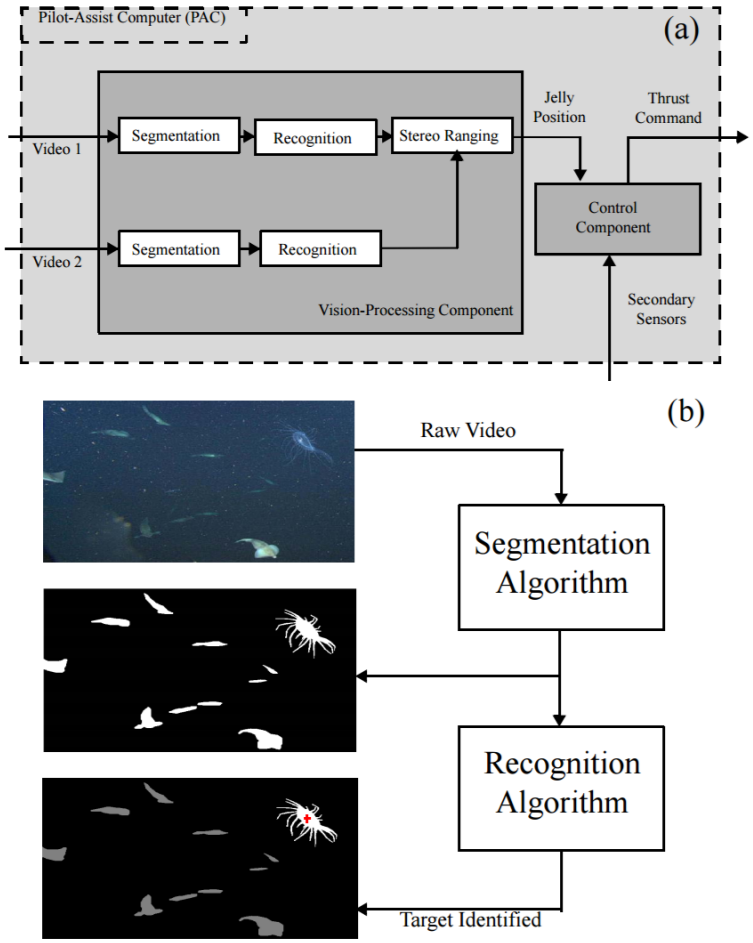

Figure 3.3 Vision-Processing System

(a) Block diagram for the PAC, with details of the vision-processing component. (b) Graphical depiction of vision-processing. The segmentation algorithm clusters pixels into associated regions, while the recognition algorithm identifies the region (indicated by a crosshair) that best matches a target profile.

Complications:

