In-stream Tidal Energy:
NW National Marine Renewable Energy Center

University of Washington
depts.washington.edu/nnmrec

AMTAS Spring 2009 Meeting
April 23, 2009

- **In-stream Tidal Energy Overview**
- **NNMREC Structure and Activities**
- **Integration of Composite Materials**

Approaches to Tidal Energy

Barrage

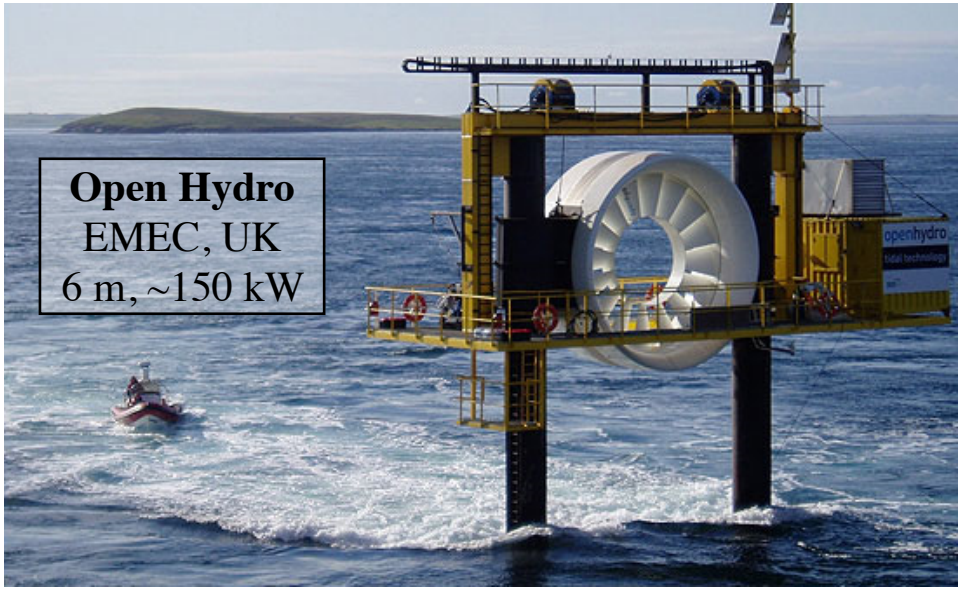
- Comparable to hydroelectric
- Very high cost and environmental footprint

