

Evaluating Environmental Risks of Marine and Hydrokinetic (MHK) Development

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Environmental Effects of MHK Energy Development

Project purpose: To address environmental issues needed to get MHK devices in the water through four tasks:

1. Classifying & evaluating environmental effects

- Organize data into a “smart”, searchable database
- Use risk assessment tools to determine the really important risks
- *This task integrates the other tasks in the project*

2. Effects of energy removal from waterbodies

3. Effects on animals

- Electromagnetic fields
- Acoustic output
- Physical interaction
 - Strike, entrainment, impingement
 - Attraction, avoidance

4. Siting constraints and opportunities

- Stakeholder engagement and spatial planning

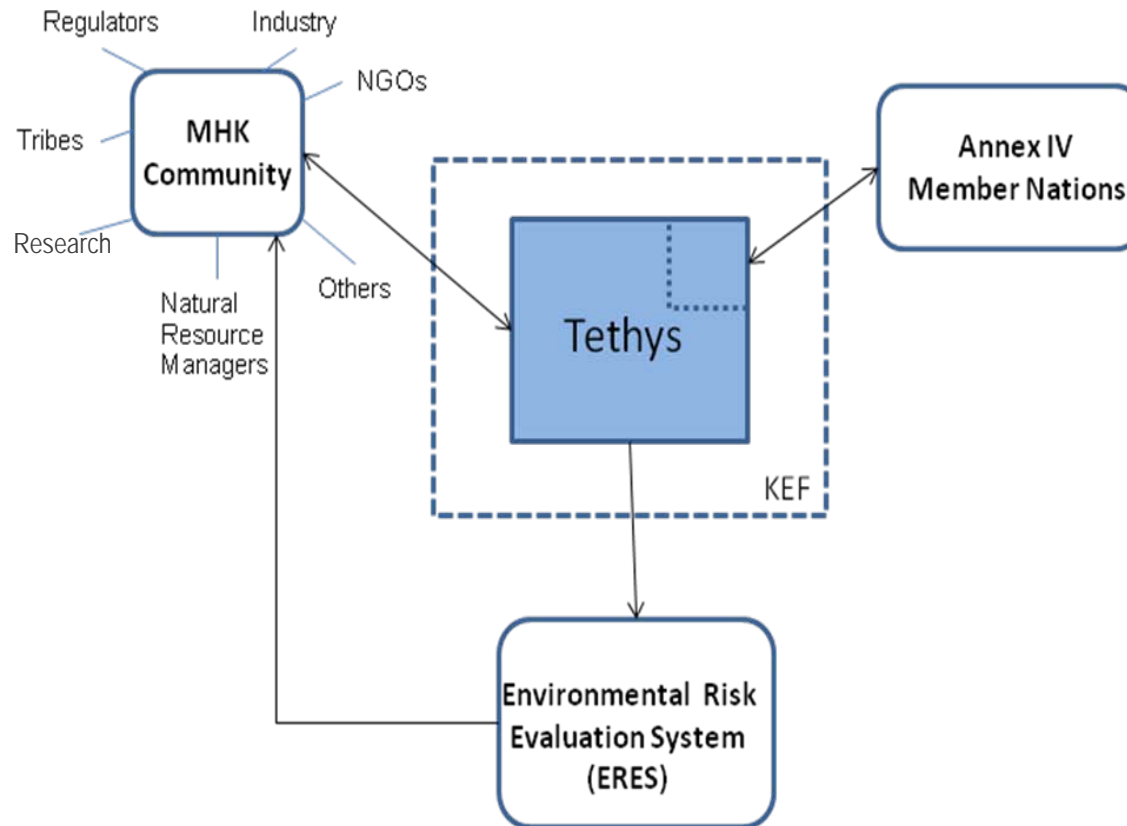


MHK Knowledge Management System, aka “Tethys”

- ▶ Named for Greek Titan goddess (daughter of Gaia, wife of Oceanus) who was seen as the embodiment of the oceans on earth
- ▶ Primary function of the system is as a knowledge base to support the risk framework (ERES)
 - Evidence collection and marshalling
 - Data navigation and management of risk model results
- ▶ Other functions expected to be important
 - Knowledge portal for various stakeholders
 - Portal to other knowledge sources (e.g., Annex IV database under construction)
 - Collaborative environment for MHK research



Tethys serves as knowledge management framework for MHK environmental studies



Tethys image courtesy of Wikipedia and used under Creative Commons license

Tethys platform features:

