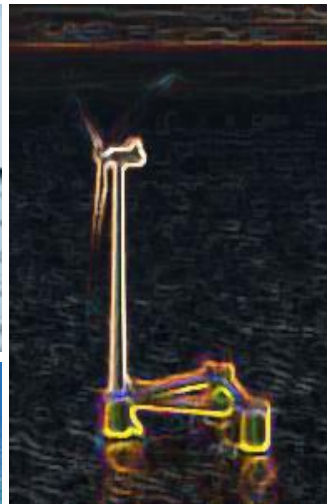




OCS Study
BOEM 2013-0113

OREGON MARINE RENEWABLE ENERGY ENVIRONMENTAL SCIENCE CONFERENCE PROCEEDINGS



George W. Boehlert
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U.S. Department of the Interior
Bureau of Ocean Energy Management
Pacific Region



Cooperative Agreement
Hatfield Marine Science Center
Oregon State University

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OREGON MARINE RENEWABLE ENERGY ENVIRONMENTAL SCIENCE CONFERENCE PROCEEDINGS

FINAL REPORT

APRIL 2013

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EXECUTIVE SUMMARY

Development of wave and offshore wind-based marine renewable energy is anticipated on the Outer Continental Shelf (OCS) off Oregon and much of the Pacific Northwest in the coming decade. Multiple issues related to environmental considerations and information needs remain for these emerging industries. The Oregon Marine Renewable Energy Environmental Science Conference was held 28-29 November 2012, at Oregon State University (OSU) in Corvallis, Oregon. The conference brought together experts to outline research and monitoring needs to assess environmental impacts of these technologies. It has been over five years since the last workshop on marine renewable energy (Boehlert et al. 2008) examined the environmental effects of wave energy off the Oregon coast; there has been no comprehensive evaluation of data needs for offshore wind energy on the West Coast to date. New research, technology development, and other activities in the intervening five years create a need to assess the current research inventory and identify information gaps and priorities for future research associated with marine renewable energy.

The conference was organized via a partnership between the Bureau of Ocean Energy Management (BOEM) and several entities within the state of Oregon. The primary goal of the conference was to evaluate environmental research needs associated with wave and offshore wind energy development in the Pacific Northwest. The conference had three major objectives: i) showcase research recently completed or currently underway that addresses environmental questions associated with marine renewable energy; ii) synthesize new research and existing information with the aim of distilling it into products that agencies and resource managers could use to carry out their planning and management duties; and iii) identify gaps in our understanding of the technologies and potentially affected systems useful to scientists, managers and funders to determine where to focus future research efforts.

Prior to the conference, a “gap analysis” was drafted and distributed for review. This analysis examined existing studies and identified apparent gaps in the environmental research needed to inform decisions about wave and offshore wind development off the Oregon coast. The gap analysis has since been revised with input from conference attendees and breakout groups and is included as an appendix (Appendix B) to this document.

The first day of the conference was designed as an open event to encourage broad participation ranging from technical experts and agency scientists to the general public. Day one featured invited speakers selected by the Steering Committee to showcase how state and federal agencies utilize environmental information, to present expert synthesis of our current knowledge on key topics, and to feature environmental studies providing information on the newest research, much of it in progress at the present time. The day concluded with a presentation and discussion on the draft gap analysis paper to provide grist for discussion on day 2. A reception and poster session of contributed papers allowed other relevant research studies to be highlighted by conference participants.

The second day of the conference was an “Experts’ Workshop” where invited scientists with technical expertise on marine ecosystems and environmental effects of marine renewable energy met to review the gap analysis and provide advice on future priority studies to address the gaps. Three facilitated breakout sessions focused on i) baseline studies, ii) impact and short-term studies, and iii) monitoring and long-term studies. The groups were asked to develop priorities that could be mapped to the categories that agencies must address as projects are proposed and

reviewed in the OCS region off Oregon. The breakout groups also addressed a variety of key questions related to the conference's scientific objectives.

The principal research priorities identified were specific to the three breakout groups. The highest-priority projects recommended by each group were as follows:

Baseline:

- Seafloor characterization at a broad-scale resolution, especially 3-10 miles offshore, in presumed sedimentary areas, with the goal of identifying sensitive unidentified ecological resources in areas that might be desirable for renewable energy development.
- Distributions of non-commercial species (i.e., forage fish species) integral to ecosystem dynamics and indicative of system vulnerability.
- Identification of ecological hotspots (including temporal variability, and especially winter and/or off-season sampling months).
- Multiple aspects of basic seabird biology and ecology need to be characterized, including mapping of at-sea migratory corridors, basic distribution information, and behavioral studies.
- Information is needed about marine mammal distribution, including temporal (inter-annual) variability, distribution in winter and/or off-season sampling months, diel distribution (as day/night distributions are likely to differ for some species), and decadal scale variation in distribution.

Impact/Short-term:

- Determine the far field and near field impacts on sediment transport induced by energy reduction.
- Measure acoustic energy transmitted by wave energy converters (WECs) and evaluate impacts by comparing to baseline ambient levels.
- Determine the electromagnetic field impacts on sensitive or migrating species, e.g., sturgeon, elasmobranchs, salmonids, crustaceans, and resident fish species.
- Evaluate thresholds for EMF detection in key species using behavioral or other approaches.
- Evaluate the impacts of WEC-produced noise on marine mammals.
- If collision risk for marine mammals exists with WECs, determine whether acoustic deterrence devices can reduce collision risk.
- Evaluate bird and bat distribution and migration patterns (including fine-scale nearshore surveys), flight altitude, and nocturnal flight characteristics.
- Determine whether and how artificial reef/FADs will impact out-migrating salmonid smolts.
- Determine the impacts of structures on green sturgeon.
- Assess the scaling impacts on benthic communities/benthic habitat, especially with respect to sediment transport and settling (based on possible circulation changes).
- Collect baseline data about noise from wind devices, including assessments of how those noise levels will exceed ambient levels, in order to determine impacts of device noise (for offshore wind only).
- Assess the potential collision impacts of cetaceans with wind energy devices/structures/mooring cables (offshore wind only).

Monitoring:

- Improve acoustics receiver network for fishes, especially listed sturgeon (which already have acoustic tags implanted in a large number of fishes).
- Conduct studies to understand habitat utilization of seabirds foraging offshore in three-dimensional air space.
- Determine methodology to confidently monitor bird strikes, including during severe weather.
- Initiate and continue long term monitoring of distribution of endangered fish, mammals, and birds (marbled murrelet, Stellar sea lion, whales, salmon, sturgeon).
- Determine encounter rates of whales for these types of facilities. Monitor opportunistic projects (e.g. Pacific Marine Energy Center, to be sited off of Newport) or existing tension leg projects and sperm whale data in GOM to gain a better understanding.

The group reports also addressed the importance of partnerships and maximizing the use of existing studies and programs. Improved data sharing, cooperative research cruises, and some form of data clearinghouse would likewise improve efficiency of environmental data collection and its application to multiple purposes. Similarly, impact studies can benefit from research conducted elsewhere on renewables and research on analog systems, like oil platforms, artificial reefs, and moorings and anchoring systems; the Impacts group discussed the conditions under which these results can be beneficially applied to marine renewable energy facilities off Oregon. Finally, the Monitoring group addressed how “shifting baselines” may impact the ability to detect change in monitoring programs.

The results of this conference will be widely disseminated. This report includes abstracts of presented papers and contributed posters, the output of the breakout groups, the gap analysis report, and a list of participants. It is available in PDF format in a permanent electronic archive (<http://hdl.handle.net/1957/36597>) that also includes the slides from presentations at the conference and other materials provided to participants. The PDF is also available on the BOEM web site (http://www.data.boem.gov/homepg/data_center/other/epis/espismaster.asp?appid=1).

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1. INTRODUCTION, BACKGROUND, AND CONFERENCE OBJECTIVES

George W. Boehlert and Mary Elaine Helix

Development of marine renewable energy, focused on the extraction of energy from wind and waves, is anticipated on the Outer Continental Shelf (OCS) off Oregon and the Pacific Northwest in the near future. Multiple issues related to the environmental considerations and information needs remain for these emerging industries, and are of interest to researchers, agencies and stakeholders. Currently, universities research diverse questions regarding potential environmental effects while state and federal entities evaluate proposed development via permitting processes and collectively review draft plans. The last workshop (in 2007) examining the environmental effects of marine renewables off the Oregon coast dealt specifically with wave energy (Boehlert et al. 2008). New research, technology development, and other activities which have taken place in the intervening five years create a need to gather information, assess the current research inventory, and identify information gaps and priorities for new research associated with marine renewable energy. There have been no efforts dedicated to understanding the environmental effects of offshore wind development off Oregon, so our background is currently based on assessments of wind technologies operating at other locations (BOEM 2011) or development of environmental study protocols for the West Coast (Boehlert et al. 2012).

This conference was stimulated by the formation and deliberations of the Bureau of Ocean Energy Management (BOEM) Oregon OCS Renewable Energy Task Force. This intergovernmental group, comprised of seven federal agencies, nine state agencies, three county governments, and four tribal governments, was formed in 2011 to coordinate and consult with the State of Oregon and others on potential marine renewable energy activities, such as leasing, on the Outer Continental Shelf off Oregon. In January 2012, Patty Snow, the Manager of the Oregon Coastal Management Program (OCMP), a division of the Oregon Department of Land Conservation and Development (DLCD), sent a letter to BOEM requesting a scientific conference to address the needed environmental studies. BOEM agreed, and contracted with Oregon State University to convene the conference in November 2012. The development and implementation of the conference (and associated Experts' Workshop) was overseen by a Steering Committee with three members from BOEM (Ann Scarborough Bull, Mary Elaine Helix, and Donna Schroeder), two from Oregon State University (George Boehlert and Sarah Henkel), and two from State of Oregon resource agencies (Caren Braby and Paul Klarin) – the same membership as the editors of this proceedings volume.

The conference was developed with three major goals. The first goal was to showcase primary research recently completed or currently underway that addresses environmental questions associated with wave and wind energy development in the Pacific Northwest. The second was to synthesize new research and existing information with the aim of distilling it into products that agencies and resource managers can use to carry out their planning and management duties. The third goal was to identify gaps in our understanding of the technologies or potentially affected systems that then can be used for scientists, managers and funders to determine where to focus future research efforts.

While the Steering Committee agreed to array the discussions by categories dictated by the National Environmental Policy Act (NEPA), it was agreed early in the planning process that socioeconomic aspects as identified in NEPA would not be considered in this forum. The Committee felt that focusing on environmental issues represented an attainable goal for the conference given the time and logistic constraints, and that the important issues represented in

the socioeconomic realm could require a like number of specialists and could take an equal amount of time and effort.

In light of the conference goals, the Steering Committee worked to develop a set of objectives and an agenda. Specifically, the Committee sought to:

- assemble scientists with relevant expertise, key regulatory agency staff, and stakeholders in a workshop setting conducive to free information exchange;
- identify existing and planned scientific research that addresses environmental concerns associated with the development of marine renewable energy;
- identify data gaps related to evaluation of environmental effects and the scientific approaches needed to address these data gaps;
- improve communication among all stakeholders in marine renewable energy development off Oregon; and
- develop conference products (website, proceedings document) that will make this information broadly available to all Oregon marine renewable energy stakeholders.

Prior to the conference two websites were developed. The first, the conference and registration website (<http://or-rescience.org>), was designed to provide a broad overview of the conference, provide registration and contributed abstract submission, and link to the second website. The second website (<http://hmsc.oregonstate.edu/rec>) provided a higher level of detail, including the meeting agenda, abstracts for invited and contributed talks, and links to available background literature and previous conferences. Additionally, this website will archive the conference materials. The Steering Committee also commissioned a “gap analysis” prior to the conference. The purpose of this analysis was to review existing studies and to develop a draft, first cut at identifying the gaps in needed environmental studies supporting wave and offshore wind development off the Oregon Coast. This draft was completed prior to the conference and distributed via the second web page as a “Conference Draft;” participants were alerted of its availability and encouraged to review it prior to the conference. The document has since been revised with input from conference attendees and is included in this document (Appendix B).

The agenda was developed as a two-day event (see Appendix A). The first day of the conference was designed to be an open event for to up 100 registrants; the intent was to encourage broad participation ranging from technical experts and agency scientists to the general public. The first three sessions featured invited speakers selected by the Steering Committee to showcase i) how state and federal agencies utilize the environmental information collected, ii) expert synthesis of our current knowledge on key topics, and iii) featured environmental studies, providing information on the newest research, much of it in progress at the present time. A summary of the gap analysis paper was then presented to set the stage for the breakout groups the following day. The final session was a reception and poster session of contributed papers, where other relevant research studies could be highlighted by conference participants.

The second day was an “Experts’ Workshop” where invited scientists with technical expertise in marine ecosystems and the environmental effects of marine renewable energy met to review the gap analysis and provide advice on priorities for future studies. The Steering Committee selected participants based on the goal of assembling a balanced and diverse group that included scientists with expertise needed to address key environmental considerations and state and federal agency administrators and scientists responsible for the appropriate programs. A focal point of the workshop was a set of three facilitated breakout sessions with specific objectives. These sessions track with the Federal/State agency energy facility review process, providing feedback to directly inform their review. The three breakout session topics were: i)

baseline studies, ii) impact and short-term studies, and iii) monitoring and long-term studies. The instructions to the breakout groups were very specific, asking participants to develop priorities based on a matrix of NEPA criteria. This approach provided a clear context of applicability to agency requirements, requesting that participants develop priorities that could be mapped to the categories that agencies must address as projects are proposed and reviewed in the OCS region off Oregon. The breakout groups also addressed a variety of key questions related to the conference's scientific objectives.

This report is the output of the conference and Experts' Workshop described above. It is organized in a manner similar to that of the agenda, with extended abstracts of invited papers, the gap analysis paper, and the breakout group reports in the body of the report, and appendices consisting of the conference agenda, instructions to the breakout groups, contributed abstracts, and a list of the conference participants. We have also developed a permanent electronic archive at <http://hdl.handle.net/1957/36597> that includes this report as well as a background document to the gap analysis and PDF versions of the electronic presentations from the first day of the conference. Appropriate links are contained in the electronic version of this report.

2. AGENCY PERSPECTIVES AND INFORMATION NEEDS

2.1 FEDERAL/BOEM PERSPECTIVE

Ann Scarborough Bull

Chief of Environmental Sciences, Pacific Region, Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) Pacific Region is actively addressing renewable energy through our Environmental Sciences Program (ESP). Continuation of a robust ESP in the Pacific Region is critical to ensuring the development of informed decisions and retaining confidence in the quality of these decisions and the bureau's commitment to sound science. The Pacific ESP is evolving and expanding our area of study along with our new responsibilities for the Outer Continental Shelf (OCS) renewable energy program and formation of a Renewable Energy OCS Task Force with the state of Oregon. Our engagement in renewable energy projects to be sited offshore of Oregon involves interaction with multiple stakeholders, both local and regional, such as federal and state agencies with decision authorities and/or resource management roles, policy makers, project developers, ocean and coastal resource users, Native Americans, and special interest groups.

BOEM's objectives for the Oregon Marine Renewable Energy Environmental Science Conference are to showcase completed and ongoing research that addresses environmental questions associated with wave and wind energy development in the Pacific Northwest; to synthesize new research and existing information and distill it into products that agencies and resource managers can use; and to identify information gaps related to the technologies or potentially affected systems that can be used for scientists, managers and funders to focus future research efforts.

The Pacific Region's ESP started in 1973 and has cumulatively funded about 306 studies at a value of nearly \$141 million including three studies specific to West Coast renewable energy. The ESP has pioneered research on the OCS along the entire Pacific Coast of the continental United States. In many cases, the results of the Pacific Region's science efforts represent the only research ever conducted in the ocean along the coast. To date, the ESP's accomplishments include:

- 306 BOEM Pacific Region studies completed at nearly \$141 million dollars. Three renewable energy studies were completed in the Pacific Region:
 - *Summary of Knowledge for Selected Pacific Coast Areas*: Report 2010-014
 - *Effects of EMF from Transmission Lines on Marine Species*: Report 2011-09
 - *Protocols for Baseline Studies and Monitoring for Ocean Renewables*: Report 2012-013

See <http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Pacific-Region/Studies/Completed-Studies.aspx> for more information. Additional information related to studies for renewable energy from BOEM is available at <http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Renewable-Energy/Renewable-Energy.aspx>

- 26 on-going studies in fiscal year 2012 for a total of approximately \$13.2 million dollars; 18 of these studies were related to renewable energy for a total of approximately \$10.3 million dollars (70% of number and 80% of budget). See <http://www.boem.gov/Environmental->

[Stewardship/Environmental-Studies/Pacific-Region/Studies/Current-Environmental-Studies.aspx](#)

- Five additional renewable energy studies for Fiscal Year 2013 for a total of approximately \$3.6 million dollars, with two specifically informative to Oregon:
 - *Using Ongoing Activities as Surrogates to Predict Potential Ecological Impacts from Marine Renewable Energy*: Study PC-13-02
 - *Predicting the Consequences of Wave Energy Absorption from Marine Renewable Energy*: Study PC-13-05
- For the Fiscal Year (FY) 2013-2015 Study Development Plan (SDP), BOEM Pacific Region (POCSR) reached out to over 30 stakeholder groups, explained BOEM's regulatory responsibilities regarding scientific research and the study process and requested input for the FY 2013-2015 Studies Development Plan (SDP). Stakeholders comprised the states of WA, OR, CA and HI, multiple federal agencies, and tribal governments. POCSR considered 23 study ideas for the FY 2013-2015 SDP: 12 study ideas from stakeholders and 11 from regional Subject Matter Experts. Through a consensus prioritization process, based on regional information needs, staff workload and comments by the BOEM Scientific Committee, POCSR recommended eight studies for the FY 2013-2015 SDP to BOEM Division of Environmental Sciences for consideration. As a result of priority needs across BOEM, POCSR received funds for six studies. Two of the six studies, i.e. 30%, originated, at least in part, from stakeholders.
- BOEM Pacific Region hosted the May 2012 BOEM Scientific Committee meeting where we obtained feedback on our SDP. We are increasing our studies' focus on renewable energy: about 70% of our total number of studies and 80% of our studies budget for FY 2013-2015 will apply directly to the Pacific Renewable Energy Program.

BOEM POCSR partnered with OSU to host today's Oregon Marine Renewable Energy Environmental Science Conference on campus in Corvallis, OR, on marine hydrokinetics and deepwater wind environmental science. BOEM studies are highlighted as well as regional environmental science conducted by other agencies and institutions. The intent is to work with scientists and stakeholders to identify available information, issues and data gaps. See <http://or-rescience.org>

2.2. USING ENVIRONMENTAL INFORMATION IN DECISION MAKING AT BOEM

Alan D. Thornhill

Chief Environmental Officer, Office of Environmental Programs, Bureau of Ocean Energy Management

This presentation will provide an overview of how the Bureau of Ocean Energy Management (BOEM) uses environmental information for decision-making and the role BOEM's Environmental Studies Program (ESP) plays in fulfilling information needs to inform Outer Continental Shelf (OCS) resource management decisions.

The ESP conducts and oversees top-quality scientific research to inform policy and management decisions regarding leasing and development of OCS conventional and renewable energy and mineral resources. This research allows BOEM to manage the exploration and development of the nation's offshore resources in a way that appropriately balances economic growth, energy development, and environmental protection through oil and gas leases, renewable energy development, and environmental reviews and studies.

