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ANNEX IV
Environmental Effects of Marine Energy Development around the World

Environmental Effects of Marine Renewable Energy Development: The State of the Science

EWTEC 2015

Nantes, France

Tuesday September 8, 2015

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Environmental Effects of Marine Energy Development around the World

Introduction

Jocelyn Brown-Saracino, US
Operating Agent Annex IV

U.S. DEPARTMENT OF ENERGY

Agenda

17:30 – 17:40 **Welcome, introductions, purpose of meeting**

Jocelyn Brown-Saracino, US Department of Energy, US
Luke Hanna, Pacific Northwest National Laboratory, US

17:40- 17:55 **Background of Annex IV and SoS report**

Overall interactions and risk
Andrea Copping, Pacific Northwest National Laboratory, US

17:55– 18:05 **Collision and Marine Mammals**

Carol Sparling, Sea Mammal Research Unit, UK

18:05 – 18:15 **Collision and Fish**

Gayle Zydlewski, University of Maine, US

18:15 – 18:20 **Electromagnetic Fields**

Samantha Eaves, US Department of Energy, US

18:20 – 18:25 **Marine Spatial Planning**

Anne Marie O'Hagan, University College Cork, Ireland

18:25 – 18:30 **Case Studies on Consenting Wave and Tidal Devices**

Teresa Simas, WaveEc, Portugal

18:30 – 18:35 **Wrap up**

Andrea Copping, Pacific Northwest National Laboratory

18:35 – 19:00 **Workshop participant feedback**

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Background of Annex IV and the State of the Science Report

Andrea Copping, US

Pacific Northwest NATIONAL LABORATORY

OES and Annex IV

- Under IEA, Ocean Energy System (OES) is a agreement among 23 nations engaged in marine energy development
- Annex IV is a collaborative initiative under OES, focusing on environmental effect of marine energy
  - OES ExCo approved Annex IV Phase 1 in 2009
  - Examine and disseminate information and metadata on projects
  - Provide a commons to facilitate communication and collaboration.

- Annex IV information housed within *Tethys*, an online knowledge management system.

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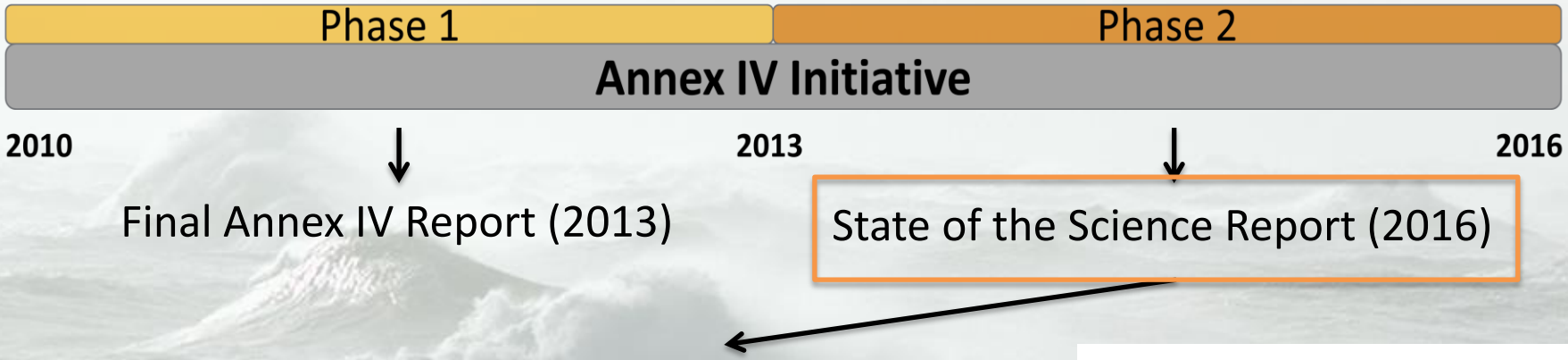
TETHYS

Annex IV Country Representatives

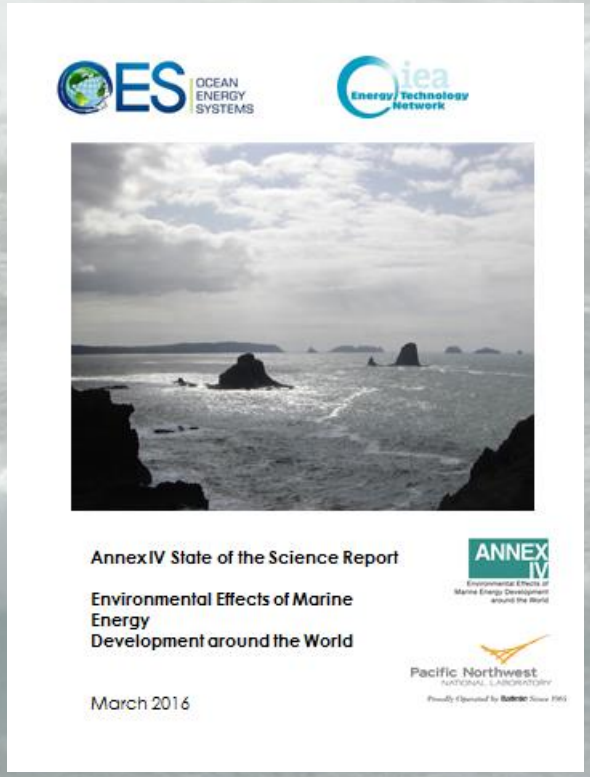
Annex IV Country	Name	Affiliation
Canada	Anna Redden	Acadia University
China	Xu Wei	National Ocean Technology Center
Ireland	Anne Marie O'Hagan	University College Cork
Japan	Daisuke Kitazawa	University of Tokyo
New Zealand	Craig Stevens	NIWA
Nigeria	Adesina Adegbie	Nigerian Institute of Oceanography and Marine Research
Norway	Lars Golmen	Norwegian Institute for Water Research
Portugal	Teresa Simas	WavEC Offshore Renewables
South Africa	Wikus van Niekerk	Stellenbosch University
Spain	Juan Bald	AZTI-Tecnalia
Sweden	Jan Sundburg	Uppsala University
UK	Annie Linley	NERC
US	Andrea Copping	Pacific Northwest National Laboratory

State of the Science Report



Update on current understanding and knowledge of priority environmental interactions of MRE devices with the marine environment

- Examines relevant stressors and interactions with the marine environment
- Updates topics covered in Final Annex IV Report (2013)
- Identifies highest priority interactions
- Evaluates risk levels for all interactions



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Priority Environmental Interactions

Stressor	Single device	Pilot scale	Large-scale commercial
Static device			
Dynamic device (tidal)			
Dynamic device (wave)			
Acoustic			
Energy Removal			
EMF			
Chemical Leaching			

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Benthic Environment and Reefing Effects

- Overall not considered to be likely to be significantly harmed
- Understanding potential effects hampered by:
  - Lack of seasonal data
  - High variability occurring naturally

- Presence of MRE devices will attract marine organisms, esp. fish
  - All structures in the sea have the potential to change bottom habitats and attract animals
- No mechanisms for harm to fish identified


Carnegie Wave Energy

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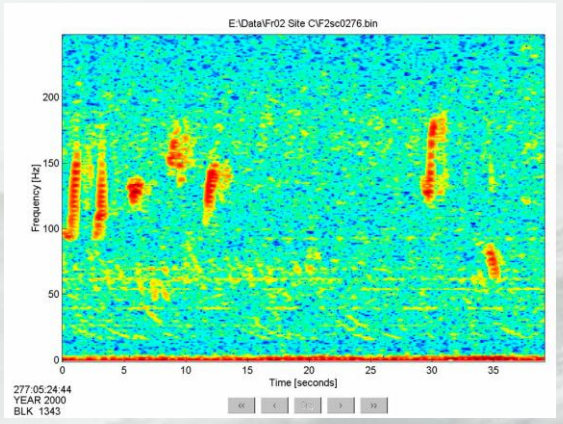
Risk to Marine Animals from Underwater Sound

- Uncertainty around characterizing sound from MRE devices
  - Standardized measuring methods and instruments not always workable in high energy environments



- Few studies have quantified response of marine animals to noise from MRE devices
  - Little reason to expect serious injury or mortality?