- ▶ Automated ingest of documents into a wiki-like environment
 - PDF files, Word documents, web pages, etc
 - Automatic semantic encoding of many meta-data fields
- ▶ Semantic “pipeline” processing to aid in recognizing and tagging key types of entities
 - People
 - Places
 - Specific vocabulary terms
- ▶ Rich annotation features
- ▶ Semantic search



Tethys Screen Shots

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Log In / Create Account
U.S. DEPARTMENT OF ENERGY
INTRANET LabWeb Topic Index SBMS PNNL External Search PNNL Intranet

MHK

Page Discussion Annotate Evidence Edit History

Navigation

- Main Page
- Announcements
- Community Portal
- Current Events
- Recent Changes
- Random Page
- Help

Toolbox

- What Links Here
- Related Changes
- Special Pages
- Printable Version
- Permanent Link
- Browse Properties

Main Page

Map Satellite Hybrid Terrain
Overlays

Map data ©2010 Google, Tele Atlas, INEGI - Terms of Use

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Tethys Screen Shots

The screenshot displays the Pacific Northwest National Laboratory (PNNL) Tethys Intranet interface. At the top, the PNNL logo and name are visible, along with the text "Proudly Operated by Battelle Since 1965". Navigation links include "INTRANET", "LabWeb", "Topic Index", "SBMS", and "PNNL External". A search bar is located on the right. The main content area features a large banner image of a coral reef with the text "MHK" overlaid. Below the banner, a navigation menu on the left lists options like "Main Page", "Announcements", "Community Portal", "Current Events", "Recent Changes", "Random Page", and "Help". The "Main Page" is selected, and a map of the Pacific Northwest is displayed. A red pin on the map indicates the "Deception Pass Tidal Energy Project" location. The map includes a scale bar (50 miles, 100 kilometers) and a "Map data ©2010 Google, Tele Atlas" attribution. The footer contains the text "Last Update: 13 April 2010 | Pacific Northwest National Laboratory | Operated by Battelle for the U.S. Department of Energy | Viewed: 86 times" and links for "Security & Privacy" and "Contact Us".

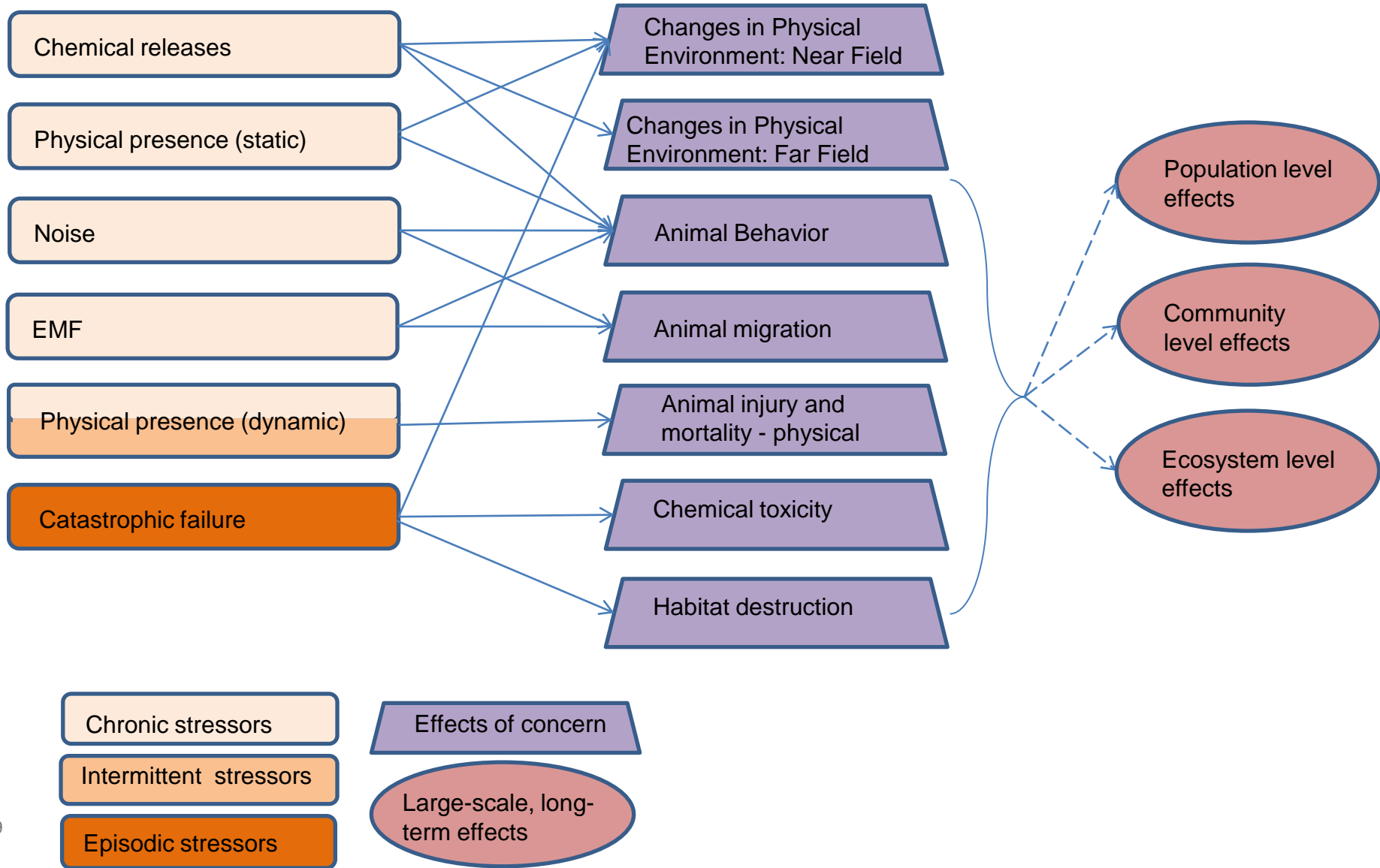
Screen Shot 2: Drill-down to individual project

