Environmental Effects of Tidal Energy
Outcomes of a Scientific Workshop

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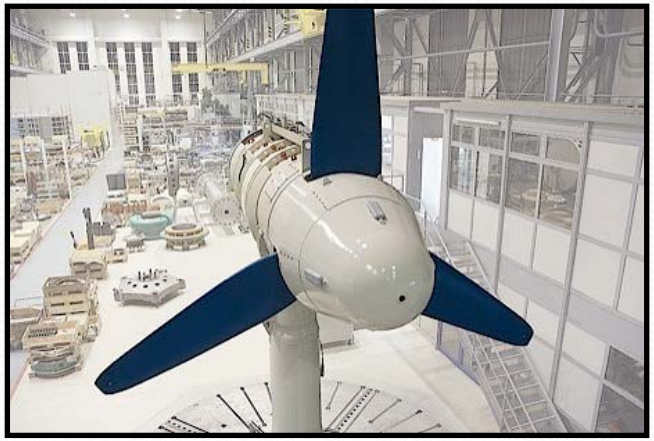
PICES 2010

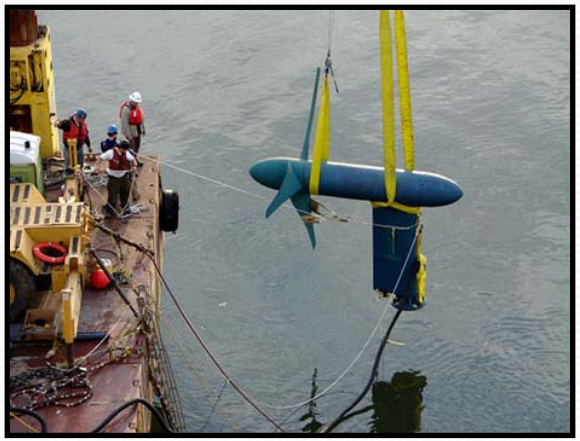
October 27, 2010

NNMREC

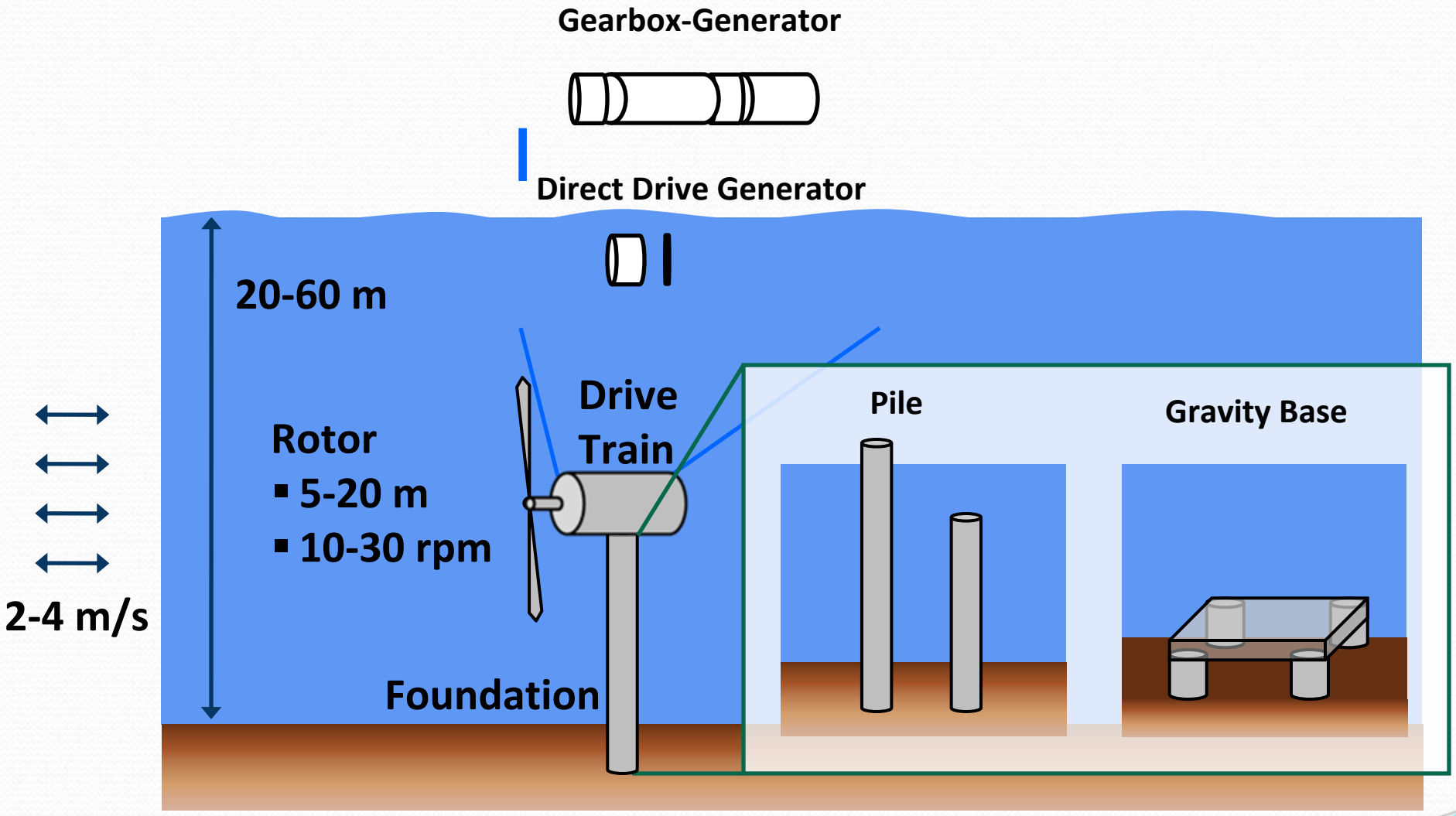
- **Environmental Effects**
- Workshop Overview
- Challenges
- Recommendations