- Research and monitoring needs:
  - Data to validate sound propagation models
  - Understanding sound fields from arrays
  - Animal responses to noise from MRE devices: individuals and populations at risk

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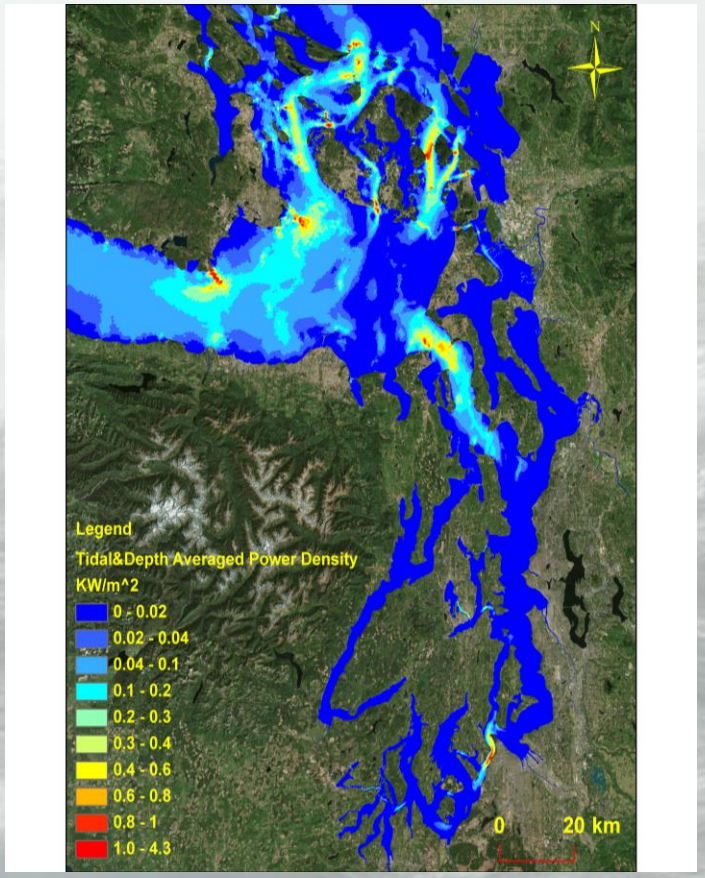
Energy Removal

- Most numerical models focus on wake effects, changes in flow, few on environmental ramifications:
- Changes in sediment transport (habitats)
- Changes in water quality, ecosystem processes

- Few environmental field studies
- Some relevant modeling studies

- Nearfield changes are unlikely to be seen at tidal or wave pilot-scale projects
- Is there a tipping point for basins?

- Research and monitoring needs:
  - Field measurements, including turbulence and inflow
  - Understand effects of multiple MRE designs
  - Modeling and validation of cumulative effects



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Other Priority Interactions

- Collision, evasion, avoidance, attraction
  - Marine Mammals
  - Fish
- Electromagnetic Fields

Other chapters included in the report:

- Marine spatial planning
- Case studies for siting and permitting

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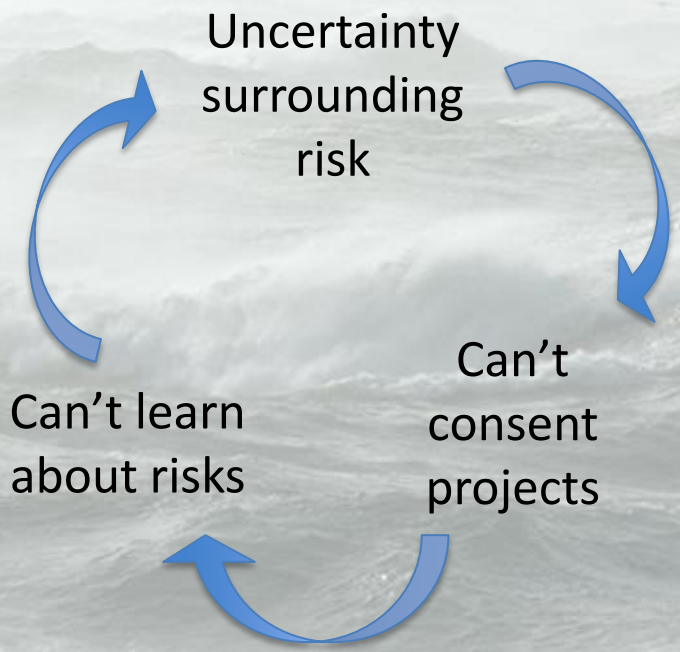
Marine Mammal Collision Risk

Carol Sparling, UK

SMRU Consulting

Marine Mammal Collision Risk



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Collision uncertainty holding back potential

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NE Scotland, Orkney & Shetland

Tidal energy: Pentland Firth 'could power half of Scotland'

20 January 2014 | NE Scotland, Orkney & Shetland

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Islands seal numbers show decline

Populations of harbour seals in Orkney and Shetland have declined by about 40% over the past five years, according to new research.

The decline, whose causes are unknown, has emerged in a study carried out by the Sea Mammal Research Unit at the University of St Andrews.

Researchers said the decline was a cause of concern

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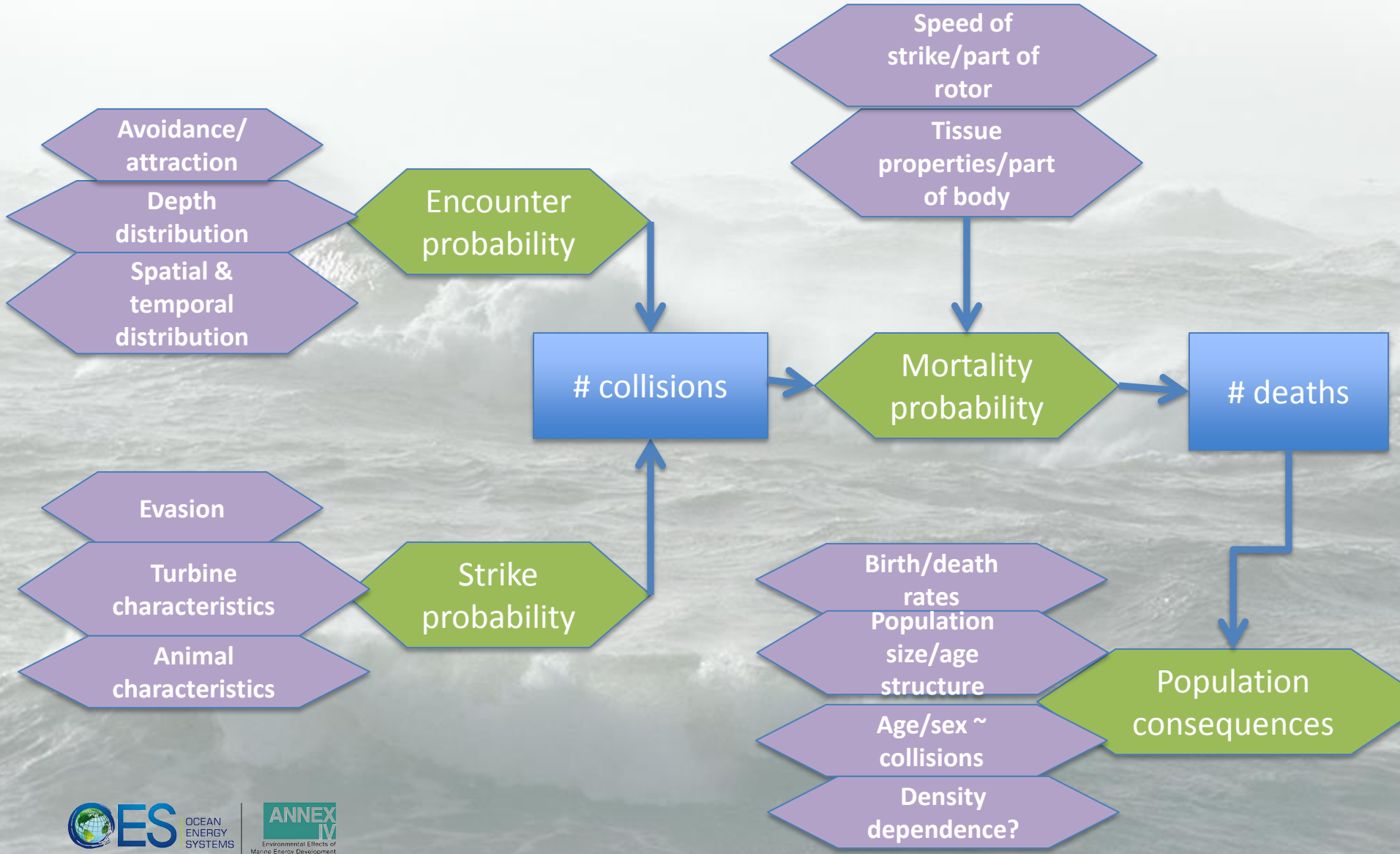
Current understanding - framework