Tethys Screen Shots

The screenshot shows the Tethys Intranet interface for the Pacific Northwest National Laboratory (PNNL). The header includes the PNNL logo, the text 'Pacific Northwest NATIONAL LABORATORY', and 'Proudly Operated by Battelle Since 1965'. Navigation links include 'INTRANET', 'LabWeb', 'Topic Index', 'SBMS', and 'PNNL External'. A search bar is present with the text 'Search PNNL Intranet'. The main content area features a banner image with the text 'MHK' and a title 'Effect of modified magnetic field on the ocean migration of maturing chum salmon, *Oncorhynchus keta*'. Below the title is a 'Contents' section with a '[hide]' button and a list of links: 1 Abstract, 2 Introduction, 3 Materials and methods (with sub-links 3.1 Magnetic field generator, 3.2 Telemetry system, 3.3 Acoustic Doppler current profiler, and 3.4 Tracking and analysis), 4 Results, 5 Discussion, and 6 References. The 'Abstract' section is expanded, showing the text: 'To investigate the role of magnetic compass orientation in oceanic migrating chum salmon, *Oncorhynchus keta*, an ultrasonic telemetry study was carried out in the western North Pacific off the coast of Kushiro, Hokkaido. Four salmon were fitted with a tag which generated an artificial magnetic field and modified the geomagnetic field around the head of the fish. Initially, the free-ranging salmon with stomach-implanted ultrasonic transmitters were tracked for a period of several hours before the magnetic field was altered for a period of 16 h. The generator produced an alternating magnetic field intensity of about 6 gauss, with polarity which reversed every 11.25 min. There was no observable effect on the horizontal and vertical movements of the salmon when the magnetic field was modified. However, it was noted that salmon slowed their swimming speed significantly before changing direction, regardless of whether the fish were swimming under the normal geomagnetic field or whether they were swimming under the modified field.'

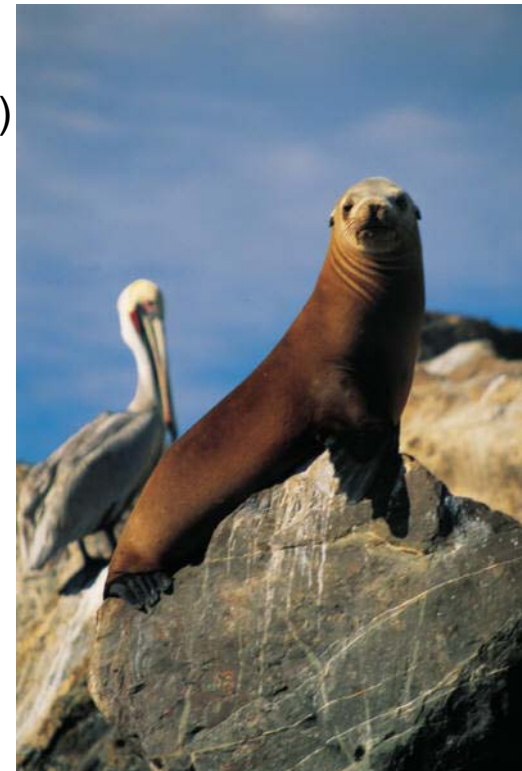
Environmental Interactions of MHK Devices