Tidal Energy Devices

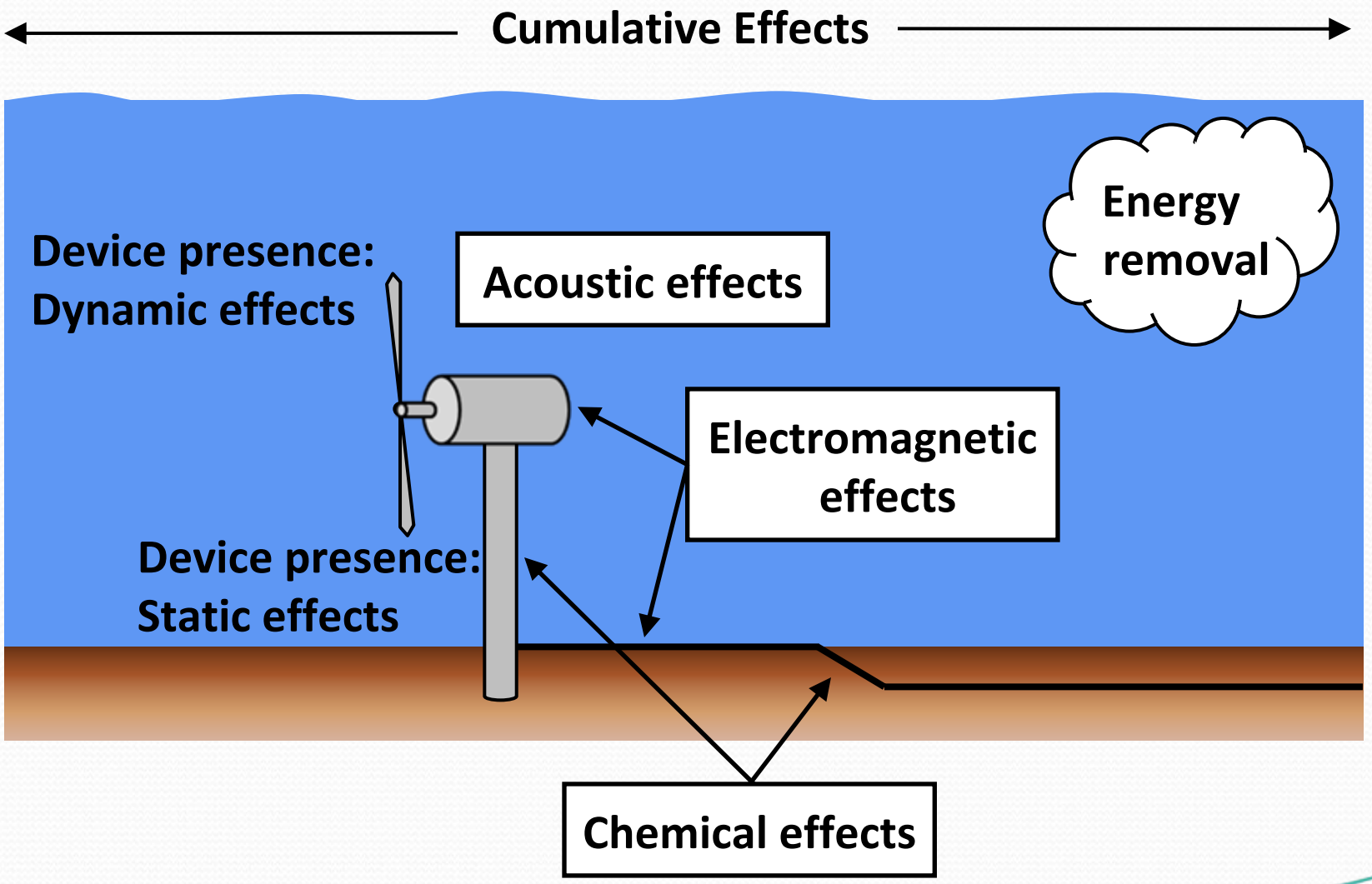




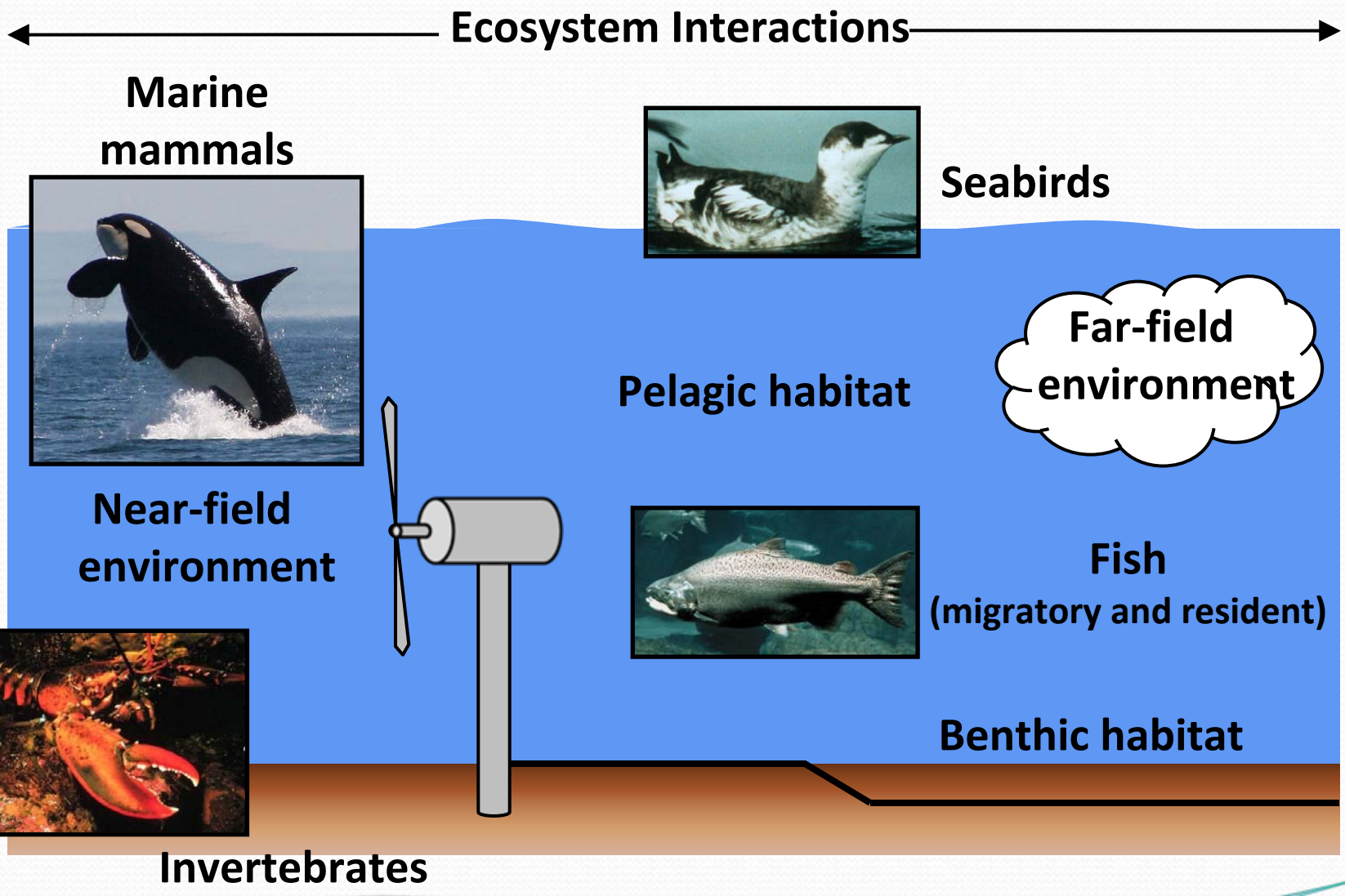
“Typical” Sites and Devices



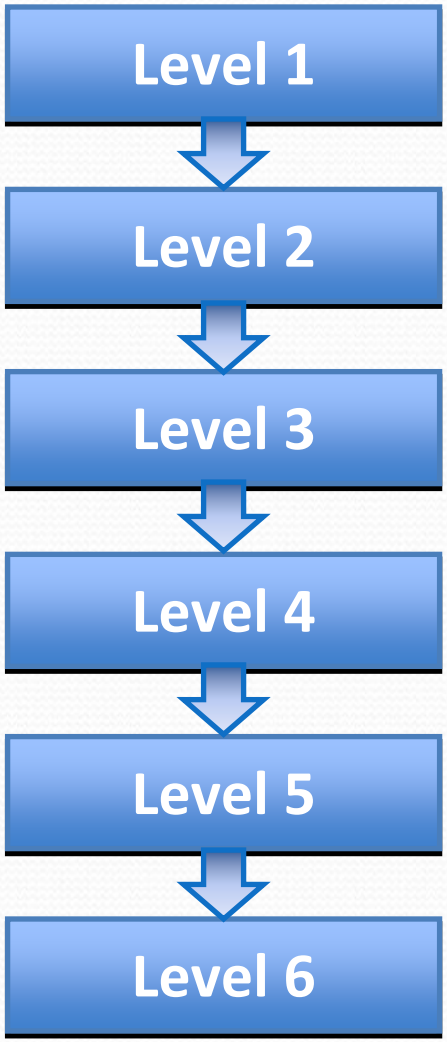
Environmental Stressors



Environmental Receptors



Environmental Assessment Framework



Type of Marine Renewable Energy

Stressors

Receptors

Environmental Effect (frequency and duration)

Environmental Impact (type and severity)

Cumulative Effects (scales and context)

Boehlert, G. and Gill, A. Environmental and Ecological Effects of Ocean Renewable Energy Development, *Oceanography,* 2010

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- **Workshop Overview**
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Need for Workshop

- Major interest in developing hydrokinetic energy in the U.S.
- Environmental compatibility of technology stated without proof.
- Environmental uncertainties present a major barrier to projects getting in the water at any scale.