- Complex, dynamic scenes
- Sudden animal movements
- Tether pull

Rife et al, 2001-2006

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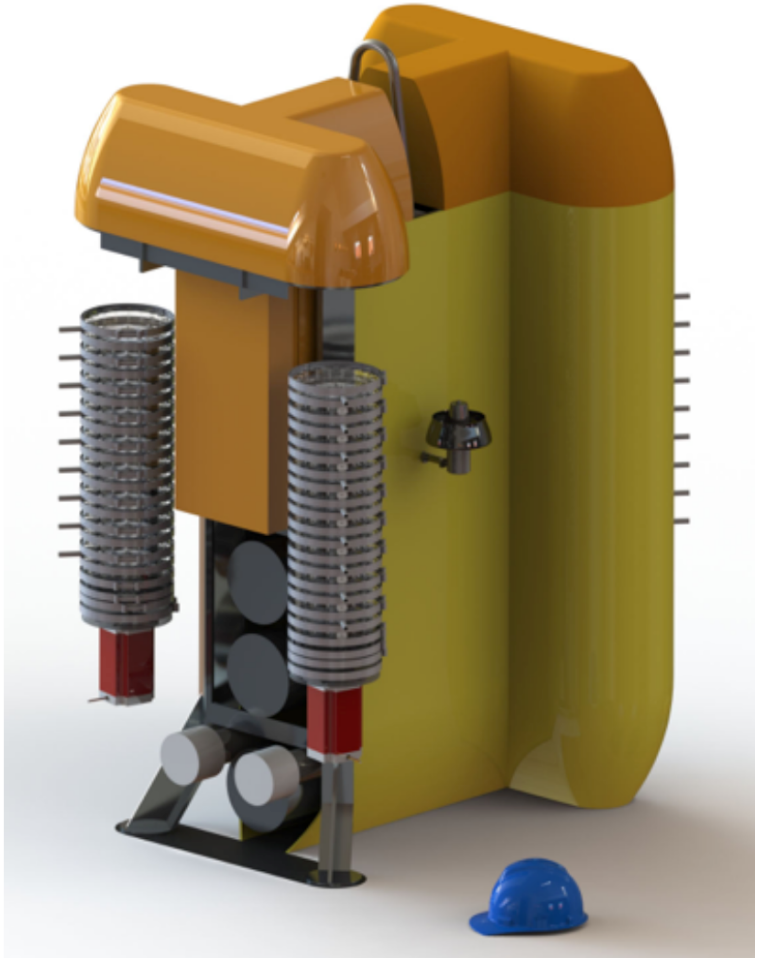
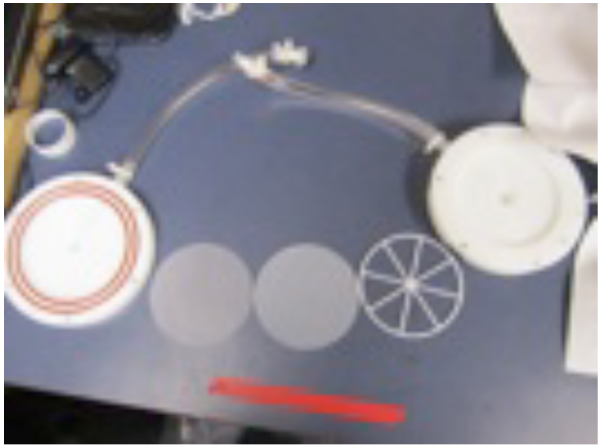
CLIO: Autonomous Profiler carrying SUPR pumped-filter samplers





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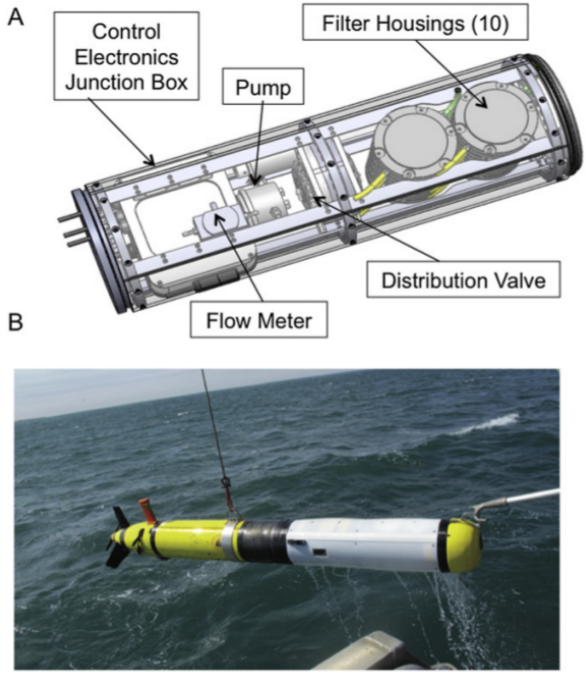
Mesobot: Can we take samples to enable genetic analysis?



SUPR Sampler on REMUS
Govindarajan, Pineda, Purcell, Breier 2015

Environmental DNA for biodiversity assessments
(Govindarajan, unpublished)

