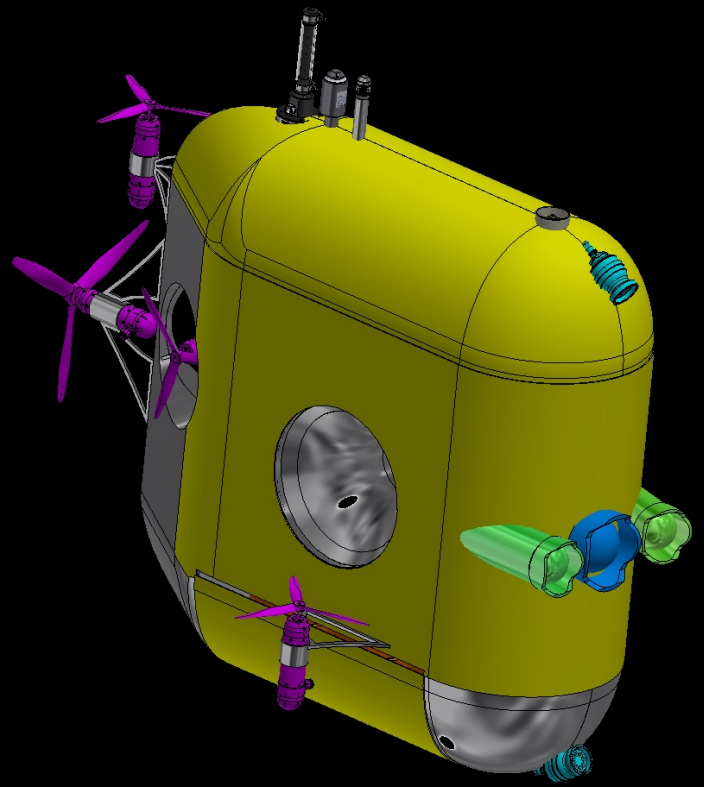
MESOBOT

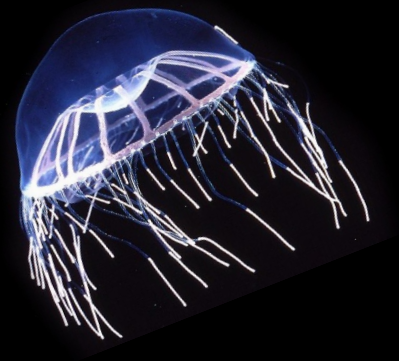
A hybrid underwater robot for multidisciplinary investigation of the ocean twilight zone



