Developing Capabilities for Tidal Hydrokinetic Blade Strike Monitoring

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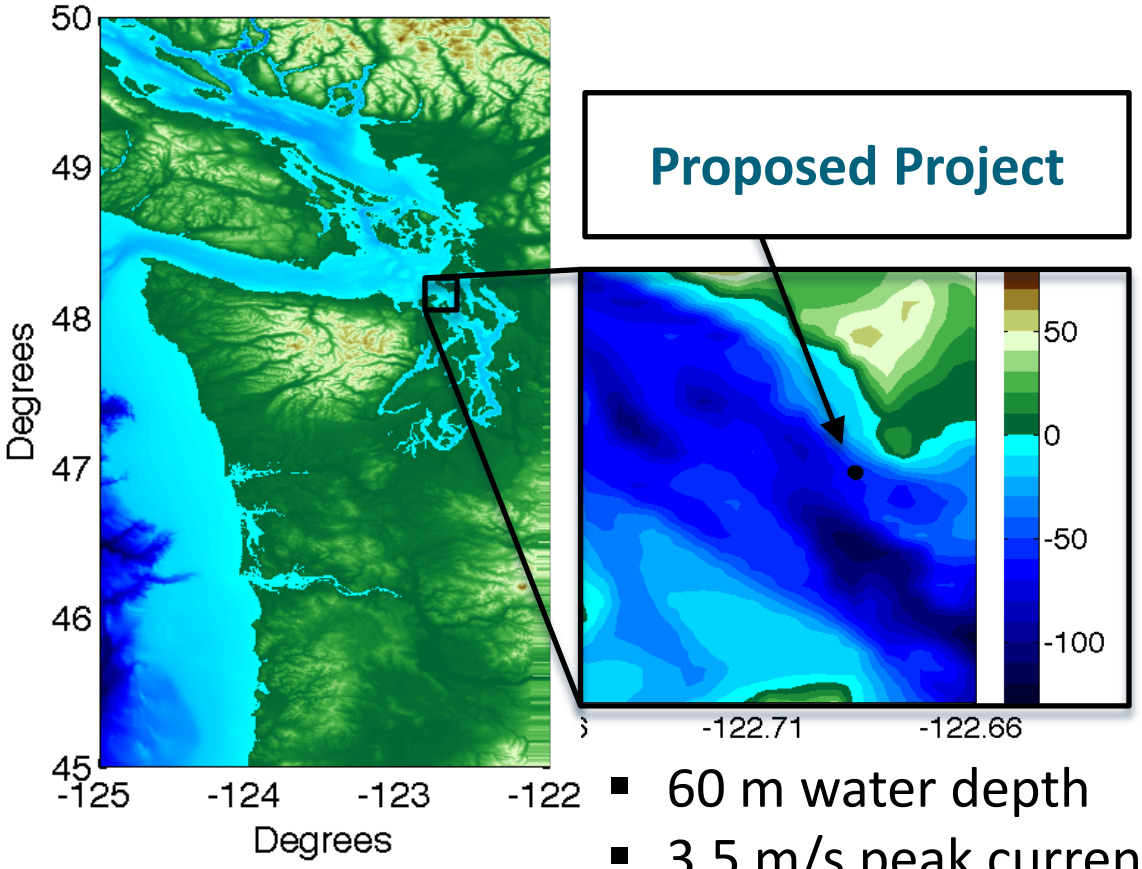
NNMREC