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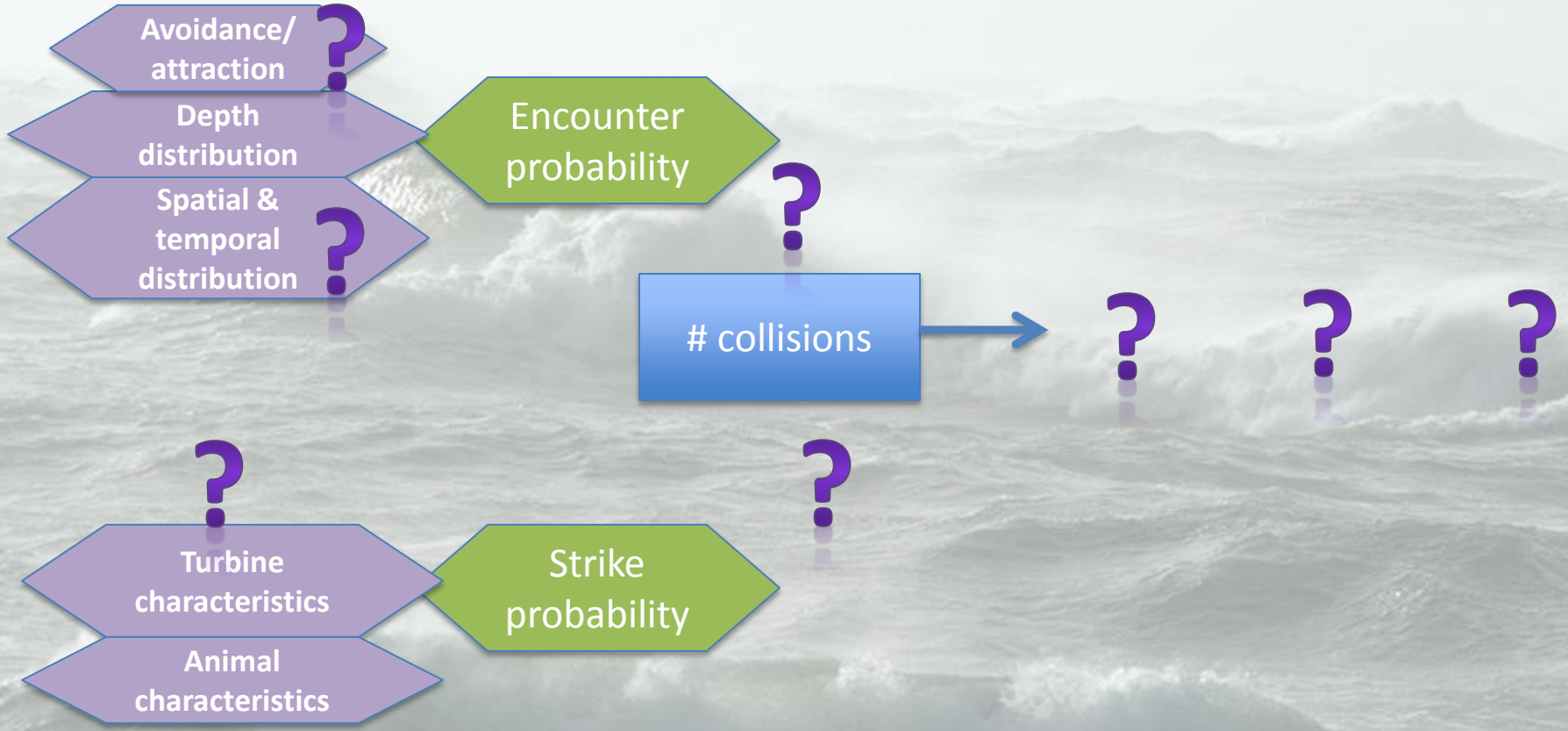
Current understanding

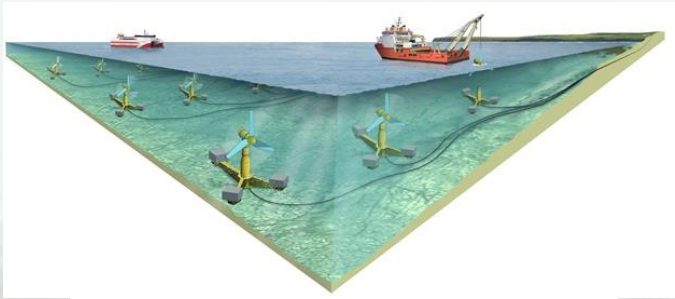


Current focus and future needs: Research

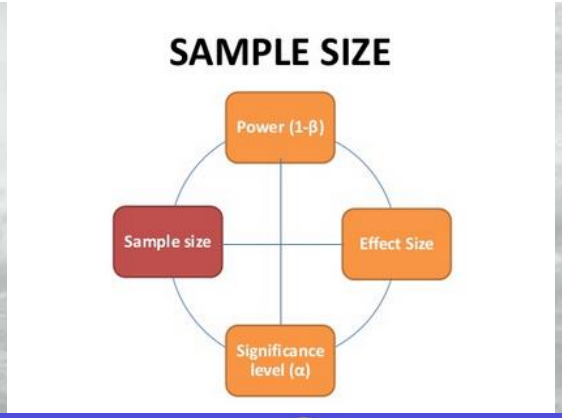
- *Consequences of collisions for individuals*
- *The detailed understanding of spatial and temporal use of tidal habitat by marine mammals*
- *Approaches to population level assessment*
- *Empirical measurement of close range behaviour of marine mammals around operating devices – avoidance/evasion*
- *Development of a confident means for the detection of collisions*

Future needs and priorities: Monitoring

- *Deploy and monitor at early arrays*



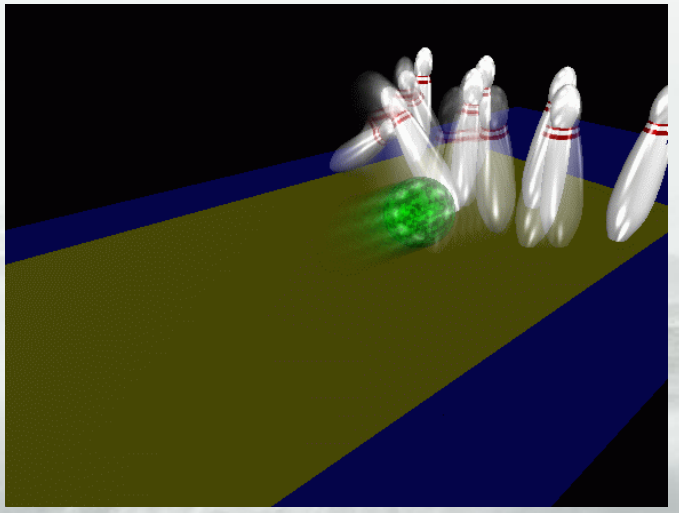
- *Statistical power is important*



- *Design, integrate and engage early*

Future needs and priorities: technology

- *'Strike' sensors*



- *Mitigation (if needed) – automated, cost effective detect and deter systems*

Future needs and priorities: standards and guidance

- *Refinement of Collision risk models*

- *Need for a common language and approach*

- *Standardisation of assessments*

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Collision Risk for Fish

Gayle B. Zydlewski

Garrett Staines, US

1865 THE UNIVERSITY OF MAINE
School of MARINE SCIENCES

The issue

Determ

1.
2.
3.
4.