Environmental studies funded through the ESP are conducted to collect baseline, site-specific, and long-term monitoring data. This environmental information is used to identify

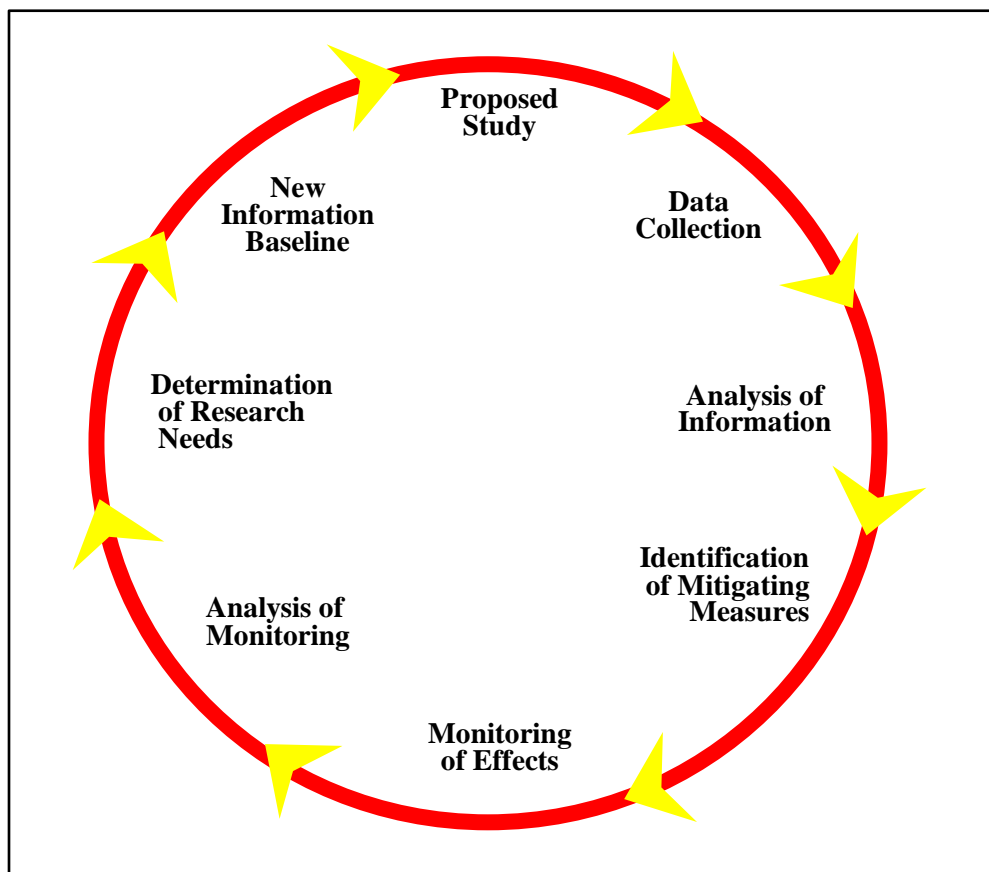


Figure 1: The BOEM Environmental Studies Program uses an adaptive management approach to decision making. New studies and analysis identify appropriate mitigation measures; existing mitigation measures are then adapted based on monitoring results.

appropriate mitigation measures which can be adapted based on the results of monitoring (see Figure 1). The ESP environmental studies focus on multiple disciplines including physical oceanography, atmospheric sciences, biology, protected species, social sciences and economics, submerged cultural resources, and the environmental effects of energy development. The ESP oversees scientific research conducted through contracts, cooperative agreements with state institutions or universities, and interagency agreements. These types of arrangements enable flexibility to leverage resources, meet national priorities, and satisfy common needs for robust scientific information at the time it is required.

The ESP has a robust process to ensure quality science is developed and used in decision making. The OCS Scientific Committee, comprised of external experts from a variety of disciplines, advises the Secretary of the Interior, through the BOEM Director, on the feasibility, appropriateness, and scientific value of the proposed research. In addition, the Secretary of the Interior has established a department-wide Scientific and Scholarly Integrity Policy. BOEM was involved in developing the policy and is fully committed to the principles therein. This policy helps ensure and maintain the integrity of scientific and scholarly activities used in decision-making across the department.

The results of completed studies, including more than 2,000 research reports, are available online to the public through the Environmental Studies Program Information System (ESPIS). To learn more about BOEM's ongoing work to further environmental studies, go to: <http://www.boem.gov/studies/>.

2.3. STATE PERSPECTIVE ON MARINE RENEWABLE ENERGY DEVELOPMENT

Gabriela Goldfarb

Natural Resources Policy Advisor, Governor Kitzhaber's Office, State of Oregon

On behalf of Governor Kitzhaber, thank you for this opportunity to join you and welcome you to this Marine Renewable Energy Environmental Science Conference.

You have come together to do compelling work. Thanks to this gathering we will more clearly understand the state of the science with respect to the environmental issues surrounding wave and wind energy development in the Pacific Northwest, and illuminate where we need to go from here. Most relevant to the State of Oregon, you are in a position to synthesize information that can inform our decisions as policy makers and managers, as we wrestle with how to balance the promise of an exciting new technology with the need to protect our ocean and its ecosystems, which are the source of so much material and spiritual bounty.

Earlier this fall, Governor Kitzhaber spoke to the issue of marine renewable energy when he spoke at the Oregon Wave Energy Trust conference. He called out energy as the single issue that will have the greatest impact on Oregon, and the Pacific Northwest, in the coming decade.

Oregon is already well along the path to changing the way we power our homes and businesses by tapping our state's wind, solar, geothermal and bio-energy resources. This is not just for the sake of energy independence and reducing our reliance on fossil fuels, important as those goals are, but also good economic policy. Since 2007, the wind industry alone has invested over \$5 billion in Oregon.

We are looking to the oceans to play a major role in the next generation of clean energy development. The Governor's new Ten Year Energy Action Plan identifies responsibly sited wave energy as having the potential to help power Oregon, foster a new industry, and generate sustainable models that can be exported to other states and countries around the world. The State has invested over \$10 million in the Oregon Wave Energy Trust and its efforts to lay a foundation for a wave energy industry.

And we have something to show for it. Oregon can boast a number of "firsts" in this emerging industry. The Northwest National Marine Renewable Energy Center (NNMREC) deployed the first wave energy test system in the United States off Newport, and will soon announce a location for a grid-connected testing facility. This coming spring, Ocean Power Technologies will be deploying the first Federal Energy Regulatory Commission (FERC)-licensed commercial wave energy device off Reedsport.

At the same time, the State of Oregon is providing a pathway to the orderly and responsible deployment of renewable ocean energy in state waters. We are in the final stretch of establishing, as part of Oregon's Territorial Sea Plan, a plan for where to site – and where not to site – marine renewable energy developments in our jurisdiction. But it has also long been Oregon's policy to recognize our interests beyond state waters, because what happens in federal waters directly impacts our citizens and our environment both on and offshore. And so, in 2000 we designated in our statewide planning goal for the ocean, an Ocean Stewardship Area that extends from the shore to the toe of the Continental Shelf. That Stewardship Area encompasses the regional ocean ecosystem that is host to the most intense concentration of human activities offshore, and affects our coastal environment and communities onshore. That is where we have to manage the human uses of our ocean, of which marine renewable energy is the newest expression.

And that is where all of you come in. Before we can advance the potential of this new energy source, both Oregon and the federal government need a much better understanding of the

ecological and other natural resources we have off our coast, we need to understand how marine renewable energy development might interact with those resources, and we will need to know how to use those lessons in adaptively managing this evolving new use of the ocean. And we cannot do that without you.

This conference represents an important opportunity to expand our knowledge of ocean energy and the environment. But it can't end here. We need, and look forward to establishing, a deep and ongoing collaboration among the State of Oregon, BOEM, and you in the academic and research community to power the safe evolution of this exciting new energy source.

2.4. MANAGING MARINE RESOURCES IN OREGON'S TERRITORIAL SEA AND STEWARDSHIP AREA: THE IMPORTANCE OF ENVIRONMENTAL INFORMATION IN PLANNING AND DECISION MAKING

Patty Snow

Manager, Ocean and Coastal Management Program, Oregon Department of Land Conservation and Development

Oregon has a strong framework for ocean planning rooted in the adoption of Oregon's Ocean Resources Goal 19 in 1976. Goal 19 establishes that it is the State of Oregon's policy to conserve marine resources and ecological functions for the purpose of providing long-term ecological, economic, and social value and benefits to future generations. To this end, all actions by local, state and federal agencies that are likely to affect the ocean resources and uses of Oregon's territorial sea are to be developed and conducted to conserve marine resources and ecological functions. Higher priority is given to the protection of renewable marine resources (living marine organisms) than to the development of non-renewable ocean resources. This ocean planning framework was further codified by the Oregon Ocean Resource Management Act (ORS 196.405 to 196.485) passed in 1991 which created the Oregon ocean governance structure. The Oregon Territorial Sea Plan (TSP) which contains specific policies for state ocean management was originally adopted in 1994. The TSP was modified in 2009 to address policies for managing marine renewable energy development. A process is underway to use spatial planning techniques to identify areas appropriate for marine renewable energy development; adoption of these amendments to the TSP is anticipated in January 2013.

Goal 19 also establishes the policy framework for the Ocean Stewardship Area which is defined to include the state's territorial sea (out to three nautical miles), the continental margin seaward to the toe of the continental slope, and adjacent ocean areas. The Ocean Stewardship area is further addressed in the TSP.

Goal 19, the Oregon Ocean Resources Management Act, and the TSP all state that prior to taking an action that is likely to affect ocean resources or uses of Oregon's territorial sea, state and federal agencies are required to assess the reasonably foreseeable adverse effects of the action. The effects assessment is also to address reasonably foreseeable adverse effects on Oregon's estuaries and shorelands. The information and protection requirements outlined below apply both on a planning scale (i.e., Territorial Sea Plan) and on a permit-by-permit basis (i.e., OPT permit). Information is needed for the territorial sea, the ocean stewardship area and the outer continental shelf. The full text of Goal 19 is available at <http://www.oregon.gov/LCD/docs/goals/goal19.pdf>.

Oregon's Ocean Resources Goal 19, the Oregon Resources Management Act, and the TSP all require the protection of certain resources, including i) renewable marine resources, ii) biological diversity of marine life and the functional integrity of the marine ecosystem, and iii) important marine habitat areas and areas important to fisheries.

To support the TSP spatial planning process and meet Goal 19 planning information requirements, the State of Oregon has developed a spatial decision support tool called MarineMap. It displays Oregon's Ocean GIS database online and currently encompasses over 200 data layers.

This information has been used as part of the geospatial analysis to develop areas to be protected by Goal 19 in the current TSP mapping process. Currently, the draft recommendation is for six areas or zones:

- a. Renewable Energy Exclusion Area;
- b. Proprietary Use and Management Area;
- c. Resources and Uses Conservation Area;
- d. Resources and Uses Management Area;
- e. Renewable Energy Facility Suitability Study Area;
- f. Renewable Energy Permit Area.

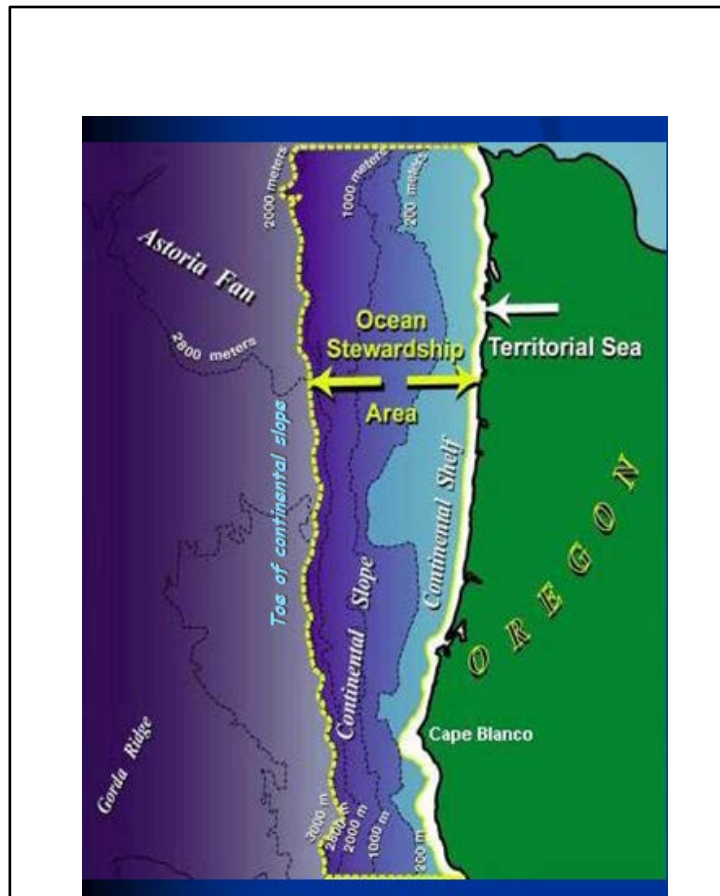


Figure 2: Oregon's Territorial Sea and Ocean Stewardship Area

Standards are the most stringent in the conservation area and least stringent in the study area. In addition, the draft recommendations include two overlay zones and screening standards that would apply across the territorial sea: the Visual Resource Area Overlay and the Marine Recreation Area Overlay.

Information will be needed for permit applications in each of these zones but will be more extensive in conservation areas to ensure that important resources are protected. Permits for marine renewable energy projects in the future will be subject to different screening standards depending on what zone or area they are proposed in.

While Oregon has created an innovative marine spatial planning decision support tool, the state continues to need additional information to ground truth assumptions, fill in information gaps, reduce uncertainties, and provide expert opinions. In addition, the state is working with other West Coast states to create a regional data framework that will facilitate regional decision-making and planning efforts.

3. SYNTHESIS PAPERS: CURRENT STATE OF APPLIED RESEARCH

3.1. EFFECTS OF ALTERED HABITATS AND FISHING PRACTICES IN WIND AND WAVE FARMS

Dan Wilhelmsson

Swedish Secretariat for Environmental Earth System Sciences

Offshore renewable energy development (ORED) could induce local ecological changes, negatively affecting species of conservation interest. If well planned and coordinated, on the other hand, ORED could be beneficial to the marine environment in the region of device deployment in several respects.

Because of the current scale and pace of offshore renewable energy development, interest is growing in the opportunities offered by the changes in fishing patterns that could result. Trawling, one of the most severe threats to the marine environment, particularly to fish and benthic invertebrate assemblages, will be prohibited or limited inside wind and wave farms. Areas of several square kilometers may therefore, in some important respects, resemble Marine Protected Areas; for areas that were previously trawled this exclusion could lead to average increases in biomass of motile organisms. Primary data from wind and wave farms are still scarce, but results to date from surveys targeting fish assemblages within offshore wind farms in Denmark, the Netherlands, and Sweden basically indicate either increased abundance of some fish species (e.g., sand eels (*Ammodytidae*), cod (*Gadus morhua*), whiting (*Merlangius merlangus*), sole (*Solea solea*)) or no effect compared to conditions before construction of the

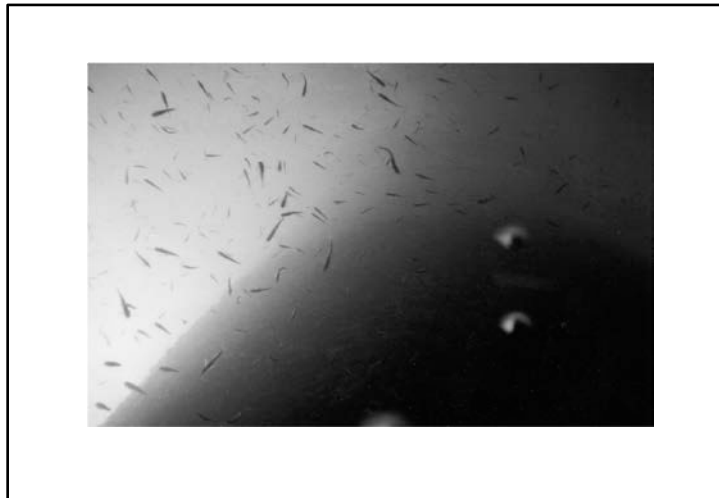


Figure 3: Fish (two-spotted goby, *Gobiosculus flavescens*) around a wind turbine anchor in the Baltic Sea. Photo: Dan Wilhelmsson.

wind farm. Effects are likely to be most prominent for species that had been heavily exploited in the area prior to the wind or wave farm establishment. It is believed that a relatively large area of exclusion is required to enhance biodiversity and generate spill-over effects.

Construction and deployment of artificial reefs (AR) in coastal waters is practiced worldwide to manage fisheries, mitigate damage to the environment, protect (i.e., from trawling) and facilitate the rehabilitation of certain habitats (e.g., spawning sites) or water bodies, or to increase

the recreational value of an area (e.g., by providing opportunities for recreational diving and fishing). Unless animals are deterred by potential disturbances, such as noise, maintenance work, and electromagnetic fields from turbines, it is reasonable to expect offshore wind energy structures, and also foundations of some types of wave energy devices, to function as artificial reef modules and enhance local abundance of marine organisms, including commercially important fish and crustaceans. However, taxon- and age-specific responses of fishes to ARs vary greatly with AR design and position as well as by region and latitude. It can therefore be difficult to predict the structure of fish and crustacean assemblages associated with the submerged parts of wind and wave energy devices, as well as the radius of influence. Nevertheless, relatively recent studies targeting the potential for wind turbines and wave energy

foundations to aggregate fish and motile invertebrates in Sweden, the Netherlands, Belgium, and Denmark suggest that densities of a number of fish and decapod species increase with proximity to these structures.

Another category of artificial habitat is a Fish Aggregation Device (FAD), a floating structure deliberately placed on the surface or suspended in the water column to attract fish and enhance fishing efficiency. FADs are widely used in Asia and the western Indian Ocean. It has been suggested that floating offshore energy devices may function as FADs for pelagic fish, which could provide additional opportunities for fisheries management.

Both ARs and FADs can have negative environmental and social effects if not properly planned and/or used. If ARs only aggregate fish from surrounding areas and do not contribute to added production, enhanced fishing efficiency in the AR area may aggravate overfishing if the new circumstances are not managed with caution. Similarly, increasing catchability, the main purpose of an FAD, may exacerbate the problem of overfishing on commercial species that are already at risk. ARs can also give rise to conflicts over user rights among fisher groups, and between recreational divers and fishers.

Further, densities of benthic prey items have been shown to decrease with proximity to ARs due to predation by fish residing on the structures. FADs have been suggested as potential “ecological traps,” meaning that their presence could lure fish into remaining near the structures under non-optimal local feeding conditions, affecting physical condition and growth. Artificial structures may also provide habitats suitable for establishment of non-indigenous species; deployment of clusters of artificial structures may facilitate the establishment of new taxa in the recipient region by providing “beach heads” and stepping-stones. Non-indigenous sessile invertebrates have already been recorded at wind farms in the North Sea and the Baltic Sea.

A range of design and location factors may influence the fish community structure on artificial reefs, such as height, size, inclination, protuberance, surface structure, void space and number of interior hollows, shade effects, distance between modules, isolation, and composition of the surrounding seabed. Research is underway to evaluate species-specific habitat preferences in the design of offshore energy foundations to optimize biomass of desired species, or alternatively, minimize artificial reef effects where desired. For example, in an experiment with wave energy foundations on the west coast of Sweden the potential for enhancing the abundance of associated fish and crustaceans through low-cost manipulations of the structural complexity of foundations was examined. Additional experiments will provide further guidance on the influence of different designs of foundations on commercially important fish and shellfish.