WHOI

MAS. S62 Review

Maisy Lam

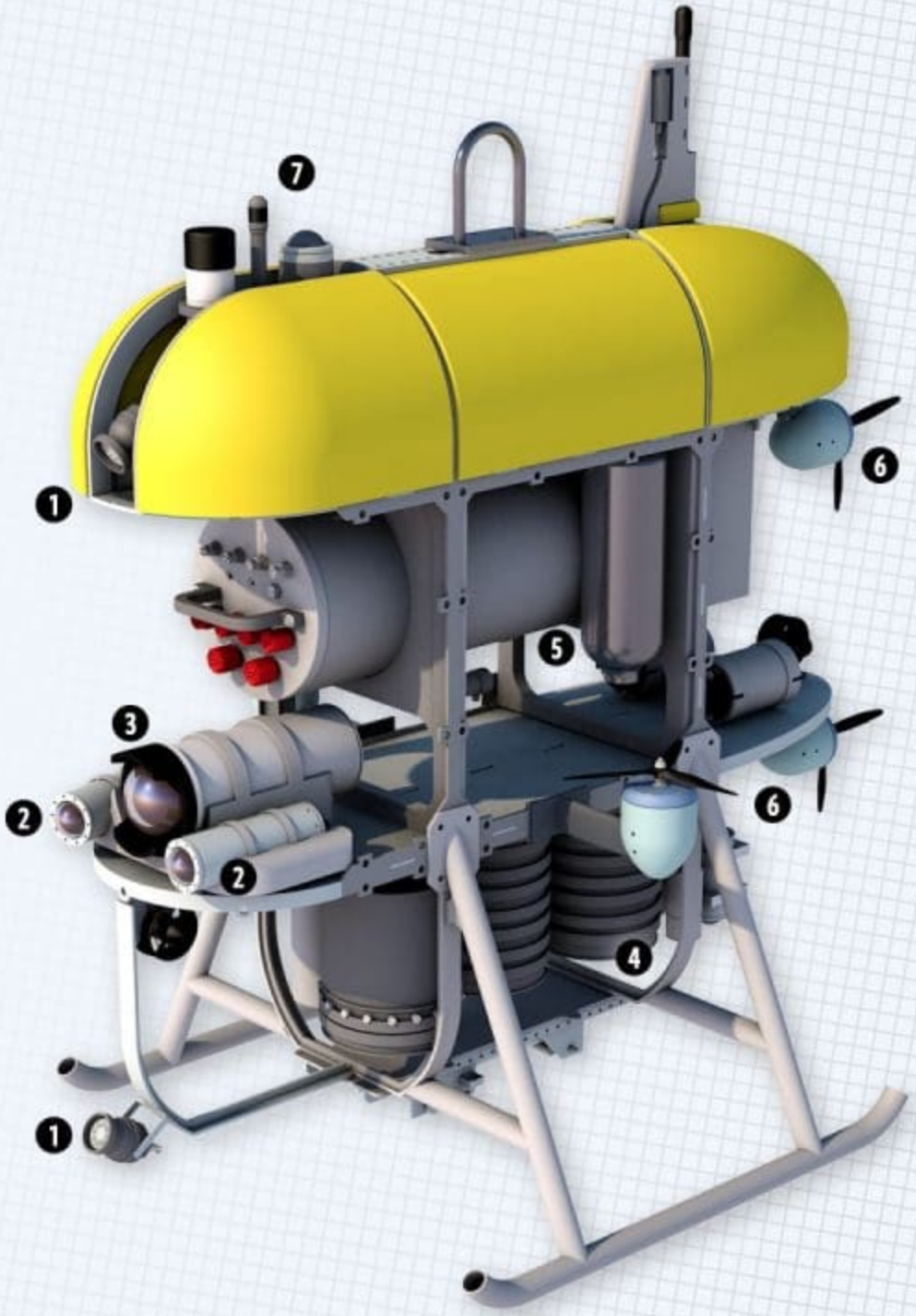


Images/Videos courtesy of WHOI

What's a *Mesobot*?

This autonomous vehicle, roughly 4-feet tall, can track animals in the ocean twilight zone without disturbing their environment and behavior.

1. **DIMMABLE LED LIGHTS** can switch from white to red, a color that many deep-sea species can't see.
2. **STEREO CAMERA SYSTEM**
3. **4K CAMERA SYSTEM**
4. **SAMPLING SYSTEM** to filter seawater for chemicals and eDNA
5. **SENSORS** to measure salinity, temperature, dissolved oxygen, and other seawater characteristics
6. **SIX LOW-POWER THRUSTERS** to enhance hovering and maneuverability
7. **RADIOMETER** to measure ambient light



Mesobot

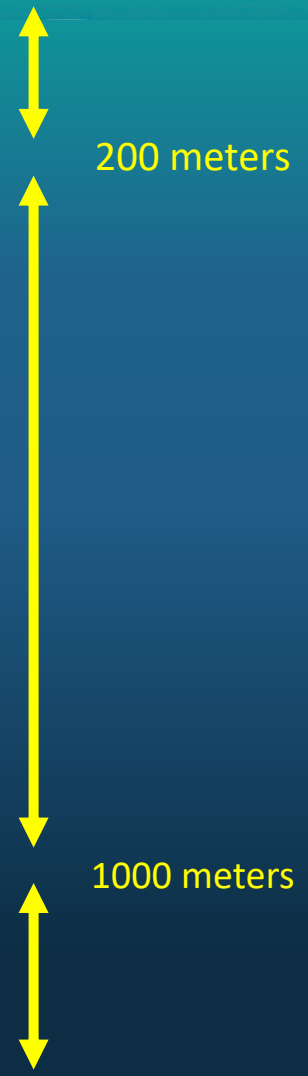
What is the Twilight Zone?