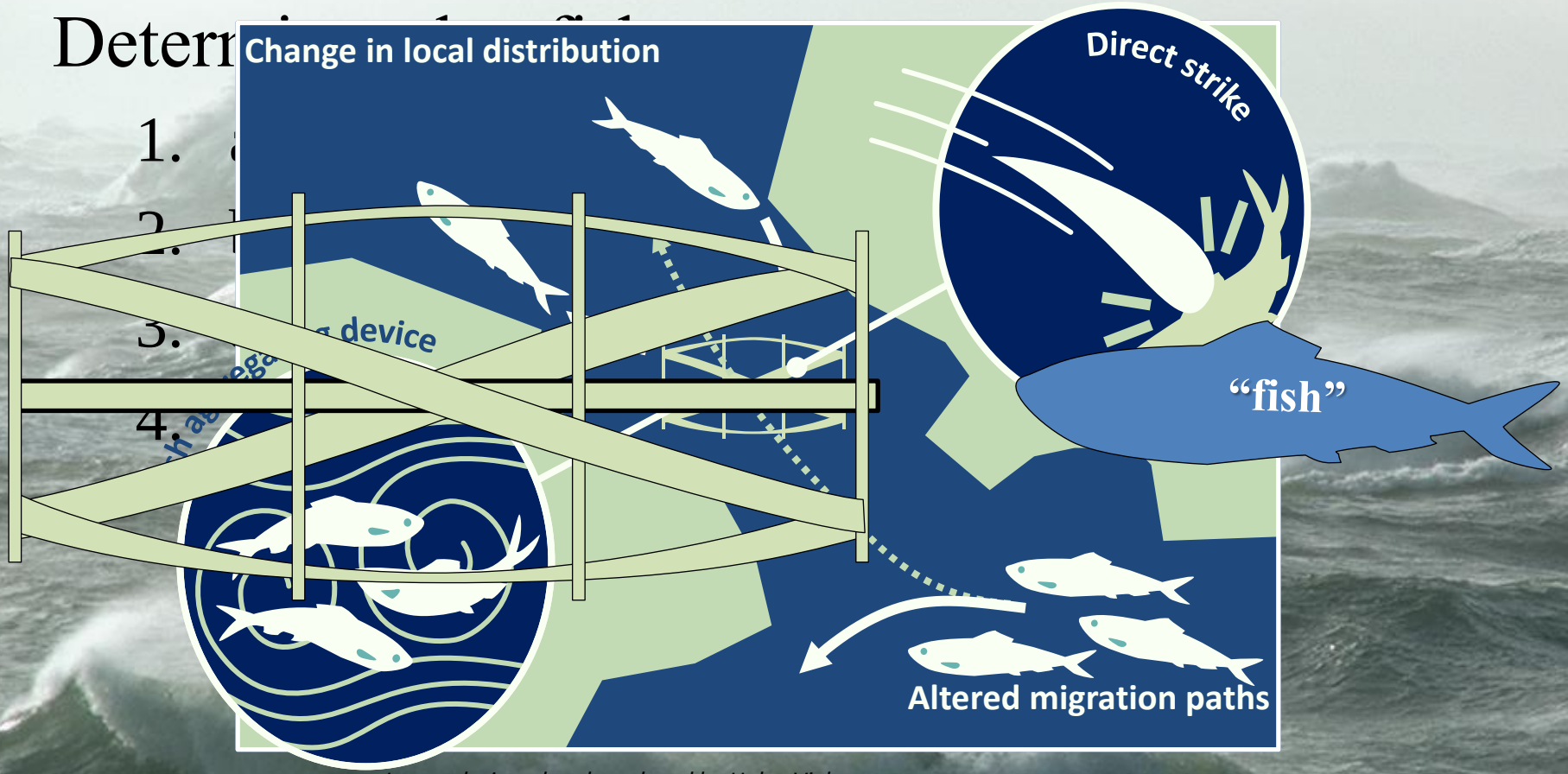

Image designed and produced by Haley Viehman

Moving the industry forward

Leg

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Current state of knowledge

Laboratory & flume studies

- Suggest high survival (>95%)
- ***Observe***: evasion and avoidance
- Water velocity and fish length influence injury rate

EPRI 2011
Amaral et al. 2014, 2015;
Castro-Santos and Haro 2015

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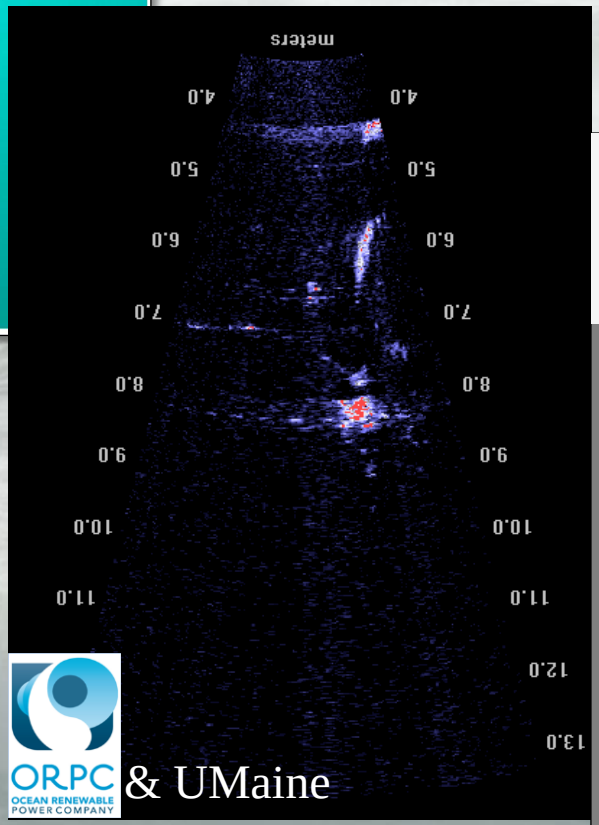
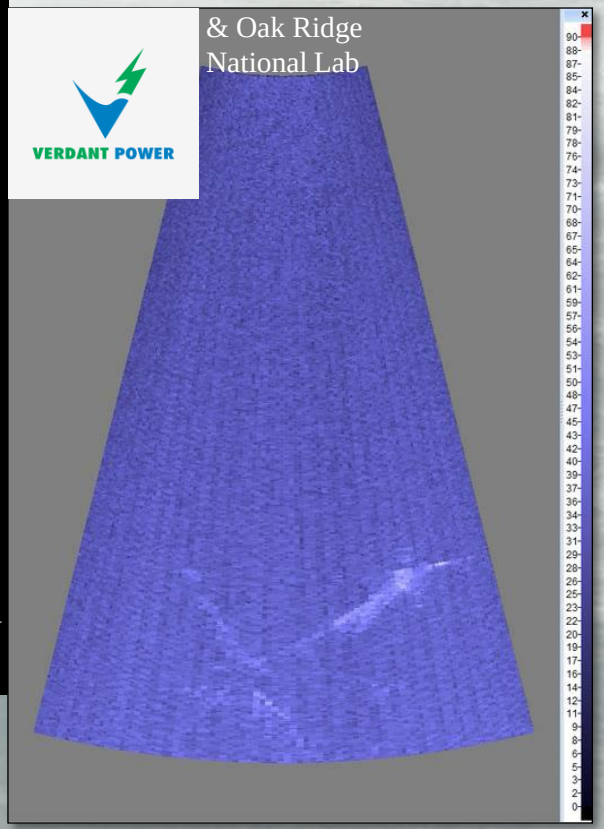
Current state of knowledge