Operational Phase

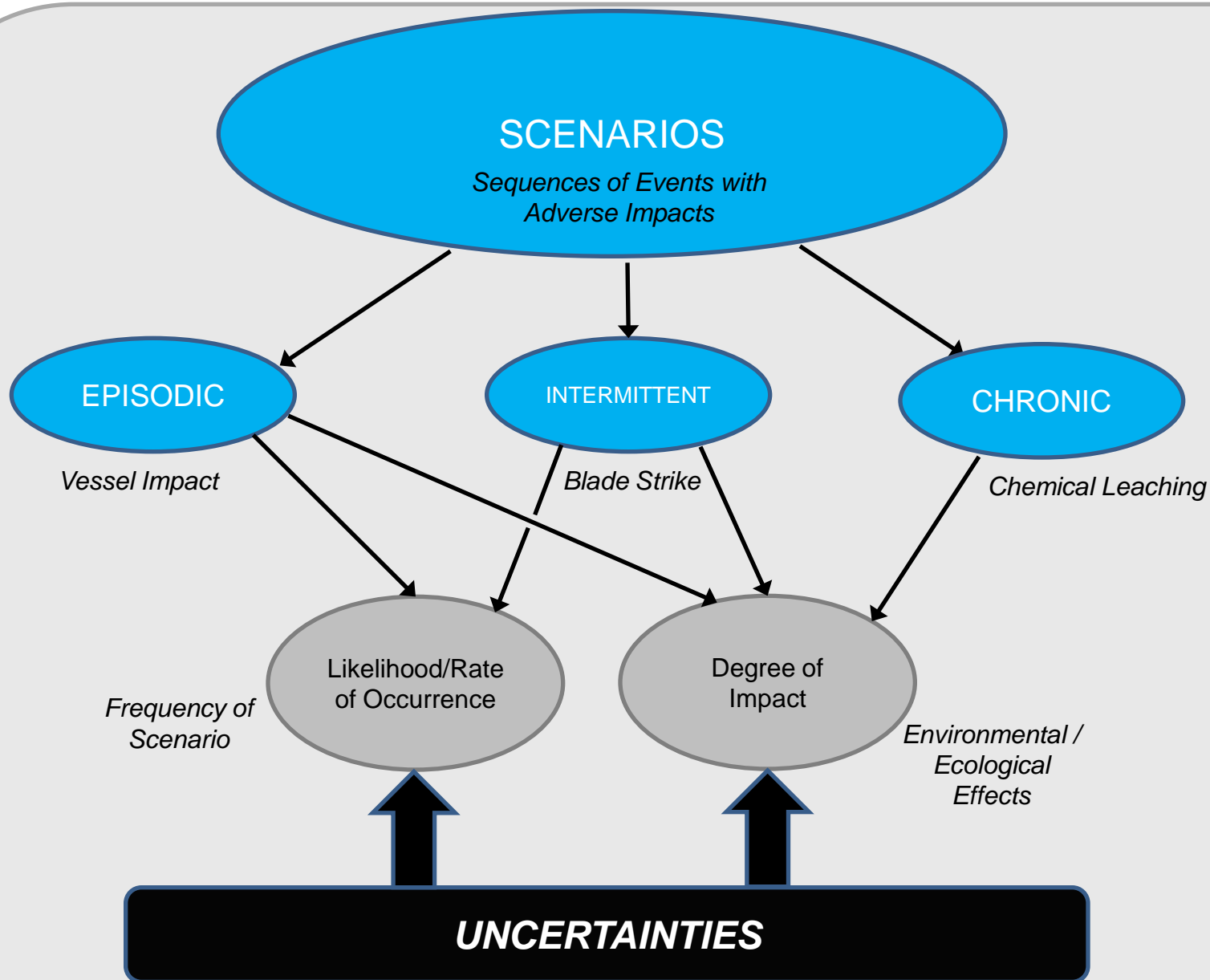


Environmental Risk Evaluation System (ERES) for MHK

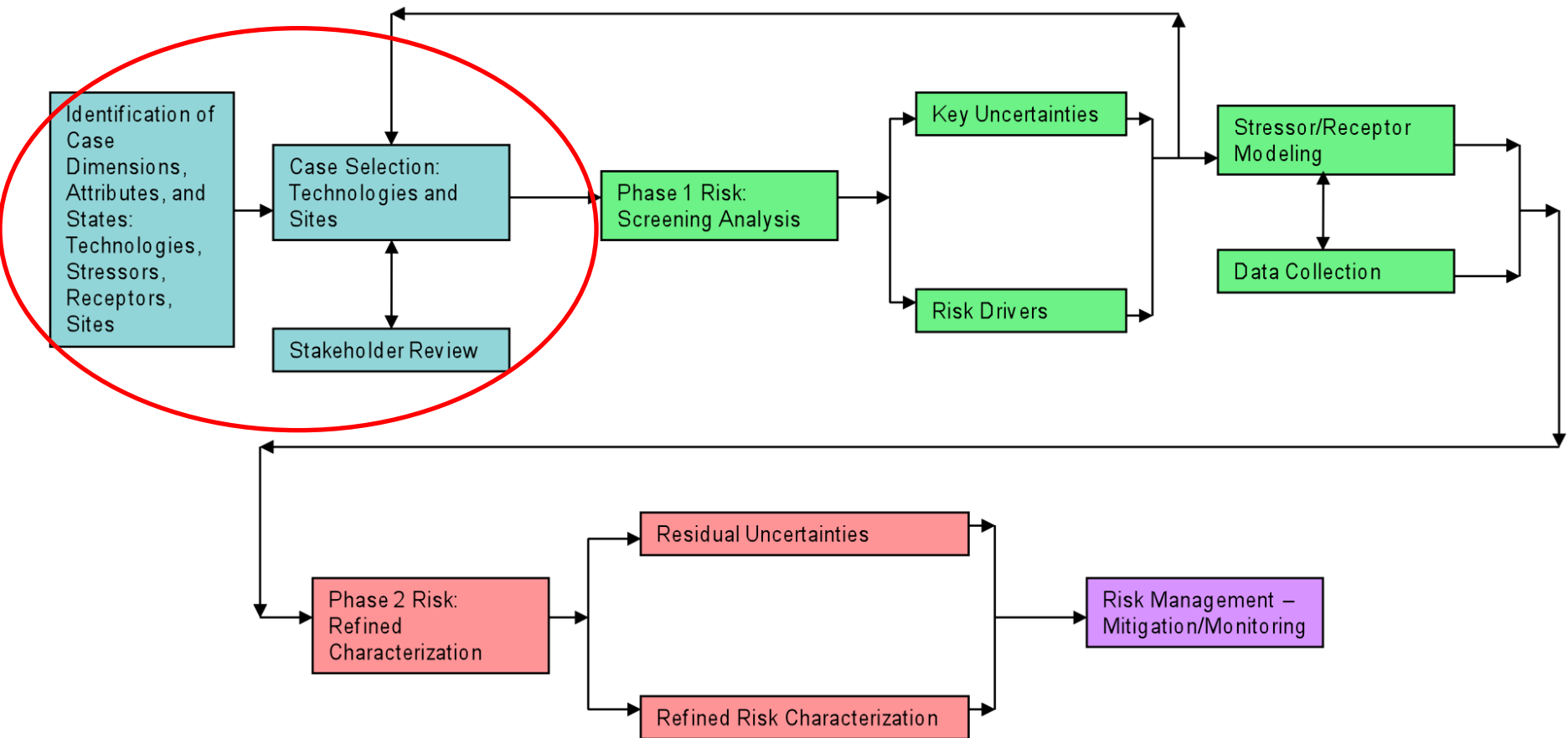
- ▶ Decision support tool to address environmental issues and get devices in the water
- ▶ System for evaluating risk of an MHK project by attributes of:
 - Technology components
 - Waterbodies
 - Site characteristics
 - Receptors (aquatic animals, aquatic system response, etc.)
- ▶ Use of cases to compile risk-relevant attributes; multiple cases will help “span the analytical space”
- ▶ Accumulation of cases will define risk of MHK devices/arrays to create predictive power
- ▶ Risk will be assigned to attributes of cases using:
 - *(initially)* Expert opinion
 - *(as they become available)* Experimental, monitoring, and modeling data