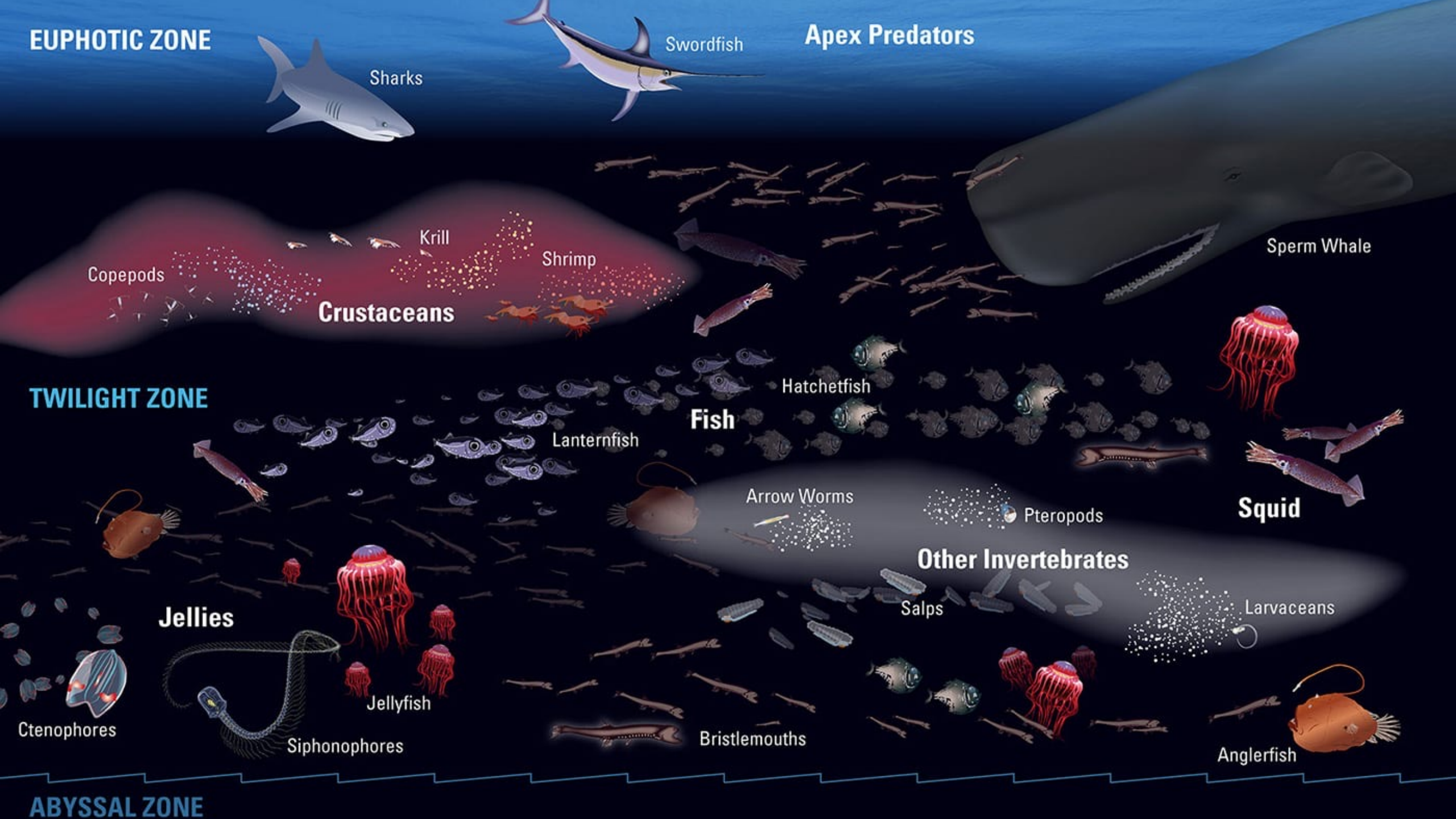
Twilight Zone/ Midwater:

- ~ 200 – 1000 m depths

Importance?

- Animals undertake daily migration to the near surface to feed at night
- Migration plays a major role in transferring carbon from shallow to deep water
- Potential for commercial markets (fish meal for agri/aquaculture, fish & krill oil)
- Epipelagic species (whales, sharks, swordfish, ect.) dive regularly into the twilight zone to feed




EUPHOTIC ZONE
Sharks
Swordfish
Apex Predators
Sperm Whale
Krill
Shrimp
Copepods
Crustaceans
TWILIGHT ZONE
Hatchetfish
Fish
Lanternfish
Squid
Arrow Worms
Pteropods
Other Invertebrates
Salps
Larvaceans
Jellies
Jellyfish
Ctenophores
Siphonophores
Bristlemouths
Anglerfish
ABYSSAL ZONE

Challenges for Midwater Monitoring

- Marine robots disrupt the environment
- Causes animals to flee or attract others
- Lighting, hydrodynamic disturbances, acoustics, electromagnetic fields, vehicle’s chemical signature elicit animal behavioral
- Bow wave or thruster of an approaching vehicle can damage species (delicate gelatinous zooplankton)

How does Mesobot Address Challenges?