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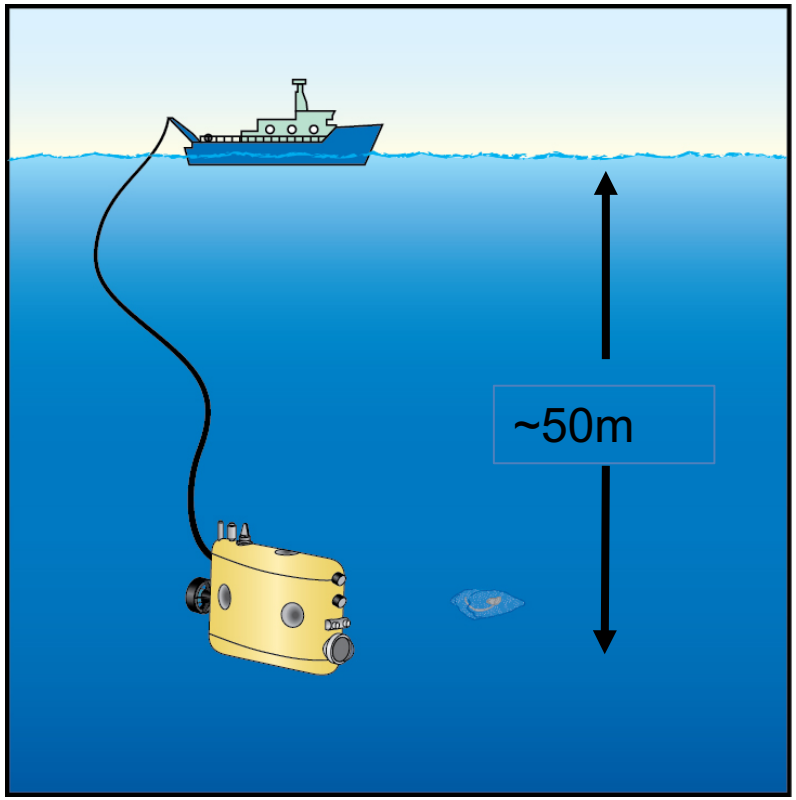
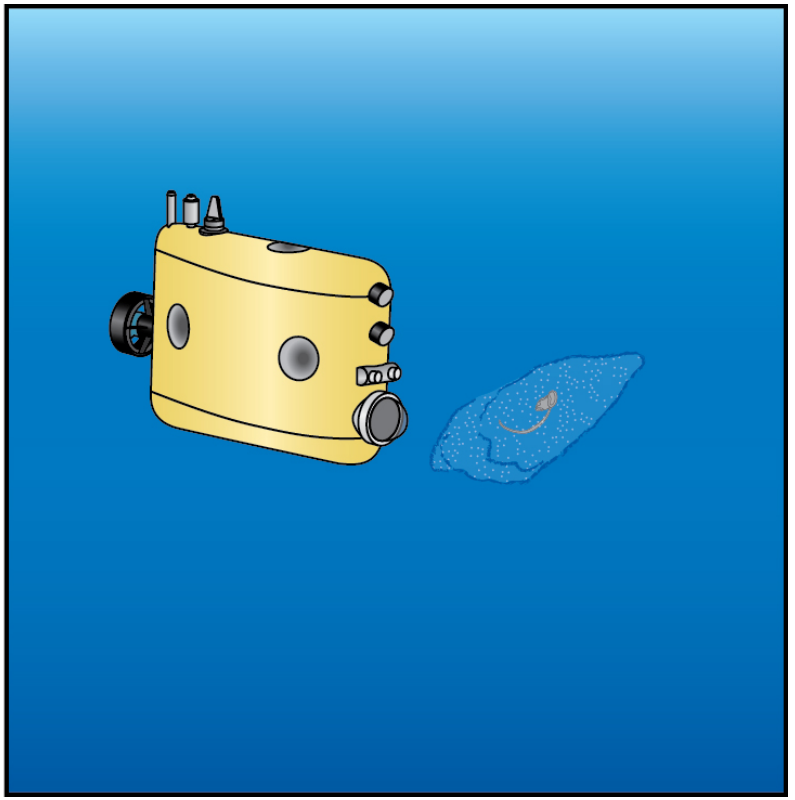
Use case 1: Larvacean daily dynamics