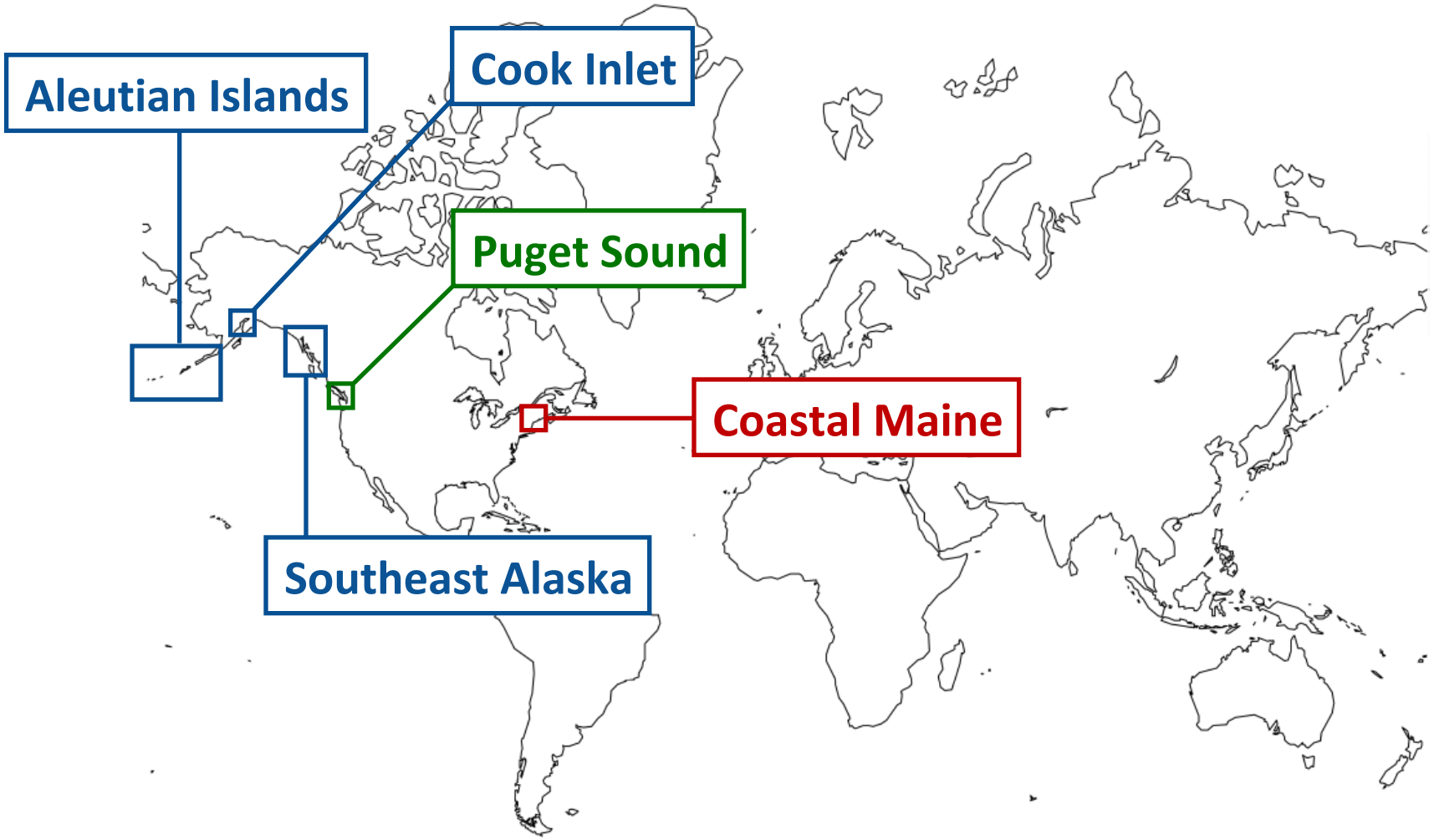
Technology Scope

Tidal Hydrokinetics

Tidal Barrage

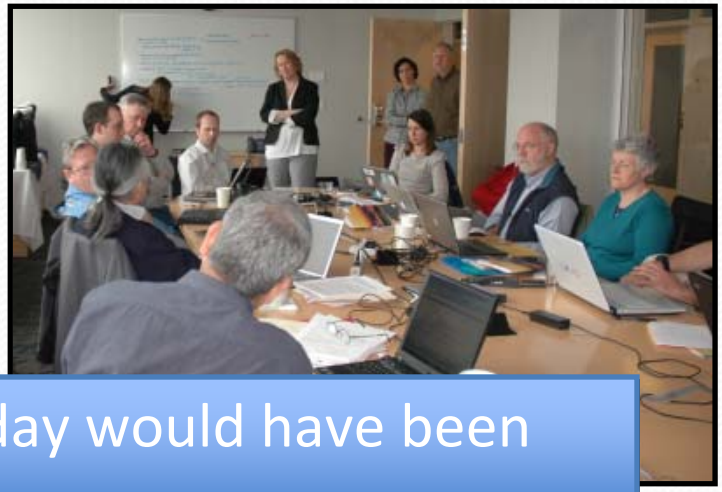
River Hydrokinetics

Geographic Scope



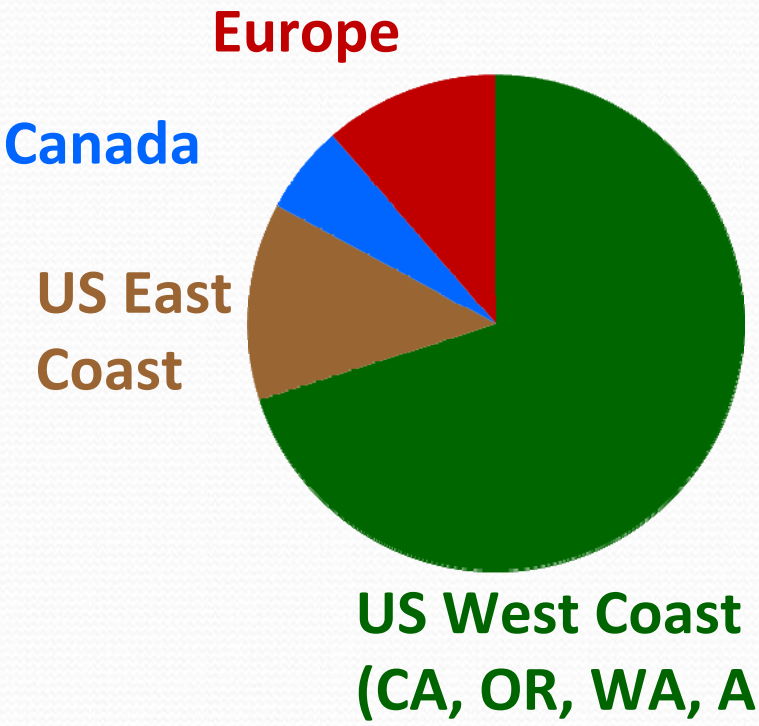
Workshop Structure

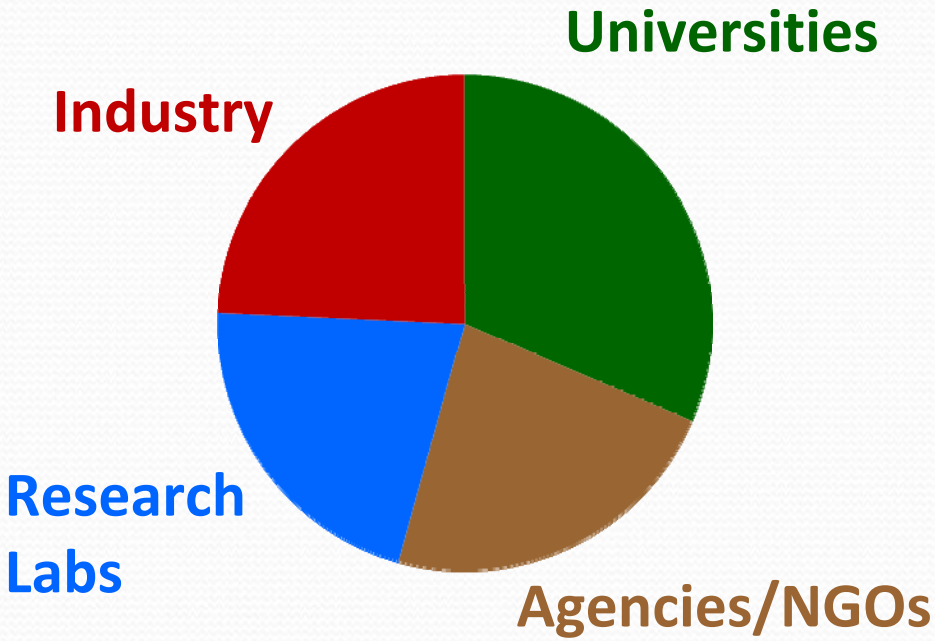
Day 1	Plenary Sessions *4 hours*	Stressors *2.5 hours*	
Day 2	Receptors *2.5 hours*	Stressors *1.5 hours*	Wrap Up *1.5 hours*
Day 3	Session Chairs Discussion *4 hours*		



