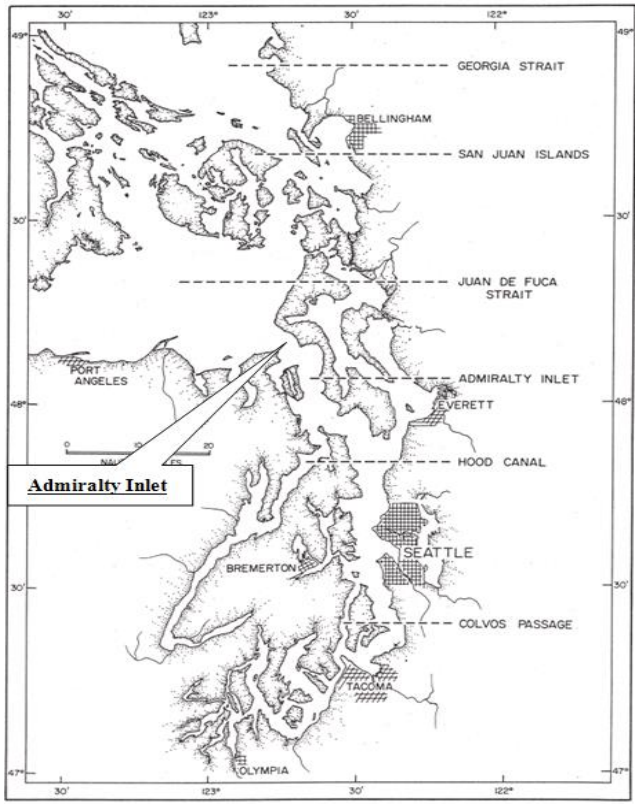


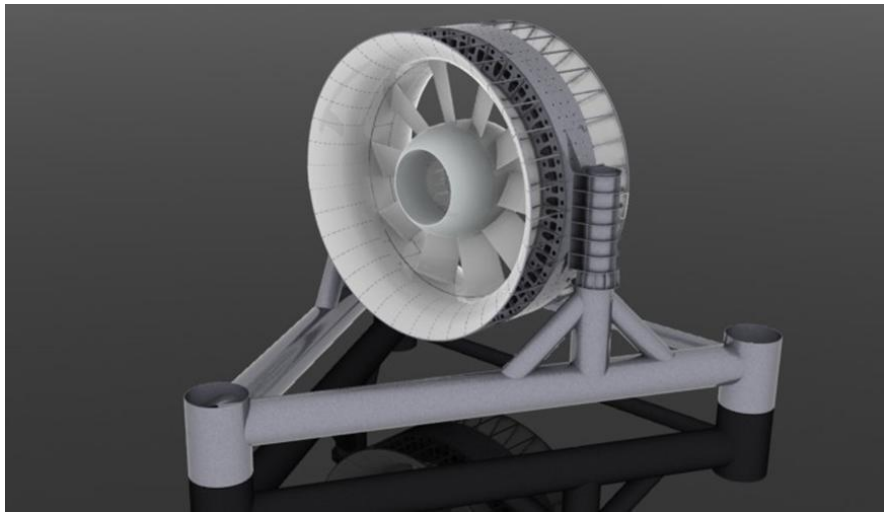

# Puget Sound Pilot Tidal Energy Project (TRL 7/8)

**Dr. Brian Polagye** (for Craig Collar)

University of Washington (Snohomish PUD)

