Annex IV Case Studies

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#1 - Interaction of Marine Animals with Turbine Blades

#2 - Effects of Acoustic Output from Tidal and Wave Devices on Marine Animals

#3 - Effects on Physical Systems

Annex IV Experts' Workshop #2

Dublin Ireland

October 15th 2012

Purpose and Process for developing the Case Studies

- Specific interactions of marine energy devices with the marine environment
- Criteria for choosing the Case Studies:
  - The topic must be a common environmental concern or questions among multiple nations;
  - The topic must be raised as a significant issue in permitting (consenting) of marine energy sites in more than one nation; and
  - There must be sufficient information available to make an assessment.
- Information gathered from all available sources, evaluated to provide an understanding of the state of the science for each topic.
- Major sources:
  - Scientific papers and technical reports
  - Annex IV metadata forms where no published reports available,
  - Each source has been documented and appears in the Annex IV database.

Purpose and Process for developing the Case Studies (cont'd)

- Each case study includes:
  - Problem statement
  - Available evidence from monitoring and/or research studies,
  - Discussion of lessons learned and
  - Data gaps
  - References cited

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Annex IV Case Study #1

Interaction of Marine Animals with Turbine Blades

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Case Study #1 Objectives

1. Identify tidal and in-stream monitoring data on marine animal interactions with turbine blades;
2. Collect information from laboratory flume and tank studies, and numerical modeling studies that inform the interaction of marine animals with turbine blades;
3. Evaluate this information from different projects to determine interactions between marine animals and turbine blades; and
4. Identify key gaps in data and studies.

Lines of Evidence CS#1

- Field Studies
  - SeaGen observations of marine mammals in Strangford Lough, Northern Ireland (MCT)
  - Observations of fish around a tidal turbine in Cobscook Bay, Maine, USA (ORPC)
  - Fish passage through a hydrokinetic river turbine on the Mississippi River, USA (Hydro Green)
  - Video observations of fish around a tidal turbine at the European Marine Energy Center, Scotland (OpenHydro)
  - Acoustic measurements of fish and birds around tidal turbines, New York, USA (Verdant)
- Laboratory Experiments
  - Alden Lab flume studies
  - Conte Lab open water flume studies
- Modeling encounters between Animals and Hydrokinetic Turbines
  - Fish and Harbor Porpoise Encounter Model (SAMS)
  - Estimating the consequences of encounter with a tidal turbine (PNNL/SNL)

Conclusions CS#1

- No evidence to date suggests direct interaction of marine mammals, birds, or fish with tidal turbine blades likely to be a significant problem.
- Attraction of animals to turbines could increase risk of direct effects (strike, entrainment) that affects feeding, mating and reproduction.
- Data collected from short pilot-scale deployments may not scale easily to large long term commercial deployments.
- Modeling needed to simulate the physics and biological interactions to design laboratory and field experiments, with special emphasis on incorporating behavioral responses of animals.
- Monitoring around multi-turbine arrays needed for information on encounters with animals, to understand the cumulative and additive effects of commercial scale developments.

Data Gaps CS#1

- Lack of observations and measurements of animal movement around tidal turbines of varying designs, in specific waterbodies.
- For example, need data with indigenous animals, that examines:
  - Open bladed and ducted tidal turbines;
  - Size of tidal turbine versus deployment depth;
  - Rotational speed of the turbine;
  - Solidity of the turbine;
  - Foundation or anchor structural design and materials;
  - Acoustic signature of the device (as a potential acoustic deterrent); and
  - Associated deterrents such as pingers or noisemakers.
- Need additional laboratory experiments with fish (other species) and turbines, where fish can make choices
- Modeling explicit for physical and biological interactions to determine outcome of encounters
- Field measurements of animals encounters with arrays

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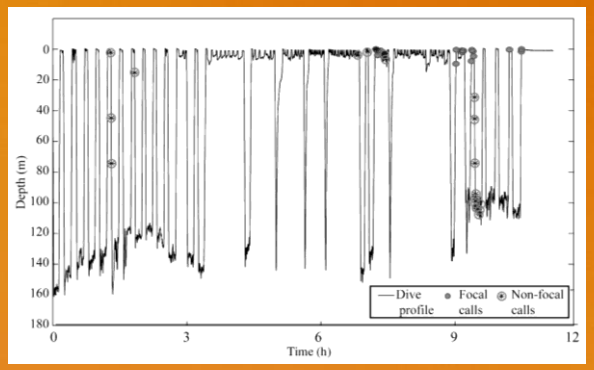
Annex IV Case Study #2

Effects of Acoustic Output from Tidal and Wave Devices on Marine Animals



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Case Study #2 Objectives

1. Identify tidal and wave monitoring data on effects of acoustics on marine animals;
2. Collect information from laboratory flume and numerical modeling simulations, that informs the effects of acoustics from tidal and wave systems on marine animals;
3. Evaluate this information from different projects to determine the effects of acoustics on marine animals; and
4. Identify key gaps in data and studies.