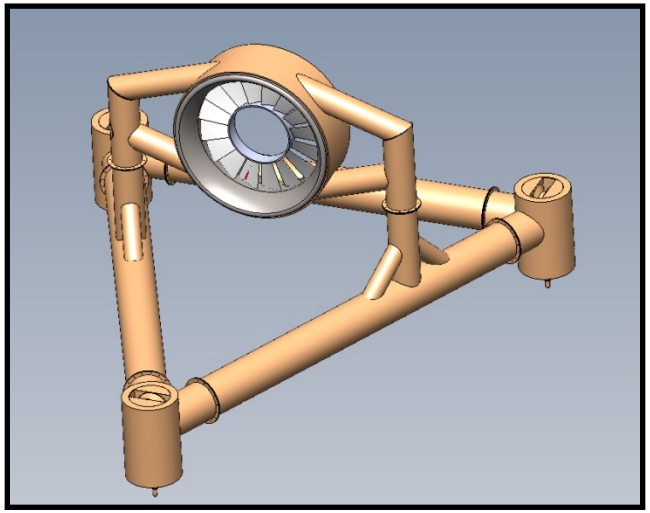
Tidal Energy Project Development

Snohomish PUD/OpenHydro



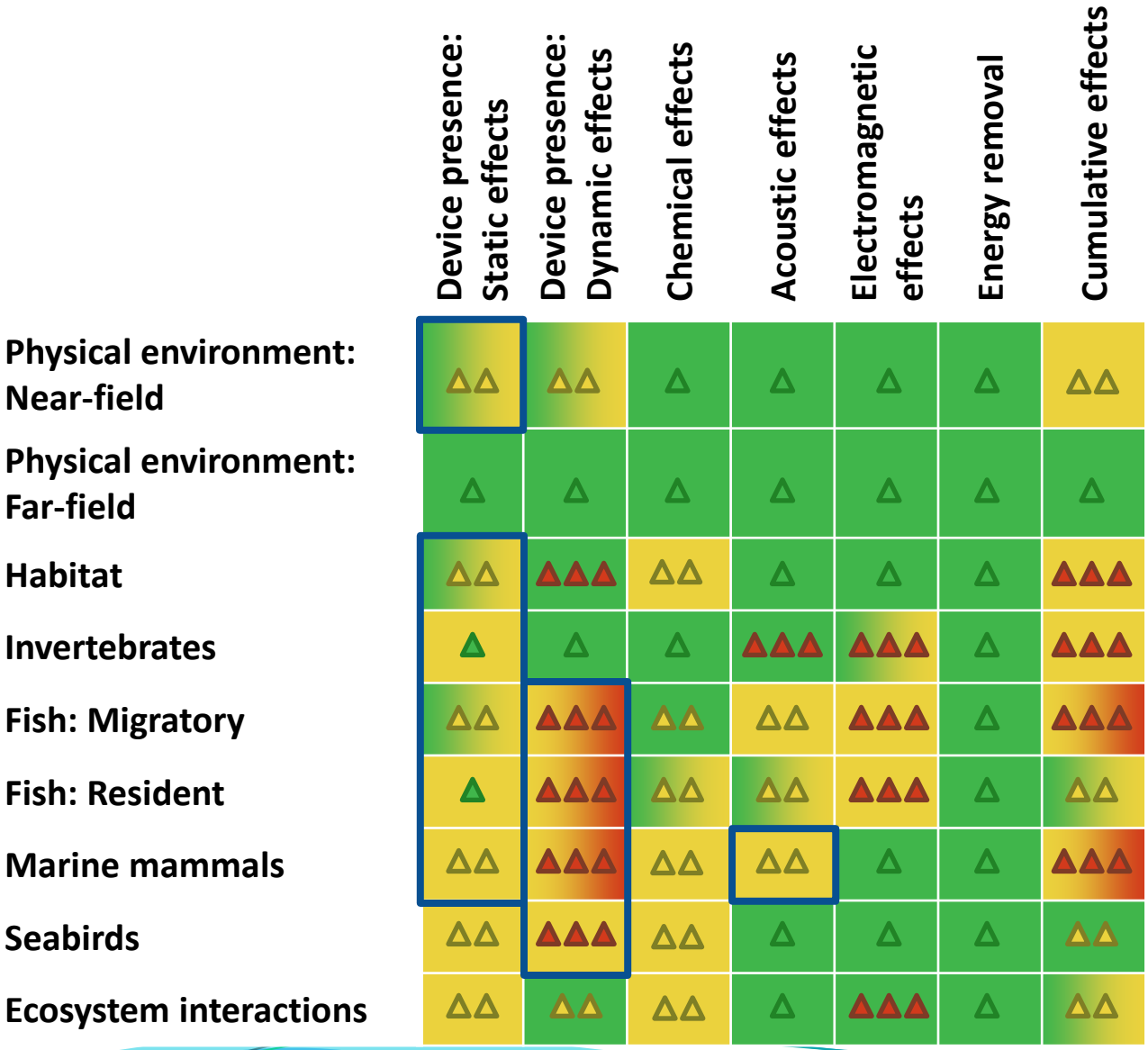
- 60 m water depth
- 3.5 m/s peak currents
- Cable to shore

OpenHydro Turbines



- 2 x 6 m turbines
- 250 kW peak power

Environmental Concerns



Pilot-Scale Effects

Polagye, B., B. Van Cleve, A. Copping, and K. Kirkendall (eds), (2011) Environmental effects of tidal energy development.