Field studies

- ***Observe***: evasion & avoidance
- Lower presence at high currents
- Avoidance distance less in dark





Hammar et al. 2013
Broadhurst et al. 2014;
Viehman & Zydlewski 2015;
Bevelhimer et al. 2015

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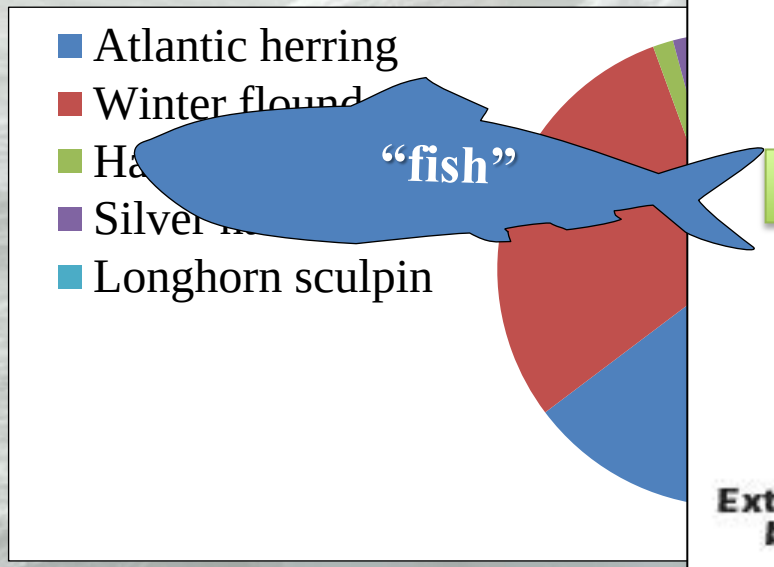
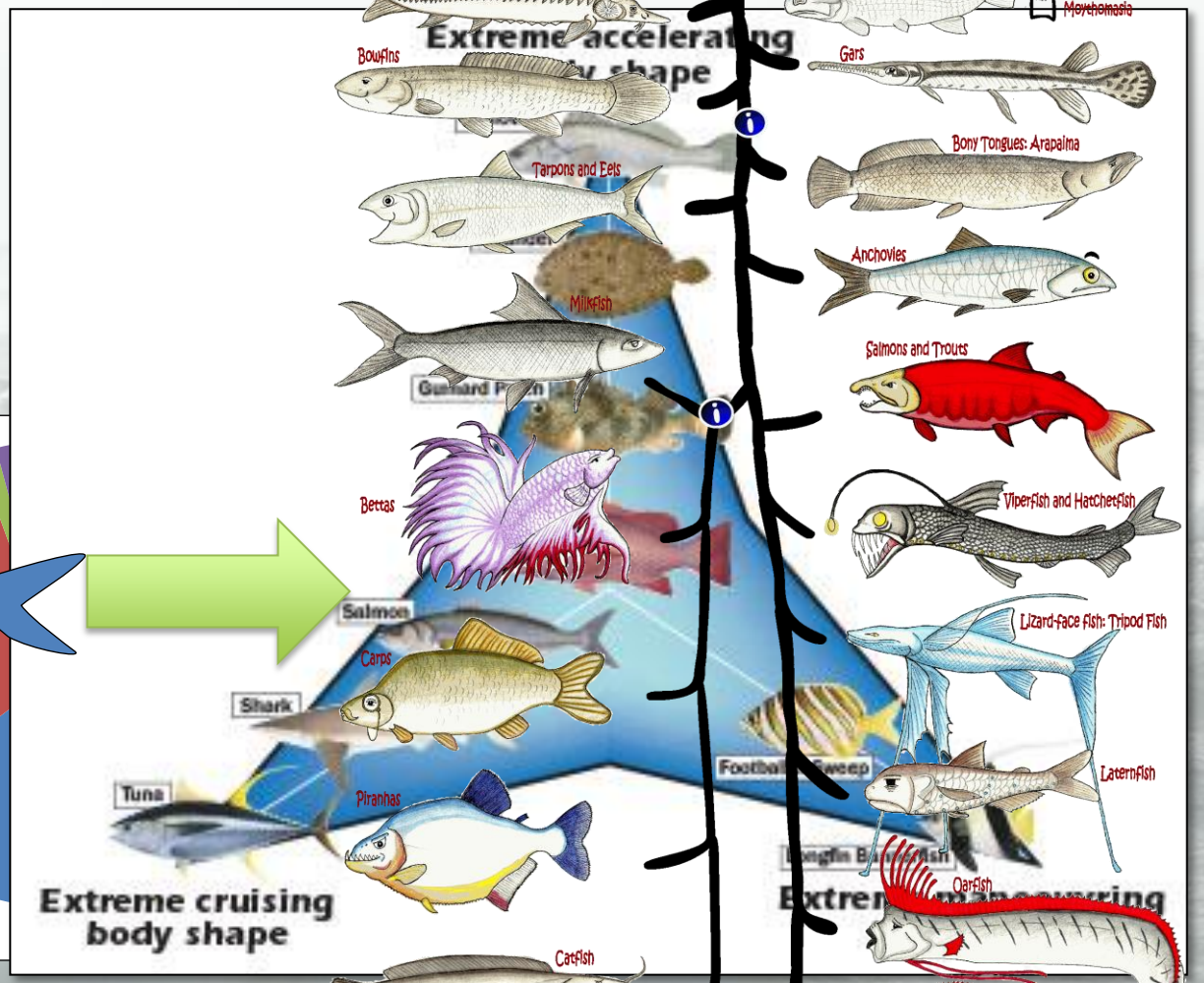
Current state of knowledge

What fish are we talking about?





Vieser 2014;

Broad[illegible] and Orme 2014;

Hammar et al. 20[illegible]