Acquire larvacean by teleoperation, disconnect tether

Track for up to 1 day

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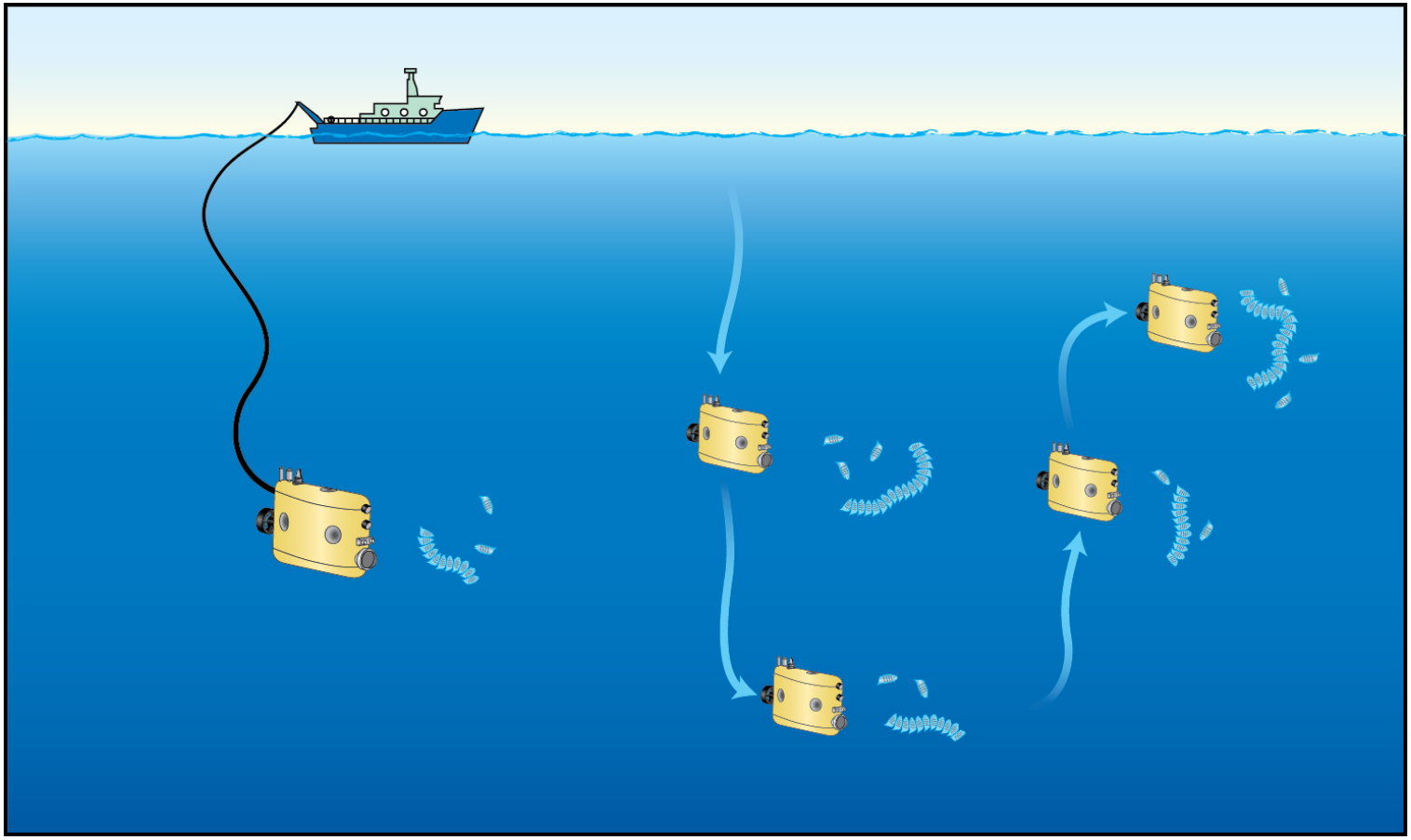
Use case 2: Diel migrating zooplankton



~1000m

- Teleoperated start, disconnect tether
- Autonomous tracking for ~ 1 day
- Document behavior, defecation rates, etc