Dynamic Effects Monitoring

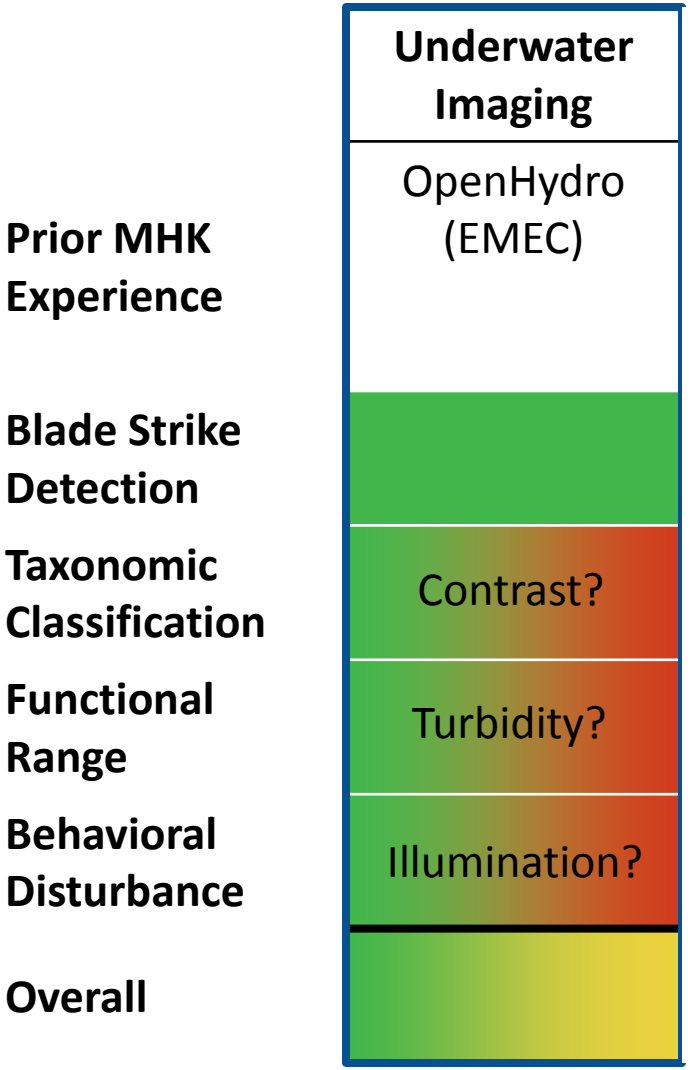
Objectives

- Quantify the risk of blade strike to marine life
- Improve understanding of how marine life responds to device presence
- Both of these should be at the lowest level of taxonomic classification possible

Challenges

- Laboratory and field studies to date suggest blade strike will be an infrequent occurrence
- Monitoring should not alter behavior
- Other projects have had limited success in improving our understanding of blade strike