What We Mean by Risk:



Process for Developing MHK Environmental Risk Evaluation System



ERES Case Selection Criteria

1. Real/Readiness (in water w/in 2 yrs; ready technology + ready project)
2. Developer Willingness (willing to share technology + project data)
3. Diverse Representation (does the case span the analytical space)
 - a) Technology Type (tidal, wave, riverine)
 - b) Technology Configuration (e.g. axial flow, horizontal flow)
 - c) Climatic Zone (temperate, tropical, sub-arctic)
4. National Interest (e.g. recipient of DOE funding)
5. Available Data (environmental effects data available)

Decision rules: No/insufficient  Reconsider later or make improvements

Yes/Optimal  Next question or select



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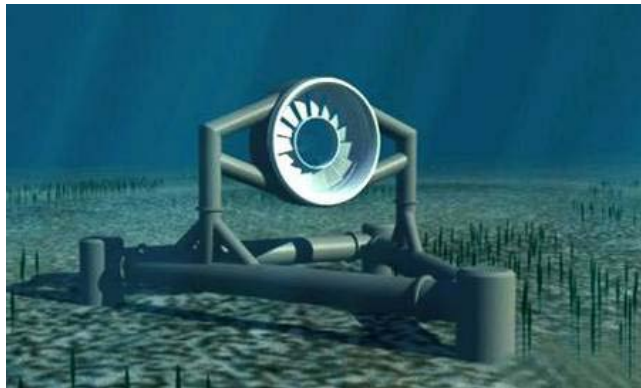
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Initial Case Selections

- ▶ Three risk cases to screening analysis level in FY10; more cases in FY11-12
- ▶ Cases drawn from real projects
- ▶ One tidal, one wave, one riverine

1. TIDAL – Open Hydro in Admiralty Inlet, WA

- Open-Center Turbine in Puget Sound, WA
- Ducted, axial flow, gravity mounted
- Temperate estuarine
- Bidirectional water flow
- Protected Southern Resident Killer Whales, other marine mammals, ESA listed species



FY10 Case Selections

2. RIVERINE - Free Flow Energy at Scotlandville Bend, Mississippi River

- Ducted, axial flow, bottom-mounted, multiple units
- Shallow riverine (comparatively)
- Unidirectional water flow
- Migrating birds, endangered sturgeon