Hydrokinetic

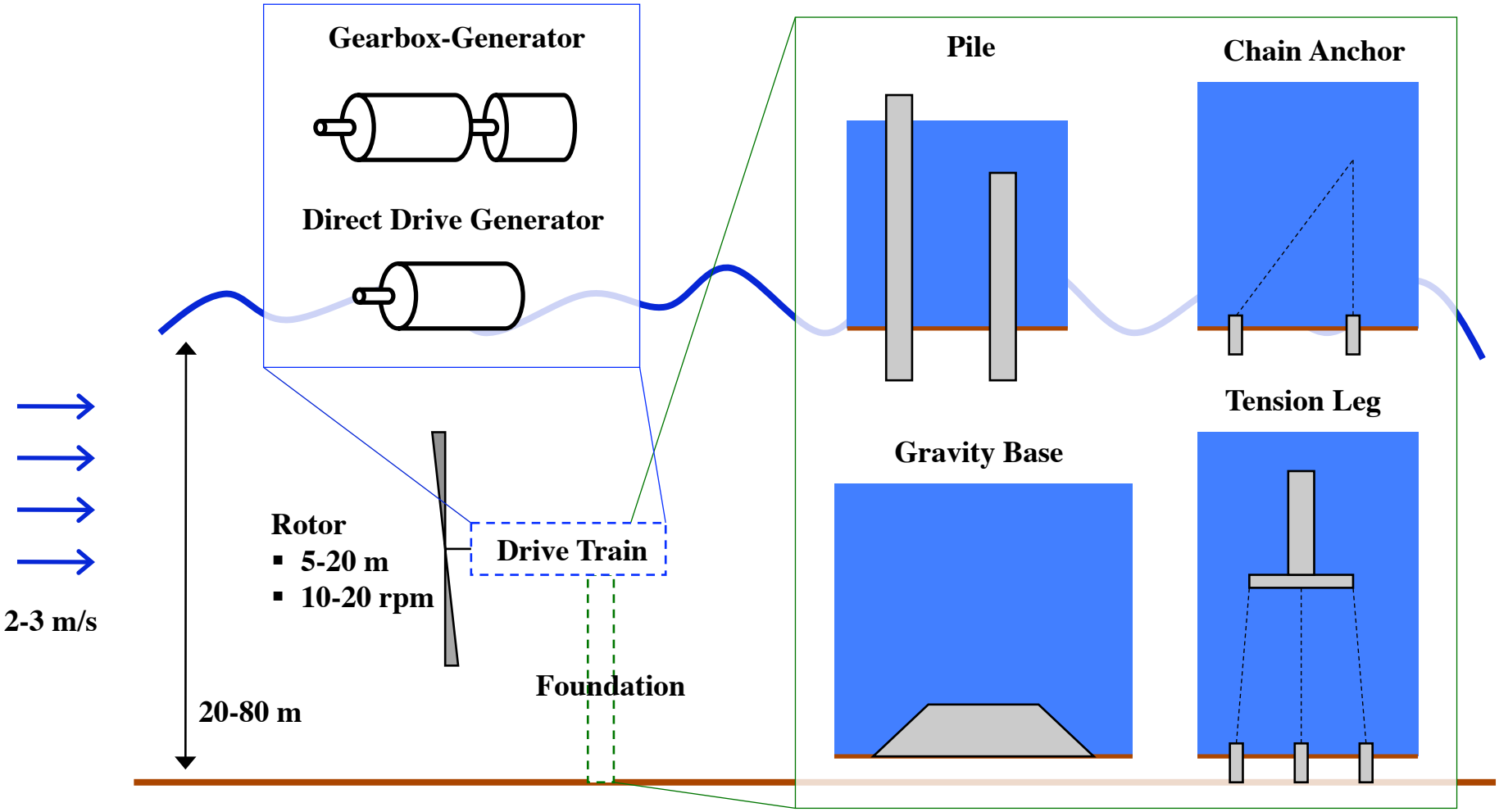
- Comparable to wind
- Potentially lower cost and environmental footprint

Hydrokinetic Devices

- **No dominant design**
  - — Hundreds of concepts
  - — Dozens of lab tests
  - — Several field tests
- **No commercial projects**



Device Parameters

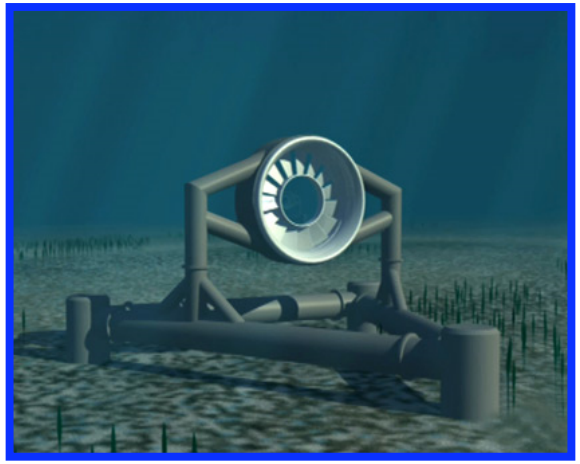


Tidal Energy Projects in Puget Sound

Race Rocks
Demonstration turbine

~100-200 avg. MW practically recoverable

Admiralty Inlet
Pilot project



Marrowstone Island
Demonstration array

Local Drivers

- I-937 obligations
- Limited transmission capacity for new wind
- Tidal energy advantages
  - Predictable resource
  - No CO_2 emissions
  - No visual impact
  - Close to load centers