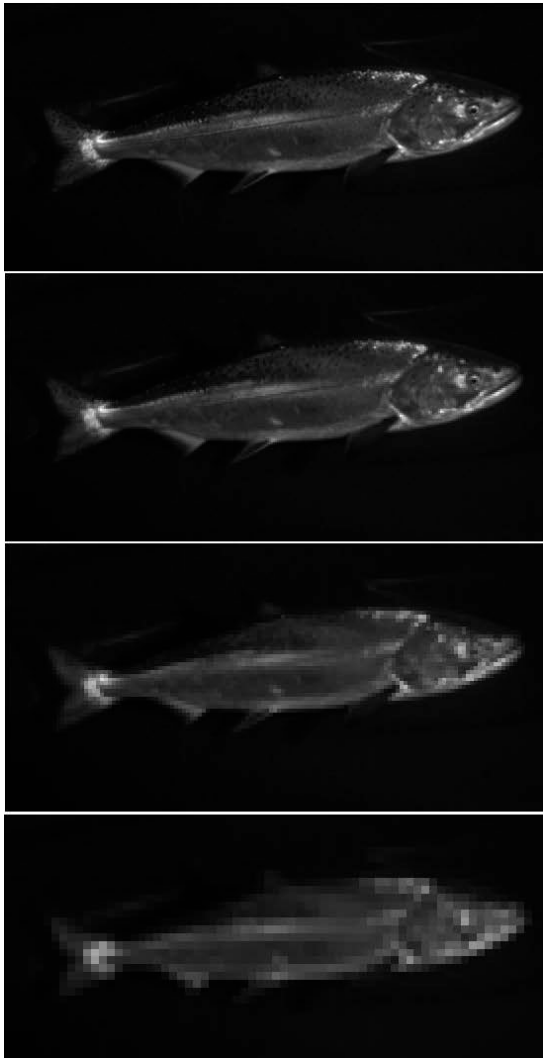
Possible Monitoring Approaches



Underwater Imaging Considerations

- **Stereo imaging – absolute size, position, and speed**
- **Similarities to trawl ground-truthing and benthic habitat surveys**
  - High relative motion between camera and target
  - Taxonomic classification required
- **Several unique considerations for turbine monitoring**
  - Positioning of lights and cameras relative to turbine
  - Long deployment time (biofouling, durability)
  - Recovery and redeployment instrumentation

Camera and Optics Selection



500 pixels/target
Chinook salmon

250 pixels/target
Chinook salmon?

125 pixels/target
Salmon

62 pixels/target
Fish?

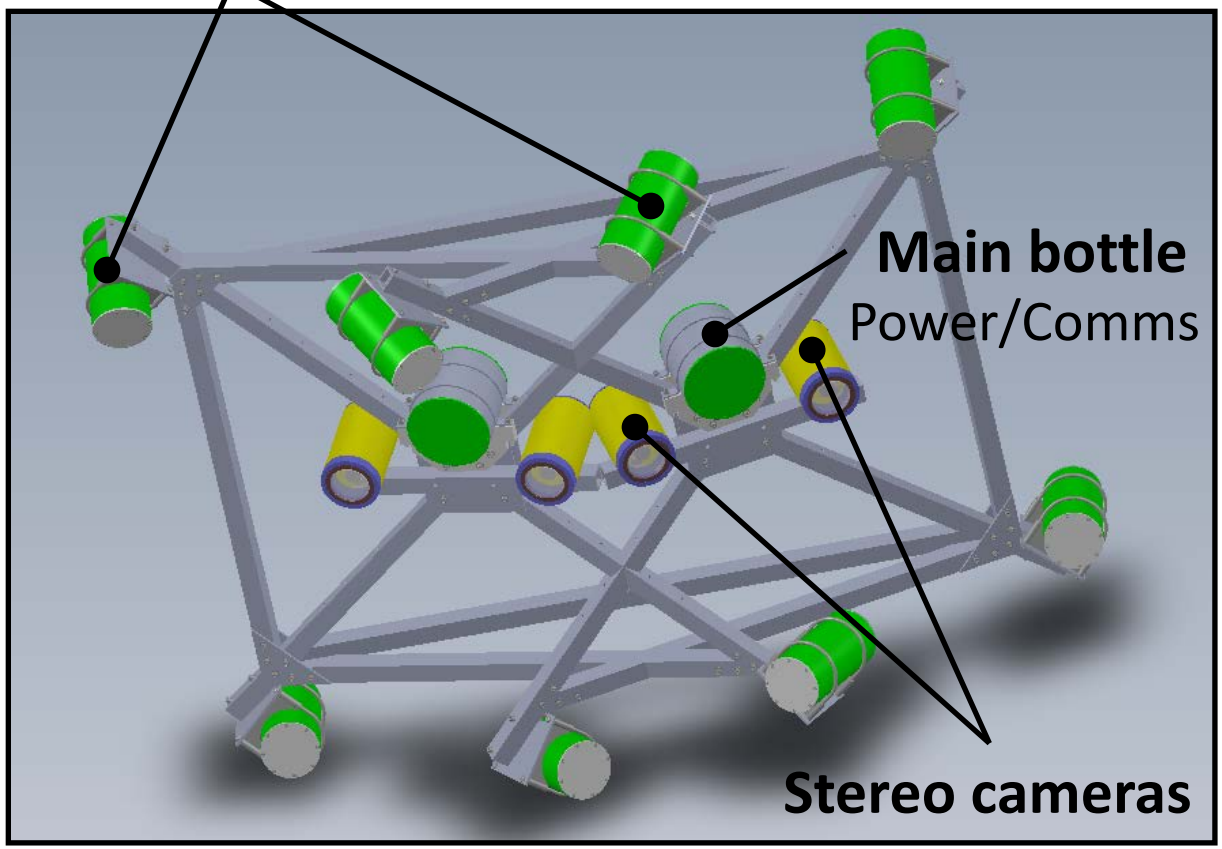
- **2 Mpx machine vision cameras**
  - ProSilica Manta G-201
  - 10 Hz maximum frame rate
  - Resolution/bandwidth
- **45º FOV lens (in air)**
- **Flat optical port (biofouling)**