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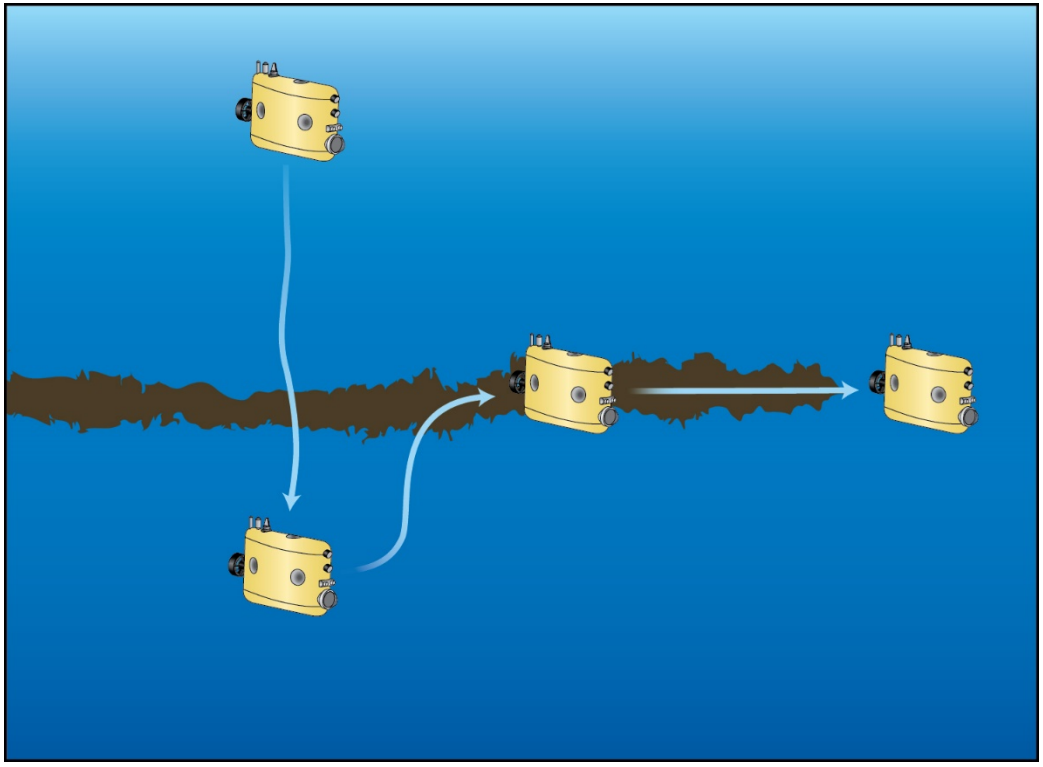
Use case 3: Mapping and sampling intermediate nepheloid layers



- Fully autonomous survey, optical backscatter will be the primary sensor
- Survey size, shape of nepheloid layer
- Sample for geochemistry and genomics with SUPR sampler

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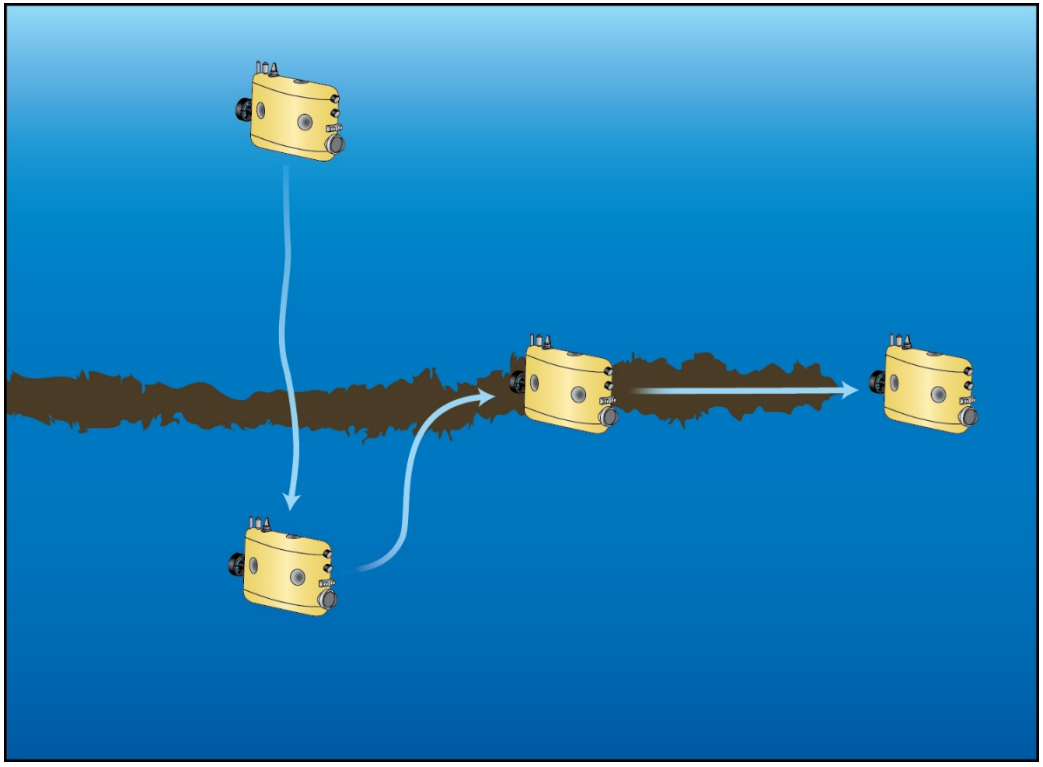
Use case 3: Mapping and sampling intermediate nepheloid layers