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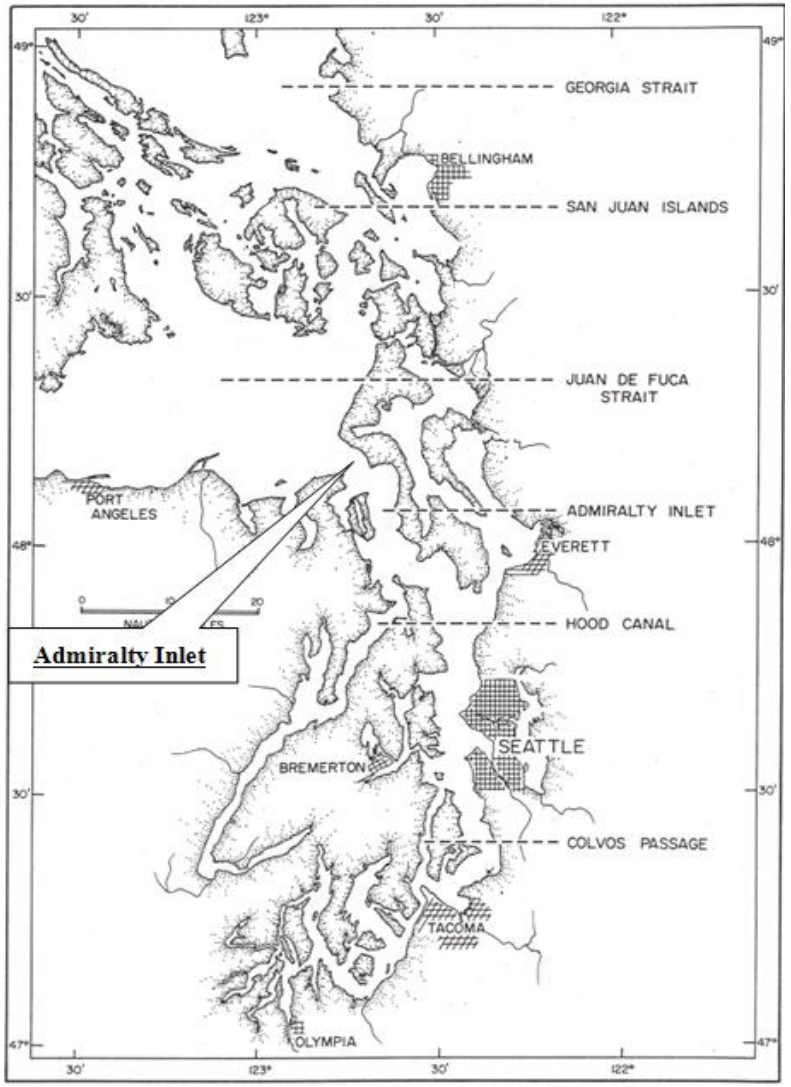
November 1, 2011

# Purpose & Objectives



- Snohomish County Public Utility District and its partners propose to deploy two tidal energy turbines in Admiralty Inlet, Puget Sound, WA. ‘
- Site identified as one of the largest tidal hydrokinetic resources in the United States.
- Requires deep water technology (depth > 50 m)
- Sensitive environment within the range of several endangered species and under existing anthropogenic stress.

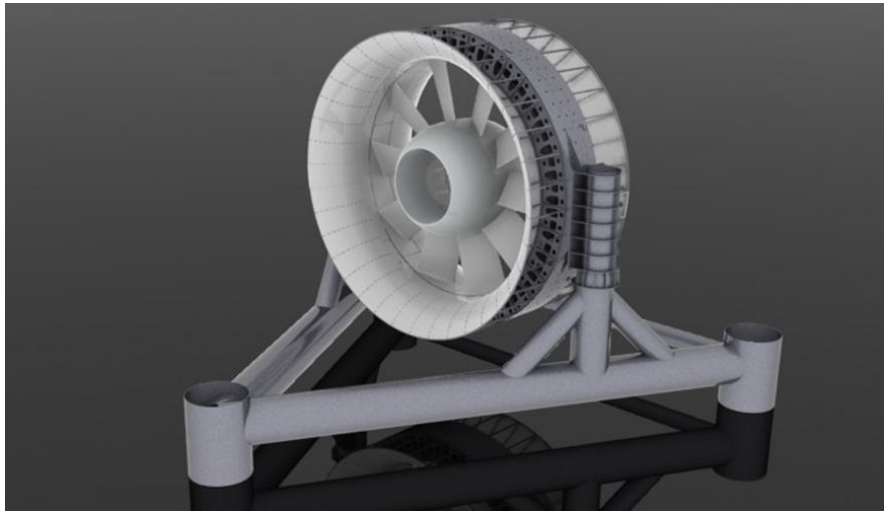


# Purpose & Objectives



**Project Statement: Deploy, operate, and evaluate** two Open-Centre Turbines developed and manufactured by OpenHydro Group Ltd.

- 6 m rotor diameter
- ~250 kW peak generation
- Grid connected (separate cables)
- 3-5 year deployment



*6th Generation Open-Centre Turbine*

**Project Purpose:** Gather data to **advance the technical, economic, social, and environmental viability** of commercial-scale tidal energy.