Lines of Evidence CS#2

- Field Studies
  - SeaGen measurement of acoustic effects on marine animals in Strangford Lough, Northern Ireland (MCT)
    - *Ambient Noise*
    - *Construction Noise*
    - *Operational Noise*
    - *Perceived Noise by Marine Animals*
  - Acoustic monitoring around a tidal turbine in Cobscook Bay, Maine, USA (ORPC)
    - *Measuring sound from a pilot turbine deployment*
    - *Sound from pile driving to install turbines*
  - Measuring sound around tidal turbines, New York, USA (Verdant)
  - Measuring sound around a 1/7th scale wave energy converter in Puget Sound, USA (CPT)
  - Measuring and evaluating the acoustic environment in a tidal deployment area, Admiralty Inlet, USA (UW/SnoPUD)

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Lines of Evidence CS#2 (cont'd)

- Laboratory Experiments
  - Measuring tidal turbine noise in a flume (Univ Newcastle)
  - Examining the effects of fish exposed to turbine noise, USA (PNNL)
- Modeling effects of noise from tidal turbines and wave energy converters
  - Modeling acoustic signature of wave energy converters, Portugal (WEC)
  - Modeling effects of acoustics from arrays of tidal and wave devices, Scotland
  - Identifying the noise from a Pelamis wave device, Scotland (QinetiQ)
  - Developing an acoustic signature for a hydrokinetic turbine, USA (SNL/PSU)
  - Field calibration of acoustic models for noise prediction, Portugal (Univ Algarve)
  - Modeling acoustics to develop mitigation for marine mammals, USA (OSU/PEV)

Conclusions CS#2

- Field deployments needed to measure ambient sound and propagation potential in water body prior to deployment, to accurately measure the sound of the operational device;
- Observations of animals around devices should be documented using multiple methods such as observers, passive and active acoustics, satellite tags and aerial surveys;
- Dose/response relationships are needed to understand the amplitude and frequencies of sounds that elicit reactions in animals;
- Must validate assumptions about the additive or multiplicative effects of acoustic outputs over single devices must be validated with field data, as arrays of devices are deployed,
- Investigations of acoustic outputs and its effects are needed for a range of tidal and wave energy devices, as well as the anchors, moorings, and foundations.

Data Gaps CS#2

- Need information on sound propagation potential within waterbodies (i.e.Strangford Lough) and uncertainty of effect on marine animals of sound propagation from turbines.
- Reconciliation of observations of animals near devices with sound levels expected to deter the animals (dB hearing threshold for marine species)
- Need proof to classify and evaluate the effect of marine energy devices on animals.
- Field deployments that measure:
  - Ambient sound field and propagation potential of the waterbody
  - Sound of the operational device
  - Observations of animals around device using multiple
  - Dose/response relationships for amplitude and frequencies of sounds that elicit reactions in animals of concern
  - Acoustic output and effects over a range of tidal and wave energy devices including various anchoring, mooring, and foundation systems

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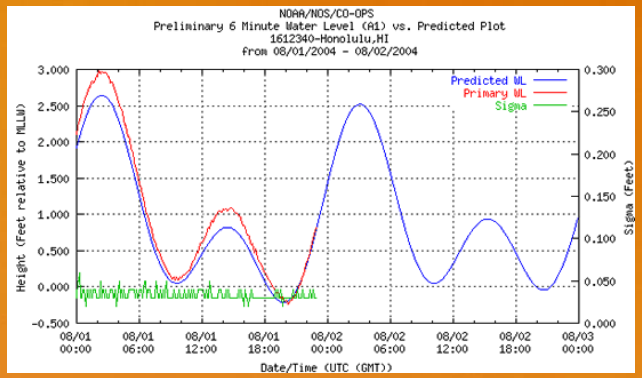
Annex IV Case Study #3

Effects on Physical Systems



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Case Study #3 Objectives

1. Identify tidal and wave monitoring data that determine physical changes in the environment;
2. Collect information from laboratory flume and numerical modeling simulations that informs the potential effects on the physical environment from tidal and wave systems;
3. Evaluate this information from different projects to determine potential effects on the physical marine environment; and
4. Identify key gaps in data and studies.

Lines of Evidence CS#3

- Few field measurements, few validated modeling efforts
- Largely numerical models to predict changes
- Field Studies
  - Water velocity measurements around the SeaGen turbine in Strangford Lough, Northern Ireland (MCT)
  - Measuring water velocity around tidal turbines, New York, USA (Verdant)
- Modeling Studies
  - Wave energy models developed in European waters
  - Wave energy models developed in North American waters
  - Tidal energy models developed in European waters
  - Tidal energy models developed in North American waters

Conclusions CS#3

- The large temporal and spatial scales present five specific measurement challenges for research:
  - Model validation
  - Turbulence
  - Effects from specific marine energy devices
  - Coupling the nearfield with the farfield
  - Cumulative effects
- Modeling results indicate that nearfield changes are not likely at the small pilot scale but could occur at large commercial scales;
- It is not known if a tipping point exists for farfield changes that might affect the overall waterbody;
- Need better measurements of turbulence and inflow to devices for estimating environmental changes (as well as power resource potential). Need more specialized instrumentation for this.

Data Gaps CS#3

- Field data collection for model validation
- Measurements of turbulence
- Energy removal effects from specific marine energy devices
- Modeling to couple nearfield effects with farfield effects
- Modeling cumulative effects of changes in water flow, sediemnt transport, ecosystem effects

Breakout Groups for Case Studies

- Structure:
  - Three breakout groups, chosen (more or less) for expertise, interest
- Purpose:
  - Obtain feedback on the overall content and interpretation of case study
  - Discuss future case studies: utility, topics
  - *Detailed feedback should be provided in writing*
  - Begin discussion of future of Annex IV
- Process:
  - 60 minutes to review at high level, focus on future case studies, Annex IV activities
  - Facilitator and recorder in each group
- Outcome
  - Guidance for correcting/enlarging content and interpretation of case study
  - Suggestions for future case studies
  - Potential new directions, activities under Annex IV

Thank you!

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