Illumination

- Longer wavelength light (red and white LED array)

Hydrodynamics

- Hydrodynamic shape, low powered thrusts, large, slow-moving propellers
- Near-neutrally buoyant and minimizing environmental disturbances

Appearance

- Does not physically resemble any marine organism
- Minimizes other known mechanisms that elicit avoidance or attraction

Goals for Mesobot

1. Observe and image targets for extended periods
2. Minimize disturbance (hydrodynamic, acoustic, and optical)
3. Behave “mostly Lagrangian” (hover and move with ambient water), maneuver actively with fine control
4. Mission duration exceeding 24 hours to observe diel migrations
5. Operate at depth of 1000 m
6. Carry auxiliary payloads (plankton imaging system, sonars, sampler, ect.)

Current Technology for Midwater Monitoring

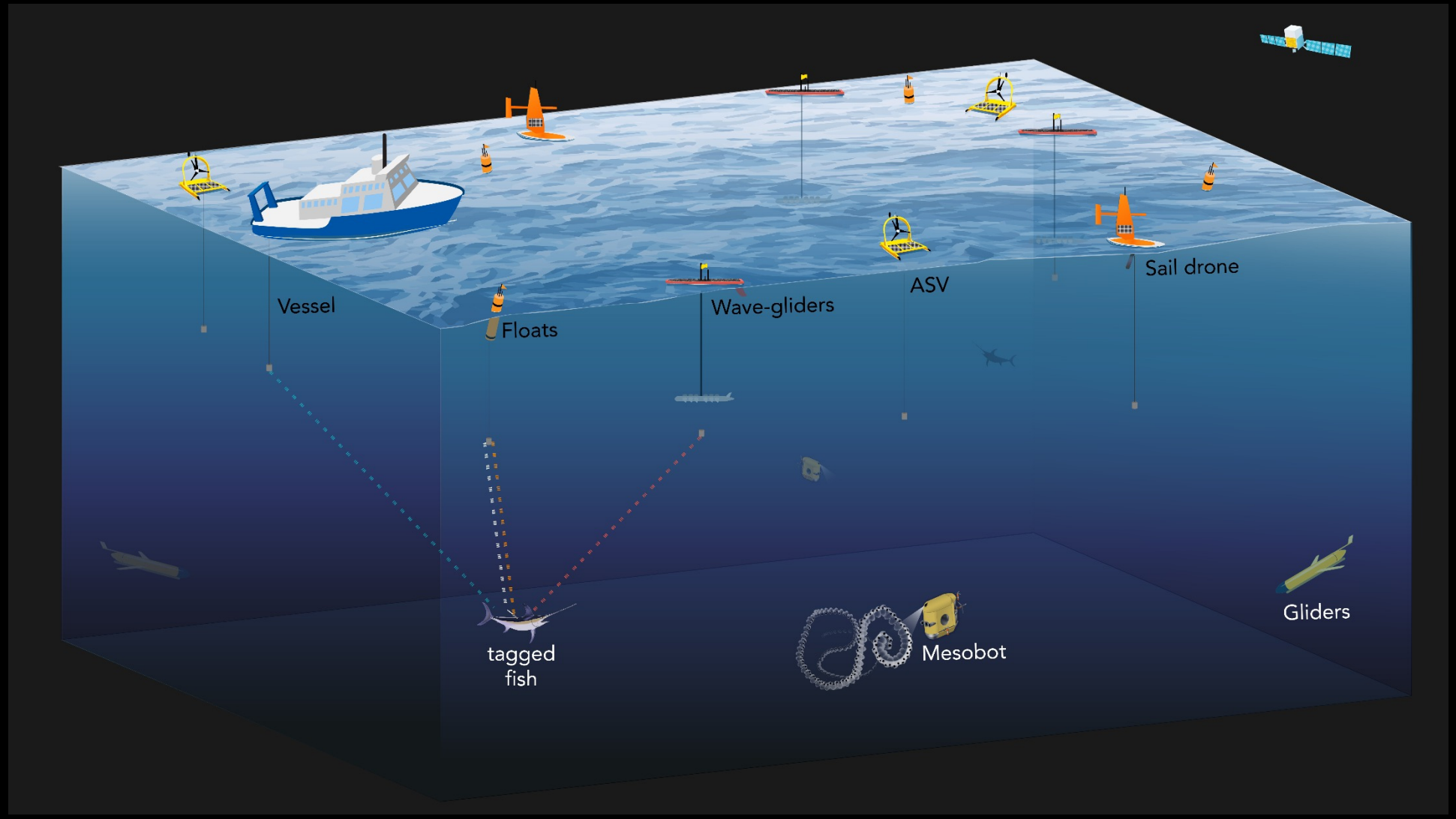
1. Sensors on towing/lowered nets
   - Species attempt to avoid capture
   - Not an accurate representation of diversity or abundance sampled
   - Destroy species (gelatinous zooplankton)