*These data are critical to the responsible advancement of commercial scale tidal energy in the United States.*

# Integration



NNMREC

Resource characteristics – informing device design

NNMREC

Acoustic characterization of tidal energy devices

Pacific Northwest NATIONAL LABORATORY

Risk assessment case study

Pacific Northwest NATIONAL LABORATORY

Passive acoustic system for localizing marine mammals

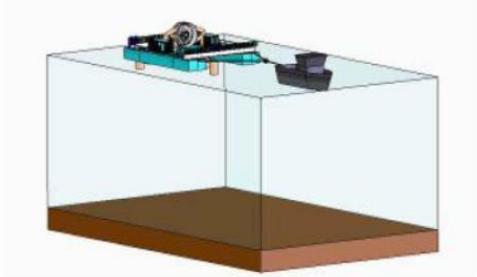
NREL

Interest in instrumentation package testing

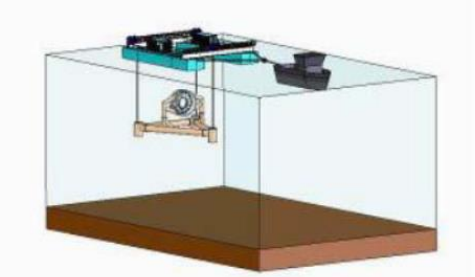
# Technical Approach – Deployment



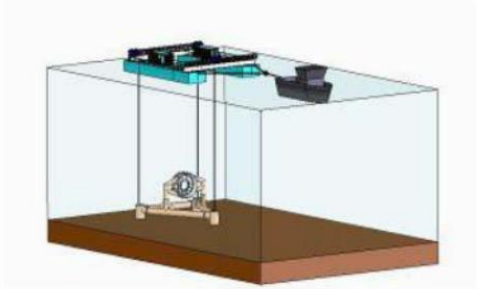
- Installed directly on the seabed (no surface visibility)
- Steel tubular frame filled with concrete and stone ballast
- No pinning, piling, or drilling to secure the turbine foundation to the seabed

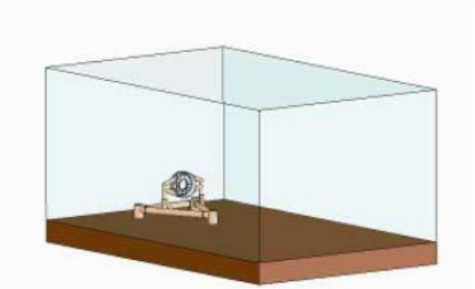
1. The Deployment Vehicle is towed out to site using a standard tug.