This presentation will focus on the potential influence of offshore wind and wave farms on fish and commercially important crustaceans. The uncertainties with regard to positive and

negative effects of on benthic and pelagic assemblages and specific species will also be discussed. The presentation will draw on results from a number of field studies and experiments conducted in offshore wind and wave farms, as well as on secondary literature on the influence of differently designed artificial habitats on benthic fauna.

3.2. THE INTERACTION OF PELAGIC, MIGRATORY AND PROTECTED FISHES WITH MARINE RENEWABLE ENERGY PROJECTS: RECENT STUDIES AND KNOWLEDGE GAPS

Pete Nelson

Collaborative Fisheries Research West

Fishes are expected to interact with Marine Renewable Energy (MRE) projects in ways dependent upon both the nature of the project in question and on the ecology of the species considered (Figure 4). The siting of MRE projects will determine the habitat affected, the species

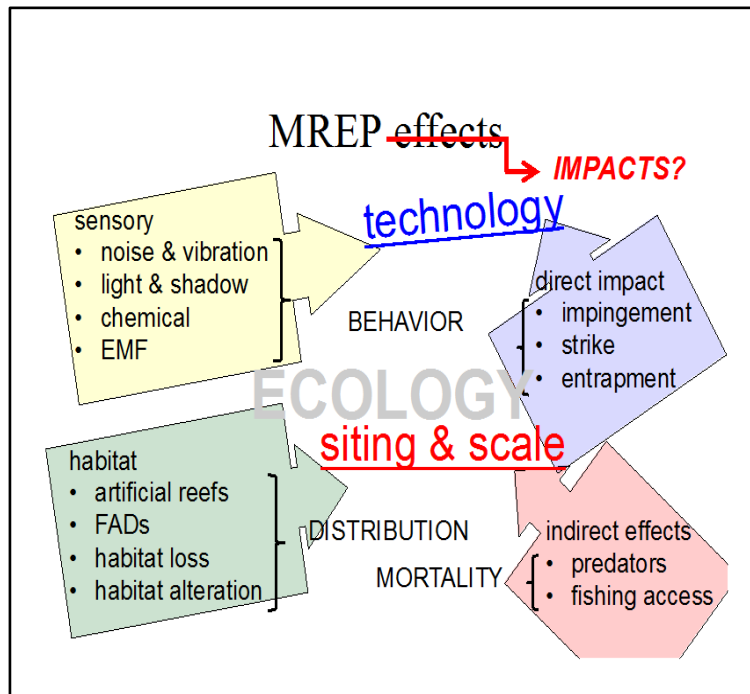


Figure 4: MRE project effects on fishes are varied, and depend upon multiple project aspects. Effects may be ecologically inconsequential or may rise to the level of impacts, sensu Boehlert & Gill (2010).

expected to encounter the project, and the length(s) of associated cables. The nature of the technology will limit the variety of interactions possible: For example, a tethered wind turbine with few or no moving parts below the surface offers a reduced suite of potential interactions than does a wave energy conversion device with subsurface moving parts. Underwater noise and vibrations, chemical coatings, lubricants and hydraulic fluids, electrical insulation, the depth to which transmission cables are buried, and even color choices for subsurface structures could all affect the nature and extent of ecological effects. Assuming that fishing activities are limited in the vicinity, these projects may function as *de facto* marine reserves, with effects on both fish populations and area fisheries. The ecology and biology of the diverse species contribute further to the array of interactions.

Pelagic or open water species may visit these projects as sources of food, preying on smaller fishes or invertebrates associated with the structures. In tropical waters, such devices would undoubtedly function as Fish Aggregation Devices (FADs); in colder waters, associated fish assemblages may aggregate according to different behavioral/ecological mechanisms. FADs and flotsam assemblages in the tropics are typically dominated by scombrids and carangids, but these taxa are less diverse in temperate waters and have not been reported to associate with flotsam at higher latitudes. Nonetheless, there is a great deal that remains to be learned about flotsam-associated fishes, and the phenomenon should not be ruled out in the case of MRE projects.

Migrating species, particularly those that travel along the coast, may be expected to encounter these projects. Salmonids generally and, along the West Coast of the United States, green sturgeon (*Acipenser medirostris*) in particular are migrating species likely to encounter offshore projects, at least in the form of their associated cables to facilities on shore. Potential interactions include concentration of predators, EMF effects, and the loss of foraging habitat.

Reef species are expected to treat these structures as reef-like habitat, and a resource for foraging, shelter, spawning and more. The structural complexity of a MRE project may be analogous to the factors affecting the efficacy or appeal of an artificial reef (for example, see Bohnsack et al. 1991 and Perkol-Finkel et al. 2006). Fishes associated with soft bottom habitats may be locally displaced, although some of these species do occupy the ecotones between natural reef and soft bottom habitat; these projects may offer these fishes additional habitat. Finally, fishes may respond by avoiding these structures, by actively associating with them, or by showing no behavioral response at all.

Recent studies have focused on baseline research, sampling potential project sites and control areas to anchor before-after-control-impact (BACI) studies once projects are established. Additional research on the response of fishes to electromagnetic fields, artificial reefs, and FADs would considerably improve our capacity to assess the potential effects of MRE on fishes. Baseline studies designed to form the foundation of a BACI study, research on fish assemblages around existing offshore analogues (e.g., oil platforms, navigational buoys, etc.) and the development of vigorous and effective citizen science programs are strongly encouraged.

3.3. AVAILABLE INFORMATION AND DATA GAPS: BIRDS, BATS, MARINE MAMMALS, SEA TURTLES, AND THREATENED AND ENDANGERED SPECIES

David M. Pereksta

Bureau of Ocean Energy Management

The offshore waters and the coastline of Oregon provide year-round habitat for a number of birds, marine mammals, sea turtles, and possibly bats, at least fifteen of which are federally listed as threatened or endangered. Previous workshops on offshore renewable energy have provided baseline information on the distribution and abundance of these species on the Pacific Outer Continental Shelf (OCS). There are varying amounts of baseline information for offshore species; however, seasonal variability and relative abundance are generally known at a broad scale.

Sea turtles are subtropical and tropical breeders and all species found on the Pacific OCS are uncommon north of Mexico. Sea turtles that occur in the waters off of Oregon are primarily leatherback sea turtles (*Dermochelys coriacea*); however, loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and olive ridley (*Lepidochelys olivacea*) sea turtles could also occur. All of these species are listed as either threatened or endangered under the federal Endangered Species Act (ESA); there is designated Critical Habitat for the leatherback sea turtle off the Oregon coast. Sea turtles are drawn to offshore waters during the summer upwelling period where they feed on a variety of pelagic and benthic organisms.

A diversity of marine mammals occur offshore of Oregon including 24 species of cetaceans and 6 species of pinnipeds. Sea otters are rare, but stragglers from Washington are occasionally seen along the Oregon coast. Among the cetaceans seen in Oregon waters, the north Pacific right (*Eubalaena japonica*), blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), humpback (*Megaptera novaengliae*), killer (*Orcinus orca*), and sperm (*Physeter macrocephalus*) whales are listed as threatened or endangered under the ESA. Federally listed pinnipeds include the Guadalupe fur seal (*Arctocephalus townsendi*) and Steller sea lion (*Eumetopias jubatus*), the latter of which also has designated Critical Habitat off the Oregon coast.

Little is known about the offshore movement of bats on the Pacific OCS, but observations from the Farallon Islands off San Francisco have regularly recorded the presence of the migratory hoary bat (*Lasiurus cinereus*) during migration periods. Modeling has shown that hoary bat arrivals and departures correlate with low wind speeds, low moon illumination, and relatively high degrees of cloud cover. In addition, low barometric pressure predicted arrivals. The status of bats offshore has received little to no attention and study is needed to determine their presence on the Pacific OCS.

Marine birds occur widely on the Pacific OCS off Oregon. Nearshore areas are inhabited by a variety of species of sea ducks, loons, grebes, cormorants, pelicans, gulls, terns, and several alcids. Deepwater areas 8-35 miles offshore and beyond are inhabited by albatrosses, shearwaters, petrels, storm-petrels, skuas, jaegers, alcids, and pelagic shorebirds, gulls and terns. Federally listed species under the ESA that have been extensively monitored and studied along the Oregon coast include the Western Snowy Plover (*Charadrius nivosus nivosus*) and Marbled Murrelet (*Brachyramphus marmoratus*). As studies reveal more information about the population status and movements of the endangered Short-tailed Albatross (*Phoebastria*

albatrus) and Hawaiian Petrel (*Pterodroma sandwichensis*), we are finding that these species are rare, but regular off the Oregon coast at specific times of the year.

Previous workshops on offshore renewable energy have also described the potential effects that the construction and operation of energy devices could have on these taxonomic groups. Activities that can have effects on these species include construction and operational activities, vessel traffic, seismic surveys, foundation and cable installation, turbine operation, foundation protection, and the ongoing presence of cables. Resulting effects include collision and entanglement, barotrauma (particularly for bats), prey base and habitat alteration, trash ingestion (particularly for sea turtles), displacement, movement barriers, electromagnetic field effects, light attraction, pollution, and noise impacts.

Renewable energy conferences and workshops have identified knowledge and data gaps that need to be addressed to inform the planning and regulating of commercial-scale projects on the Pacific OCS. Gaps identified for sea turtles include understanding their seasonal use of the OCS particularly for post-hatchling stages; noise and EMF effects; and comprehensive population estimates; the latter will be difficult to assess due to the turtles' solitary nature and wide distribution. Gaps identified for marine mammals include information on site-specific baseline data on occurrence, distribution, and behavior; site-specific acoustic effects on species with low frequency sensitivity; baseline information on migration routes and home ranges; impacts on gray whales (*Eschrichtius robustus*); monitoring to understand interactions between marine mammals and renewable energy devices; and acoustic-related effects. Gaps identified for marine birds include site-specific spatial and temporal distribution and abundance of birds at sea; nocturnal activity; important areas of bird activity that should be avoided; important migration patterns; potential effects on seabird prey; energetic consequences; and effects of EMF, noise, lights and structures, and collision risk. Sensitivity analysis and decision support tools have also been identified as necessary to assess the risk to marine birds.

The Bureau of Ocean Energy Management's Environmental Studies Program has funded a variety of seabird and marine mammal studies to collect baseline information and assess the effects of conventional and renewable energy projects on the Pacific OCS. Recently completed studies focused on renewable energy include a summary of knowledge of select areas of the Pacific coast, an analysis of the effects of EMFs from undersea power cables on marine species, and protocols for baseline studies and monitoring for ocean renewable energy. A number of additional studies focused on renewable energy are underway or proposed, several of which should eliminate some of the identified knowledge and data gaps. These include aerial surveys of seabirds and marine mammals off the Pacific Northwest, assessing vulnerability of marine birds to offshore renewable energy devices, data synthesis and high-resolution predictive modeling of marine bird distributions in the Pacific, and several others. In addition, there are pilot studies in the Atlantic that are assessing and testing technologies that could be used for surveying and monitoring birds, bats, marine mammals, and sea turtles in the Pacific.

3.4. PHYSICAL-ENVIRONMENTAL EFFECTS OF WAVE AND OFFSHORE WIND ENERGY EXTRACTION: A SYNTHESIS OF RECENT OCEANOGRAPHIC RESEARCH

Merrick C. Haller
Tuba Özkan-Haller
Oregon State University

The ocean deployment of arrays of Wave Energy Converters (WEC arrays) appears likely in the near future, and deployment of offshore wind turbines has already started. These technologies tap into a potential renewable energy resource but also involve complex systems with uncertain environmental consequences that will likely scale with the size of their ocean footprint. This synthesis talk will concentrate on the potential physical effects of these array technologies.

Both WEC arrays and offshore wind farms consist of sizable structures placed in the water column; hence, their mere presence is a potential environmental stressor. Possible effects on the physical environment include wave scattering and wave shadowing; added drag on the coastal current field; modifications to sediment transport (by way of the aforementioned changes to the wave and current forcing); and changes to local sediment characteristics (due to anchors and pilings). In many ways, these effects are similar to those caused by other ocean structures that have been studied for some time (e.g., offshore platforms). However, there are additional potential effects of WECs and wind turbines that require further attention. For example, extraction of wave energy by WECs could have additional environmental consequences. Similarly, offshore wind farms can alter the local wind field, in turn altering locally-generated waves. We will address effects due to wave or wind installations on the wave field, on local ocean circulation, and on sediment transport characteristics.

Because WECs partially extract and scatter incident wave energy, they cause significant modifications in the near-field. In fact, if device performance can be optimized at field scales, then by definition the near-field effects will be maximized, i.e., if energy extraction is maximized the potential physical effects of WECs are also maximized. Over the past decade a sizable number of studies have applied theoretical principles using varying assumptions and simplifications to the problem of WEC-wave interactions. Some of these assumptions (e.g., “optimal” motions, monochromatic wave conditions, etc.) have now been shown to be unrealistic, and there has been a convergence toward classes of models that appear to produce reasonable estimates. While recent model studies have managed to provide bounds to the problem, significant uncertainties remain. The primary cause for the remaining uncertainties is the lack of observational studies, particularly data sets that provide spatial information about the wave field in the vicinity of *in situ* devices. Nonetheless, a few studies have undertaken scaled laboratory testing, and these data sets are beginning to lend confidence to the available numerical model results and shed light on the dominant processes.

Once near-field effects are understood, far-field effects can be assessed. Far-field effects influence the wave field near beaches, which, in turn, influences the sand transport processes that govern the morphodynamics of the beach face. Fortunately, hydrodynamic modeling of large-scale wave propagation processes in the absence of structures is highly advanced, i.e., if given accurate incident wave conditions in the lee of an installation and bathymetry for the model domain, models can well-simulate local wave conditions, wave-driven currents and sediment transport patterns. Therefore, once near-field WEC/wave dynamics are understood, expanding

our understanding to the far-field will be relatively straightforward. Nonetheless, observational studies of far-field beach modifications shoreward of an installation will help to further solidify our understanding of beach behavior.

Offshore wind farms can also potentially influence the local wind field around them. Previous studies of such modifications at land-based wind farm installations serve as a reasonable basis for predictions offshore. Any changes to offshore winds will also influence the local wave field, especially where local winds are the dominant source of waves. Such effects will be minimal near coasts where the local wave climate is dominated by incident swells generated at large distances (e.g., the U.S. West Coast). In contrast, locally generated waves are a more important component of the wave climate on the East Coast of the U.S.

Modification to ocean currents by an array of structures can be assessed by considering the additional frictional effects (“form” drag) caused of the array. If the drag caused by a dense of array of structures is large, circulation will be altered, which might result in reduced current velocities or the diversion of currents toward an area of less drag. Note that ocean currents already experience drag due to bottom friction; hence, the question hinges on the relative magnitude of the drag induced by structures versus the pre-existing frictional drag.

Finally, any near-field modifications to the wave and circulation field (due to either WEC arrays or wind farms) will necessarily result in changes in sediment transport. Any local reduction in flow velocities can result in a reduction of the sediment carrying capacity of circulation leading to sediment accumulation at the site. Small-scale modification to a current will also likely cause bumps and holes around the pilings or anchors. These effects are similar to those observed around existing offshore structures and pilings, and can be accounted for in the design of the structures.

Far-field modification of waves and associated changes in wave-induced currents can also result in changes in sediment transport patterns near beaches. Although some recent studies exist, questions regarding far-field effects on beaches are still relatively poorly addressed.

3.5. A UK PERSPECTIVE ON MARINE RENEWABLE ENERGY ENVIRONMENTAL RESEARCH: KEEPING UP WITH A “DEPLOY & MONITOR” PHILOSOPHY

Ben Wilson

Marine Alliance for Science and Technology Scotland

There are many drivers for the pursuit of renewable energy extraction from coastal seas. In the United Kingdom these include moving away from fossil fuels to mitigate the impacts of climate change, improving energy security by diversifying supply options, increasing wealth generation in outlying coastal communities, and seeking alternative sources of power as existing infrastructure (power stations) near the end of their useful lives. In Scotland these drivers are particularly strong because of the additional factors of decline of North Sea oil reserves; the political pressure not to re-develop nuclear power plants; and the abundant offshore wind, wave and tidal-stream resources.

While these drivers are strong, and backed up by ambitious political targets, a variety of constraints currently limit development of a vibrant marine renewables sector in UK coastal waters. In addition to financial, technological and logistical issues, a diversity of environmental restrictions limit progress of the renewables sector. Many of these environmental issues actually stem from a lack of basic knowledge of how marine renewable energy devices are likely to interact with the receiving environment and vulnerable species (particularly those protected by European legislation such as the Habitats and Species as well as the Birds Directives). Furthermore where negative interactions are known, there may be limited knowledge about, or options for, mitigating these impacts. Strictly applying precautionary principals to these new and diverse technologies with respect to their potential local negative environmental impacts threatens to halt development of these technologies despite their potential benefits for global climate and other environmental issues. This problem applies particularly to wave and tidal-stream technologies which are diverse, new, and without track-record. To overcome this issue, the Scottish government is implementing a staged introduction of these technologies under what has been termed a “Survey-Deploy-&-Monitor” policy. That is, commercial scale devices are being placed singly or in small arrays (≤ 10 MW) into areas of pre-determined and acceptable environmental sensitivity and then impacts are being quantified through a monitoring program. In parallel to this approach, The Crown Estate (the seabed owner) has performed a series of licensing rounds to lease preferred sites to specific wind, wave and tidal-stream developers. If consented, these sites will represent commercial-scale developments of all three technologies in Scottish and wider UK waters. Part of that consenting progress requires that developers provide evidence (through Environmental Impact Studies and the production of Environmental Statements) that their developments will not harm the surrounding environment.

It is these consenting exercises and related fundamental questions about impacts that are currently driving most of the environmental research related to offshore wind and marine renewable technologies in the UK. Research tends to fall into three divisions based on the source of funding and the geographic scope of the issues. At the smallest scale are studies of individual sites of interest to individual developers seeking consents for a specific technology. More generic studies funded by government or industry consortia may be performed to understand environmental issues surrounding a particular group of technologies, installation methods, or operational parameters. In this case, the actual site may be less important. Finally, fundamental research (funded by Research Councils) may be carried out to understand how and why animals use renewable energy relevant sites.

Because there are a large number of research studies currently underway at a wide range of scales, sites, and taxa in Scotland and the wider UK, it is not possible to summarize them all in this short talk. Instead, I will outline examples of the three broad areas of environmental research (site/device specific, technology generic and more basic ecology). These examples have also been chosen because they represent an ongoing project, a recently established group of research studies, and a potential new research program.

Some of the perhaps less intuitive lessons that have arisen from some of such projects include:

1. The responses of organisms may not be tied to particular brands of device or energy extraction, whether wind, wave, tidal-stream or even oil platform. For fouling organisms the particulars of the substrate might be the important factor rather than the device's method of energy extraction. Likewise for fish it may be the device complexity and position in the water column that is key to their interactions.
2. Conversely, particular, seemingly unimportant features of devices may have relevance to marine organisms. For example, the color of a turbine may be extremely important for animals maneuvering around the rotors, a duct or the pile.
3. Test centers used to assess full-scale devices may seem like excellent places to also perform environmental research; however care must be taken as the devices in test centers are typically early generation prototypes and may be swapped out frequently. Furthermore activities by other companies at neighboring berths may invalidate site or device specific experiments.
4. Inter-annual variability does not suit the current pace of marine renewables development and careful consideration of the use of control sites and BACI designs should be made.
5. Cumulative impacts of multiple renewable and other developments offer a massive challenge to determining environmental impact. This difficulty represents a significant area of uncertainty for developers seeking consent and may encourage a development race with companies not wanting to have to consider their development relative to all of the others that preceded them.
6. Finally, while much effort is currently being devoted to gathering sufficient data to permit consent and early stage deployments, the significant investments only come when developers set up arrays capable of producing commercially relevant power. At this point there may be a step change in the degree of monitoring required of any potential environmental interactions. Should intolerable impacts be found, then mitigation will be urgently required or an exit strategy implemented.