Source: Kresimir Williams, NOAA Fisheries

Illumination Selection

- **Imaging fast moving targets**
  - Short exposure time: 2-50 µs (Gallager, et al. 2004)
  - Large camera-light separation (Jaffe 1988)
- **Full-spectrum strobes (Excelitas MVS 5002)**
  - Four strobes per stereo imaging system
- **Behavioral disturbance is problematic**
  - Considered red, IR, and NIR lighting options
  - Initially, pre-set duty cycle with monitoring
  - As behavior/interactions are better understood, progress to event-based illumination

System Layout



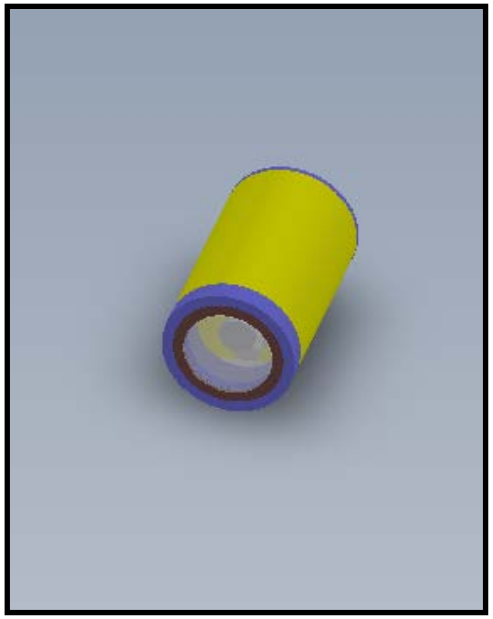
Compact frame concept

- **2 stereo camera systems**
  - Strike detection
  - Taxonomic classification
- **1 m camera-light separation**
- **Compact frame for maintenance**