- Fully autonomous survey, optical backscatter will be the primary sensor
- Survey size, shape of nepheloid layer
- Sample for geochemistry and genomics with SUPR sampler

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Tracking descending aggregates and particles

- Tracking descending aggregates and particles
  - Use stereo cameras for tracking
  - Determine true sinking speed
  - Observe changes in aggregates over time
  - Track to depths of ~1000m
  - Requires long vehicle endurance
  - Initial efforts will focus on larger aggregates

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Mesobot design challenges

- Real-time Tracking (Rock et al, ~1000 MBARI ROV dives)
  - Initial target acquisition
  - Reliable, long term tracking
  - Low-contrast, complex, dynamic scenes
  - Extreme target shape changes
- Avoidance/Attraction/Interference
  - Lights
  - Acoustic noise
  - Thruster wash
  - Electromagnetic?
  - Countershading?
- Vehicle maneuverability
- Buoyancy control/trim
- Energy supply
- Video compression, storage

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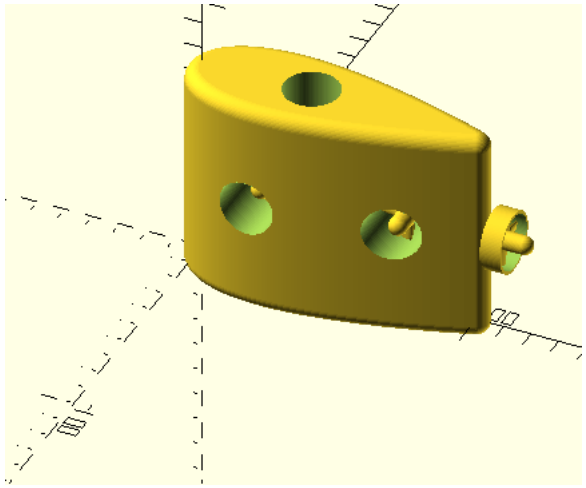
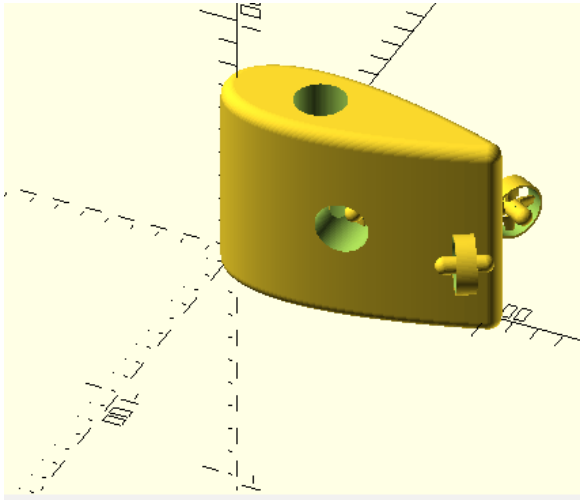
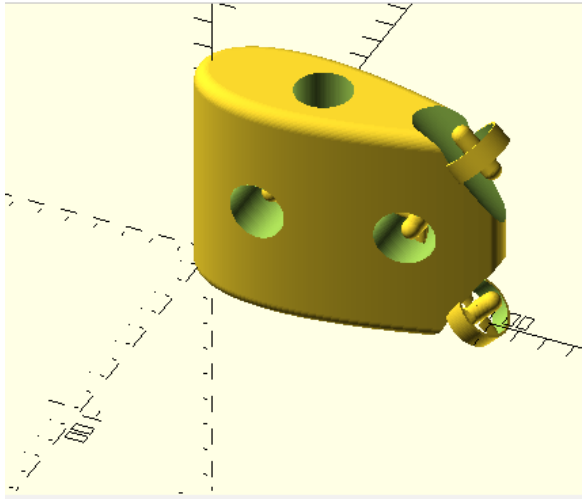
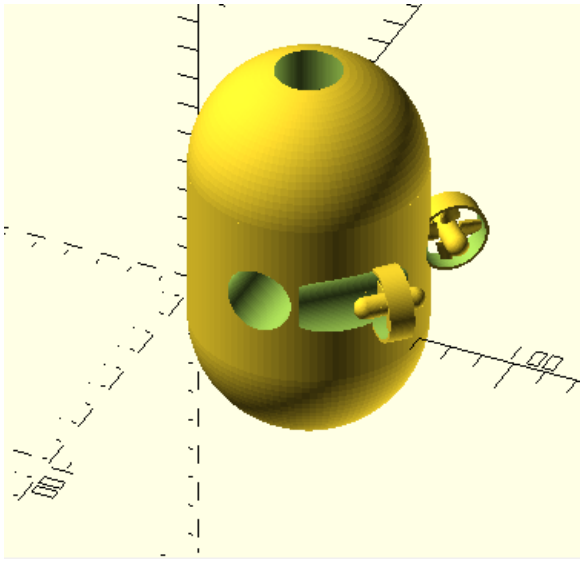
Alternative layouts