4. CONTEMPORARY RESEARCH STUDIES

4.1 LINKING HABITAT AND BENTHIC INVERTEBRATE SPECIES DISTRIBUTIONS IN AREAS OF POTENTIAL RENEWABLE ENERGY DEVELOPMENT

Sarah K. Henkel

Hatfield Marine Science Center, Oregon State University

While the coastal waters of western North America hold great promise for wind and wave energy development, many concerns have been raised about the potential environmental impacts of the installation of these devices and their complex mooring systems. Here I focus on characterizing benthic habitats and biological communities in offshore sedimentary and reef habitats where wind and wave energy facilities could be located. While little is known about species-habitat relationships and community processes in the depths and substrate types targeted for offshore renewable energy installation, an understanding of the natural dynamics of these systems is of utmost importance if we hope to forecast changes that might be brought about by wind and wave development. Since May 2010 we have conducted surveys of benthic habitats from northern California to Washington using a variety of techniques, providing baseline data on habitats and species potentially affected by wind and wave development, identifying species-habitat relationships, and quantifying spatial and temporal trends in species abundances and distributions.

The first step in identifying and evaluating benthic communities is sonar mapping to determine depth and substrate types. In summer 2010 and 2011 six new offshore sites were mapped by the Seafloor Mapping and Plate Tectonics Lab at OSU using high-resolution multi-beam sonar and acoustic backscatter. In addition to the backscatter, Shipek grabs were taken in soft-bottom areas to collect sediment samples, which were run through a laser particle size analyzer (LDPSA) to determine actual grain size. Mapping began at the federal jurisdiction line and extended 9 – 12 miles offshore. Oregon and California have undertaken extensive mapping of state waters, so many areas have been mapped inshore of these sites as well. In summer 2011 and 2012, we visited 8 sites (6 newly mapped sites, one previously mapped, and one unmapped site) to collect a total of 153 cores using a 0.1 m² box-corer. A sub-sample of sediment was collected from the corer and analyzed using the LDPSA; the rest was sieved through 1 mm mesh and all infaunal organisms were counted and identified. At each box core sampling station, CTD casts were conducted to obtain physical data describing the overlying water column for further habitat characterization.

Unique infaunal invertebrate assemblages were found in sedimentary habitats at each of the Pacific Northwest shelf sites. Thus for renewable energy siting, it does not appear that baseline surveys conducted at one site can necessarily serve as a proxy for distant sites. However, some general trends were detected. Significantly different invertebrate assemblages were found in different depth ranges with a break at approximately 80 to 90 m depth; deeper sites exhibited greater diversity. Shallower sites had greater spatial heterogeneity in infaunal invertebrate assemblages than deeper sites; thus as monitoring protocols are developed we recommend that shallower sites be sampled more extensively in order to adequately characterize those communities. Molluscs seemed to be the most responsive to substrate type, with different assemblages found in pure sand, slightly muddy sand, and mostly silt/clay.

In addition to sampling of sedimentary habitat, we conducted limited surveys of offshore reef habitats. Although it is unlikely that devices would be installed in these areas, reefs may be

crossed by electrical cables, and changes in sediment transport due to ocean energy extraction or alterations of flow around large device arrays could lead to community impacts. The aim of this study was to describe baseline relationships between macroinvertebrate communities and habitat features against which to measure potential future impacts and to develop tools to predict community compositions of unsampled areas in the region based on substrate features. To date we have analyzed submersible dive video from three sites conducted in the mid-1990s. In the summers of 2011 and 2012, we visited these previously surveyed sites with an ROV.

Analysis of submersible and ROV surveys indicated that two major substratum groups held different macroinvertebrate assemblages: moderate to high-relief rocky habitats and low-relief fine sediment habitats. The majority of macroinvertebrate taxa were associated with high-relief rocks; these taxa were further differentiated between flat and ridge rock habitats. Low-relief fine sediment habitat was most often associated with motile invertebrates. Within this habitat it appeared that fine-sediment substrata mixed with mud, boulders, or gravel each yield unique macro-invertebrate associations versus those found on uniformly mud or sand substrata. Latitude also was correlated with variation in macroinvertebrate assemblages.

A major challenge will be detecting effects of wind and wave energy installations above the inherent natural variability in these systems. Decadal scale shifts in the California Current affect this ecosystem, with warm regimes and associated declines in planktonic production resulting in degradation of benthic community. On shorter timescales El Niño events can cause major, short-term disturbances. Off the Oregon coast, summer hypoxia events can have dramatic effects on benthic communities, and ocean acidification is an increasing concern. Thus, evaluation of this ecosystem must be made in the context of seasonal and climatic trends. Prior to installation of device arrays, baseline sampling is usually required as part of the permitting process. However, one-time sampling will not capture the variability of the system in a given area, and developers and regulators typically are not able to make the investment (in time or money) to repeatedly survey an area before development. Funding agencies rarely support long-term monitoring studies. Thus, finding support for repeated field sampling across time and space is especially challenging. The biggest issue facing wind and wave energy developers in the environmental arena is the high level of uncertainty regarding environmental effects. Without a substantial understanding of the natural dynamics of a system, it will be difficult to reduce that uncertainty.

4.2. PACIFIC CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT (PACSEA): SEABIRD AND MARINE MAMMAL SURVEYS OFF THE NORTHERN CALIFORNIA, OREGON, AND WASHINGTON COASTS

Josh Adams¹, Jonathan Felis¹, John W. Mason², Jeff N. Davis³, K. Ben Gustafson¹, David M. Pereksta⁴ and John Y. Takekawa¹

¹U. S. Geological Survey, Western Ecological Research Center, CA ²Environment International, ³Moss Landing Marine Laboratories, ⁴Bureau of Ocean Energy Management, Pacific Outer Continental Shelf Region

Interest has increased in developing renewable energy sources to reduce U. S. dependence on oil. Policy makers and resource managers now are considering power generation technologies proposed for development along the Continental Shelf of the U. S. Pacific coast beyond state waters. This region supports abundant populations of seabirds and marine mammals, but comprehensive, multi-seasonal aerial surveys were last conducted two decades ago. Marine spatial planning, including potential site selection for offshore energy development, requires the description and quantification of recent species-specific and community distribution patterns. To relate patterns of seabird abundance to physical and biological characteristics of ocean habitats, we conducted low-elevation aerial seabird surveys during January-February, June-July, and October 2011 and 2012 along parallel strip-transects spanning continental shelf and slope waters from Fort Bragg, CA to Gray's Harbor, WA. Although effort focused on Federal Waters outside of the 3-nautical mile state boundary, surveys included inshore waters to allow comparisons both within and adjacent to potential renewable energy developments. In the past, environmental analyses of aerial seabird surveys have relied on satellite-derived products of ocean optical properties that are coarse in scale or temporally averaged to produce better spatial coverage. Therefore, in addition to aerial pyrometry to measure sea-surface temperature, we installed an on-board hyperspectral radiometer to collect remotely-sensed reflectance simultaneously with species observations. Herein, we discuss survey methods and describe inter-seasonal trends in abundance and distribution of marine birds and variability in the ocean environment, and introduce aerial hyperspectral radiometry as a potential tool for delineating fine-scale ocean habitat features (fronts and water masses) based on ocean color.



Figure 5: The ocean off Oregon supports diverse and abundant seabird and marine mammal communities. The image above shows a mixed foraging assemblage that includes humpback whale (*Megaptera novaengliae*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and Sooty Shearwater (*Puffinus griseus*). Photo: Jonathan Felis, USGS.

4.3. WAVE ENERGY DEVELOPMENT AND GRAY WHALES IN OREGON: POTENTIAL RISK AND MITIGATION

B.A. Lagerquist and B.R. Mate

Marine Mammal Institute, Hatfield Marine Science Center, Oregon State University

The Oregon coast has been identified as an area with great potential for production of electricity from wave and wind energy, and development of marine renewable energy facilities are being discussed for several locations along the Oregon coast. The potential impact of this development on eastern gray whales is largely unknown, but collisions, entanglement, or displacement are all possible effects. To evaluate their potential level of exposure to such risks, gray whales were tracked from shore during their southbound and northbound migration along the central Oregon coast from December 2007 to May 2008. This study's objective was to generate accurate, up-to-date baseline information on gray whale behavior and distribution relative to shore in an area where installation of wave-driven electricity generators has been proposed. Three observers surveyed gray whales from an observation station at Yaquina Head, Oregon (44.67675° N, 124.07956° W, 25.39 m above mean sea level) using binoculars (7x50 Fujinon) and a theodolite (Sokkia, 2 sec resolution, 30x scope) during daylight hours when environmental conditions permitted. Locations were recorded of all whales seen during scan surveys of the 200° field of view of the ocean, and of individual groups tracked during focal follows. Average distance from shore (Fig. 1), median depth of locations, and average speed were all significantly different between southbound and northbound phases of migration. 61% of all whales and 78% of mothers and calves passed within 3 nautical miles of shore, through areas of proposed wave energy development, thereby putting them at potential risk of collision, entanglement, or displacement from the structures.

During winter and spring 2012, a low-powered acoustic deterrent was tested off Yaquina Head to see if it could successfully keep whales a modest distance (500 m) away from wave energy buoys in case such risks are realized. In this test, an acoustic device was moored in the migration path of gray whales and transmitted a 1-s, 1-3 kHz warble signal three times per minute during daylight experimental periods. The device was turned off during the remainder of each day to serve as control periods. Shore-based observers conducted observations using the same sampling protocol as the 2007/08 study. Whale locations were compared between experimental (active sound transmission) and control (no sound) periods to determine whether the device successfully deterred gray whales.

A combination of bad weather and equipment problems resulted in a much smaller sample size than required to detect a difference in whale locations between experimental and control periods. To achieve the desired sample size will require continuing the experiment for another winter migration season and increasing power to make the zone of influence 3 km, rather than 500 m. We have prepared the necessary equipment changes and are actively seeking funding partners to create the first ever tool that could protect whales from future anthropogenic stressors, including wave energy facilities, oil spills, or other issues.

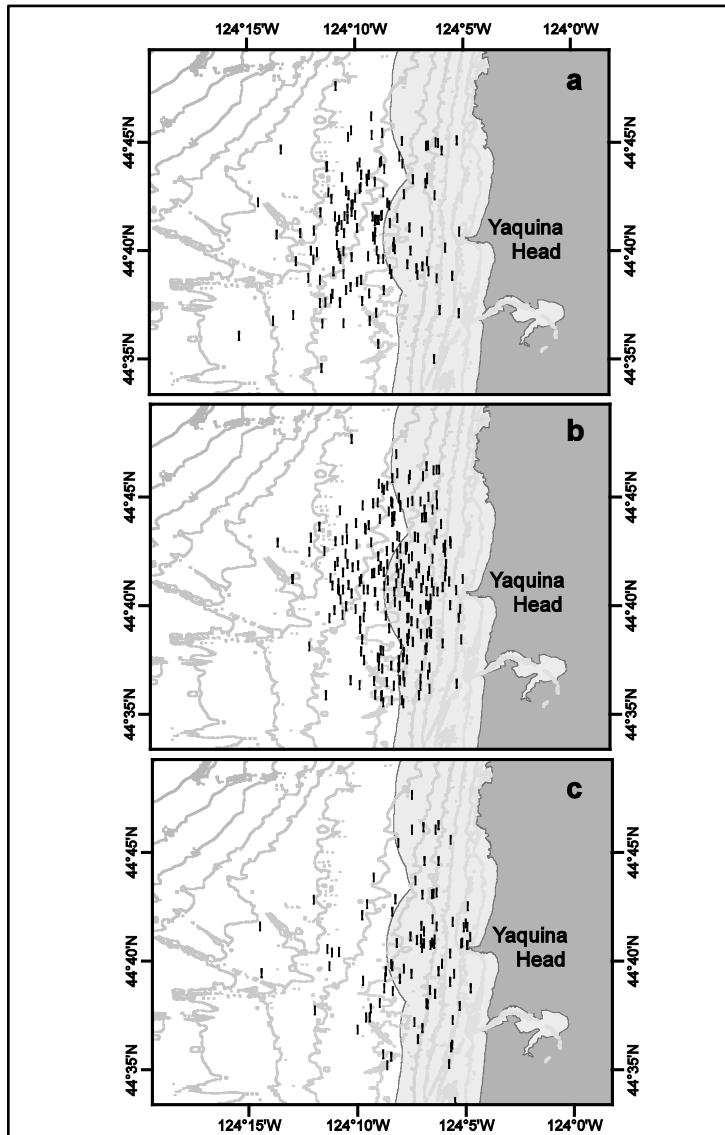


Figure 6: Locations of gray whales (black dots) observed on scan surveys off Yaquina Head during a) southbound migration (January 11 – February 25, 2008), b) northbound Phase A migration (February 26 – April 9, 2008), and c) northbound Phase B migration (April 10 – May 30, 2008). Contours indicate 10-120 meter isobaths (every 10 meters). The light shaded area represents the Oregon territorial sea (within 5.6 km from shore).

4.4. POTENTIAL IMPACTS OF OCEAN ENERGY PROJECTS ON MIGRATION AND HABITAT USE OF GREEN STURGEON (*ACIPENSER MEDIROSTRIS*)

Daniel L. Erickson¹, Michael Donnellan¹, Steve Lindley², and John Payne³

¹Oregon Department of Fish and Wildlife, ²National Marine Fisheries Service, NOAA, ³Independent Consultant

Construction of a wave energy facility is planned for a site off of Reedsport, Oregon. The initial licensed development will consist of ten buoys within a 0.25 mile² area at depths of 50 - 69 m and will produce up to 1.5 megawatts (MW; Figure 7)^a. A proposed project expansion (not currently licensed) could include 100 buoys that may occupy an area of approximately 1 mile x 5 miles and produce 50 MW (Figure 7)^b.

Green sturgeon, currently listed as threatened under the U.S. Endangered Species Act (ESA), commonly migrate in oceanic waters along the U.S. West Coast at depths of 40 – 70 m during winter and spring months, which places the wave energy project directly within this species' migratory corridor (Figure 7). Furthermore, given the proximity to the Umpqua River estuary (designated critical habitat), it is possible that the site selected for this wave energy project may be a concentration area for certain green sturgeon activities, such as feeding. An acoustic telemetry study has recently been funded to determine whether, and how, the proposed wave energy development may affect green sturgeon behavior and migration patterns. Outcomes of the study will include a determination of the potential cumulative impacts of the numerous ocean-energy projects planned for development along the U.S. West Coast. The study will have a Before-After design, with the Phase I "Before" [wave energy buoys] component planned for early 2013 to late spring 2014, encompassing three oceanic migration periods. Phase I will gather baseline information on sex- and age-specific spatial and temporal patterns of habitat use. To these ends, we will deploy three parallel lines of acoustic telemetry receivers, oriented onshore/offshore, with the central line bisecting the wave energy development (Figure 7). The receivers, spaced closely enough in each line to yield a detection rate near 100%, will measure metrics including depth of detection, speed, and minimum transit distance through the array. Phase II, the "After" component of the study, will mirror the design of the "Before" component. Phase II results will be compared with Phase I results in order to determine if the fully operational wave energy installation affects patterns of habitat use. Phase II is unfunded at this time, but funding will be sought once the wave energy installation is more definite and is close to fully operational.

In addition to their relevance for green sturgeon along the U.S. West Coast, results of this study may also be used to evaluate the potential impacts of planned ocean energy projects on threatened or endangered sturgeons in the Atlantic ocean (e.g., Atlantic sturgeon) and in the Gulf of Mexico (e.g., Gulf sturgeon). Furthermore, this study will be useful for identifying potential impacts of this wave energy park to other acoustically-tagged species (e.g., white shark, which is currently under consideration for ESA listing).

Funding for this study will be provided by the Oregon Wave Energy Trust (OWET), NOAA, Southwest Fisheries Science Center, and the Northwest National Marine Renewable Energy Center (NNMREC).

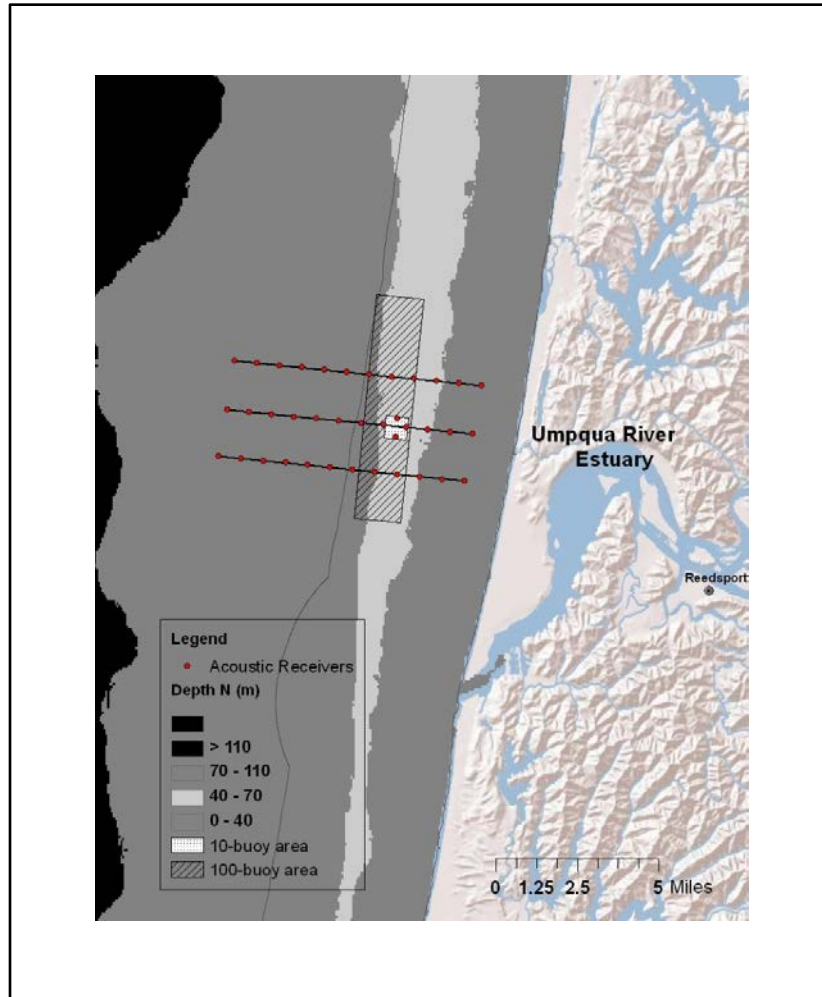


Figure 7: Location of the proposed OPT wave energy developments off of Reedsport, OR near the Umpqua River Estuary (small-dotted box = licensed project, 10 buoy array; large-hashed box = proposed expanded project, 100 buoy array). Green sturgeon critical habitat (to 110 m) is dark gray. Depths most frequently inhabited by green sturgeon during oceanic migration (40 to 70 m) are light gray (= migratory corridor). Black represents depths greater than 110 m (i.e., seaward of green sturgeon critical habitat). The study design, including proposed locations for three lines of receivers extending through the OPT Wave Energy projects, is also shown.