Tidal Energy Challenges

- **Engineering**
- **Economics**
- **Environment**

Complicated by broad range of uncertainty

Northwest National Marine Center

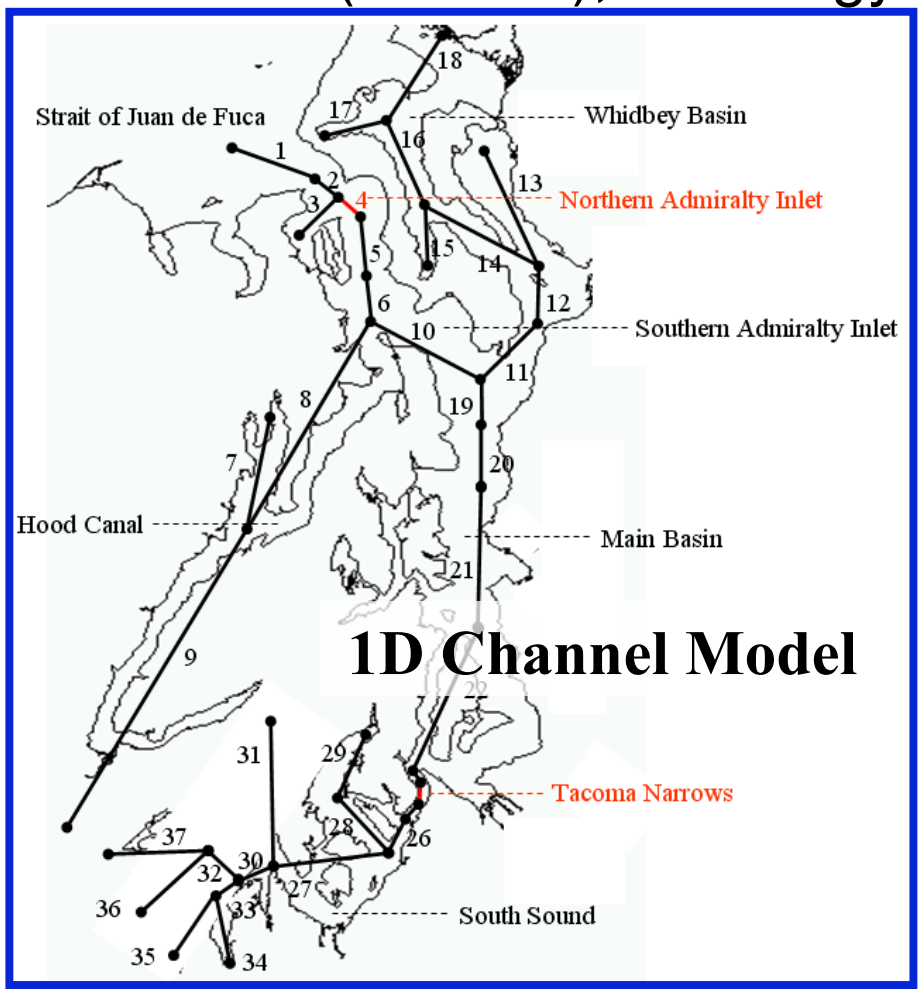
- **Oregon State University**
  - Headquarters and Director (Bob Paasch)
  - Focus on **Wave Energy**
  - College of Engineering, Oceanography, Hatfield Marine Sciences Center
- **University of Washington**
  - Co-Director (Phil Malte)
  - Focus on **Tidal Energy**
  - Mechanical Engineering, Oceanography, Applied Physics
- **Partners**
  - NREL, Snohomish PUD, BioSonics, Sound & Sea Technology, EPRI, Verdant Power, PNWER