2. Whilst being held in position by the tug, the turbine and Subsea Base are lowered by the Deployment Vehicle.



3. Once on the seabed, the lifting lines are released and the Deployment Vehicle is towed back to harbour.

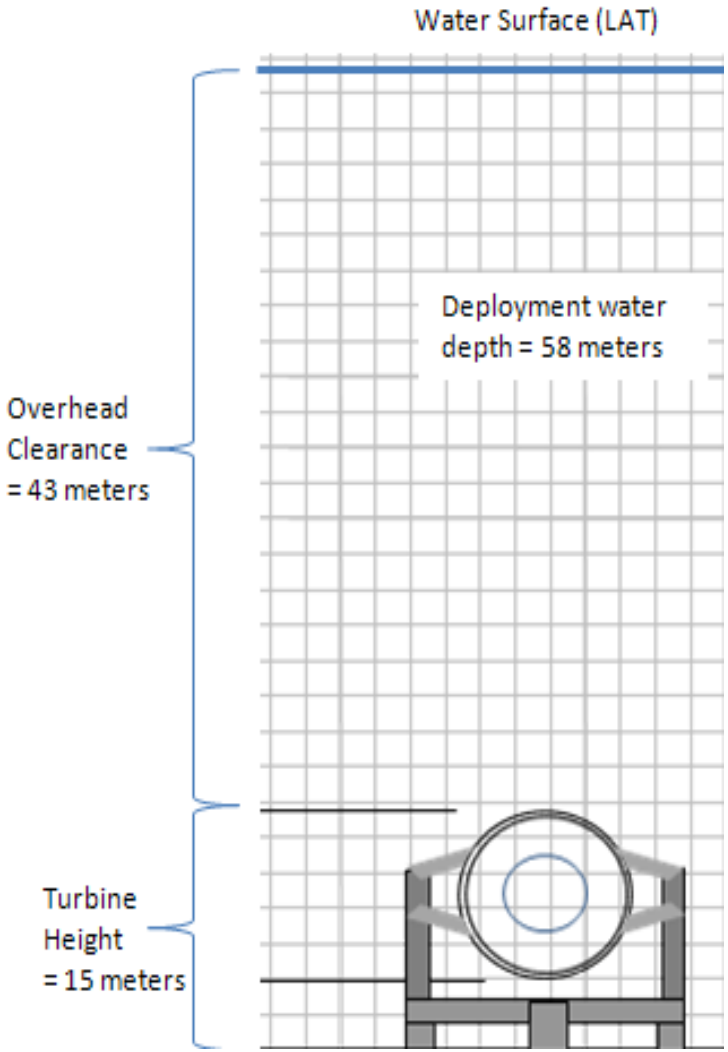


4. The Subsea Base will be located on the seabed with no part of the structure visible from the surface.

# Technical Approach – Monitoring Challenges

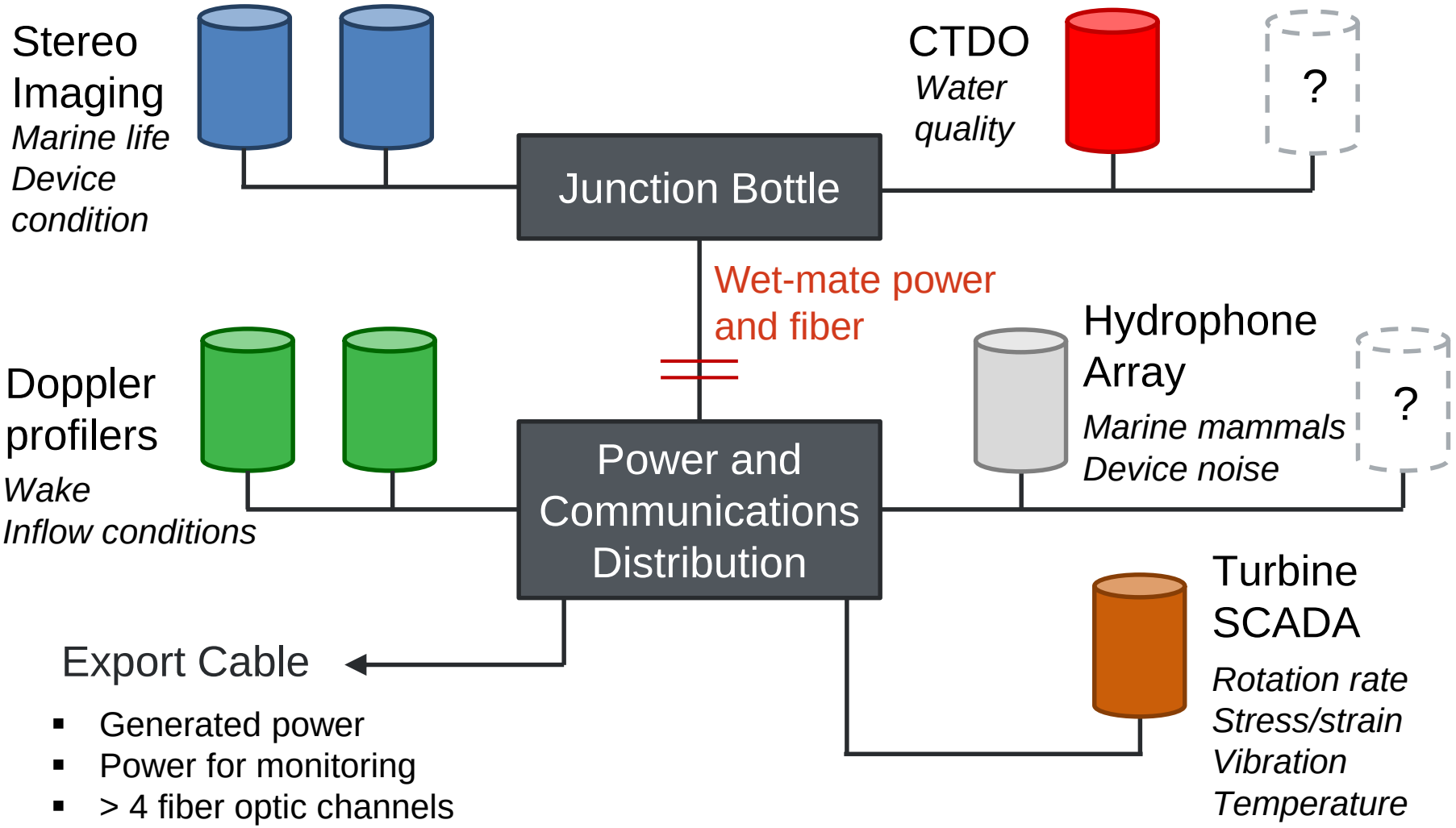


- **Adequately monitored pilot projects are the only viable way to reduce technical, economic, social, and environmental uncertainties**
- **Challenging for any tidal energy development , but more so for deployment in Admiralty Inlet**
  - — Largely beyond the reach of human divers
  - — Beneath the photic zone