4.5. EMF AND MARINE ORGANISMS

Milton Love¹, Ann Bull², and Donna Schroeder²

¹University of California, Santa Barbara, ²Bureau of Ocean Energy Management

Electromagnetic fields (EMF) originate from both natural and anthropogenic sources. In the sea, natural sources include the Earth's magnetic field, sea and tidal currents traveling through that field, and various processes within organisms. Electricity moving along cables and various other devices (as a part of renewable offshore energy development) produces both electric and electromagnetic fields. In addition, water currents and organisms moving through human-induced EMF create electric fields. The larger the organism and the closer it is to the cable, the larger the induced electric field.

A potential issue is that some organisms detect electric and/or magnetic fields.

Electric fields are detected by cartilaginous fishes (sharks, skates, and rays), as well as ratfishes, sturgeons, and paddlefishes. Some experiments imply that sea lamprey, European river lamprey, European eels, and Atlantic salmon can also detect these fields, although these taxa appear to be much less sensitive than the cartilaginous fishes, sturgeons, and paddlefishes. These animals use this capability for prey and mate detection and perhaps orientation.

Among marine organisms, the ability to detect magnetic fields is known to occur in fishes (e.g., eel, trout, salmon, tuna, and sharks) as well as lobsters, turtles, and cetaceans. Several behavioral and physiological experiments imply that rockfishes and flatfishes might also be able to sense magnetic fields. Research implies that organisms may be able to sense EMF down to a few microteslas. Magnetic field detection is likely used by these organisms for orientation, navigation, and homing.

It has been hypothesized that anthropogenic EMF might have some or all of the following effects on marine organisms: 1) Disrupt migrations and movements of marine organisms; 2) Disrupt successful search for prey; 3) Disrupt successful search for mates; 4) Disrupt successful avoidance of predators.

To this end, we will first discuss the quite limited laboratory and field research available on this issue. We will then present the early results of our surveys that compare the fish and invertebrate assemblages inhabiting electrified and non-electrified cables in the Santa Barbara Channel, southern California.

4.6. OREGON DATA INTEGRATION: A PERSPECTIVE ON INFORMATION NETWORKING

Andy Lanier

Oregon Coastal Management Program

Demands for space in Oregon's Territorial Sea and Outer Continental Shelf are increasing over time, putting pressure on existing ecological resources, uses, and users of this shared public resource. Data and information are critical to understanding the impacts of this "sea change." Key ecological questions need to be answered to understand both the short- and long-term effects of implementing marine renewable energy facilities in an environment about which we know relatively little. Ocean management processes within the state, such as planning for ocean hydrokinetic energy projects and the establishment of marine reserves, require a wide variety of data and information to be used by agencies, scientists, communities, and stakeholder groups. Efforts to find, share, and manage needed data to evaluate these processes have demonstrated the need for Oregon to improve current data management and data sharing practices and capabilities. The emerging policy of the federal government to utilize marine spatial planning techniques to address marine management and policy at the regional and state levels reinforces the need for the State of Oregon to better structure its marine data and information sharing practices and to minimize duplication of effort. To address these concerns the Nearshore Research Task Force, a group of concerned stakeholders and agencies, convened and recommended (August 2010) the following actions:

- Establish a framework community of data stewards for key marine data sets.
- Specify metadata standards consistent with federal standards for all data acquired or used by the agencies and organizations responsible for ocean management in Oregon.
- Maintain a data catalogue to track new datasets that are developed and clarify when datasets become obsolete.
- Facilitate data interoperability by the adoption of cross-platform open standards.
- Accommodate a variety of information including traditional geospatial (GIS) data; gridded data from ocean and coastal observing programs from satellites, radar, and models; point observation data from sensors such as current meters and wave buoys; and non-geographic informational data such as PDFs, reports, images, websites, and spreadsheets.

To that end, the Oregon Coastal & Marine Data Network has recently (September 2012) been endorsed by the Oregon Geographic Information Council (OGIC) as a new Framework Implementation Team (FIT). As part of the endorsement process the network put forward the following mission statement:

The mission of the Coastal-Marine FIT is to foster and support a community of producers and users of Oregon coastal and marine data to proactively address emerging data needs.

The participants in this effort have been slowly working out a process to address some of the above issues, including working towards the establishment of a collection of network provider catalogs related to ocean and coastal data. Throughout their ongoing effort, the OCMDN has been tracking the data coordination work at the regional level by the West Coast Governor's Alliance (WCGA) Regional Data Framework (RDF) Action Coordination Team (ACT). The community has members actively participating in both efforts, thereby ensuring that future

efforts will enhance the connectivity and collaboration between state and regional data initiatives. The approach and goals of the RDF ACT and the OCMDN are consistent in that they recognize similar elements of an integrated framework for data discovery, dissemination, and distribution of effort. In this way the OCMDN is nested within the RDF effort and both networks will contribute and benefit from each other's expertise, infrastructure, and access to resources.

5. GAP ANALYSIS: MARINE RENEWABLE ENERGY ENVIRONMENTAL EFFECTS ON THE U.S. WEST COAST

Greg McMurray
Pacific Energy Ventures

The specific intent of the gap analysis document (see Appendix B) and the presentation in the plenary session is to provide a framework to stimulate thought and discussion about the issue of the potential ecological effects of marine renewable energy development, and in particular, to identify knowledge or data gaps that may constrain our ability to move ahead. The complicated relationship between newly introduced technologies and the function of marine ecosystems is deconstructed using stressor-receptor matrices. The matrices are applied to the project phases for wave and wind energy development: siting and construction, operations and maintenance, and decommissioning. There are only few fundamental differences between wind and wave development: 1) wave energy electrical generation is accomplished within the water column; 2) wind development includes dynamic (i.e., moving) structures only above the water's surface, and 3) the density of proposed arrays is much higher for wave than for wind development.

Despite the lack of marine renewable energy installations in U.S. waters, some current sources of data and information can be applied to improve our understanding of the relevant environmental concerns. *Existing data* are those that are derived from marine renewable energy installations in other areas such as Europe, or from other industrial activities and resources studies on the U.S. West Coast. *Proxy data* are from other industrial activities or resource studies undertaken elsewhere. Sufficient existing or proxy information suggests that no real information gaps exist about impacts of the siting and construction phase of device deployment. Site-specific gaps exist until specific project sites are proposed, and technology-specific gaps exist largely for wave energy development because the technologies are in a nascent stage of development. Operations and maintenance gaps are generally similar for the wind and wave technologies, and include principally the environmental stressor groups of static device presence; dynamic device presence in the water (for wave energy devices); energy removal (for wave energy devices); noise and vibration; and electromagnetic fields. Uncertainty about effects originates from lack of adequate information about specific stressor signatures, levels and duration of exposure to receptors and sensitivity of specific species, communities, habitats or ecological processes. Gaps in our ability to predict decommissioning effects seem limited to those relating to infrastructure (e.g., anchors, monopiles) that is left in the marine environment. Many of these gaps are potentially related to scaling effects.

Finally, it is important to note that this presentation describes a manuscript that is considered a work in progress. One assignment for the breakout group sessions at this conference and workshop is to improve the existing gap analysis; results of those discussions are included in this conference proceedings.

NOTE: The complete gap analysis is included in this document as Appendix B.

6. BREAKOUT SESSIONS

6.1 INTRODUCTION TO BREAKOUT SESSIONS

The overall goal of the breakout groups was to develop recommendations for future directions of environmental research needed to predict and assess potential ecological impacts from marine renewable projects in Oregon, especially for the Outer Continental Shelf. Using information presented in the gap analysis and provided in the presentations and posters the first day of the conference, participants in each group further refined the assessment of data gaps associated with the siting, deployment, and operations of wave and offshore wind marine renewable energy projects off Oregon and placed priority levels on the remaining needed research.

The breakout sessions differed from the “stressor-receptor” approach common in past workshops, using instead a “process approach” which more closely follows the process of agency review of a project. This approach convened multidisciplinary groups to examine the stages of the environmental impact assessment process (baseline, potential impacts and predicted consequences, and monitoring) and scale characteristics inherent in the life cycle of a proposed marine renewable energy project. Groups were asked to place the gaps and their priorities in a table of National Environmental Policy Act categories provided to each group. The three breakout groups are further described as follows:

1. **Baseline studies:** This group considered the information needs for programmatic decisions across a wide geographic area, before site-specific information is known. Keeping in mind the types of decisions BOEM needs to make and the scale and intensity of potential impacts from various types of projects (single test device, pilot project of several devices, small commercial development and large commercial development), this group considered the quality of the baseline data in all disciplines and the resolution of the information needed to determine where gaps exist. The Baseline breakout group focused on those studies needed to help select “Opportunity Zones,” those areas where ecological resource mapping suggests there would be the least negative impact from development.

2. **Impact/short-term studies:** This group picked specific impacting agents and reviewed what research has been done globally to inform those issues. The group built upon previous syntheses and the gap analysis to update the information with newly or nearly completed studies from both the scientific and grey literature; priorities were then placed on the studies in terms of the urgency of getting the needed results.

3. **Monitoring/long term studies:** This group evaluated information needs spanning larger spatial and temporal scales than those considered by breakout group #2, and provided feedback on three aspects: (1) surveillance monitoring to supplement or validate impact assessments and inform future analyses, (2) condition monitoring to assist in determining long-term natural and anthropogenic changes, including shifting baselines, and (3) cumulative impacts.

The interdisciplinary nature of the breakout group membership provided an opportunity for the groups to address several specific questions. These questions focused on (1) extrapolating data collected elsewhere for regional use, (2) opportunities for collaboration and data sharing, (3) developing studies in the absence of marine renewable installations using analogous facilities (artificial reefs, buoys and platforms, etc.), and (4) how climate change can result in shifting baselines which affect the ability to attribute detected changes to development impacts.

The groups were allowed approximately five hours of deliberation, including a break and a working lunch. This time was expanded from that originally planned in the agenda (Appendix A).

6.2. BREAKOUT GROUP SESSION REPORTS

6.2.1 Breakout Group: Baseline

Facilitator: Ross Holloway

Science Leads: Caren Braby, Sarah Henkel

Rapporteur: Caitlyn Clark

Participants: Josh Adams, Jack Barth, Jocelyn Brown-Saracino, Chris Goldfinger, John Horne, Keith Kirkendall, Andy Lanier, Milton Love, Jean Thurston, Waldo Wakefield, Ben Wilson, Rick Yarde

6.2.1.1. Introduction

The principal objective of this group was to refine the identification of data gaps in the area of baseline studies to support decision-making for siting Marine Renewable Energy (MRE) projects on the OCS. Within this broad goal, the group focused on describing ecosystem components and vulnerabilities and placing priority levels on the remaining needed research. This process differed from characterizing baseline conditions to provide a point of comparison for effects monitoring (for particular MRE installations) with the assumption that much of this aspect of baseline characterization would be covered in the Impacts Breakout Group.

This group considered the information needs for programmatic decisions on the Oregon coast, particularly for the “Opportunity Zones” described below. Keeping in mind the types of decisions BOEM and the state of Oregon need to make and the scale and intensity of potential impacts from various types of projects, this group considered the quality of baseline knowledge in the relevant disciplines, the resolution of the information, and where there are gaps in knowledge. Finally, participants prioritized the need to address those gaps using the process outlined below.

6.2.1.2. Identifying Gaps & Setting Priorities

The Baseline Breakout Group went through three steps to identify priority information needs: 1) careful discussion of the goal and scope of the gap analysis, 2) identification of data/knowledge gaps in each of the subject areas identified in the matrix, and 3) prioritization of each gap identified. The original goal and scope of the gap analysis for this group was determined to be too broad, so the group focused on identification of the subset of information that will best inform siting of areas for potential MRE development. The process of identifying appropriate development sites requires information for a broad geographic area (ideally the entire area that might be open for development) to better understand ecosystem dynamics and vulnerabilities. An improved understanding will help determine which areas on the OCS may be at lower risk of negative impacts to ecological resources from development. In contrast, baseline information needed for an individual project would be more detailed and cover a small geographic area.

To identify data gaps, the group reviewed the provided subject areas and identified three that did not require discussion: Meteorology/Air Quality, Water Quality and Physical Oceanography. For the first two subject areas, a nexus with baseline data for siting could not be identified, although relevant project-specific baseline needs were recognized. Since this project-specific approach was outside the agreed-upon scope, the group did not discuss those two subject areas further. For Physical Oceanography, it became clear that while much is known about physical oceanography, much less is known about how it affects the ecology or biology of a system. To address this problem, the group created a new subject area, “Ecological Hotspots,” to capture this need.

The group agreed that the data gaps discussed would be relevant for any renewable energy siting projects (wave or wind) unless otherwise specified (see matrix for more details). However, it was presumed that seabirds and bats would likely exhibit a greater vulnerability to impacts from wind energy devices than wave energy devices. Therefore, line items relevant to seabirds or bats on the priority matrix are designated as either wind- or wave-related (for each data gap there are two line items prioritized separately by device type).

Once gaps were captured in the matrix, each breakout group member (11 scoring members total) assigned a score of 1-3 to each gap, with 3 being the highest need. Those individual scores were summed and the resulting total score was assigned to the data gap and formed the basis of an overall division of data gaps into three categories – Highest Need (red), High Need (yellow), and Moderate Need (green) (Table 1). Below are brief narratives for subject areas identified as having the Highest Need for information.

6.2.1.3. Highest Priority Information Needs

The group agreed that the 5 highest priority needs (in order of priority) are:

1. Geology: Seafloor characterization is needed at a broad-scale resolution that can inform management processes (rather than at the high resolution required for scientific inquiry); the highest priority geographic area is 3-10 miles offshore, in presumed sedimentary areas. The principal goal is to identify sensitive ecological resources in areas that might be desirable for renewable energy development.

2. Fish: Distributions of non-commercial species (i.e., forage fish species) integral to ecosystem dynamics and indicative of system vulnerability need to be determined. It may be possible to use other indicators as proxies for some species (e.g., oceanographic measures as proxies for fish distribution, seabird distribution as proxy for fish distribution, etc.).

3. Biological Resources: Identification of ecological hotspots (including temporal variability, and especially winter and/or off-season sampling months) is needed. Ideally, this data collection would include further elaboration of the concept of biological-physical coupling, as explained above.

4. Seabirds: Multiple aspects of basic seabird biology and ecology need to be characterized. First, at-sea migratory corridors need to be mapped, both for non-resident species moving through, and for resident species breeding/foraging). Basic distribution information is also needed, including characterization of temporal (inter-annual) variability, distribution in winter and/or off-season sampling months, diurnal distributions, especially for those species for which daytime and nighttime distributions are likely to differ, and, for some species, residence time at-

sea (to identify species that are at highest risk). Finally, more information is needed about seabird behavior. For example, how does meteorology (which is well characterized) affect seabirds at a siting scale (feeding and migratory behavior, flight altitude)? *Note: These projects were highest priority for wind energy siting and moderate for wave energy siting.*

5. Marine Mammals: Information is needed about marine mammal distribution, including the following elements: temporal (inter-annual) variability, distribution in winter and/or off-season sampling months, diel distribution (as day/night distributions are likely to differ for some species), and decadal scale variation in distribution.

6.2.1.4. Discussion of Additional Questions for the Breakout Group

The group was also asked to consider the following questions:

What is the best way to use current or previous surveys/studies as baseline for marine renewable energy environmental effects studies?

The group did not discuss this question.

Are there opportunities for shared data collection? Are there synergies/collaborations possible to fill these gaps? Is this realistic given variable funding sources/timing needs for surveys?

The group discussed several aspects of these questions, and developed the following recommendations for future baseline research efforts:

- Add other subject area researchers to seafloor sampling cruises or similar “lawn-mowing” type cruises (that provide significant spatial coverage, ideally coastwide).
 - This type of cruise would be particularly compatible with seabird and mammal sampling but may also be compatible with other research efforts and techniques that can fill data gaps such as collection of oceanographic data (e.g., CTD casts) and acoustic tag sampling (e.g., fish tagging studies).
- Use multiple research platforms simultaneously to address complex data gaps.
 - Multiple examples were discussed, including research conducted for the Rhode Island Special Area Management Plan, and the New Jersey Department of Environmental Protection where air and boat sampling were simultaneously conducted to collect an integrated snapshot of the environment.
- Find role(s) for long-term data collection platforms.
 - The Oregon Ocean Observing System (OOI) now being built could be used as a platform for new data collection to address data gaps (i.e., put relevant instruments on moorings or nodes).
 - Use OOI data (e.g., to inform predictive modeling work).
- Increase data accessibility through building data clearinghouse(s).
 - Improvements in data accessibility will help inform the discussion of data gaps, as well as improve data sharing for a range of analyses, such as predictive modeling.
 - Data should be accessible to all interested parties, providing access to data from industry, government, academia, non-profits, and citizen science.

- FLAG for Impacts Breakout Group: participants suggested to the Impacts group that they consider recommending use of the OOI installation (nodes, moorings) as surrogate wind and wave energy devices for studying potential impacts prior to actual device deployments.

How much variability is there and how much data/time series do you need to capture it?

The group did not discuss this question.

6.2.1.5. Other Topics Discussed and Concluding Comments

The group recognized the value of sampling over a broad geographic area to help with interpretation of patterns in the OCS, thus better informing the baseline characterization of the smaller areas that are most likely to be attractive to and well-suited for marine renewable energy project developers. This emphasis on broad geographical sampling includes conducting coastwide studies and surveys in some areas that might be excluded from sampling design for financial or jurisdictional reasons. The group recommended collecting baseline data in the Oregon Territorial Sea as well as the area of interest for the OCS for any new studies (0-10 miles), and collecting baseline data in “closed” areas (Marine Protected Areas, Marine Reserves, Rockfish Conservation Areas, etc.).

The primary recurrent and overarching theme in the Baseline Breakout Group discussion was the keen interest in better understanding biological-physical coupling, because of the presumed importance of these processes to many taxonomic groups that are relevant to MRE siting. A better understanding in this area would allow the use of data from other geographic locales, and would help with predictive modeling for species of interest. The second recurrent theme was that data required for baseline characterization (with the intention of using it for siting only) would be the same for most taxonomic groups for both wind and wave devices. The exceptions are for seabirds and bats, for which there is elevated concern and need for information for siting wind facilities relative to wave energy facilities. The third theme was that in some cases, “snapshot” data sets appear to fill data gaps when in reality they represent only a partial fill of that data gap. For example, seabird and marine mammal sampling occurs during the day and during good weather because sampling is by visual identification. Almost no information is available about distribution or behavior at night, during foul weather, or during winter months when the seas are high. Often, these data sets are from a snapshot in time (one year or a few years) when distribution likely changes over long periods of time (requiring many years of data and analysis of decadal scale patterns).

Table 1: Baseline studies recommendations for supporting decision-making for siting Marine Renewable Energy opportunity areas on the OCS with the goal of understanding ecosystem dynamics and vulnerability. Red () indicates the highest priority projects, yellow () is medium priority, and green () is lowest priority.