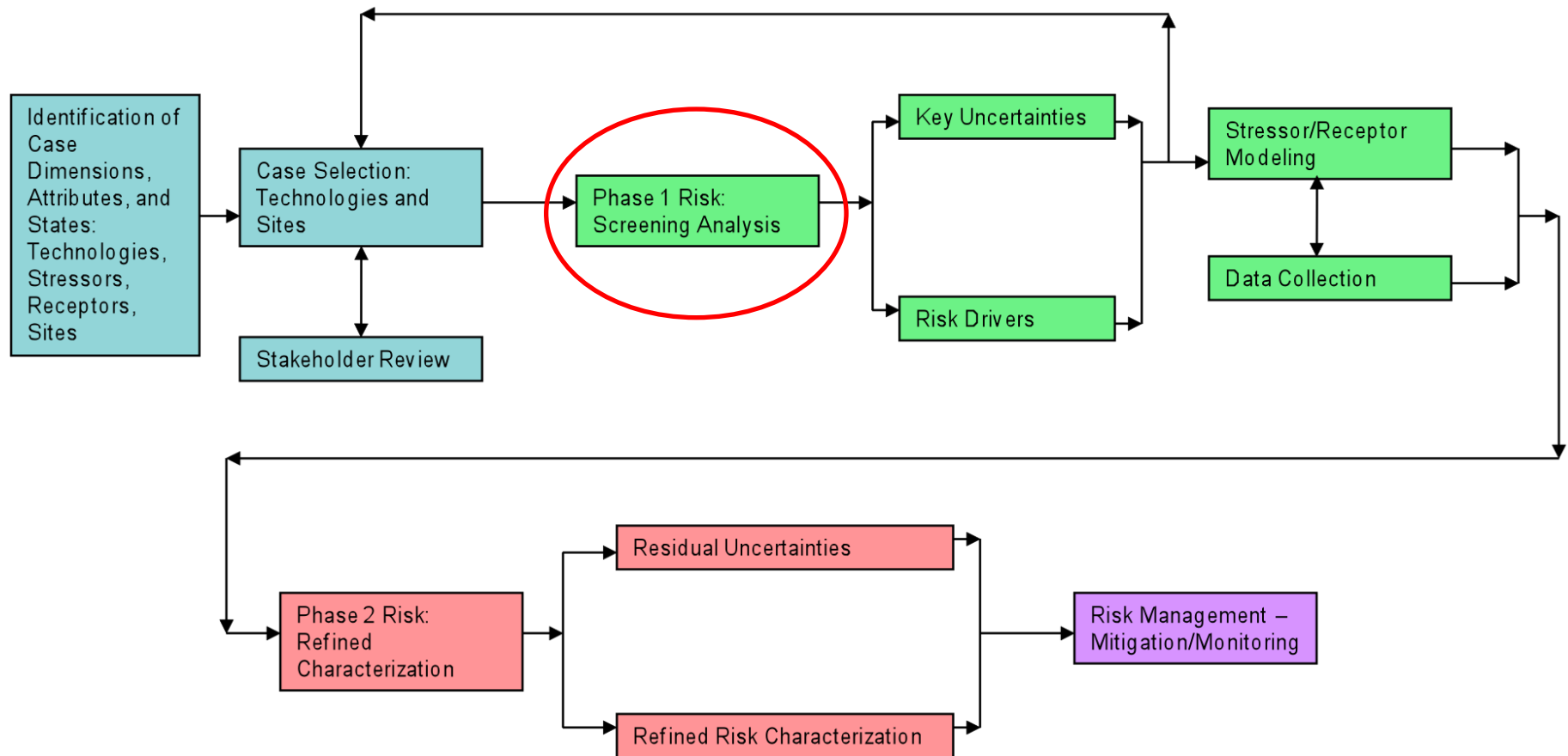


3. WAVE - OPT PowerBuoy off Reedsport, OR

- Point attenuator
- Open coast continental shelf (< 3 mi offshore)
- Dominant wave direction
- Migrating whales, endangered fish



Process for Developing MHK Environmental Risk Evaluation System

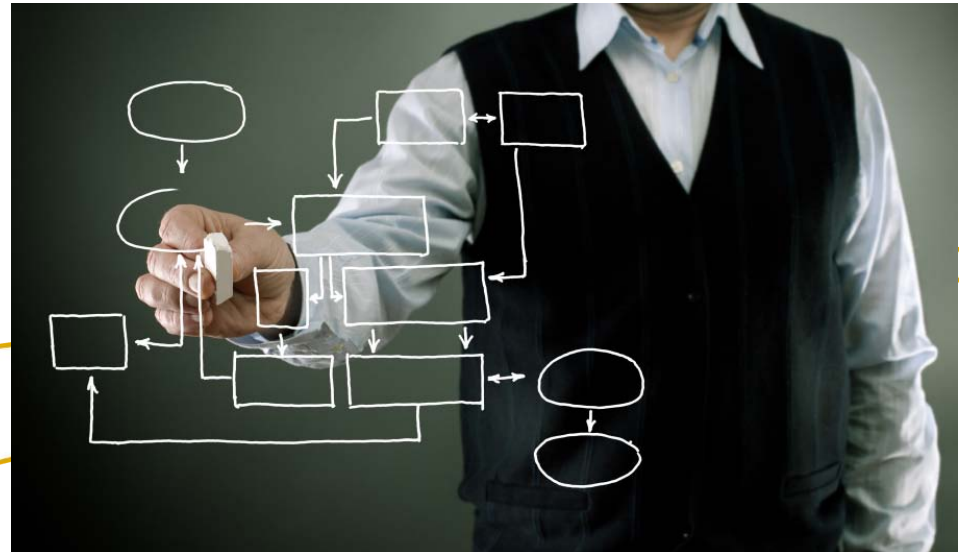


Current ERES Work

► Screening Analysis:

- Determine risk-relevance of each stressor/receptor interaction
- Determine “risk factors” to rank stressor/receptor interactions:
 - population size
 - affected life stage
 - proximity to device
- Work with scientists to rank risks for each receptor according to risk factors

► Output = Three screening analyses by Oct 2010



Ranking Scheme

Take into account risk weighting:

Migrating fish

- Sort
&
rank**
1. Blade strike
Tidal
 2. Behavior, attraction
Wave
 - 3....