2. Camera Systems
   - Typically provide snapshots of targets
   - Rarely observe individual animals for extended periods of time

3. Echo sounders
   - Dominant remote-sensing methodology

4. Conductivity, temperature, and depth profilers (CTDs)
   - Lowered from research vessels

Underwater Monitoring

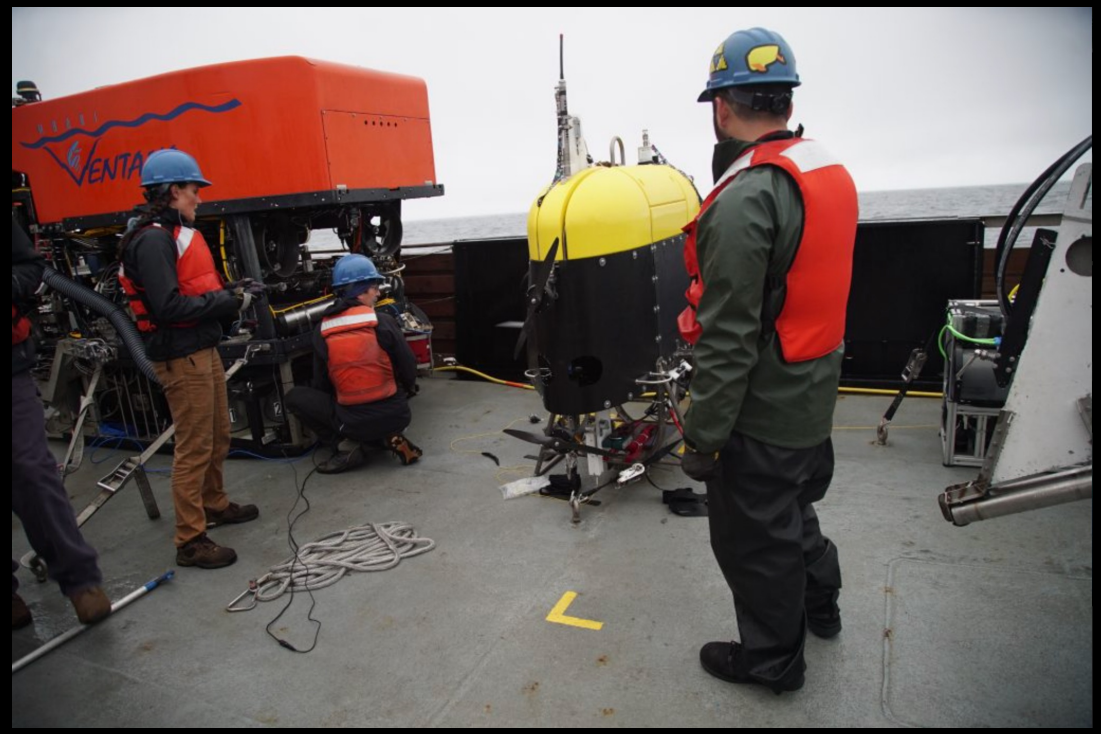


Mesobot System

1. Oceanographic sensors
   - Conductivity, temperature, depth sensors
   - Sensor data available in real time
   - Adaptive survey and sampling
   - Flexible payload

2. Stereo Camera
   - Sensitivity to red light
   - 2064 pixels × 1544 pixels resolution

3. Science Camera
   - 27° w and 17° h FOV
   - HD/ 4K and high resolution 12 MP



Deploying mesobot in open water.