  - — *Conditions are the rule – not the exception – for most utility-scale tidal energy resources*
- **Maintaining and upgrading monitoring**
  - — Requires recovery, redeployment, and reconnection to turbine power and communications
  - — Need to minimize biofouling over periods of several months



# Technical Approach – Monitoring Implementation

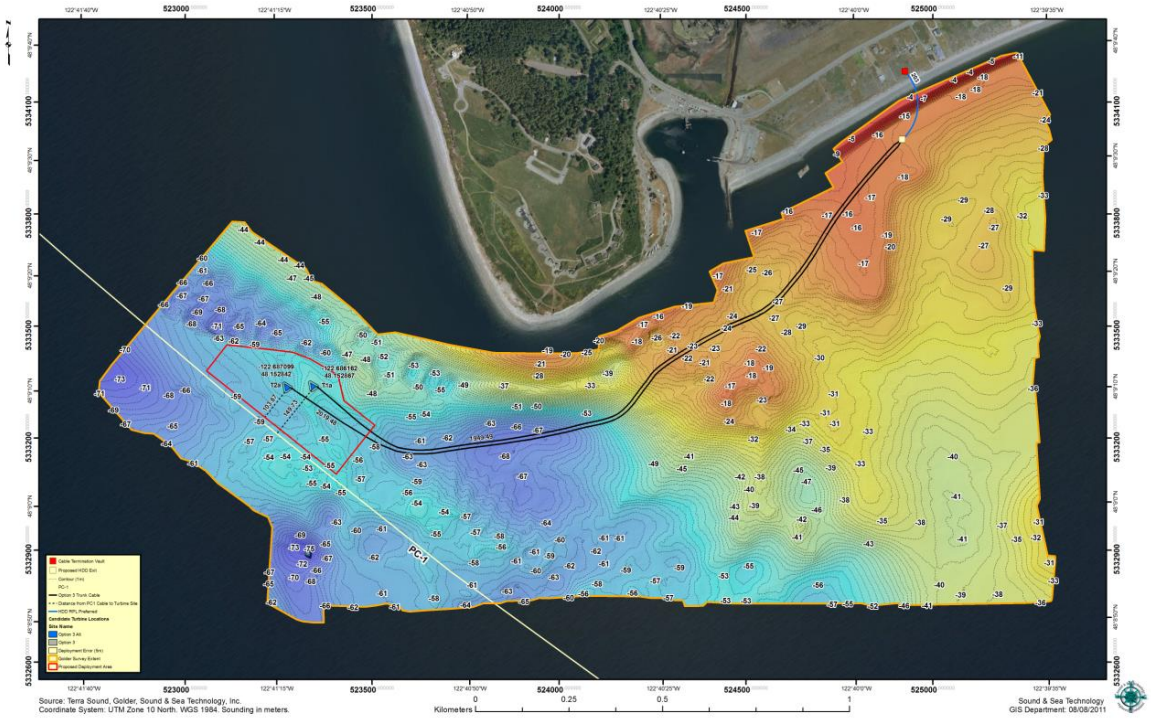




# Technical Approach – Performance Evaluation



- **Turbine SCADA**
  - — Rotational rate
  - — Structural strain
  - — Vibration
  - — Generator temperature
- **Shore Station**
  - — kWh produced
  - — Capacity factor
  - — Power quality
  - — Availability
  - — System Efficiency
- **Operations**
  - — Reliability
  - — Maintainability
  - — O&M costs by process