***Participant Feedback*:** Another day would have been useful

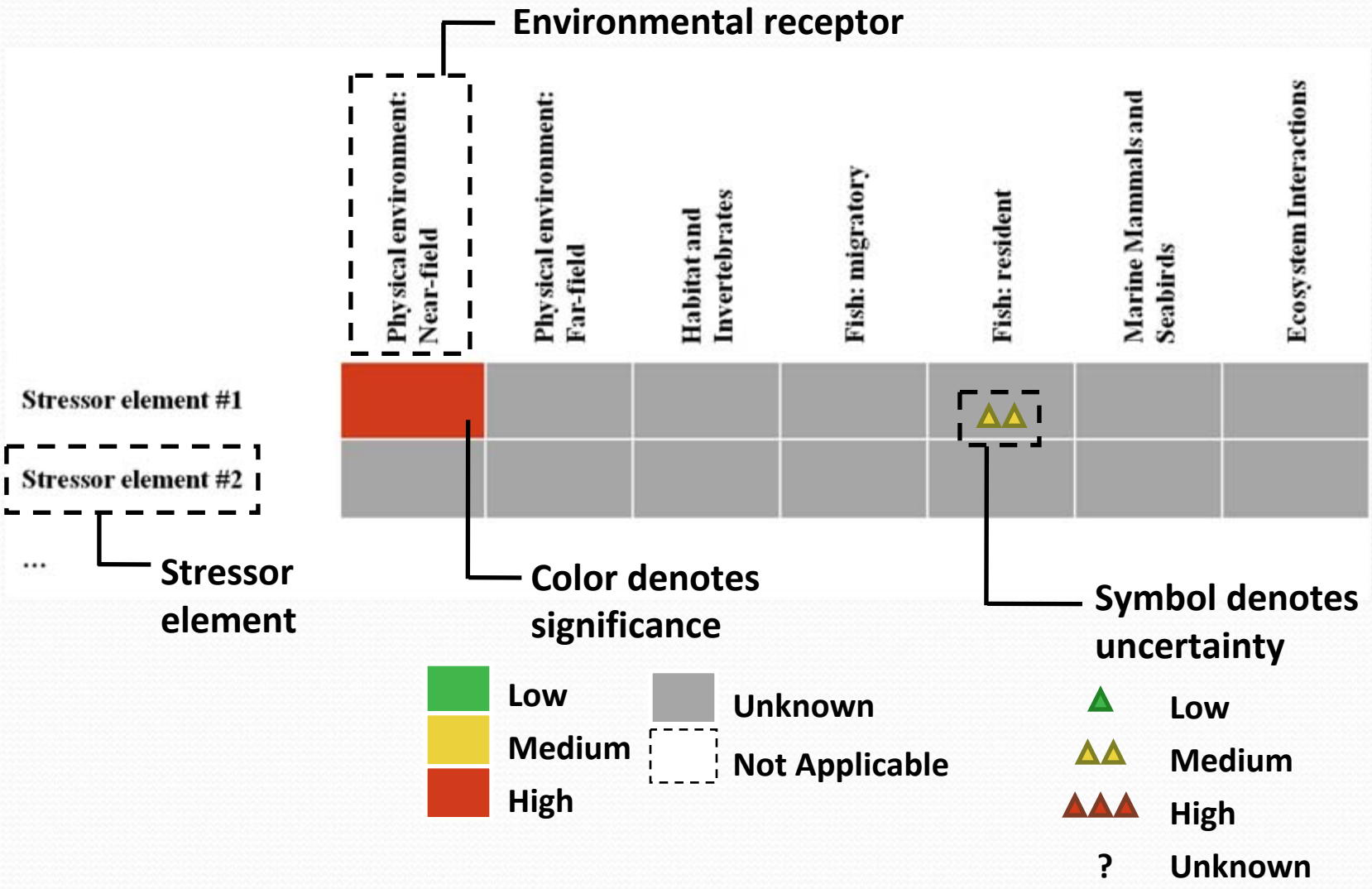
Workshop Participants





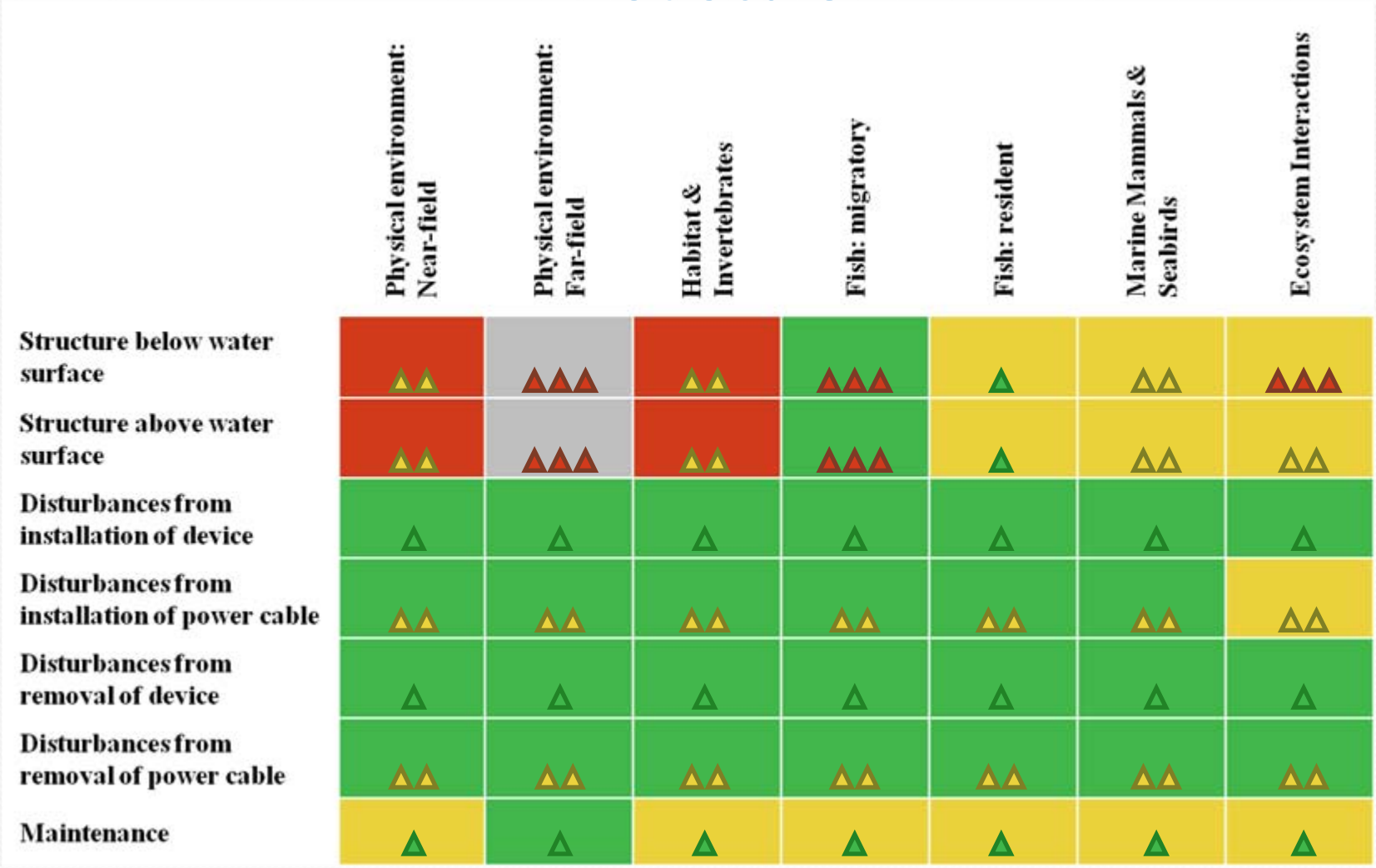
- Specific technical or scientific expertise
- Representative distribution of affiliation
- Interest greatly exceeded capacity