Mesobot System

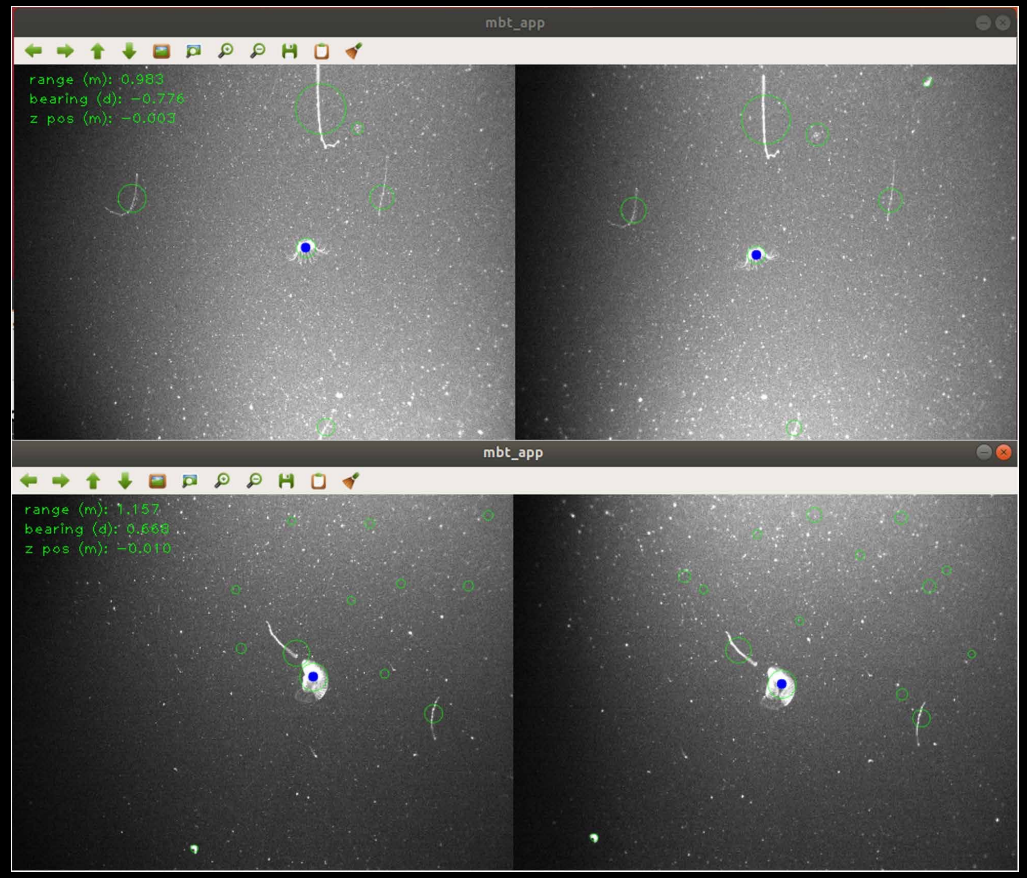
1. Thrusters and motor controllers
   - Low-powered
   - 8:1 gear reduction
   - Large 46-cm propellers
   - Seawater fills gap between rotor and stator - reduces friction and startup torque