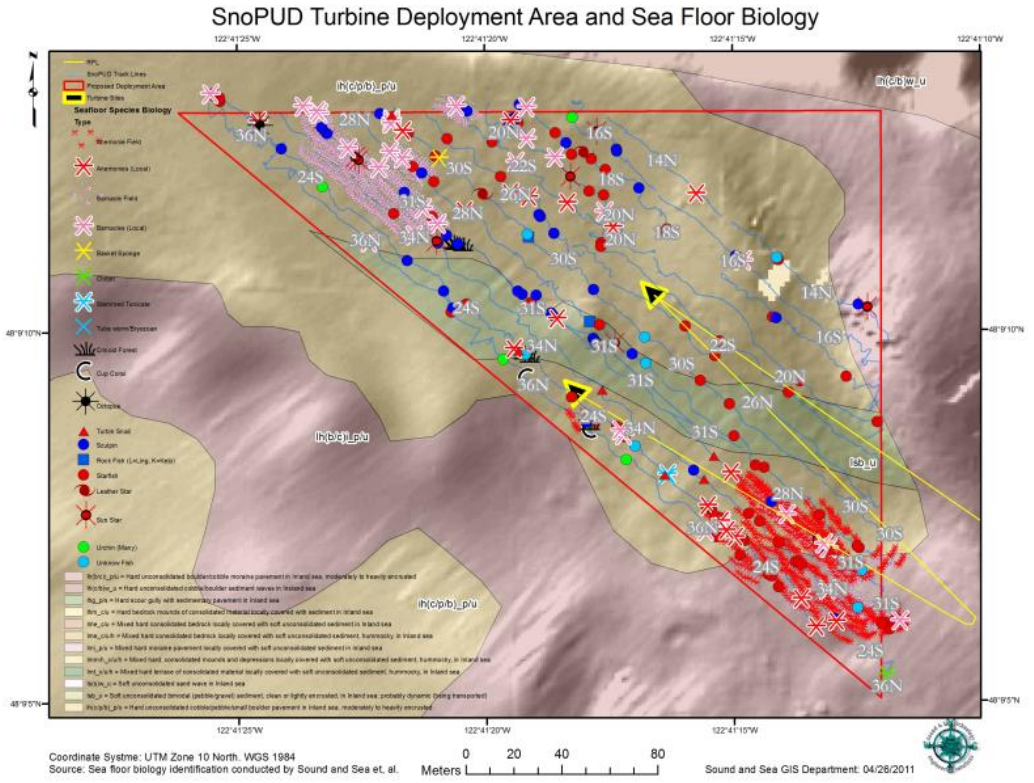



*Project Layout: Turbines and Export Cables*

# Technical Approach – Static Effects



- **Concerns Addressed**
  - Colonization of support structures (artificial reef effects)
  - Modification to benthic habitat around turbine base
  - Modification of benthic habitat by turbine wake
- **Approach**
  - ROV surveys during diurnal inequality
  - Benthic habitat monitored at several “monuments”
  - Quarterly during first year
  - Six months thereafter