Relative Significance and Uncertainty



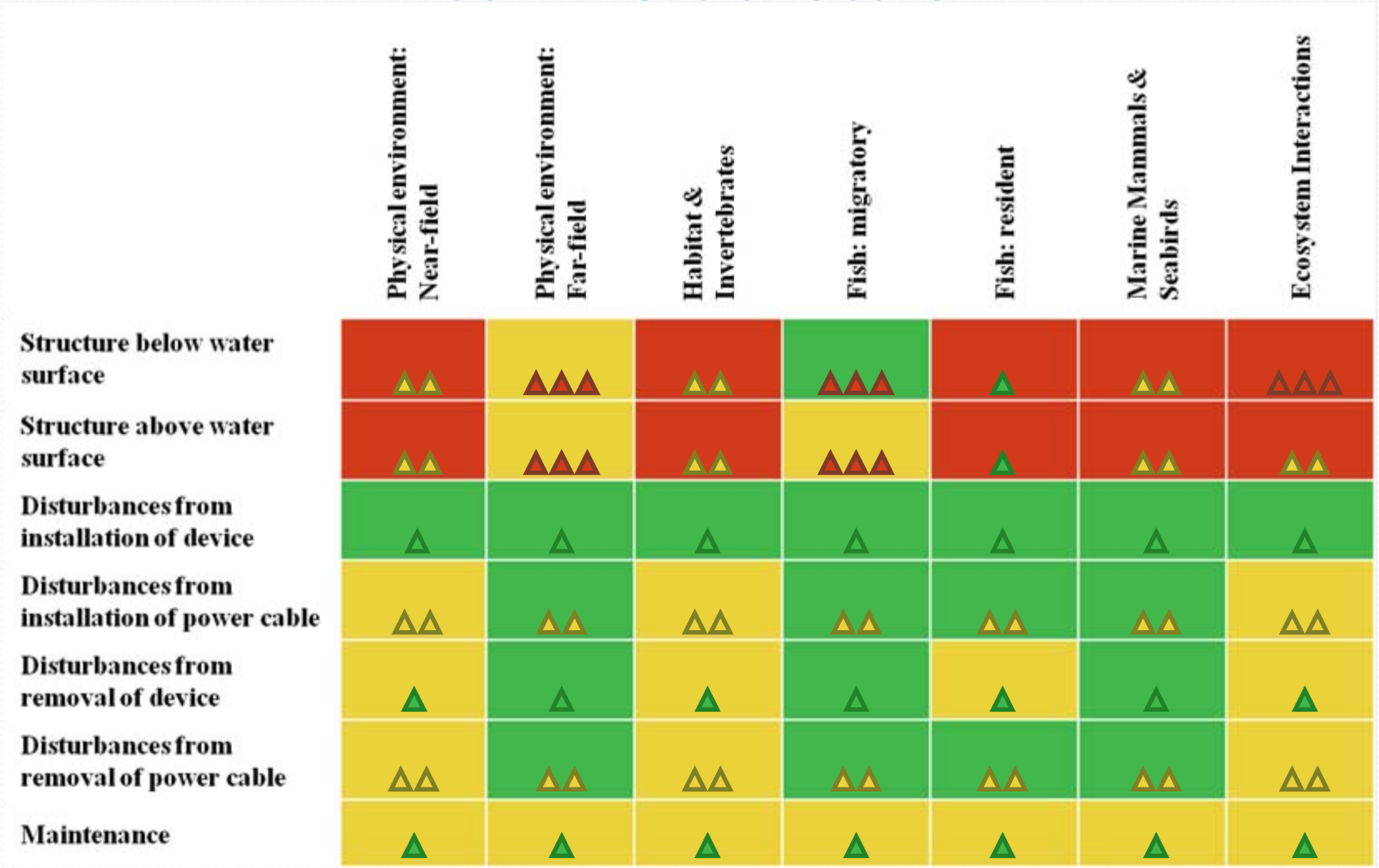
Presence of Devices – Static Effects

Pilot Scale



Presence of Devices – Static Effects

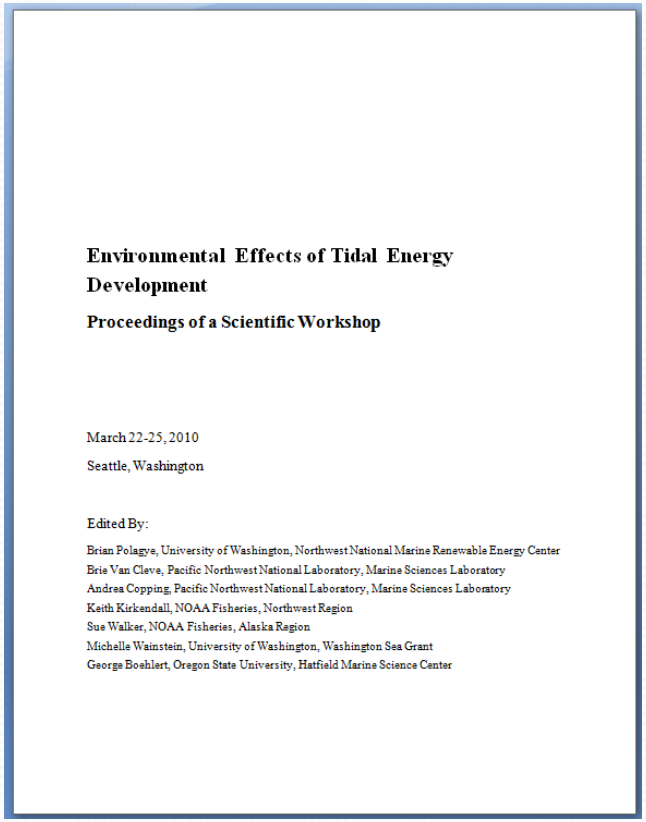
Commercial Scale



Identification of Priority Interactions

- **Selection Criteria**
  - —High potential significance
  - —High uncertainty
- **Summarize Key Information**
  - —Description
  - —Gaps in Understanding
  - —Monitoring Approaches
  - —Mitigation Measures (stressor only)

Workshop Report



Environmental Effects of Tidal Energy Development

Proceedings of a Scientific Workshop

March 22-25, 2010

Seattle, Washington

Edited By:

Brian Polagye, University of Washington, Northwest National Marine Renewable Energy Center
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Sue Walker, NOAA Fisheries, Alaska Region
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George Boehlert, Oregon State University, Hatfield Marine Science Center