2. Power Management
   - 12 lithium-ion battery subpacks with total 4.5 kWh capacity

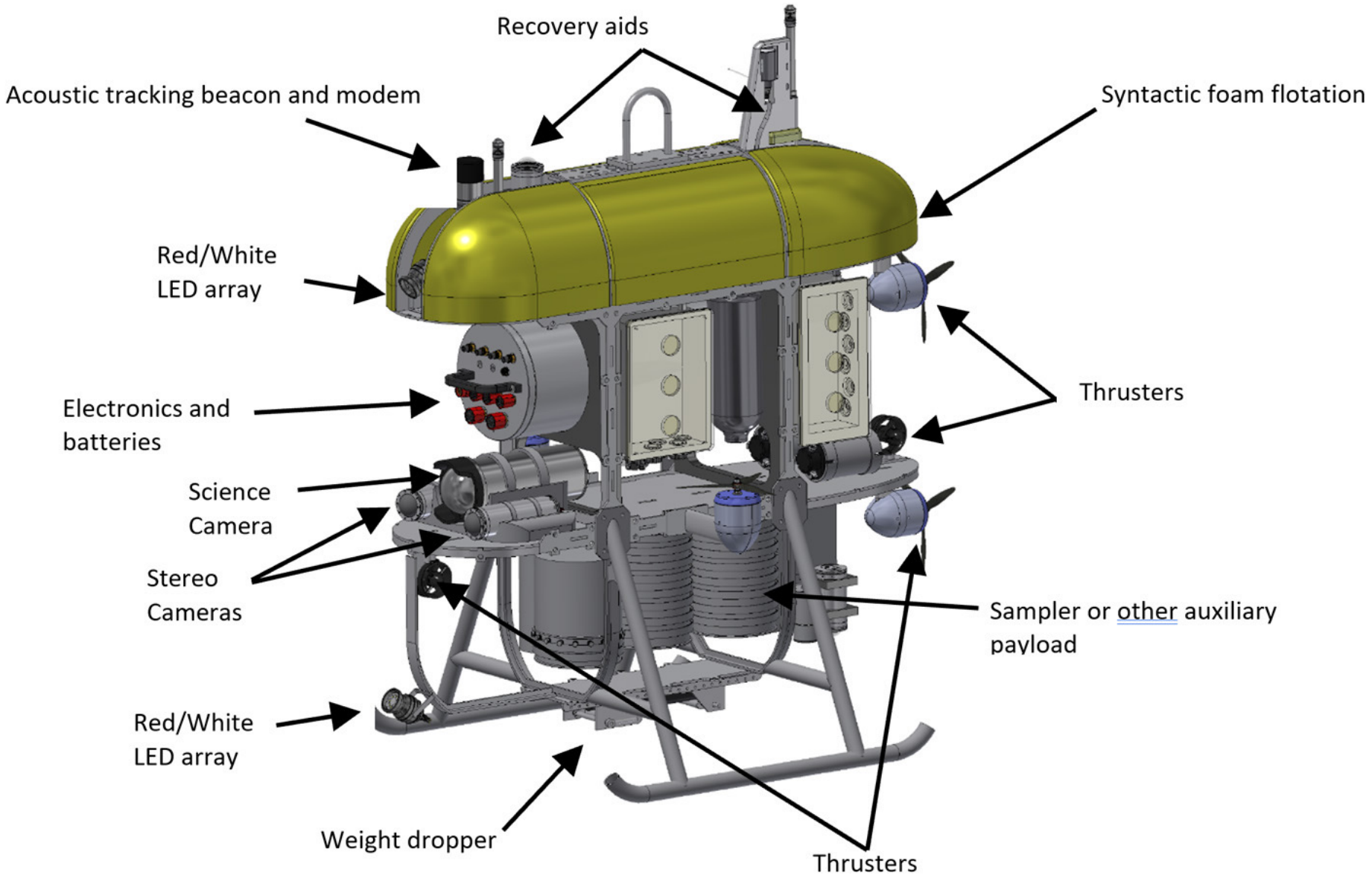
- Recovery Aids
  - Strobe lights
  - GPS
  - Drop weights

Tracking Species

- System
  - Real-time (10 Hz) updates of target
  - Results passed to servo controller
- Algorithm
  - OpenCV blob detector
  - Filtered by intensity, size, intensity, or inertia
  - Epipolar calculations for all blob
  - Results converted to range, bearing, vertical offset



(top) tracking *Solmissus.* (bottom) tracking larvacean.


Recovery aids
Acoustic tracking beacon and modem
Syntactic foam flotation
Red/White
LED array
Thrusters
Electronics and
batteries
Science
Camera
Stereo
Cameras
Sampler or other auxiliary
payload
Red/White
LED array
Weight dropper
Thrusters