Category	Baseline Data Gaps	Priority Level	Notes*
Seafloor Habitats	Seafloor mapping: fully characterize at management level resolution (not publication quality science); highest priority would be 3-10 miles offshore, in presumed sedimentary areas that would be attractive to renewable energy developers; goal - map sensitive unidentified resources		
Ecological Hotspots	Temporal variability in hotspots (especially winter and foul weather)		
Physical Oceanography	Biological-Physical Coupling: effect of physical oceanography on biological distribution		
Water Quality	Hypoxic zones: Seasonality of sub surface hypoxic events on OCS		
Fishes and Essential Fish Habitat	Fish distribution: non-commercial species (i.e. forage fish species); augment existing sparse data, additional data analysis		
Fishes and Essential Fish Habitat	Fish distribution: nursery habitat, habitats vulnerable to life cycle		
Fishes and Essential Fish Habitat	Fish distribution: adult aggregation sites (e.g. crab molting areas)		
Fishes and Essential Fish Habitat	Fish distribution: spawning habitat		
Fishes and Essential Fish Habitat	Fish distribution: analysis of commercially important spp. (data are available, somewhat); finfish, crab, pink shrimp		
Fishes and Essential Fish Habitat	Fish distribution: migratory pathways (crab, salmon)		
Marine and Coastal Birds	Bird distribution: at-sea migratory corridors (for species moving through, for breeding/foraging of more resident populations)		Wind
Marine and Coastal Birds	Bird distribution: non-summer distribution		Wind
Marine and Coastal Birds	Bird distribution: residence time at-sea		Wind
Marine and Coastal Birds	Bird behavior: meteorological effects on seabird behavior at siting scale (feeding and migratory behavior, flight altitude)		Wind
Marine and Coastal Birds	Bird distribution: day vs. night distribution		Wind
Marine and Coastal Birds	Bird distribution: non-summer distribution		Wave
Marine and Coastal Birds	Bird distribution: residence time at-sea		Wave
Marine and Coastal Birds	Bird distribution: at-sea migratory corridors (for species moving through, for breeding/foraging of more resident populations)		Wave
Marine and Coastal Birds	Bird distribution: day vs. night distribution		Wave
Marine and Coastal Birds	Bird behavior: meteorological effects on seabird behavior at siting scale (feeding and migratory behavior, flight altitude)		Wave
Marine Mammals	Mammal distribution: non-summer distribution, on-going/consistent distribution surveys (not just snap-shot), distribution during foul-weather (including depth distribution and activity/behavior), diurnal distribution, decadal scale distribution		
Marine Mammals	Mammal distribution: residence time in the area, migratory pod distribution vs. resident pods		
Marine Mammals	Mammal distribution: Harbor porpoise distribution offshore (seen as particularly sensitive to development and distribution is unknown)		
Marine Mammals	Pinniped distribution: at-sea foraging areas and/or migratory corridors		
Terrestrial Biota			Wind

* Prioritization is relevant to both Wave and Wind (unless noted)

6.2.2. Breakout Group: Impact/Short-Term Studies

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Rapporteur: Stephanie Labou

Participants: Jennifer Ewald, Lisa Gilbane, Joe Haxel, Delia Kelly, Barbara Lagerquist, Bridgette Lohrmann, Laura Margason, Peter Nelson, Tuba Ozkan-Haller, Mark Page, Patty Snow, Rob Suryan

Observers: Deborah Boone, Douglas Boren, Michael Karnosh

6.2.2.1. Introduction

The principal objective of this group was to refine the identification of information gaps related to potential impacts of deployment of wave and wind marine renewable energy projects in the waters off Oregon, and to prioritize the remaining needed research. The group reviewed the two gap analysis tables provided prior to the workshop dealing with post-deployment operations and maintenance and discussed specific potential impacts in a stressor-receptor context using their knowledge of completed and ongoing global and regional research. The group built upon previous syntheses and updated the information with expert knowledge of newly or nearly completed studies from both the scientific and grey literature. Information from the papers presented the first day of the conference was also considered. The group then placed priorities on the studies in terms of the urgency of getting the needed results. Finally, the group addressed questions related to extrapolating data collected elsewhere for regional use and opportunities for collaboration.

The group agreed that there are varying levels of crossover among the topics of the three breakout groups (Baseline, Impacts, and Monitoring). While the group thoroughly discussed the potential for working backwards by first deciding how many devices at a given density are acceptable for energy development and then examining what gaps may need to be filled given those development parameters, ultimately this approach was not adopted as a formal recommendation. The group thought location, e.g., inshore versus offshore or northern Oregon versus southern Oregon, is of primary importance in determining what information may be needed in order to evaluate a submitted industry plan. The group agreed that scientific research under any specific “Affected Environmental Component” (see Gap Analysis) should emphasize listed and protected species, e.g., Pacific eulachon/smelt (*Thaleichthys pacificus*), and many others where possible, and where not possible it should focus on keystone and surrogate species. Finally, the Impacts Breakout Group discussed a general need to use established threshold of impact, where available. There are a number of established thresholds, e.g., acoustic thresholds for marine mammals as set by the National Oceanic and Atmospheric Administration, which should guide research plans so that resulting data are most useful.

6.2.2.2. Gap Analysis: Discussion and Comments

The Impacts Breakout Group addressed the following topic and questions.

Review previously identified gaps and identify research or proxy data that exist to inform gaps.

- a. *Review operations, maintenance and decommissioning tables from gap analysis and update impact table as appropriate. What information do you have to add from ongoing or completed research that addresses a gap?*

Participants in the Impacts Breakout Group discussed research presented during the November 28, 2012, conference session and sought to elaborate with other research that might change the overall ratings suggested in the Gap Analysis tables. Discussion included available data sets regarding marine mammal collision with cables, investigations taking place in Europe, and use of analogue and surrogate projects. The Impact Breakout Group knew of no additional research that had not already been considered that would further address a gap. There was consensus that the Gap Analysis tables for operations, maintenance and decommissioning were correct and required no further correction or alteration. As mentioned in the conference open session, the Impact Breakout Group agreed that Atmospheric and Meteorological Science be added and thoroughly researched for the final Gap Analysis paper.

6.2.2.3. Identification of Projects Addressing Gaps

Review operations, maintenance and decommissioning tables and update impact table as appropriate.

- a. *Rank the gaps in order of importance to a decision or in order of progression.*
- b. *If possible, specifically identify the research question needed for each gap identified.*

Using the tables from the Gap Analysis as background, the Impact Breakout Group identified remaining important impact study gaps or research questions needed for each of the topical areas ("affected environmental component") noted on the left-hand column of the tables below for wave (Table 2) and offshore wind (Table 3) energy facilities. The breakout group ranked the gaps in order of priority, with each participant assigning scores of 1-3. Where possible, participants specifically identified the research question needed for each gap identified. The numerical scores were summed with the highest scores in each component category reflecting the highest and most immediate need for information. The tables below are followed by a narrative discussion of the highest needs.

6.2.2.4. Identification of Projects Addressing Gaps – Wave

The impact studies addressing gaps were assigned priorities using numerical ranking with the results presented in the color scheme outlined in the table.

Table 2: Prioritization of research needs for siting of wave energy projects (Impacts group). Red () indicates project is very important and reflects the highest level and immediacy of information need; yellow () indicates project is important, reflecting an element of a high level of importance or follow-up secondary need; green () indicates moderate need and reflects an element of lesser importance or follow-up secondary or tertiary need.

Affected Environmental Component	Impact/Short-term Studies Supporting Decision-Making for Marine Renewable Energy Projects (Wave Energy)	Priority Level
Geology (Sediments)	Determine the far field and near field impacts of sediment transport induced by energy reduction.	
	Evaluate the impacts of anchor type on local sediment characteristics	
Meteorology, Air Quality and Climate Change		
Physical Oceanography	Determine how the wave shadow (lee of WEC) impacts nearshore habitat	
	Determine the near field effects of WECs on waves and circulation, including the thresholds for changes in circulation	
	Determine the biological implications of near field effects, such as downstream eddies. For example, zooplankton accumulation could lead to a local grazing area, which could attract higher concentrations of predators.	
	Evaluate the array effects of multiple WECs. In addition to modeling, determine if proxy data are available.	
Acoustic Environment	Measure acoustic energy transmitted by WECs and evaluate impacts in the context of baseline ambient levels.	
	Determine whether WEC-generated sound outputs affect local cetacean distributions.	
Hazardous Materials and Waste Management	Given the infrastructure for WEC support and launching, evaluate the potential leaching impacts (of paint, biofouling agents, in bays and estuaries).	
Electromagnetic Fields	Determine EMF impacts on migrating species (sturgeon, elasmobranchs, salmonids, crustaceans, others).	
	Evaluate behavior modifications (if any) EMFs cause in key species.	
	Evaluate ecosystem interactions such as attraction of predators and community effects.	
	Evaluate thresholds for EMF detection in key species using behavioral or other approaches.	
Marine Mammals	Determine potential collision impacts of cetaceans with devices/structures/mooring cables.	
	Assess potential for mooring design to reduce entanglement (perhaps using information from DOD, Navy).	
	Evaluate the impacts of WEC-produced noise on marine mammals.	
	Assess the probability of entanglement using strike/collision modeling approaches developed elsewhere and apply available proxy data to Oregon.	
	Determine the vocalization response of cetaceans in the presence of elevated noise levels.	
	If collision risk for marine mammals exists with WECs, determine whether acoustic deterrence devices reduce the risk.	
	Evaluate whether marine mammals suffer an increased predation risk from predators aggregated around WEC devices.	
Marine and Coastal Birds and Bats?	In the case of moving devices, assess the underwater impacts on diving birds.	
	Determine the impacts of turbulence/wake on bird/bat flight paths/migrations.	

	Evaluate the collision impacts of birds and bats with above-water elements of wave energy devices.	Yellow
	Evaluate bird and bat area use (including fine-scale nearshore surveys) and migration, as well as flight altitude, particularly for nocturnal flights.	Red
	Apply strike/collision modeling with WECs to birds/bats.	Yellow
	Assess possible impacts on bats/birds of prey (e.g., insects) attracted to offshore lights.	Green
Fishes and Essential Fish Habitat	Determine how mooring design can reduce entanglement.	Green
	Assess how artificial reef/FADs effects impact out-migrating salmonid smolts.	Red
	Assess the possible FAD/reef impacts (like predation).	Yellow
	Evaluate the impacts of structures and EMF on green sturgeon.	Red
	Determine the possible predation impacts on juvenile salmonids and/or changes to salmonid movements.	Yellow
	Evaluate the possible impacts of elevated predation to Pacific eulachon (newly listed). *Baseline needed*	Green
	Determine benthic changes due to hydrodynamic impacts.	Green
Sea Turtles	Evaluate sea turtle entanglement risks at WEC sites.	Green
	Assess whether aggregation of predators will lead to increased predation risk for sea turtles.	Green
Coastal Habitats	Determine the impact of bathymetric change on coastal habitats, including asking how these changes are connected to specific species.	Yellow
Seafloor Habitats	Evaluate the consequences of removing/leaving devices in the water -- what is the impact of long-term habitat alteration?	Green
	Assess how anchor types impact seafloor habitat, with a goal of minimizing impacts and defining areas to avoid.	Green
	Conduct research to determine whether introduction of a hard bottom substrate facilitates invasive species.	Yellow
	Determine the impact of wave energy reduction/sediment transport on benthic communities.	Green
	Assess the scaling impacts on benthic communities/benthic habitat, especially in relation to sediment transport and settling (based on possible circulation changes).	Red
Areas of Special Concern	Assess whether array areas could function as marine reserves. (Note: safety zone determined by Coast Guard).	Green
	Determine whether there are possible adjacent impacts, such as beach erosion in national parks.	Green

6.2.2.5. Highest Priority Information Needs – Wave Energy

As described above, the Impacts Breakout Group scored individual projects, ultimately dividing them into three categories: Highest Need (red), High Need (yellow), and Moderate Need (green) (Table 2, above). Here, the Highest Need projects are described in more detail. The Highest Need category includes about the top quarter to third of the total numerical rank.

1. Geology (Sediments): Determine the far field and near field impacts on sediment transport induced by energy reduction. In the near field, increased sediment transport and sorting around anchors could be a direct hydrodynamic effect of scouring. In the area between the shore and the WECs, however, energy will be reduced to the degree that it is absorbed by the WECs and converted to electricity. In a large array, this energy loss could be substantial, potentially resulting in altered sedimentary environments in the near field as well as changes in the far field

mediated by changes in alongshore currents; these effects, in turn, could impact sediment processes in the nearshore including transport and accumulation, resulting in ecological impacts.

2. Acoustic Environment: Measure acoustic energy transmitted by WECs and evaluate impacts by comparing to baseline ambient levels. Acoustic signals generated by WECs need to be measured and characterized, including broadband sound pressure levels and spectral energy content; combined with baseline data, these data would allow for an evaluation of potential threshold violations, for example, those related to marine mammals. Additionally, source level estimates would enable acoustic propagation modeling to determine distances from which WECs can be detected by marine mammals and other organisms sensitive to variations in sound levels.

3. Electromagnetic Fields: Determine the electromagnetic field impacts on sensitive or migrating species, e.g., sturgeon, elasmobranchs, salmonids, crustaceans, and resident fish species. EMFs from cables and devices may affect migrating species that use EMFs, either through diversion of movement patterns or through aggregation around EMF sources. In addition, it is possible that EMF sources may cause aggregation of predators that could increase predation on important species.

4. Electromagnetic Fields: Evaluate thresholds for EMF detection in key species using behavioral or other approaches. Thresholds for EMF detection for key species are important, because they identify the levels at which mitigation through shielding or burial may render the signal harmless. Thresholds can be identified through neurophysiological or behavioral means. The latter may include either tank-based experimental work or field work using induced electrical and magnetic fields.

5. Marine Mammals: Evaluate the impacts of WEC-produced noise on marine mammals. In combination with measurement and propagation of WEC acoustic signals, this study would assess behavioral changes in marine mammals in the vicinity of WECs to determine avoidance, attraction, or impacts on migratory routes. It is important that the acoustic deterrence not in itself produce an unacceptable negative impact.

6. Marine Mammals: If collision risk for marine mammals exists with WECs, determine whether acoustic deterrence devices can reduce collision risk. Acoustic deterrence devices have been successfully used to improve the detection and avoidance of fishing gear or other items by marine mammals. Any acoustic deterrent that would be used could not in itself cause an unacceptable negative impact. If use of the deterrents is successful, this approach could be an important tool to reduce negative interactions between marine mammals and WECs.

7. Marine and Coastal Birds and Bats: Evaluate bird and bat distribution and migration patterns (including fine-scale nearshore surveys), flight altitude, and nocturnal flight characteristics. The above-water expression of WECs has the potential to induce avian species to collide with the devices. The nearshore and offshore distribution of bats and some seabird species is poorly understood. Understanding the flight altitude of bird and bat species can determine the potential magnitude of collision potential relating to specific device designs.

8. Fishes and Essential Fish Habitat: Determine whether and how artificial reef/FADs will impact out-migrating salmonid smolts. WECs placed either in close proximity to estuaries with salmon populations or in the migratory routes of juvenile salmonids could result in interactions. Specifically, the artificial reef or fish aggregating device effects of WEC arrays could have several effects, including aggregation of predators causing higher predation of salmonids or aggregation of juvenile salmonids, resulting in alterations to normal migratory patterns.

9. Fishes and Essential Fish Habitat: Determine the impacts of structures and EMFs on green sturgeon. The southern district population segment of green sturgeon is listed as federally Threatened. Green sturgeon migrate along the coast at depths where WEC installations are likely to be sited. Changes to the habitat include the imposition of benthic structure (anchors, cables), aggregation of potential predators, acoustic signals, and EMF signals. The potential effects of these changes on green sturgeon should be evaluated.

10. Seafloor Habitats: Assess the scaling impacts on benthic communities/benthic habitat, especially with respect to sediment transport and settling (based on possible circulation changes). As WECs are installed and nearshore energy is reduced, changes associated with the scale of the project, or on larger scales, the siting of projects, will likely have non-linear effects. Assessment of the cumulative effects of size of single array installations, and of the effects of adjacent installations, must be confirmed.

6.2.2.6. Identification of Projects Addressing Gaps – Wind

The impact studies addressing gaps were identified as to prerequisite or order of importance using numerical ranking with the results presented in the following color scheme outlined in the table.

Table 3: Prioritization of research needs for siting of wind energy projects (Impacts group). Red () indicates project is very important and reflects the highest level and immediacy of information need; yellow () indicates project is important, reflecting an element of a high level of importance or follow-up secondary need; green () indicates moderate need and reflects an element of lesser importance or follow+-up secondary or tertiary need.

Affected Environmental Component	Impact/Short-term Studies Supporting Decision-Making for Marine Renewable Energy Siting (Wind Energy)	Priority Level
Geology (Sediments)	Assess the far field and near field impacts of sediment transport.	
	Evaluate the impacts of anchor type on local sediment characteristics	
Meteorology, Air Quality and Climate Change	Determine the impacts of turbulence/wake on bird/bat flight paths/migrations.	
	Determine whether there will be local moisture/temperature changes or changes in the air/sea boundary layer.	
Physical Oceanography	Assess wave modification impacts.	
	Determine the near field effects on waves and circulation, including the thresholds for changes in circulation	
	Determine the biological implications of near field effects, such as downstream eddies. For example, zooplankton accumulation could lead to a local grazing area, which could attract higher concentrations of predators.	

	Assess array effects and evaluate use of proxy data in this assessment.	Green
	Assess effects of structure.	Green
Acoustic Environment	To determine impacts, there is a need for baseline data about noise from wind devices including changes to ambient levels. Acoustic energy transmitted by wind energy devices needs to be measured and quantified.	Red
	Conduct passive acoustic monitoring.	Red
	Determine whether sound outputs cause changes in cetacean distribution.	Red
	Determine acoustic thresholds for species of interest - coordinate with NOAA (permitting).	Yellow
	Evaluate the impacts of siting/decommissioning mitigation measures, and determine how any impacts could be mitigated (bubble curtains, seasonal siting).	Green
Hazardous Materials and Waste Management	Given the infrastructure for WEC support and launching, evaluate the potential leaching impacts (of paint, biofouling agents, etc.) in bays and estuaries.	Green
Electromagnetic Fields	Determine EMF impacts on migrating species, sturgeon, elasmobranchs, crustaceans, and other endangered species.	Red
	Determine how ecosystem interactions (such as attraction of predators) should be considered. A related question is, how should community effects be determined (ongoing study - using aquarium set up with resident populations of captive species of interest)?	Yellow
	Evaluate thresholds for EMF detection in key species.	Yellow
	Develop a compilation of studies about EMF.	Green
Marine Mammals	Determine potential collision impacts of cetaceans with devices/structures/mooring cables.	Red
	Determine whether mooring design can reduce entanglement (perhaps using information from DOD, Navy).	Green
	Identify and describe the general impacts of noise on marine mammals.	Yellow
	Determine the probability of entanglement (using strike/collision modeling and applying proxy data to Oregon specifically).	Yellow
	Evaluate whether animal behavior changes in proximity to devices (Monitor near field interactions/behavior, use IR/video to capture interactions).	Yellow
	Determine the vocalization response in the presence of elevated noise levels and the distance from device the device at which this effect is evident.	Yellow
	If noise affects whale migration/behavior, assess whether acoustic deterrence devices could be used to mitigate.	Red
Marine and Coastal Birds	Assess the underwater impacts of moving devices on diving birds.	Green
	Assess the impacts of turbulence/wake on bird/bat flight paths/migrations.	Yellow
	Collect data (especially fine scale nearshore surveys) regarding area use and migration, as well as flight altitude, particularly for nocturnal flights.	Red
	Strike/collision modeling can be used for birds/bats.	Yellow
	If insects are attracted to offshore lights, determine the possible impacts on bats/birds.	Green
Terrestrial Biota (Including bats and butterflies)	Determine the impacts of turbulence/wake on bird/bat flight paths/migrations.	Yellow
	Collect data (especially fine scale nearshore surveys) regarding area use and migration, as well as flight altitude, particularly for nocturnal flights.	Yellow

	Strike/collision modeling can be used for birds/bats.	
Fishes and Essential Fish Habitat	Determine how mooring design can reduce entanglement.	
	Assess how artificial reef/FADs effects impact out-migrating salmonid smolts.	
	Assess the possible FAD/reef impacts (like predation).	
	Evaluate the impacts of structures and EMF on green sturgeon.	
	Determine the possible predation impacts on juvenile salmonids and/or changes to salmonid movements.	
	Evaluate the possible impacts of elevated predation to Pacific eulachon (newly listed). *Baseline needed*	
	Evaluate benthic changes due to hydrodynamic impacts.	
Sea Turtles	Assess whether there are entanglement risks.	
	Assess whether there is an increased predation risk.	
Coastal Habitats	Evaluate the impact of bathymetric change on coastal habitats - how are these changes connected to specific species and/or tribal issues?	
	Determine the consequences of removing/leaving devices in the water and the impact of long-term habitat alteration.	
Seafloor Habitats	Determine how anchor types impact seafloor habitat, with a goal of minimizing impacts and determining areas to avoid.	
	Assess the impact of removing/leaving devices in the water with respect to habitat alteration (long-term).	
Topographic Features	Determine whether introduction of a hard bottom substrate will facilitate invasive species.	
Other Benthic Resources	Assess the impact of wave energy reduction/sediment transport on benthic communities.	
	Assess the scaling impacts on benthic communities/benthic habitat, especially in relation to sediment transport, and settling (based on possible circulation changes).	
Areas of Special Concern	Determine whether array areas could function as marine reserves. (Note: safety zone determined by Coast Guard).	
	Determine whether there are possible adjacent impacts, such as beach erosion in national parks.	