- **Will be published as NOAA Tech Memo**
- **Draft out for review to participants by end of week**
- **Details of breakout sections**
- **Challenges indentified**
- **Recommendations**

http://depts.washington.edu/nnmrec/workshop

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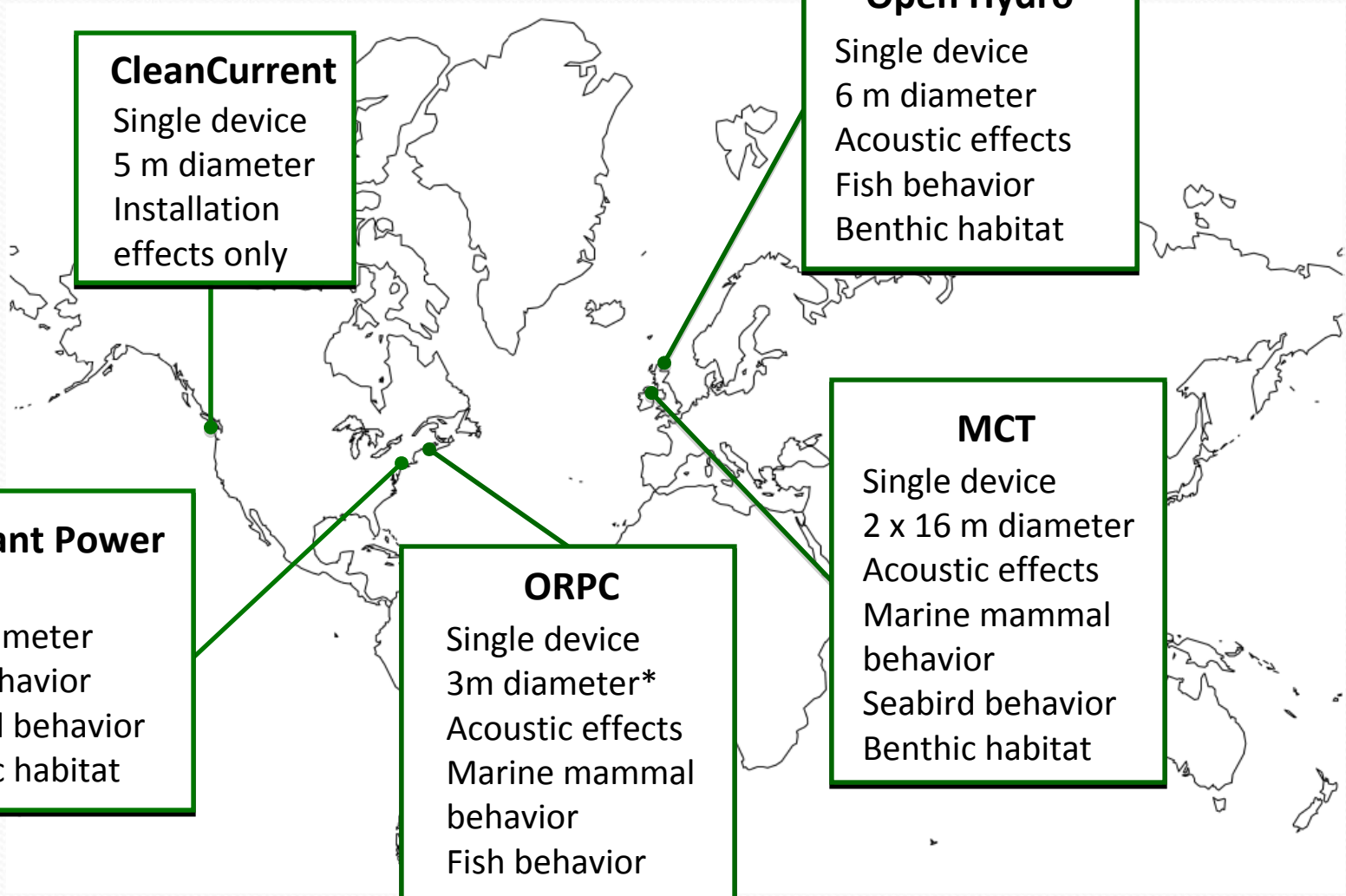
Project Environmental Data are Scarce



CleanCurrent
Single device
5 m diameter
Installation effects only

Open Hydro
Single device
6 m diameter
Acoustic effects
Fish behavior
Benthic habitat

Verdant Power
Array
5 m diameter
Fish behavior
Seabird behavior
Benthic habitat

ORPC
Single device
3m diameter*
Acoustic effects
Marine mammal behavior
Fish behavior

MCT
Single device
2 x 16 m diameter
Acoustic effects
Marine mammal behavior
Seabird behavior
Benthic habitat

Information Needs at Pilot Scale

Stressor	Priority Area	Before Pilot	During Pilot
Presence of devices: static effects	Effects of static structures on benthic ecosystems	Characterize benthic habitat. Characterize species presence/absence and behavior.	Disruptions to benthic habitat installation/recovery. Rate at which structures are colonized. Fish and marine mammal interactions with modified benthic ecosystems.
Presence of devices: dynamic effects	Potential for direct interactions of marine species with turbine rotor	Characterize movements of marine mammals, fish, and seabirds at temporal and spatial scales required to assess potential for direct interactions.	Types of interactions and at what frequency they occur.

Information Needs at Pilot Scale

Stressor	Priority Area	Before Pilot	During Pilot
Chemical effects	Approaches to preventing biofouling are poorly defined	Assess potential impacts of anti-fouling biocides.	Fate of chronically released biocides.
Acoustic effects	Behavioral responses to increases in broad band noise	Behavioral response of species to acoustic signals.	Measurements of sound pressure levels from device operation.
Electromagnetic effects	Electromagnetic fields from operating and idle devices	Laboratory studies of electric and magnetic fields. Models of electric and magnetic fields from proposed devices.	Measurements of magnetic fields from energized cables and operating devices.