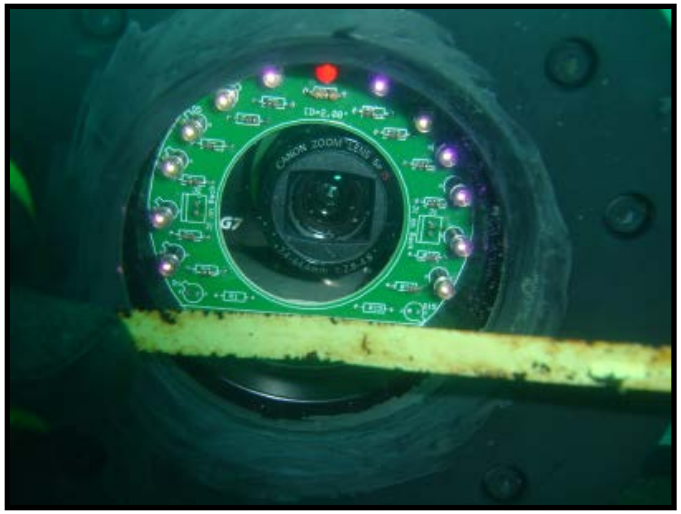
Biofouling Mitigation

- **Biofilms formation begins immediately after deployment**

Mechanical Wiper



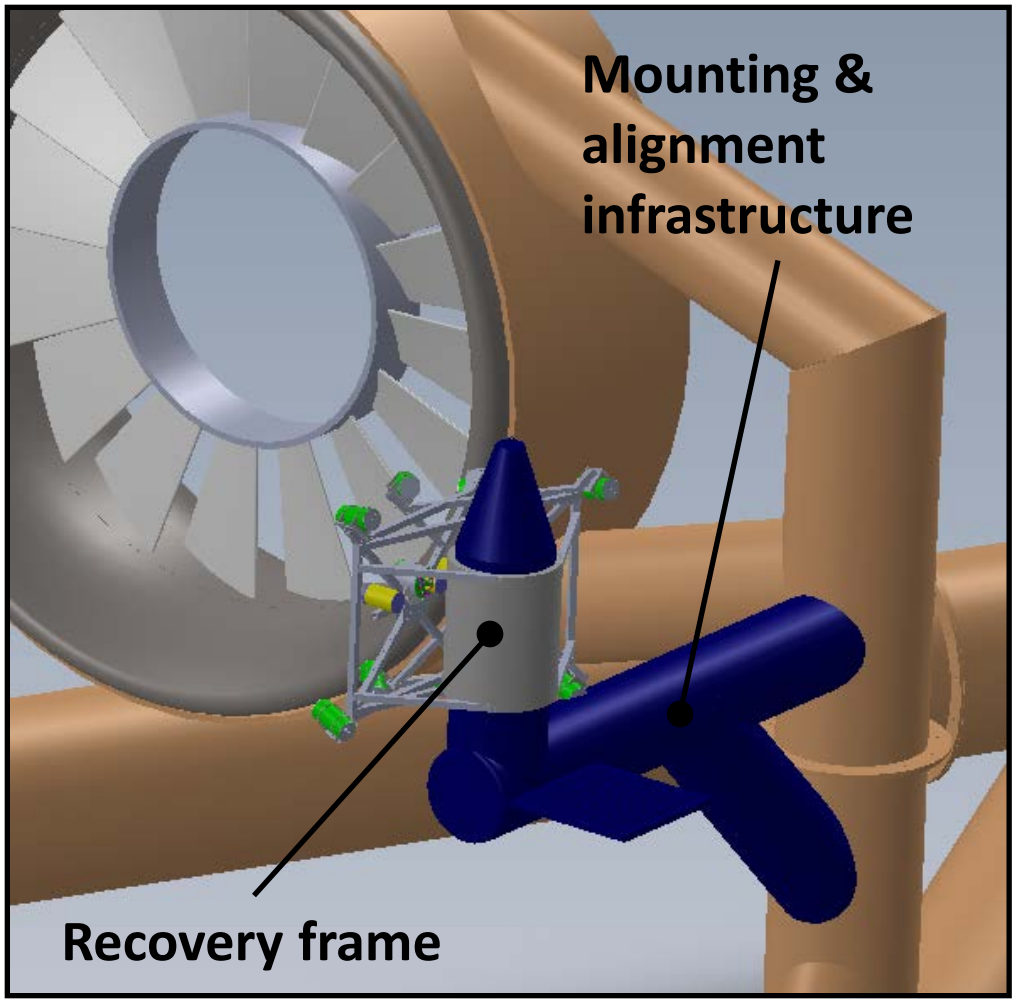
Copper Ring



Ultraviolet Lighting
(capability)