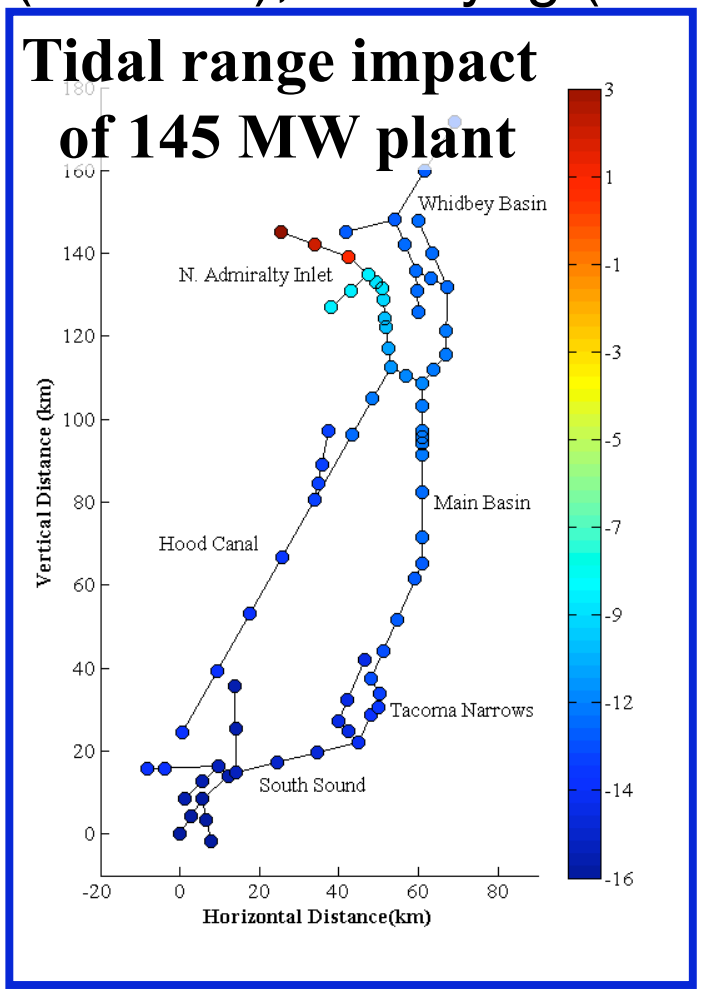
Center Activities

- **Environmental Effects (OSU/UW)**
- **Site and Device Characterization (OSU/UW)**
- **Array Optimization (OSU/UW)**
- **Device Survivability/Reliability (OSU/UW)**
- **Advanced Wave Forecasting (OSU)**
- **Synergies with other Renewables (NREL)**

Area 1: Environmental Effects

M. Kawase (UW-SO), B. Polagye (UW-ME), K. Thyng (UW-ME)





Area 2: Mobile Testing

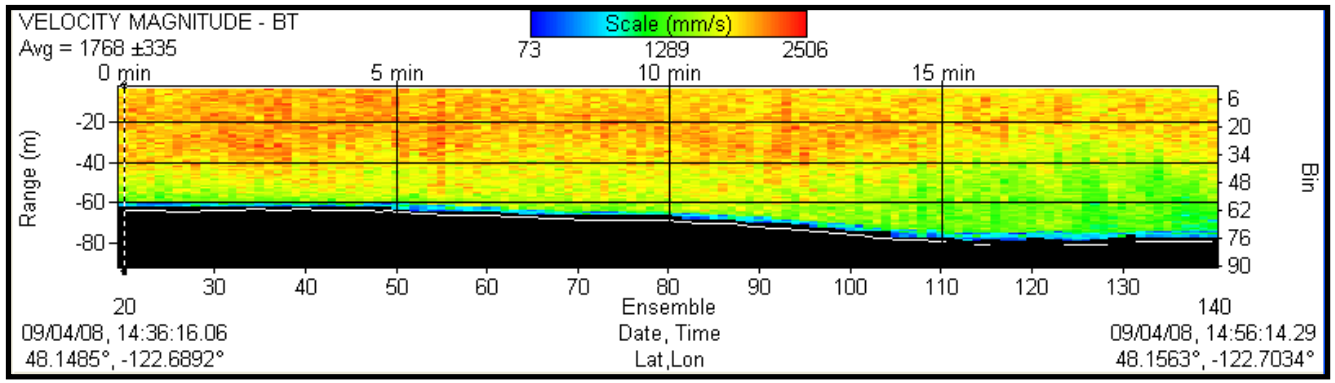
J. Thomson (UW-APL), B. Polagye (UW-ME)