Challenges to "Deploy and Monitor"

- **Monitoring technologies are underdeveloped**
  - —Existing methods focused on population effects
  - —Existing methods may not function in tidal energy environments
- **Difficulty of predicting, detecting, and attributing changes to tidal energy devices**
- **Legal protections or ethical considerations prohibit studies of some interactions**
- **Some important effects can only be measured at commercial scale**

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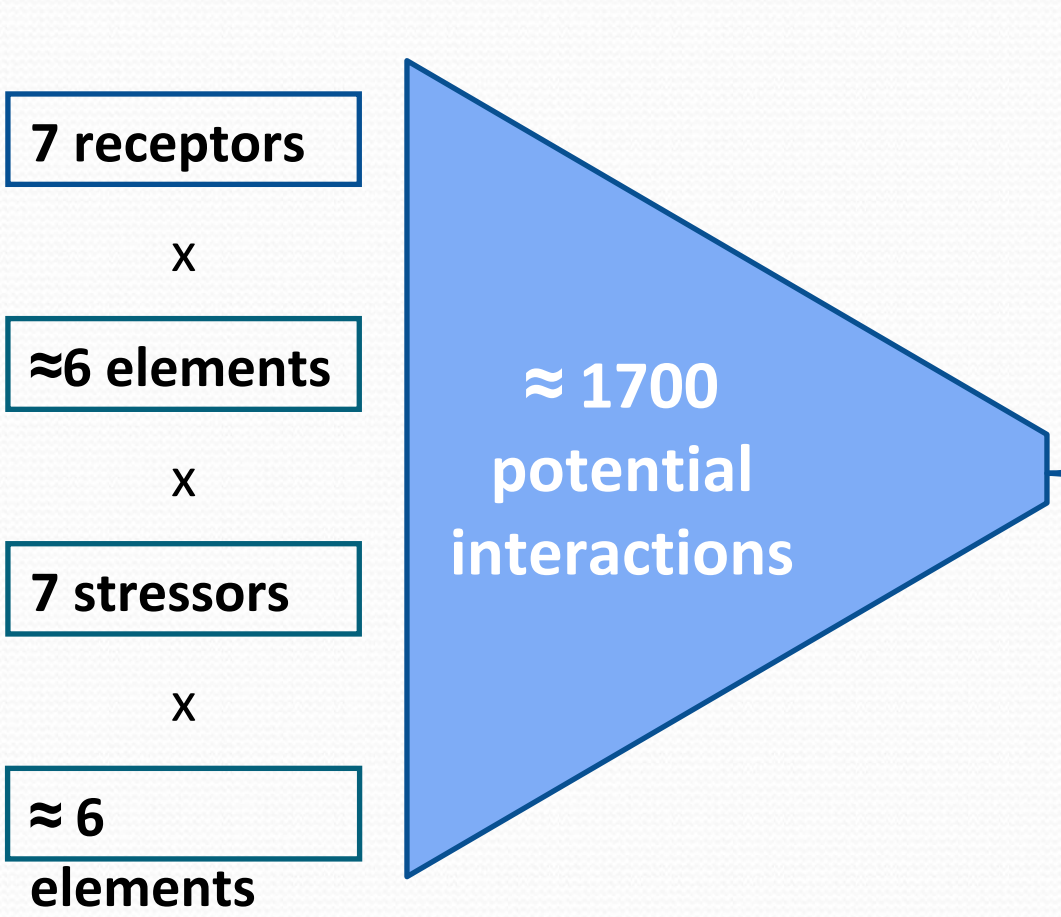
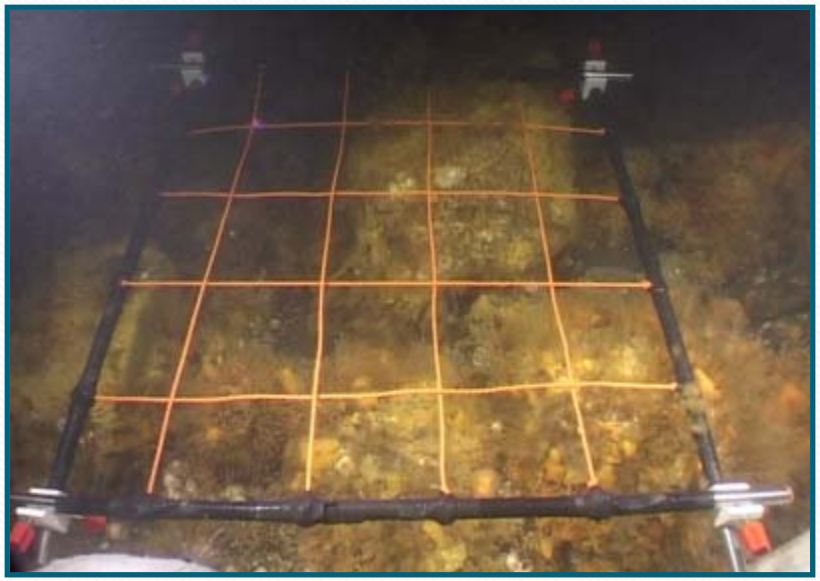
Preliminary Research Prioritization



- **Marine mammal-device interactions**
  - — Blade strike
  - — Acoustic effects
- **Fish-device interactions**
- **Environmental tipping points for energy removal**

Pilot Projects are Required

- Recognized need by participants of all affiliation
- Must be well-monitored
- Prioritize objectives
- Use common protocols



Courtesy of Marine Current Turbines

Develop Assessment Capabilities

- **Close monitoring instrumentation gaps**
  - —Detect, classify, and identify marine organisms at a variety of scales
  - —Real-time monitoring for decision making
- **General monitoring protocols**
  - —Objective of data collection
  - —Type of data to be collected
  - —Mechanisms for data collection
- **Numerical models**
  - —Turbine scale: hydrodynamics, fish interactions
  - —Regional scale: tipping points

Mitigate Impacts when Possible

Stressor	Priority Area	Recommended Mitigation
Presence of devices: static effects	Effects of static structure on benthic ecosystems	Minimize anchor sizes. Minimize number of moorings and slack lines. Streamline support structures.
Presence of devices: dynamic effects	Potential for direct interactions of marine species with turbine rotor	Increase visibility of rotors to fish. Acoustic avoidance measures. Shock absorbers on leading edges of blades. Temporary device shutdown.
Electromagnetic effects	Behavioral disruption from electric and magnetic fields	Bury power cables. Twist cores for AC cables. Run DC cables of opposing polarity in close proximity.
Cumulative effects	Effects on large, mobile species	Limit number of devices at a given location until effects of operation are sufficiently understood.

Collaboration is Essential

- **Information needs to be shared between projects**
  - —IEA-OES Annex IV
  - —Significant intellectual property concerns
- **Hydrokinetic industry needs to engage with the oceanographic community**
  - —Leverage active areas of research
- **Expand opportunities for interdisciplinary collaboration**

Acknowledgements

- **Workshop organizing committee**
  - **Andrea Copping, Pacific Northwest National Laboratory**
  - **Keith Kirkendall, NOAA Fisheries**
  - **George Boehlert, Oregon State University**
  - **Michelle Wainstein, University of Washington**
  - **Sue Walker, NOAA Fisheries**
  - **Brie Van Cleve, Pacific Northwest National Laboratory**
- **Workshop sponsors**
  - NOAA Fisheries
  - US Department of Energy
- **Workshop participants, particularly session chairs and note takers**