Endangered
marine
mammals

1. Entanglement
mooring lines
Wave
2. Blade strike
Tidal
3. Change in
migration,
avoidance
Wave

Changes in
water quality,
sedimentation
patterns

1. Scour of river
bed
River
2. Hypoxia farfield
Tidal
3. Change in
beach form
Wave

Benthic
habitats

1. Disturbance due
to anchoring
Wave
2. Scour of river
bottom
River
- 3.....



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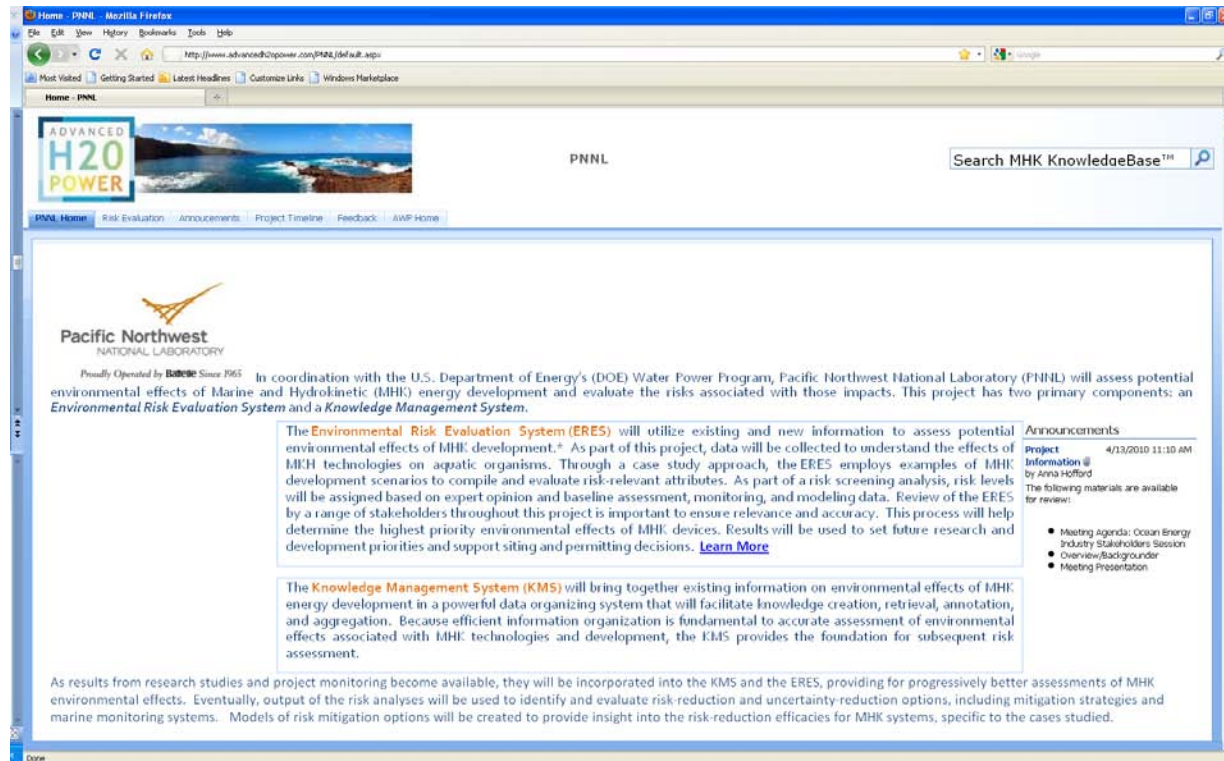
Next Steps and Outcomes of ERES

- ▶ Risk modeling: (2010-2012)
 - Deterministic, probabilistic, impact assessment, sensitivity analysis
 - Output = risk scores
- ▶ Design of risk management, mitigation
- ▶ Risk Communication:
 - Guidance for regulators
 - Visualization tools



For More Information

Project website: www.advancedh2opower.com/PNNL



Annex IV



- ▶ International Energy Agency – Ocean Energy Systems
 - “Annex” is an agreement to carry out collaborative tasks

- ▶ IEA Annex IV
 - Eight member nations, U.S. is lead, DOE/MMS/FERC
 - Gather environmental effects data from member nations, evaluate effects, monitoring methods, mitigation strategies

- ▶ PNNL will lead for U.S.
 - Create portion of *Tethys* for Annex IV data
 - Contractor to assist with data collection, analysis
 - Experts’ workshop in Dublin in September

Acknowledgements & Contact Information

- ▶ This work supported by the US Department of Energy Office of Energy Efficiency and Renewable Energy's Wind & Hydropower Technologies Office (WHTP)
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