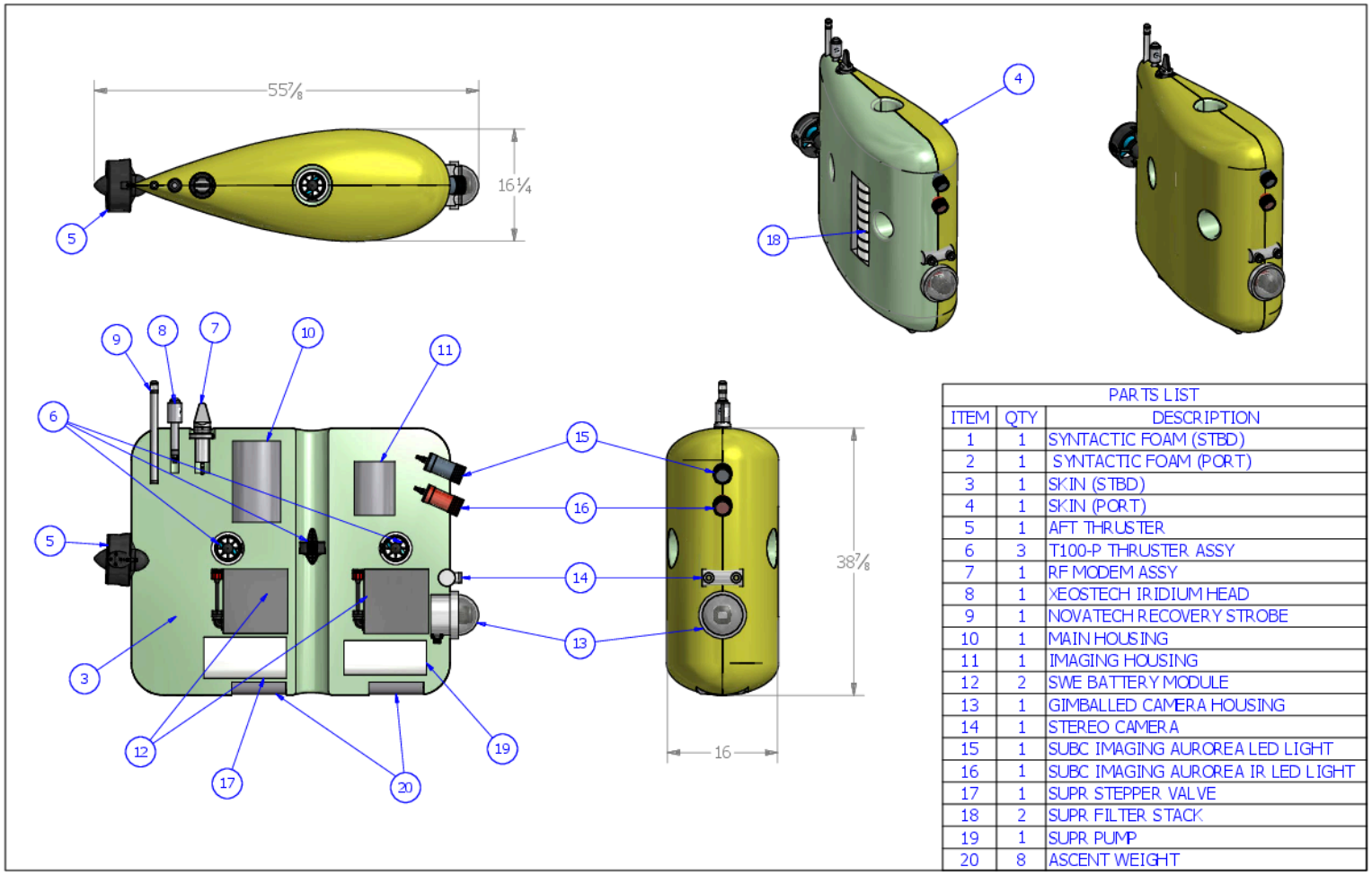








Mesobot: Notional layout



PARTS LIST		
ITEM	QTY	DESCRIPTION
1	1	SYNTACTIC FOAM (STBD)
2	1	SYNTACTIC FOAM (PORT)
3	1	SKIN (STBD)
4	1	SKIN (PORT)
5	1	AFT THRUSTER
6	3	T100-P THRUSTER ASSY
7	1	RF MODEM ASSY
8	1	XEOSTECH IRIDIUM HEAD
9	1	NOVATECH RECOVERY STROBE
10	1	MAIN HOUSING
11	1	IMAGING HOUSING
12	2	SWE BATTERY MODULE
13	1	GIMBALLED CAMERA HOUSING
14	1	STEREO CAMERA
15	1	SUBC IMAGING AUROREA LED LIGHT
16	1	SUBC IMAGING AUROREA IR LED LIGHT
17	1	SUPR STEPPER VALVE
18	2	SUPR FILTER STACK
19	1	SUPR PUMP
20	8	ASCENT WEIGHT

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OCE-1636575
OCE-1636575