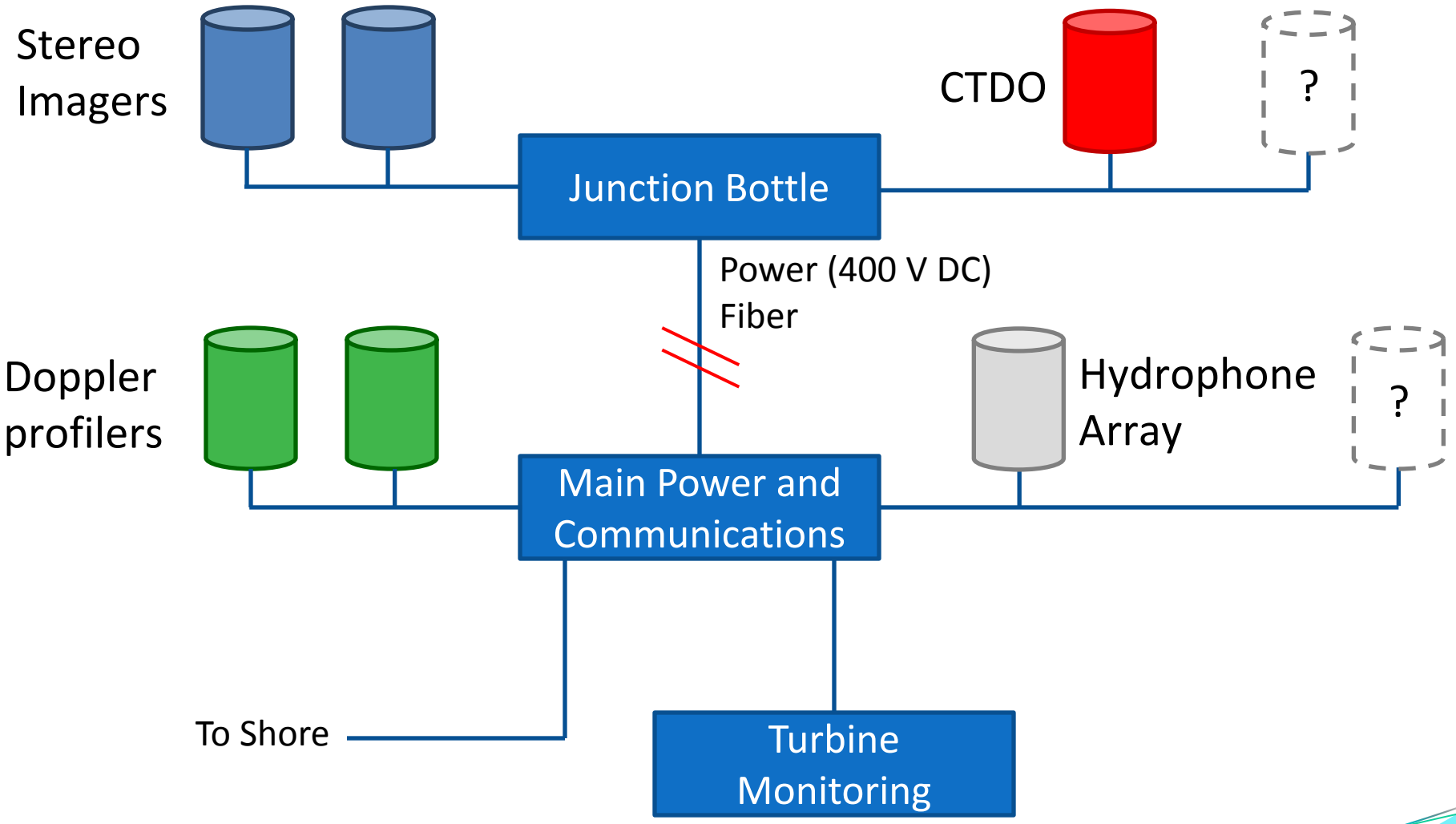
Recovery and Redeployment

- **Reasons for recovery:**
  - Biofouling removal
  - Maintenance and repair
  - Additional instruments
  - Reorientation of cameras
- **Must be recovered independent of turbine**
- **Must be reconnected to turbine power and data systems**



Compact frame concept

Monitoring System Integration



Discussion

- **How much emphasis should be placed on monitoring for blade strike?**
  - Laboratory tests suggest low likelihood
  - How much species-to-species, site-to-site, and turbine-to-turbine variability is there?
- **Regulatory mandates are species-specific, but this limits the toolkit available to answer questions**
- **Leverage environmental monitoring infrastructure whenever possible – camera can also monitor for fouling, damage, and vibration**
- **Post-installation monitoring is essential, but technically challenging – need for prioritization**

Questions?

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