http://www.thetreeofnature.com/ray-finned%20fish.html

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Current state of knowledge

Probabilistic

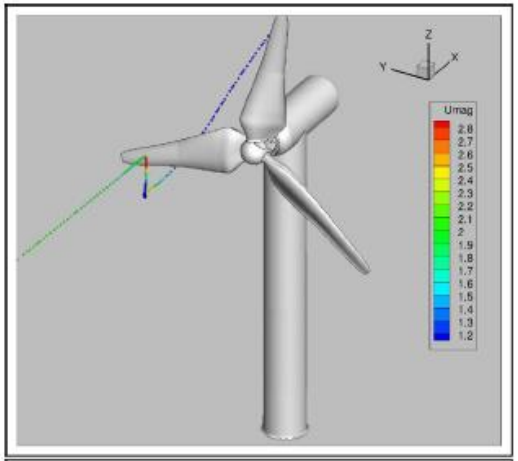
Computational

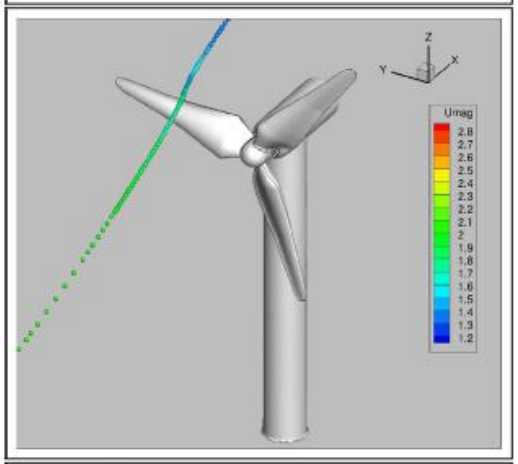
Population

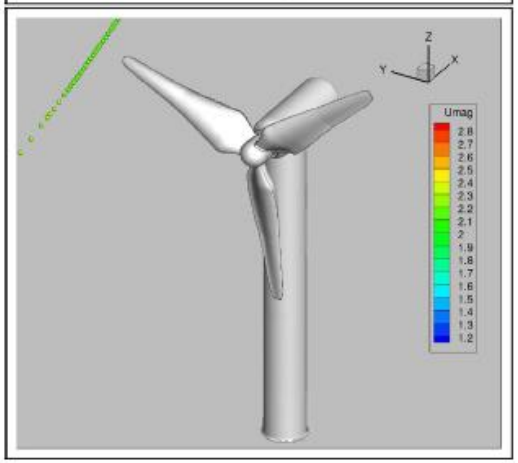
Conceptual Risk assessment

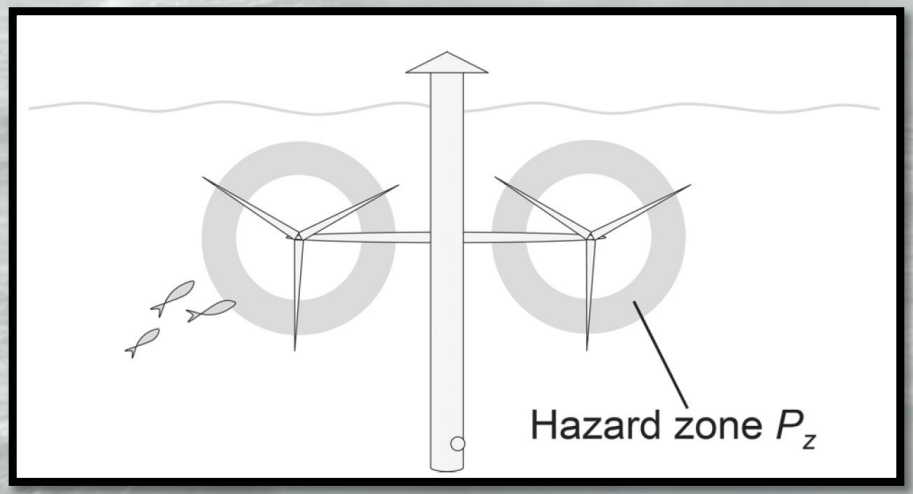
Modeling

- Probability of "encounter"
  - 0.1-6%
- Modeled survival:
  - 97-99%
  - Need data on avoidance behavior









Shen et al. 2015; Tomichek et al. 2015; Romero-Gomez & Richmond 2014; Hammar et al. 2015; Amaral et al. 2015; Copping et al. 2015; Busch et al. 2013

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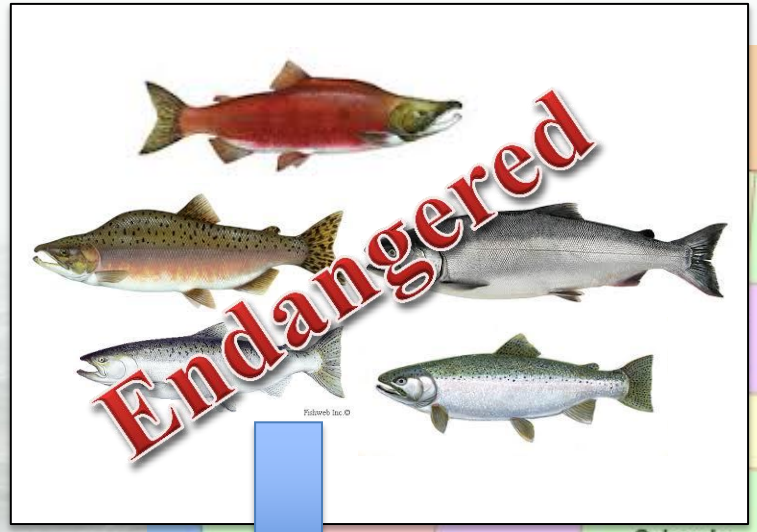
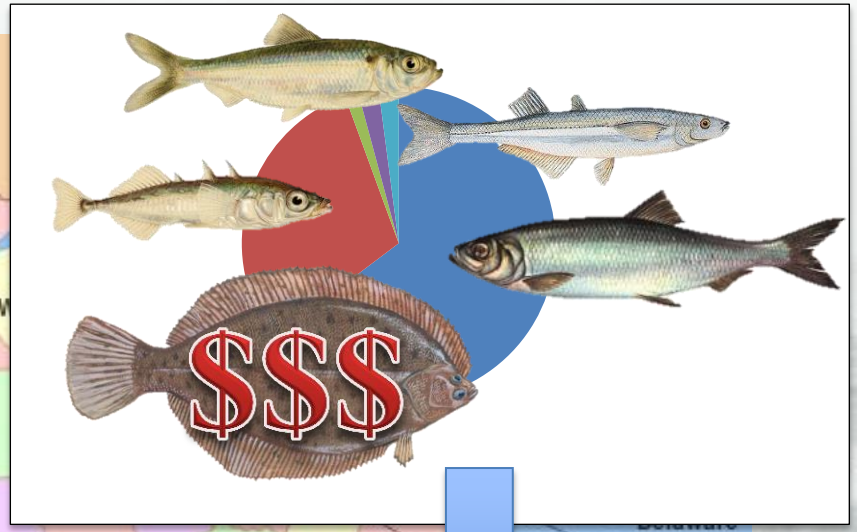
Context of issue





Legal acceptance

Social acceptance

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What is the path forward for addressing this issue?

- Observing collision/strike (lab & field)
- Embracing diversity to focus studies

http://marinewaters.fish.wa.gov.au/2012/08/the-shape-of-fish/#.Veb0S_m6dhE

Polagye et al. 2014

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Electromagnetic Fields

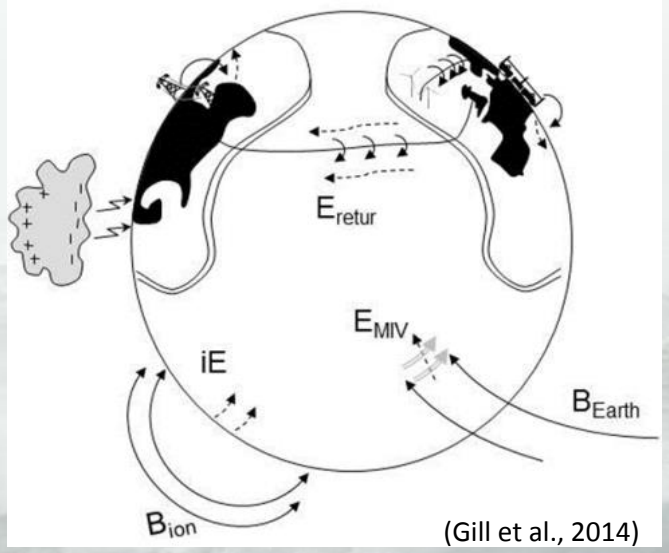
Andrew Gill, UK
Samantha Eaves, US

Cranfield UNIVERSITY

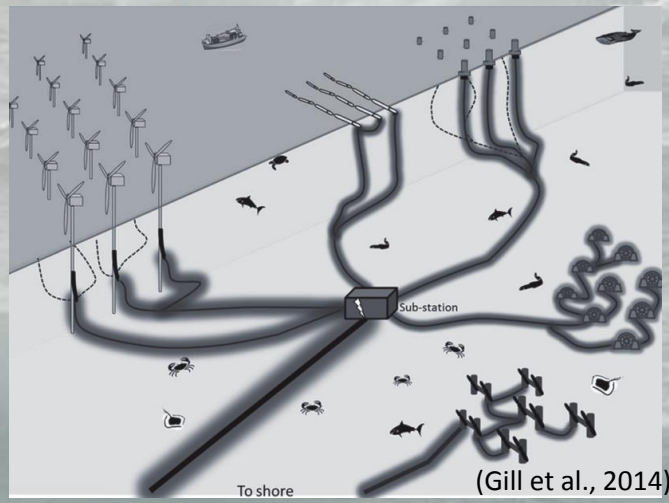
U.S. DEPARTMENT OF ENERGY

Concern around EMF

- EMFs occur **naturally** and are also created by **anthropogenic** activities
- **Concern:** Introduction of additional EMFs to marine environment will alter marine organisms' ability to detect natural EMFs, potentially impacting migration, reproduction or survival