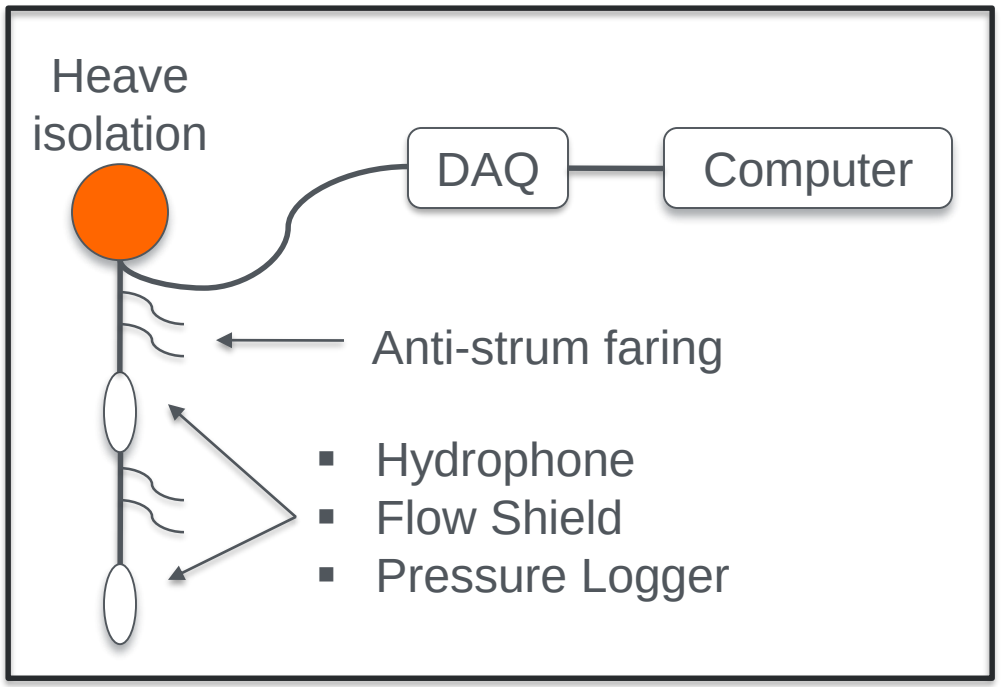

*Benthic habitat survey*

*Deep Ocean Phantom 2+2 ROV*

# Technical Approach – Acoustics



- **Concerns Addressed**
  - — Received levels of noise in vicinity of project
  - — Variations in received levels with power output
  - — Variations in received levels over time
- **Approach**
  - — Intensive post-installation characterization (drift measurements)
  - — Low duty-cycle, long-term monitoring (on turbine)

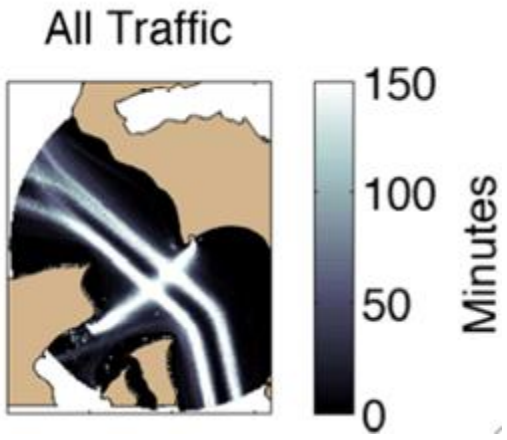



*NNMREC drifting survey instrumentation*

# Technical Approach – Marine Mammals



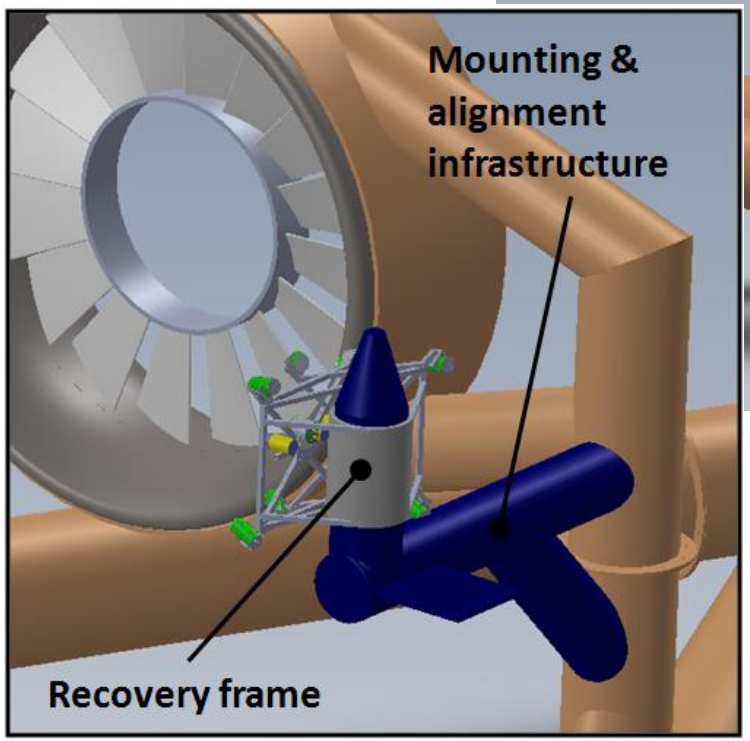
- **Concerns Addressed**
  - — Behavioral changes associated with project operation
- **Approach**
  - — Shoreline observers
  - — Click detection
  - — Vocalization detection (and localization)
- **Key Challenges**
  - — Signal to noise