6.2.2.7. Highest Priority Information Needs – Wind Energy

As described above, the Impacts Breakout Group scored individual projects, ultimately dividing them into three categories: Highest Need (red), High Need (yellow), and Moderate Need (green) (Table 3, above). Here, the Highest Need projects are described in more detail. The Highest Need category includes about the top quarter to third of the total numerical rank.

1. Acoustic Environment: To determine impacts of device noise, there is a need for baseline data about noise from wind devices, including assessments of how those noise levels will change to ambient levels. Information on existing background acoustic energy levels is critical. Baseline data allow for comparisons of measured acoustic signals transmitted by offshore wind energy devices and therefore an evaluation of possible threshold effects, for example those related to marine mammals or birds. Source level measurements also enable modeling of acoustic propagation to determine distances from which the wind turbines can be detected by organisms sensitive to changes in sound levels. Investigations could use passive acoustic monitoring, where species-applicable, to detect impacts and/or local cetacean distribution.

2. Electromagnetic Fields: Determine impacts of EMFs on sensitive or migrating species, e.g., sturgeon, elasmobranchs, salmonids, crustaceans, and resident fish species. EMFs from cables and devices may affect migrating species that use EMF, either through diversion of movement patterns or through aggregation around EMF sources. In addition, it is possible that EMF sources may cause aggregation of predators that could increase predation on important species.

3. Marine Mammals: Assess the potential collision impacts of cetaceans with wind energy devices/structures/mooring cables. Floating wind energy devices will extend 10-20 meters below the sea surface and be anchored with multiple cables. Their presence may present collision hazards for some species of marine mammals. Marine mammals with good echolocation abilities may avoid the installations while baleen whales may not sense the devices and collide with the structures. Acoustic deterrence devices have been successfully used to improve the detection and avoidance of fishing gear or other items by marine mammals. Any acoustic deterrent that would be used could not in itself cause a negative impact. If successful, the use of such deterrents could be an important tool to reduce negative interactions between marine mammals and wind energy devices.

4. Marine and Coastal Birds and Bats: There is a need for data (especially fine scale nearshore surveys) regarding area use and migration, as well as flight altitude, particularly for nocturnal flights. Offshore wind devices will have very large turbine blades that may sweep a vertical circle from 30 meters to 150 meters above the sea surface. There is already evidence that birds can collide with turbine blades and bats are severely affected by downwind barometric changes caused by spinning turbines. Understanding the flight altitude (flight height) of important bird species, their migration routes, and offshore feeding areas can help define the potential magnitude of this problem and guide development of parameters for siting installations. Determining distances at which bat species are most frequently found offshore is a baseline information need.

6.2.2.8. Discussion of Additional Questions for the Breakout Group

The Impacts Breakout Group also addressed and discussed the following questions:

What is the most effective means of applying the results of impact studies done elsewhere (e.g., Europe, UK) to the physical and biological systems off the coast of Oregon? What kind of follow-up studies off the Oregon coast would be necessary to confirm the applicability of results? What recommendations does the group have for evaluating proxy data and determining its applicability?

Studies done elsewhere can, in most instances, help to inform study designs in Oregon to improve efficiency of research planning and usefulness of results. In limited instances, these studies may apply directly to information needs for offshore Oregon. Numerous studies on the effects of both wave and wind energy devices have been and continue to be carried out in other offshore locations such as Europe (United Kingdom, Belgium, Germany, Denmark). Usually these studies are resource- or species-specific. However, a good deal of the European research results is proprietary, unavailable to U.S. decision-makers because it was paid for by the

developers and not government funding. Additionally there are no known studies of European test sites for wave devices. There are far fewer studies that have been completed here on the West Coast of the United States where applications for both floating wind and wave energy installations are expected. In examining European studies several comparisons are important.

It is important to look for device design similarities. Studies of pile-driven anchoring systems and of electromagnetic field emissions from power cables conducted anywhere could be directly appropriate to considering effects on Oregon fish, invertebrates and marine mammals. In addition artificial reef effects have been well studied and are likely applicable to installations off Oregon. There have been assessments of noise changes brought about by monopile wind devices off the United Kingdom and bird migration studies around wind farms off Denmark and Germany. There have been a few studies that investigated benthic communities, sediment grain size, etc. Information about physical characteristics of devices, i.e., vibration, acoustics, etc., can be useful to begin designing impact and monitoring projects. Sound (dB, spectrum) would be the same for the same device, for example, but sound propagation would differ in different environments.

It is important to look for appropriate scale and range of effects. For example European studies may have determined that sediment transport effects are seen within several hundred meters of the installations, but not thousands of meters away. Determining the appropriate scale of effect by comparison with European studies, e.g., for sediment transport or benthos, may allow studies of offshore Oregon to gather a smaller amount of data to determine whether the same effect or pattern is present, resulting in greater statistical power without doing a larger amount of research. Researchers should always perform power analyses to determine the need for data and design studies appropriately.

It is important to recognize and repeat experimental designs that work best to answer given questions. The design of a number of European studies, e.g., those related to migrating eels and birds using acoustic tags, transmitters and radar, answered specific questions relevant to placement of devices and power cables. Although repeating similar studies off Oregon may require an increase in funding or length of time to complete, results will determine the impact without ambiguity and also be useful to other important research.

It is important to look for species analogues that are similar in morphology, behavior, and ecological role to the local target species. For example although there are no large cetaceans off Europe and therefore no studies of large whales, there are many Delphinidae and Phocoenidae species that have been studied and may be appropriate proxies for dolphin or porpoise species located off Oregon. For seabirds, European studies provide adequate guidance as to how to design seabird studies in Oregon, and comparison of behavior and ecological role between European and West Coast species can help inform the design of the most efficient research. However, trustee agencies, including NOAA and USFWS, with which federal and state agencies consult, may not allow the use of proxy data for Endangered Species Act and Magnuson-Stevens Fisheries Conservation and Management Act Consultation purposes.

It is important to look for model equivalents as proxy models may be applied to West Coast species and work well when used with relevant input. For example, the collision model for marine mammals used in Scotland for wave devices might be beneficially applied to species off Oregon. Models can be tuned and tailored to the West Coast; however, they do require ground-truthing with real environmental or biological response data.

There are some difficulties in using proxy data for regulatory purposes. Proxy studies can be used as surrogate examples or starting points, or to assist with study design. For Oregon,

researchers and agencies can use proxy data to improve the efficiency of local and regional studies; however, for most regulatory purposes, there will likely be a requirement for specific local data, especially for endangered and threatened species.

What synergies can be applied in research programs maximizing efficiency in meeting multiple objectives (e.g., addressing multiple gaps)? Consider collaborative research, resource sharing, and cross-agency approaches.

The National Oceanic Partnership Program (NOPP) was established in the United States to, among other things, coordinate and strengthen oceanographic research efforts by identifying and carrying out partnerships among federal agencies, academia, industry, and other members of the oceanographic scientific community in the areas of data, resources, education, and communication. NOPP allows pooling of funds from multiple sources. NOPP research encompasses numerous areas, including oceanographic research and exploration, technology development, resource management, and ocean education. NOPP supports many diverse topics, such as: Sensors for Marine Ecosystems, Assessing Meridional Overturning Circulation Variability – Implications for Rapid Climate Change, Improving Cyclone Intensity Forecasting, Exploration and Research of Deepwater Coral Communities, the Global Ocean Data Assimilation Experiment, and Understanding and Predicting Changes in the Ocean Workforce. NOPP focuses on ocean-related objectives too large for single agencies to undertake but satisfy multiple agency missions and would benefit from partnerships among government, private industry and academia. NOPP uses a peer-review process, which identifies and funds the most scientifically and technically meritorious research that clearly demonstrates public/private sector partnerships in areas of interest each year.

The Cooperative Ecosystem Studies Unit (CESU) network is a national consortium of federal agencies, tribes, academic institutions, state and local governments, nongovernmental conservation organizations, and other partners working together to support informed public trust resource stewardship. CESUs bring together scientists, resource managers, students, and other conservation professionals, drawing upon expertise from across the biological, physical, social, cultural, and engineering disciplines to conduct collaborative and interdisciplinary applied projects that address natural and cultural heritage resource issues at multiple scales and in an ecosystem context. Each CESU is structured as a working collaborative with participation from numerous federal and nonfederal institutional partners. The state of Oregon and BOEM both belong to the Pacific Northwest Cooperative Ecosystems Studies Unit. PNW CESU is a cooperative venture among 17 leading academic institutions in the Pacific Northwest region, several state agencies and ten federal land management and natural resource research organizations. The overarching goal of the CESU network is to improve the scientific basis for managing federal lands by providing resource managers with high-quality scientific research, technical assistance, and education. CESUs make it possible for academic institutions to minimize their overhead and use the savings as in-kind funding for a proposal, thus encouraging the application of maximum funding toward actual lab or field aspects of a project.

In the absence of operational marine renewable energy devices, what approaches can be taken to initiate key impact studies to collect data that will address the most important gaps? Will results need to be confirmed when devices are installed?

One approach would be to decide what would be an acceptable level of change to an aspect of the ecosystem and determine the threshold number of devices that would cause such a change. This approach is essentially “working backwards,” as its application would involve first deciding how many devices at a given density are acceptable for energy development and then examining what gaps may need to be filled. For example, when considering longshore oceanographic currents, how many WECs or wind energy devices would it take to cause sufficient additional drag to change the longshore current regime? In such a case, changing long-shore currents would not be acceptable. Once that decision is made and the number of devices needed to exceed the acceptable limit is determined, policy decisions would only allow development and installation of devices up to that limit. Another example with respect to wave height and type might be, how many WECs or wind energy devices would it take to decrease wave height by 50 percent? In such a case, decreasing wave height by more than 50 percent would not be acceptable. Once that decision is made and the number of devices needed to exceed the acceptable limit is determined, policy decisions would only allow development and installation of devices up to that limit. In both of these cases research would be needed to determine how many devices it would take to cause the ecosystem change. This could be approached through modeling.

Another approach would be to use existing surrogate situations and structures that are in the ocean now to help determine the likely impacts from future energy conversion devices. For example, a ship that sinks could be surveyed to address questions pertinent to anchors (determining artificial reef or FAD effects, assessing sediment transport and scouring, etc.) that may be used to hold floating wind or WECs in place. Another example would be extrapolating from results of studies of fouling communities on existing buoys, such as those from the National Data Buoy Center and Ocean Observation Initiative.

Europe does not have the same regulatory environment as the United States and in some cases few ecological studies have been done on existing offshore energy devices, especially in locations where devices are being tested. It might be possible for U.S. students and investigators to take advantage of existing European installations and conduct research in Europe to answer questions pertinent to potential installations offshore of Oregon. The challenge will be how to acquire funding for U.S. scientists to go overseas.

It was agreed that robust analyses of data in domestic and international databases should be accomplished. Databases such as TETHYS, Annex 4 and the Pacific Coast Ocean Observing System (PaCOOS) should be examined and explored for proxy data that are relevant to potential impacts from renewable energy installations offshore of Oregon.

6.2.2.9. Other Topics Discussed

The impacts group discussed the general benefits of wave and wind energy -- for example, how much energy can be produced to offset fossil fuel energy production, and how can it reduce fossil fuel emission impacts? Although this discussion represented an interesting thought exercise, the topic was not directly applicable to the objectives of the breakout group.

6.2.3. Breakout Group: *Monitoring*

Facilitator: Meleah Ashford

Science Leads: Mary Elaine Helix, Paul Klarin

Rapporteur: Todd Hallenback

Participants: Brad Blythe, Cathie Dunkel, Daniel Erikson, Jim Harvey, Murray Levine, Gregory McMurray, David Mellinger, David Pereksta, Donna Schroeder, John Steinbeck, Scott Terrill, Dan Wilhelmsson, Susan Zaleski

6.2.3.1. *Introduction*

The principal objective of this group was to identify the long-term monitoring studies needed for continued deployments of wave and offshore wind marine renewable energy projects off Oregon, and to place priority levels on the remaining needed research. This group evaluated information needs spanning large spatial and temporal scales and provided feedback on studies needed for large scale monitoring of the environment in the vicinity of projects once in place, and for smaller scale monitoring of individual projects.

The approach used by this group was to evaluate specific facility deployment scenarios. The group considered a large-scale wave energy facility with 50-100 devices placed at the 3 mile line in 80 m water secured with a honeycomb of 100 anchors; or a large (tall) floating wind farm 10 miles offshore with an array of five devices. Given these hypothetical facilities and two missions -- one to monitor a specific facility, called surveillance monitoring, and one to monitor the environment in which the facilities are located over time, called condition monitoring -- the group discussed priority monitoring needs. For a given issue, if members of the group agreed that it was something that would be mitigated/monitored and knew how to conduct the monitoring, it was not considered an information gap. Before undertaking the discussion, the group first prioritized what needed to be monitored and spent the most amount of time discussing the six priority resource categories: Marine Mammals, Seabirds, Fishes/EFH, Acoustic Environment, and Pelagic Environment (Forage Fish). The group also gave higher priority to studies that should be done now in anticipation of proposed energy projects. The group recognized that in some cases the study needs to be started now to inform decision-making models, carried out through the process, and then continued after projects are in the water, to provide proper monitoring of the environment. The group defined “threshold” as a level of effect or condition that would be detected during monitoring and be of sufficient size to warrant invocation of adaptive management measures.

6.2.3.2. *Gap Analysis: Discussion and Comments*

The group discussed the gap analysis tables in detail, developing the following recommendations: First, the group felt that there was a gap in our knowledge about the effects of static devices on pinnipeds. Some proxy data from interactions with buoys are available that could provide information on species behavior, group responses, and mitigation measures to

discourage hauling out on equipment. However, it was felt that the honeycomb facility configuration could result in effects that have not been studied and that monitoring would be needed to fill the gap. The group suggested that “Static Devices” for pinnipeds be assigned as a gap with some proxy data available.

The group also discussed whether a gap remained with respect to research on effects of static devices on benthic invertebrates and resident fishes. It was felt that some proxy data might be useful from oil and gas facilities and so two “P’s” were added, meaning that proxy data are available.

It was suggested that it is necessary to review existing information from tension leg facilities in the Gulf of Mexico on potential effects on whales and other species and/or to collect additional information on this topic. It was not known whether any specific work is ongoing in relation to sperm whales and avoidance/entanglement with tension leg facilities, but this issue is worth investigating because data from these structures may be applicable to the anchoring systems proposed for floating wind devices.

Boat traffic (currently listed as “Existing” across all categories), especially as it relates to pinnipeds, was discussed, with reference to the severe propeller damage observed in Scotland. This category was left as-is, as a rating of “E?” (data may exist) for pinnipeds.

In the case of wave energy, energy removal and its effects on sedimentation, water circulation, and habitats was discussed; the group determined that there are many factors including the amount of sand deriving from rivers, estuaries, and bluff erosion, etc. which exhibit large and highly dynamic interannual variability. In addition, large events, such as storms, tend to overwhelm the system. Each littoral cell behaves differently depending on angle, source of sand, etc. Therefore, it would be difficult to set up a monitoring program at a scale that could detect subtle energy removal effects (projected at ~10%) in such a dynamic system.

For offshore wind energy, a rating of “G” (gap exists) for “Energy Removal” for birds and bats was recommended, as well as a “G” for “Noise and Vibration” for birds and bats. There was discussion about the offshore distribution of bats, whether there might be data from fishing boat sightings, and whether bats would migrate from offshore islands or other long distances if a device was placed in the water.

The group decided that some of the acoustics issues would be best answered by a focused study or set of focused studies rather than monitoring. Some basic information recommended by the Baseline group is needed before determining the proper focus for monitoring.

6.2.3.3. Identification of Projects Addressing Gaps

The approach taken by the group for reviewing the tables is described above. The group voted on the top priority categories from the NEPA table and they fell out in the following order: Marine Mammals, Seabirds, Fishes/EFH; Acoustic Environment, Pelagic Environment (Forage Fish).

Table 4: Key monitoring studies that will be important for wave and offshore wind installations off the Pacific Northwest coast. In particular, the monitoring group was interested in filling gaps where information is lacking on the effect or there is a gap in how to monitor. If it is known how to collect the information needed to monitor, it was not considered a gap or a high priority for research. Red (█) shading indicates the highest level of importance; yellow (█) indicates a medium level of importance. These projects are described in more detail below (parenthetical numbers after project titles in the table refer to the numbered detail items below).

Affected Environmental Component	Importance of Issue Ranking	Monitoring Studies Supporting Decision-Making
Geology (Sediments)		Offshore facilities have little effect on sediment deposition in nearshore, concerns arises for devices in nearshore - beach deposition, benthic effects
Meteorology and Air Quality		
Physical Oceanography		BOEM - Monitoring changes in wave pressure, energy, height at the shoreline
Water Quality		
Acoustic Environment		After establishing sound threshold of effects on fishes and marine mammals, monitor to make sure the levels are below threshold. (6)
Haz. Material Waste Mgmt		
Electromagnetic Fields		Continue BOEM ongoing studies of EMF measurement
MARINE MAMMALS Cetaceans Threatened Endangered (<i>Fin, Blue, Humpback, Sei, North Pacific, Right, Orca, Sperm</i>) Pinnipeds Endangered (Stellar sea lion) Food Web Impacts		Monitor cetacean occurrence and encounters with marine renewable energy (MRE) installations. (5) Use passive acoustic monitoring to understand changes in distribution near MRE installations. (5) If effective acoustic deterrent devices are developed, monitor their use and effectiveness around MRE installations. (6) Monitor effects of MRE installations on pinniped distribution, behavior, and possible changes in behavior with focus on endangered Steller sea lion. (1,4) Monitor changes in predation vulnerability to key species due to aggregation or attraction of prey or predators. (7)
MARINE AND COASTAL BIRDS Threatened Endangered (<i>Marbled Murrelet, Short Tailed Albatross, Hawaiian Petrel</i>)		When acceptable technology is developed, monitor 3-d habitat utilization by foraging seabirds. (2) Monitor bird strikes and effects of lighting regimes on MRE installations. (3) Monitor interactions of marbled murrelet with MRE installations. (4)

FISHES AND ESSENTIAL FISH HABITAT Threatened Endangered (<i>Salmonids, Eulachon, Green Sturgeon</i>)		Monitor key fish species (with focus on listed species, e.g., green sturgeon, salmonids, and eulachon) around MRE installations using a combination of passive acoustics (tags) and active acoustic surveys. (1,4)
FADs		Monitor the FAD effect at MRE installations.(7)
Sea Turtles		
Coastal Habitats		
Seafloor Habitats		
Topographic Features		
Other Benthic Resources		
Areas of Special Concern		(National Parks, National Marine Sanctuaries, National Wildlife Refuges, National Estuarine Research Reserves, National Estuary Program)
Pelagic		Monitor changes in key productivity parameters near MRE installations and compare with control sites. (8)

6.2.3.4. Highest-Priority Information Needs

Table 4 shows the medium- and high-priority monitoring projects identified by the group. To narrow down this list, the group’s criteria for ranking the importance of each study included: 1) studies that should be started now and carried out through the installation and operation phase, 2) studies that are needed to understand the severity of effects and could greatly change our approach, and 3) studies to develop technology to monitor items thought to be critical for any project. The first five priority studies below were developed by the group ranking and in some cases use monitoring approaches to group similar projects, in many cases combining across NEPA categories in an efficient manner. Additional monitoring projects (numbered 6 and above) were lower in priority and follow from the table above.