Field measurements (surveys + stationary) to inform:

- Site developers – resource and site characteristics
- Device developers – device performance
- Regulators – near-field effects

Area 2 Detail: Shipboard Surveys

Water Quality



High-resolution Velocity Survey

ROV Survey

Bottom Sampling

Area 2 Detail: Stationary Surveys

Acoustic release
(redundant recovery)

300 kHz ADCP
(velocity)

Hydrophone
(background noise)

Programmed for 4 month deployment

Mini-CTD
(salinity and temperature)

Sea Spider
(heavy duty fiberglass frame)

Lead Weight
(600 lbs)

Area 3: Array Optimization

A. Aliseda (UW-ME), J. Riley (UW-ME)

Wave-Current Flume:
Experimental studies of device wakes.

Computer Cluster:
Parallel simulations of array performance.

Area 4: Survivability and Reliability

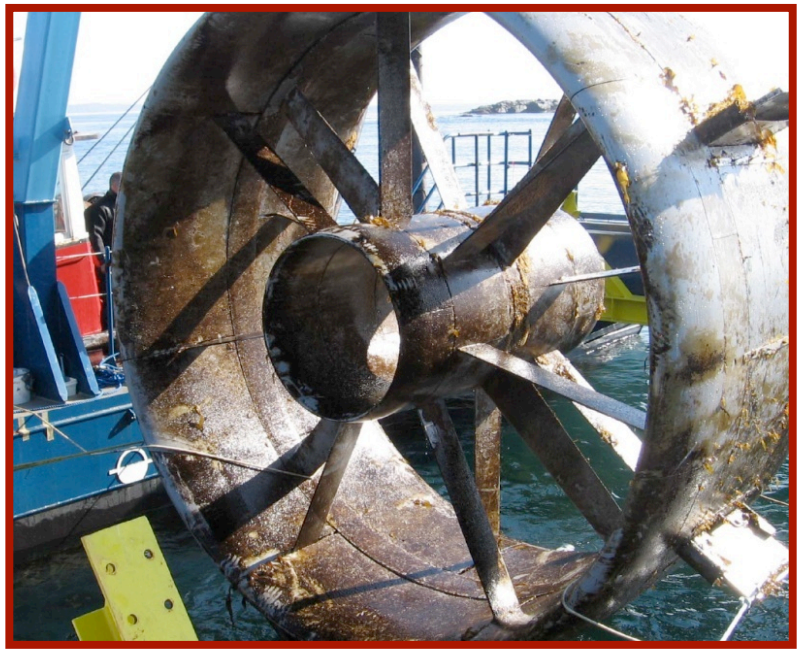
M. Tuttle (UW-ME)

- Studies of composite structural design options
- Estimation of long-term durability of composites in salt water environment
- Identification of composite materials that naturally minimize bio-fouling and corrosion

Biofouling in the Marine Environment

Before

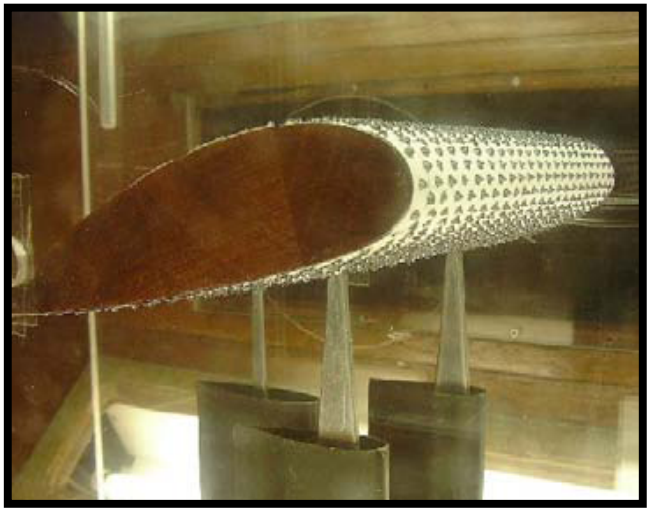
After



Clean Current turbine: 6 *months* deployment

Effect on Tidal Energy Devices

- **Reduced rotor performance**
  - Orme, Masters, and Griffiths (*2001*)
  - Rotors serviced every 2-4 years