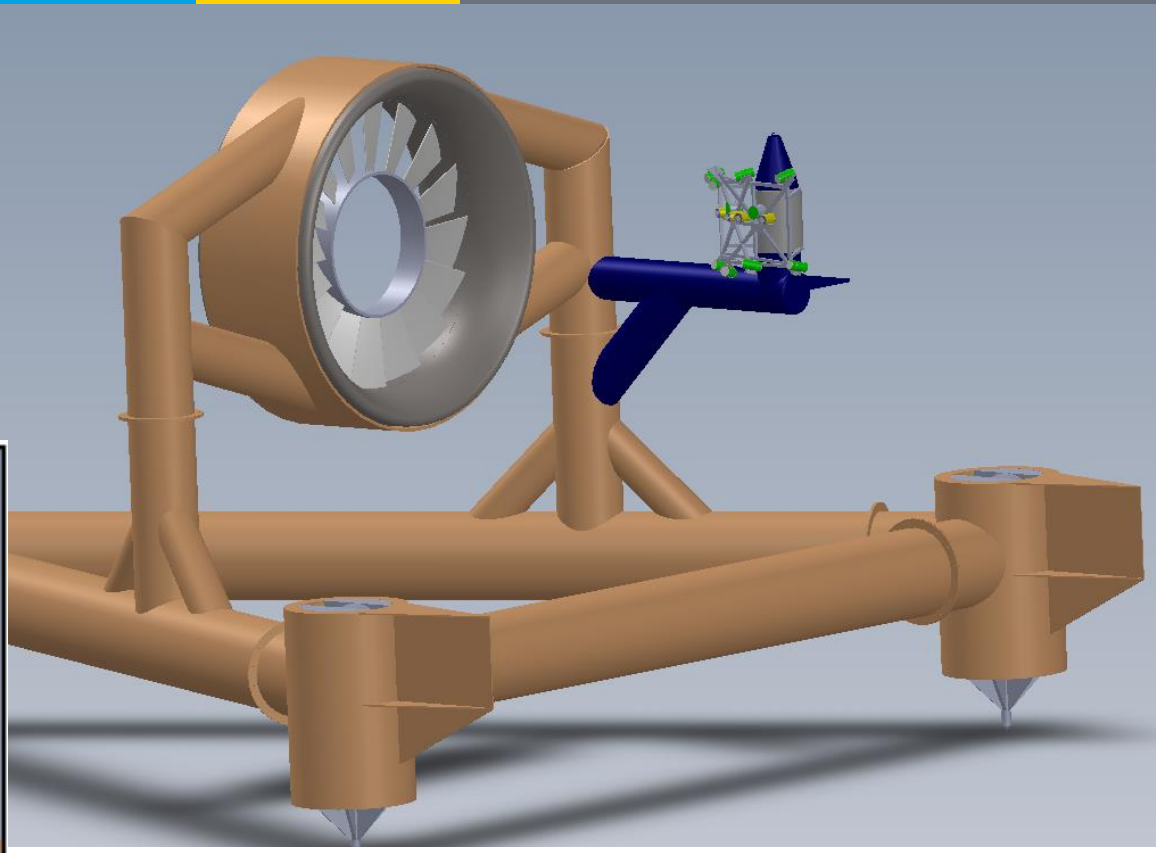


# Technical Approach – Dynamic Effects



- **Concerns Addressed**
  - — Interaction of marine animals with turbine rotor
  - — Species interacting with turbine



- **Approach**
  - — Stereo imaging with artificial illumination
  - — Duty cycle, transitioning to triggered or event-based illumination

# Plan, Schedule, & Budget

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## Schedule (Calendar Year – Under Development)

- **4Q11**: Complete contract negotiations with DOE.
- **1Q12**: Submit Final Pilot Plant License Application to FERC.
- **2-3Q12**: Final Project design.
- **3-4Q12**: Complete all permitting processes and project budget.
- **4Q12**: Go/No-go decision to move forward with turbine order.
- **2013**: Turbine and foundation fabrication, shipping, staging.
- **2014**: Project installation and commissioning
- **2014-18**: Project operations and testing.

## Budget

- Proposed Project Budget: $20,300,000
- Proposed Recipient Cost Share: $10,300,000