(Gill et al., 2014)



(Gill et al., 2014)

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Current State of Understanding – EMF

EMF Emissions

- Both A.C. and D.C. cables emit EMF to marine environment
  - Magnetic fields (B-field) and induced Electric field (E-field)

European Commission MaRVEN Project* - most up to date

OBJECTIVES:

- Detect & quantify EMFs emitted by the subsea cable of an Offshore Wind Farm

METHODS:

- Measured EMF at inter-array cables, export cables and near a transformer station

RESULTS:

- Both E- and B- fields were measured over 10's metres
- EMFs from cables were the dominant source of EMFs associated with generating electricity
- EMF directly associated with the wind turbine was negligible

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* Project supported by DG RTD (Directorate-General for Research and Innovation of the European Commission)

Current State of Understanding - animals

Response of Marine Animals

- Many animals potentially receptors (studies have focussed on fish)
  - very few data on the effects of EMF from subsea cables
  - behavioural responses have been observed but do not allow impacts of biological significance to be determined
  - benthic and demersal species more likely to be exposed to higher field strengths from buried cables than pelagic species
- Results from laboratory studies generally equivocal
  - indications of developmental, physiological, and behavioural responses (not statistically significant) to **high** and **long** duration EMFs
- To date, no demonstrable impact (negative or positive) of EMF related to marine renewable energy on EM-sensitive species
- Need for greater evidence base to improve assessment confidence

Key Considerations

Response of Marine Organisms

- To evaluate potential effects, EMFs need to be compared to both natural fields and other anthropogenic EMFs in the area
- Consequences of exposure to EMF for sensitive species are most likely to be associated with multiple encounters with a short timescale between encounters
- EMFs are not known to cause any negative effects on receptor species – hence no current need for mitigation
- Whether EMFs cause negative effects cannot be ruled out owing to lack of knowledge

Addressing Knowledge Gaps

- **Sources of EMF:** Determine EMF strength produced by different cables, networks, number of devices and associated hardware in different locations
- **Exposure Assessments:** Measure EMFs at marine renewable energy installations to determine levels that marine animals may be exposed to, with relation to source (see above)
- **Dose-Response Studies:** studies of level of response/effect on EM sensitive species with exposure to different EMF sources and intensities
- All this can be facilitated by deploying MREDs and ensuring appropriate/targeted data collection is strongly encouraged

Acknowledgements: Dr Frank Thomsen (DHI; MarVEN Project Manager, Susanna Galloni (European Commission; client project manager).

Contact: Andrew Gill: a.b.gill@cranfield.ac.uk

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Marine Spatial Planning

Anne Marie O'Hagan, Ireland

ucc
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

ERI
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE CORK

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

MaREI
Marine Renewable Energy Ireland

Issue to be Addressed

- Marine Spatial Planning – new way of planning and managing marine activities
- Now a legal requirement in many countries
  - Integrated, ecosystem-based, adaptive, participatory, strategic
- Practices are not well-established but have the **potential** to influence future sectoral development
- Important to know
  (1) How MSP is being implemented in Annex IV Participant Countries
  (2) If MRE is being considered in the development and implementation of MSP and how

Relevance of Industry Progress

- MSP should provide a robust and transparent framework for decision-making in the marine environment
- Consenting is an integral part of MSP and has often occurred in the absence of an over-arching management framework
- It *should* help to provide regulatory certainty
- It *should* reduce conflicts and enable complementary activities to coexist
- It *should* assist in the assessment of cumulative impacts (ecological, social and economic)
- Little evidence base so far…

Current State of Knowledge

- Not all countries have a formalised MSP system
  - Integrated Management Plans, Coastal Management Plans, etc.
- Little consideration of MRE in MSP or equivalent to date
  - Few practical examples, new sector, another form of development…
- Limited demand for marine space in certain jurisdictions
- Scientific data to support MSP needs strengthening – MRE data limited to availability of the physical resource
- Cumulative impacts remain problematic
- Conflicts dealt with on a case-by-case basis
- Rare to have allocated MRE zones, restrictions commonly due to conservation and military uses
- Numerous limitations…

Over-Arching Context

- Arguably issue is not as prominent as it should be at this time
- Certainty and clarity in the regulatory framework is necessary for investors
- Any changes in the strategic planning system impacts upon development decisions
- Cumulative impacts are not adequately addressed in existing instruments (SEA/PEIS, EIA etc.)
- Lack of a strategic planning framework could be used to delay decisions?
- As a developing sector MRE should be communicating its needs to plan-makers (synthesis of needs/issues?)

Path Forward

- Wait and see?
- Desire among regulators for 'best practice' examples already
- Clear messages from those in the sector
- Learn from other marine industrial sectors – available mechanisms?
- Ensure that governance frameworks facilitate sustainable development

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Case Studies and Consenting

Teresa Simas, Portugal

Juan Bald, Spain

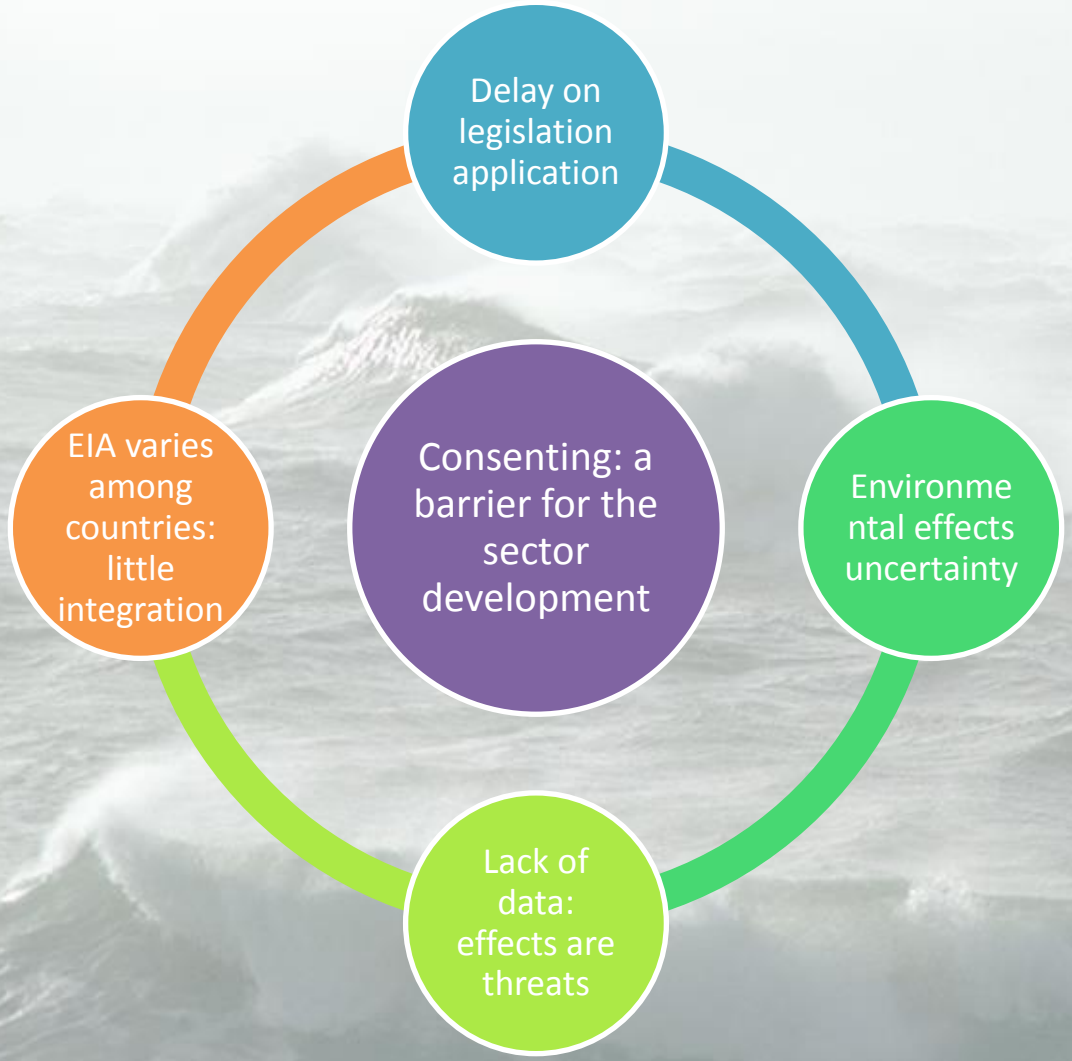
Anne Marie O'Hagan, Ireland

WavEC
Offshore Renewables

azti tecnalia

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

What is the issue and why is it important?