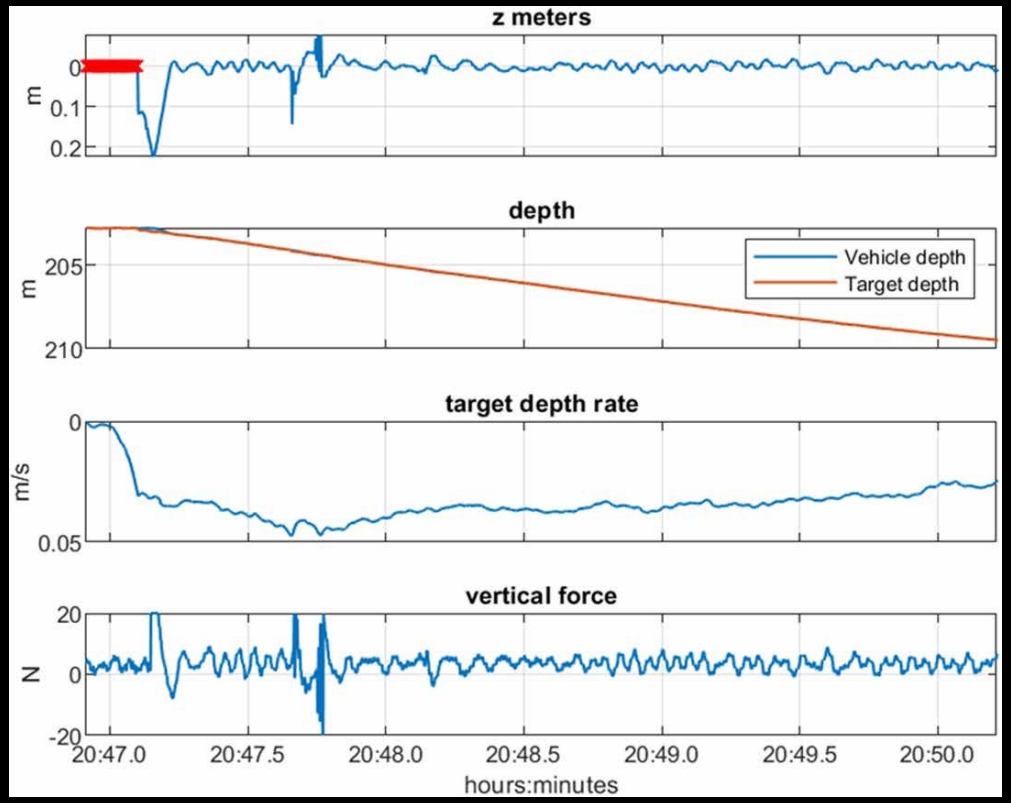
Mesobot Mission

Solmissus Tracking

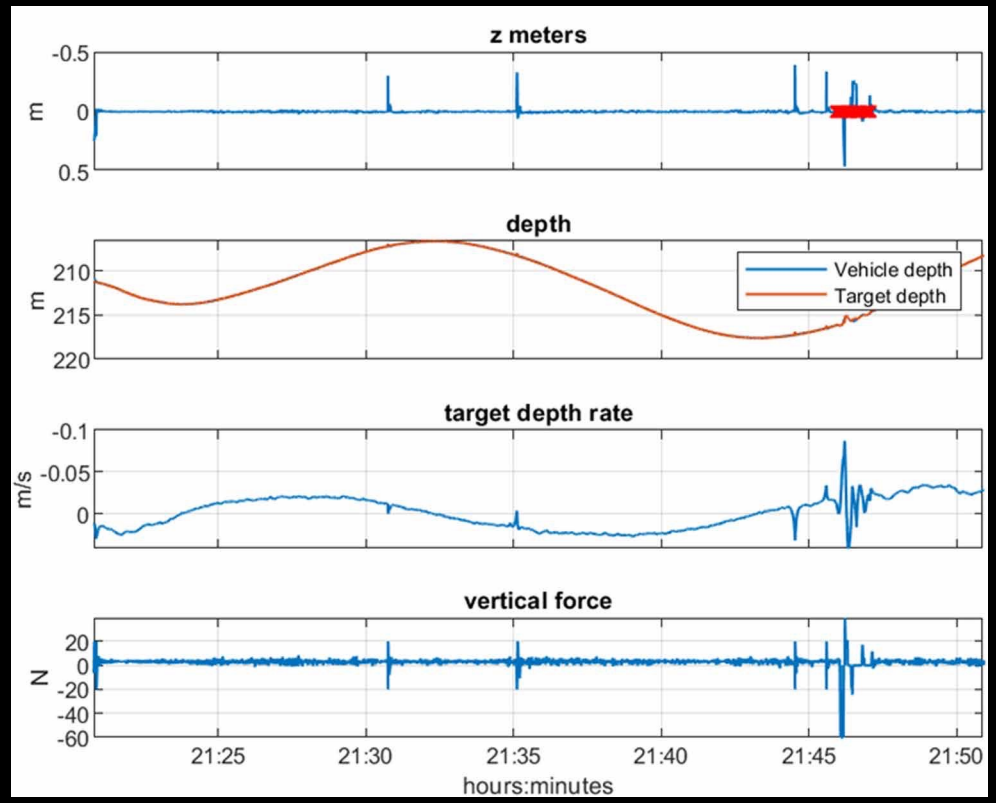
Mission #2: Bathochordaeus Tracking

Results

Mission #1: Solmissus



Mission #2: Bathochordaeus



Conclusion

Accomplished

- Observe midwater targets unobtrusively
- Operate remotely or fully autonomous

Application

- Enable better understanding of midwater region and the inhabiting species