Mesobot: Schedule and Acknowledgements

- Year 1: Preliminary and final design
- Year 1-3: Tracking system development at MBARI using simulated and live targets
- Year 2: Construction and bench testing
- Year 3: Dock and at-sea testing

Acknowledgements

- WHOI Independent Study, Smith Chair
- Preliminary design by guest undergraduate students
- Development and testing funded by the National Science Foundation OCE-1636575

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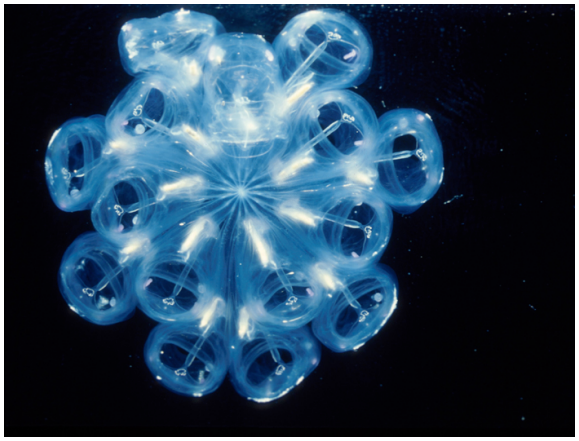
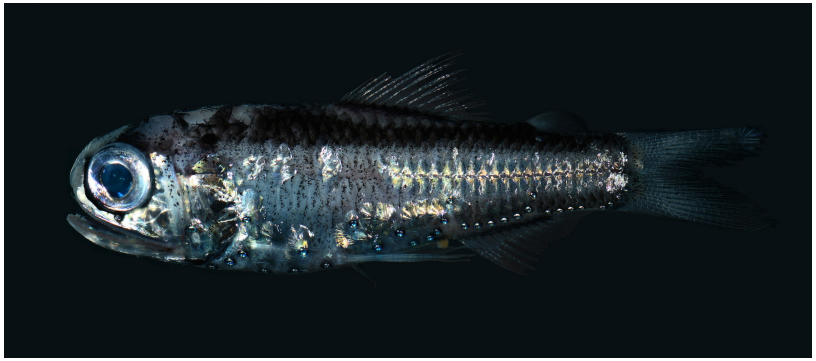
Exciting opportunities and challenges





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