Objectives

- Description and analysis of case studies: wave energy, tidal energy and site type (designated test centre or technology test site)
- To address the barriers regarding consenting for the sector development
- To identify main issues and provide a description of lessons learned
- To discuss recommendations on better practices for the specific case studies

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What is our current state of knowledge?

Data and information on environmental effects are being derived from time-limited single device projects licensed or from specific studies to support EIA

Wave energy case study

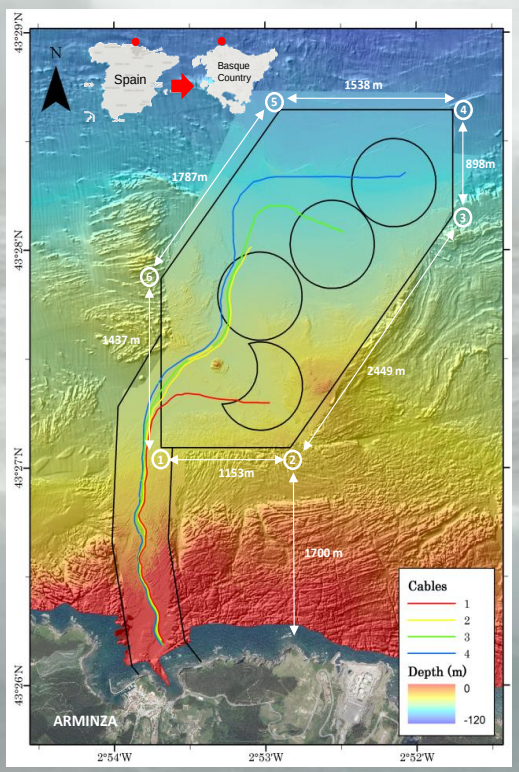
- Technology: WaveRoller
- Location: Peniche, Portugal

Tidal energy case study

- Technology: SeaGen
- Location: Strangford Lough, Northern Ireland

Test site case study

- Test site name: bimep
- Location: Bilbao, Spain



1. Consenting process description
   - Pre-consent requir.
   - Post-consent requir.
2. Environmental monitoring
   - Program
   - Results
   - Reporting
3. Lessons learned
   - Main barriers
   - Recommendations

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ANNEX IV Environmental Effects of Marine Energy Development around the World

How important is this issue in the overall context?

- The consenting process/EIA: a barrier for the ocean energy sector to scale up.
- Is up to date research reaching decision-makers?
- What are current knowledge gaps and uncertainties hindering the process?

Analysis of case studies may help to understand what are the needs

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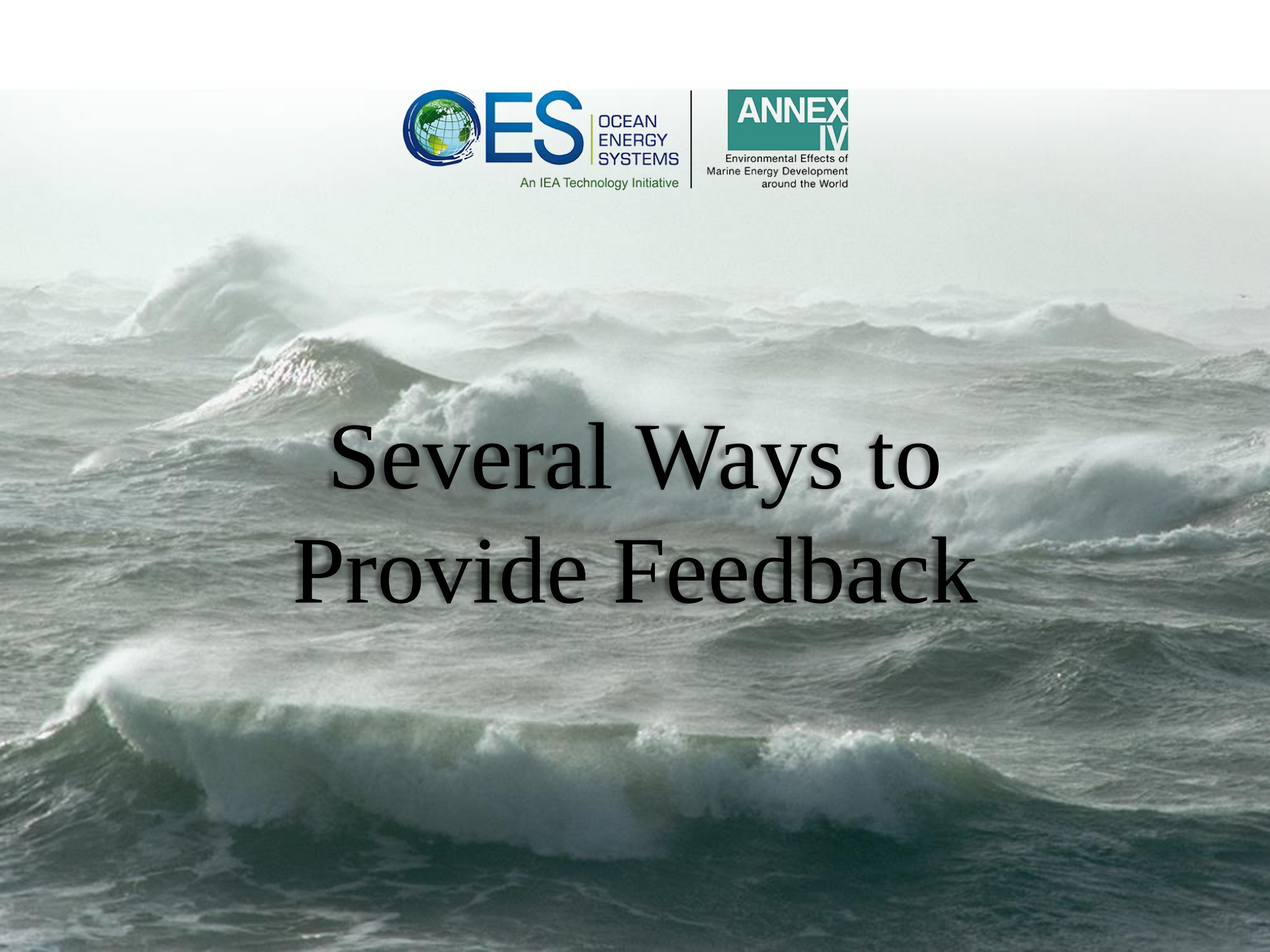
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around the World
Several Ways to
Provide Feedback

Schedule of State of the Science Report

Date	Action
February 2016	Public draft circulated for comment
March 2016	Final changes to report
April 2016	Final report released

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ANNEX IV
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Feedback on State of the Science Report

1. What is your relationship to the MRE industry?
2. How long have you known about the Annex IV project?
3. Are the topics examined in the SoS report the most important topics?
4. Rank the following SoS topic areas in order of importance
5. Are there any new research studies, papers, or reports, that have been recently published, that should be summarized in this report?

http://tethys.pnnl.gov/state-science-report-2016-feedback-survey

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Andrea Copping
Andrea.copping@pnnl.gov
001.206.528.3049

Luke Hanna
Luke.hanna@pnnl.gov

Jonathan Whiting
Jonathan.whiting@pnnl.gov

Nikki Sather
Nichole.sather@pnnl.gov

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