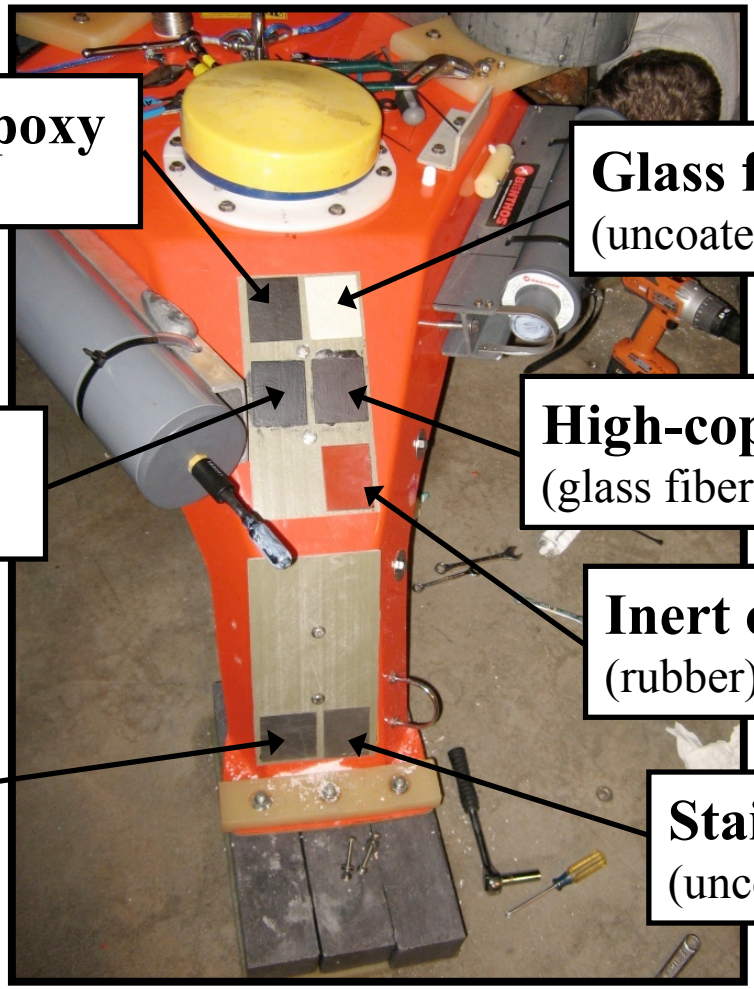


- **Disrupted flow in diffuser**
  - No service over device lifetime (20+ years)
  - Very sensitive hydrodynamics

Approaches to Minimize Biofouling

- **Biocide coatings**
  - —Effective
  - —Significant toxicity
  - —Tin-based banned, copper-based phased out
- **Inert coatings**
  - —Effectiveness
  - —Cost
- **Engineered materials**
  - —Composites
  - —Polymers

Preliminary Center Activities



Carbon fiber in epoxy
(uncoated)

Glass fiber in epoxy
(uncoated)

Low-copper coating
(glass fiber in epoxy)

High-copper coating
(glass fiber in epoxy)

Inert coating
(rubber)

Aluminum
(uncoated)

Stainless steel
(uncoated)

Questions?

Northwest National Marine Renewable Energy Center

nnmrec.oregonstate.edu (OSU - Wave)

depts.washington.edu/nnmrec (UW - Tidal)