The monitoring group’s highest ranked studies are:

1. Improve acoustics receiver network for fishes, especially listed sturgeon (which already have acoustic tags implanted in a large number of fishes) and salmonids. This project could be initiated now so that when energy projects are deployed, the acoustic receiver network would be ready to monitor many key effects; additional receivers can be installed as monitoring systems for MRE installations. This monitoring could conceivably apply to species such as Steller sea lion, which otherwise may require visual surveys. The drawback of this project is that it would require considerable effort to expand the network to include fishes other than sturgeon. The broad array of receiving networks near reefs and other areas is beneficial to understanding movements of important species and addresses multiple issues such as aggregation, spatial distribution

around devices, potential predation (e.g., from pinniped or shark aggregation), and related ecosystem effects.

2. Conduct studies to understand habitat utilization of seabirds foraging offshore in three-dimensional air space. While seabirds are generally near the water nearshore, studies have shown that flight height is a function of wind speed, a finding that is highly relevant to offshore wind installations.
3. Determine methodology to confidently monitor bird strikes, including during severe weather. The highest probability of strikes may be during severe weather, and the traditional methods (visual, radar) will not work. Current research on a multi-sensor monitoring system (with infrared cameras, radar, and other sensors) may develop appropriate approaches to address both this question and that in 2, above. Lighting is also an important consideration. A related study would involve testing different colors or configurations of lights to evaluate the potential for lighting to attract certain bird species. Work is needed (which could be started now) to determine the balance between navigational visibility of the devices from the U.S. Coast Guard's perspective (bright navigation lights) vs. reduced impacts on birds (muted navigation lights).
4. Initiate and continue long term monitoring of distribution of endangered fish, mammals, and birds (marbled murrelet, Steller sea lion, whales, salmon, sturgeon). This will be a multi-pronged sampling approach including visual, acoustic, camera, tagging, and other approaches for this multi-species group. It also addresses many topics, such as aggregation (the FAD effect), increased predation, and foraging. In concert with item 1, above, it is recommended that the tagging of Steller sea lions be specifically increased to determine their pattern of activity and presence near MRE installations.
5. Determine encounter rates of whales for MRE installations and the outcomes of the encounters. This need encompasses the first two priorities under Marine Mammals related to cetaceans using visual and both passive and active acoustic methodologies. An important part of this work will be understanding cetacean distributions in all weather conditions, including severe weather. There is a need to monitor opportunistic projects (e.g., Pacific Marine Energy Center, to be sited off Newport, Oregon) or proxy data from existing tension leg projects (floating oil platforms) and sperm whale data in the Gulf of Mexico to gain a better understanding.

In addition to the highest priority projects identified above, the group commented on the additional monitoring projects in categories with moderate to high priority discussed during the breakout session. These three additional items are not listed in priority order.

6. Monitoring acoustic signatures of devices will require well defined thresholds for marine mammals and fishes. The technology for such monitoring is well developed, and increasing use of gliders is a positive development; the thresholds, however, remain a data gap. Likewise, acoustic deterrent devices hold promise, and if proven to work for marine mammals, their use should be monitored at any MRE installations.
7. A remaining concern for marine mammals is food web impacts. For example, if marine mammals are attracted to devices or MRE installations, this could also attract large sharks or even killer whales, resulting in greater predation on those marine mammals. This phenomenon is related to the FAD effect for forage and other fishes, wherein fish

concentrations may increase predation and potentially fishing mortality; these effects should be monitored.

8. In the pelagic environment, “hot spots” for productivity exist, and the distribution of other features, like upwelling or hypoxia, is not uniform. It will be important to monitor changes in key productivity parameters near MRE installations and determine whether any changes are related to the presence of the installations.

6.2.3.5. Discussion of Additional Questions for the Breakout Group

The group also considered the following questions.

What is the best way to include existing monitoring programs or datasets to answer wave and wind monitoring questions? What types of new monitoring might apply to a suite of devices or take advantage of larger datasets?

Are there monitoring programs in place which will provide information for wind and wave energy projects? What are they?

Existing monitoring programs include: data collected on physical oceanography by the Ocean Observing System – Northwest Association of Networked Ocean Observing Systems (OOS-[NANOOS](#)) project; the OOI glider network collecting data along the Newport and Gray’s Harbor lines; National Buoy Data Center ([NBDC](#)); Coastal Ocean Dynamics Applications Radar (CODAR)-[PaCOOS](#) surface current studies (including larval distribution models, monitoring of oil spills etc.); Pacific Fisheries Information Network ([PacFIN](#)), Pacific Fishery Management Council ([PFMC](#)), Pacific States Marine Fisheries Commission ([PSMFC](#)), Recreational Fisheries Information Network ([RecFIN](#)), NMFS observer program for commercial and recreational fishery catch statistics; NMFS stock assessments for fishes and marine mammals; Global Ocean Ecosystem Dynamics ([GLOBEC](#)) zooplankton and marine mammal studies; recreational birders; Partnership for Interdisciplinary Studies of Coastal Oceans ([PISCO](#)) subtidal studies; Multi-agency Rocky Intertidal Network ([MARINE](#)) shoreline rocky intertidal studies; Automatic Identification System (AIS) ship traffic and vessel monitoring; satellite data; Light Detection and Ranging (LiDAR) data from the U.S. Geologic Survey (USGS); Coastal Observation and Seabird Survey Team ([COASST](#)) bird mortality monitoring coordinated by Julia Parrish.

What questions do they answer of interest to offshore renewable energy?

These existing monitoring and research programs provide context for monitoring the condition of the environment in the vicinity of ongoing projects, evaluation of larger effects, and baseline data for natural and anthropogenic effects.

How can existing monitoring programs address required monitoring for marine renewable energy projects?

The group suggested mining older and existing data sets to gain some relevant information (Marine Mammal Stranding Network data could be used to evaluate existing boat strike incidence, for example). In order to optimize efficiency of new sampling, it would be necessary to first examine the sampling plans and scopes of existing monitoring programs, and fill in gaps

with devices and additional monitoring to ensure adequate temporal and spatial coverage for reference points, and for OCS projects. It will be important to ensure baseline monitoring is compatible with future monitoring parameters.

What synergies can be applied in monitoring programs to maximize efficiency in meeting multiple objectives (e.g., addressing multiple questions)? Consider collaborative research, resource sharing, and cross-agency approaches.

The group concluded that acoustic monitoring does not lend itself well to collaborating between species (e.g., fishes and marine mammals), and therefore separate acoustic monitoring systems would be needed for each species of interest.

There were many synergies identified that could encourage collaborative data collection, particularly for monitoring basic distributions of threatened and endangered species, tagging species, etc. Improvement in the acoustic network for fishes needs to be a collaborative effort which would answer a variety of questions for a range of resource agencies.

How do we detect the effect of development against a shifting baseline affected by climate change and other parameters?

What recommendations does this group have for design considerations to account for shifting baselines?

It is important to determine if observed changes are related to development or changing ocean conditions. In order to make this determination, baselines are needed to understand underlying conditions and interannual variability. Monitoring to determine baseline conditions needs to be undertaken now so that we have long-term data and so that we maintain a consistent methodology before and after installation of devices. Baselines are needed to understand indirect effects of device installation, while ongoing monitoring is needed in order to understand direct effects. The need to initiate monitoring now would require establishing controls for species of interest and other indicators.

Research questions and monitoring goals need to address whether shifting conditions provide an additive or synergistic effect with wave energy effects. Resources need to be focused on key indicators; otherwise we will not detect signals.

The group agreed on the following list of conditions that require monitoring:

- Ocean acidification
- Sea level rise
- Pacific Decadal Oscillation/ El Niño-Southern Oscillation cycles
- Upwelling events
- Hypoxia
- Extreme weather
- Species population range shifts
- Storm event-generated mortality.

The group assumed that basic parameters such as temperature and O₂ are being monitored, and suggested that the placement of OOS buoys be evaluated to determine if they capture data relevant to energy projects on the OCS.

The group recognized that data collected in some baseline studies will act as the starting point, or time-zero, in a time series for long-term monitoring studies. Therefore, baseline surveys that shall continue as monitoring studies should begin as soon as possible to ensure that these time series have an adequate “before impact” temporal sequence.

For any monitoring plan, proper consideration needs to be given to selecting appropriate reference points against which potential impacts are measured. Impacts are difficult to detect unless they generate effects sizes of approximately 50% or greater. Therefore, monitoring effort should focus on species or questions where there is some likelihood of detecting potential effects, and when possible use shorter-term field experiments for other questions that are subject to high levels of natural variability.

6.2.3.6. Other Topics Discussed and Concluding Comments

Technologies such as cameras and video are rapidly improving and over the next couple of years may make substantial advances which will assist in better monitoring of bird/marine mammal/fish interactions.

7. NEXT STEPS AND CONCLUDING REMARKS

This section focuses on the outcomes of this conference and associated Experts' Workshop, and outlines how the results will be used. Comments are provided from federal and state perspectives.

7.1 A FEDERAL PERSPECTIVE

Ann Scarborough Bull, Bureau of Ocean Energy Management

BOEM has a well-established Environmental Studies Program (ESP). Over the past few years, our ocean mission has expanded to include evaluation of offshore renewable energy projects on the Outer Continental Shelf (OCS). The ESP, as directed by the OCS Lands Act Section 20 (a) and (b), provides targeted research information to inform decisions regarding future ocean energy projects under the purview of the Bureau. The ESP includes research efforts that are national in scale and those that are specific to OCS regions. The Pacific OCS Region encompasses the area from the state/federal offshore boundary out to 200 miles off California, Oregon, Washington and Hawaii.

Responding to a request from the State of Oregon, OSU and BOEM held the marine renewable energy conference November 28 and 29, 2012, at Oregon State University in Corvallis. This conference focused on existing and needed environmental information; it did not address socio-economic or technological aspects of renewable energy. BOEM's objectives for the Oregon Marine Renewable Energy Environmental Science Conference were to showcase completed and ongoing research that addresses environmental questions associated with wave and wind energy development in the Pacific Northwest, to synthesize new research and existing information, to distill it into products that agencies and resource managers can use, and to identify and prioritize information and research gaps related to the technologies or potentially affected systems that can help scientists, managers and funders to focus future research efforts. This report presents results from the conference. Study priorities include acquisition of baseline information at potential sites, studies to anticipate direct impacts at potential sites, and monitoring of devices after installation.

The Pacific Region of BOEM initiates its Environmental Studies Development Plan (SDP) in anticipation of the upcoming budget for the next fiscal year in the fall of each year. For example, Fiscal Year 2013 for the federal government began October 1, 2012. Thus, the Study Development Plan for Fiscal Year 2014 began in October 2012. A significant focus of any future plan will be offshore renewable energy.

The findings of the conference will play a significant role in developing future studies and research through the ESP. Some of the data gaps and research needs identified through the Expert's Workshop are already being addressed by the Pacific ESP and SDP. For more information see: <http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Pacific-Region/Pacific-Studies.aspx>. The Pacific Region plans to review the report in detail, and where appropriate, use the document as a guide for future study plans. Within funding constraints, the remaining data gaps and research needs that are clearly understood will be addressed in future plans. Data gaps and research needs requiring more discussion will likely be addressed through numerous internal and external discussions.

In addition, BOEM is often approached by other agencies and organizations interested in funding or addressing data gaps and research needs related to offshore renewable energy. This conference summary is also intended to benefit those agencies and organizations. It is important to note that funding fluctuates from year to year. Over the past several years, the Pacific Region has averaged three to five new studies each year. More studies are proposed than can be funded in any one year.

7.2 A STATE OF OREGON PERSPECTIVE

Caren Braby, Oregon Department of Fish and Wildlife

Paul Klarin, Oregon Department of Land Conservation and Development

While Oregon has created an innovative marine spatial planning decision support tool with over 200 data layers, the state continues to need additional information to ground truth assumptions, fill in information gaps, reduce uncertainties, and provide expert opinions, to better inform decision-making relevant to marine renewable energy development. In addition, the state is working with other West Coast states to create a regional data framework that will facilitate regional decision-making and planning efforts.

The State of Oregon has used existing data for baseline environmental information, rather than conducting new data collections, to identify the areas of Oregon's territorial sea (0-3 miles) with the resources of greatest ecological value (e.g. resources that are most abundant, resources that are legally most important to protect or rarest, etc.). In compiling these data, we recognize that there are many ways to improve the information; for some topics, there are no data, while for others data need improvement (e.g., better geographical coverage, more recent data, etc.).

We also recognize that filling information gaps is an ongoing and continuous process that will require collaboration among agencies and academics. The gap analysis and prioritization exercise from this conference and Experts' Workshop will provide additional information on the priority research areas to address and will inform our long-term plans for research and collaboration.

In addition, Oregon has focused more on baseline data gaps and needs than on impact or monitoring needs, since we have yet to get "steel in the water." The prioritization exercise herein will help us transition to the next phase, focusing on these later stages in the development process.

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APPENDIX A
CONFERENCE AGENDA

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**Oregon Marine Renewable Energy Environmental Science Conference
28 – 29 November, 2012
CH2M-Hill Alumni Center, Oregon State University**



November 28, 2012

0830 – 0850 Welcome and Conference Objectives George Boehlert

0850 – 0950 Agency Perspectives and Information Needs
 0850 Welcome to Oregon, Federal/BOEM Perspective Ann Bull
 0855 Using Environmental Information in Decision Making at Alan Thornhill
 BOEM

0920 Welcome to Oregon, Governor’s Office Perspective Gabriella Goldfarb
 0925 Managing Marine Resources in Oregon’s Territorial Sea and Patty Snow
 Stewardship Area: The Importance of Environmental
 Information in Planning and Decision Making

0950-1010 Break

1010 – 1210 Session 1: Synthesis Talks
 1010 Effects of Altered Habitats and Fishing Practices in Wind Dan Wilhelmsson
 and Wave Farms
 1035 The Interaction of Pelagic, Migratory and Protected Fishes Pete Nelson
 with Marine Renewable Energy Projects: Recent Studies
 and knowledge gaps
 1100 Available Information and Data Gaps: Birds, Bats, Marine Dave Pereksta
 Mammals, Sea Turtles, and Threatened and Endangered Species
 1125 Physical-Environmental Effects of Wave and Offshore Wind Merrick Haller
 Energy Extraction: A Synthesis of Recent Oceanographic
 Research
 1150 The European Experience in Marine Renewables Ben Wilson

1215 – 1330 Lunch

1330 – 1600 Session 2: Featured Studies (20 min break during this time)
 1330 Linking Habitat and Species Distributions in Areas of Potential Sarah Henkel
 Renewable Energy Development
 1350 Pacific Continental Shelf Environmental Assessment Josh Adams
 (PACSEA):Seabird and Marine Mammal Surveys off the
 Northern California, Oregon, and Washington Coasts
 1410 Gray Whales; Fine Scale Tracks and Acoustic Deterrence Bruce Mate
 1430 Potential Impacts of Ocean Energy Projects to Migration and Dan Erickson

Day 1, Continued

Habitat Use of Green Sturgeon (*Acipenser medirostris*)

1450 Break

1510 EMF and Marine Organisms

Milton Love

1530 Oregon Data Integration: A Perspective on Information
Networking

Andy Lanier

1600 – 1700 Session 3: Gap analysis

1600 Gap Analysis: Marine Renewable Energy Environmental Effects
on the U.S. West Coast

Greg McMurray

1630 – 1700: Open discussion of findings and priorities of research needs

1730-2000 Session 4: Lightning round and Poster session/reception

November 29, 2012 0730 – 1630

0730 Coffee and pastries

0800 Summary of previous day

Mary Elaine Helix

Session 1: 0830 – 1200

0830 – 0850 Guidance for the breakout sessions

Donna Schroeder

0900 – 1200 Breakout groups

1215 – 1345 Lunch

1400 – 1600 Session 2: Breakout Group presentations and discussion

- 30 min per breakout presentation
- 30 min for general discussion

1600 – 1630 Next Steps and Concluding Comments

George Boehlert

APPENDIX B
GAP ANALYSIS

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***Gap Analysis:
Marine Renewable Energy Environmental
Effects on the U.S. West Coast***

**Oregon Marine Renewable Energy
Environmental Science Conference
Corvallis, Oregon
November 28-29, 2012**

Author: Gregory R. McMurray

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Operations and Maintenance

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Offshore Wind Energy Development Decommissioning Table Explanation and Examples

Offshore Wind Energy Development Decommissioning Data Gaps

Summary and Conclusions

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[Appendix A: Context and Background Information](#)

This Appendix, included in the conference Scholars Archive web site, contains background information on the conceptual approach taken in developing the gap analysis and the parameters, research areas, and sources included in the analysis.

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Table 1. Key to stressor-receptor matrices.

Table 2. Stressor-receptor matrix for wave energy development siting and construction phase environmental data gaps.

Table 3. Stressor-receptor matrix for wave energy development operations and maintenance phase environmental data gaps.

Table 4. Stressor-receptor matrix for wave energy development decommissioning phase environmental data gaps.

Table 5. Stressor-receptor matrix for offshore wind energy development siting and construction phase environmental data gaps.

Table 6. Stressor-receptor matrix for offshore wind energy development operations and maintenance phase environmental data gaps.

Table 7. Stressor-receptor matrix for offshore wind energy development decommissioning phase environmental data gaps.

Introduction

This gap analysis briefing paper was conceived and scoped by the steering committee for the 2012 Oregon Marine Renewable Energy Environmental Science Conference. It is intended to stimulate an informed dialog among the attending subject matter experts that will result in identifying and prioritizing the information required to achieve the following future outcome:

In the nearshore to Outer Continental shelf waters of the state of Oregon, sufficient knowledge of the potential environmental impacts of marine renewable energy exists to make well-informed decisions about siting, deployment, and commercial development of wave and offshore wind projects.

For practical purposes in this exercise, a working definition for a gap is: a lack of information that, if available, would or could identify whether environmental effects will have sufficiently negative impacts to result in a “fatal flaw” in project design or siting when illuminated against the background of regulatory information needs for decision-making. A fatal flaw can be described as an issue serious enough to prevent development of a given project.

Report Organization

This gap analysis is broken into two sections to best serve the necessarily broad array of familiarity with ocean renewable energy of the subject matter experts at this conference. Thus, Part One is an effort to present the presumed environmental data gaps for marine renewable energy development into the shortest, simplest presentation possible, using graphics and lists that will be evaluated and updated by conference participants and speakers as well as experts in the breakout groups, who will also provide advice on the priorities. The most efficient use of the report by workshop participants will be to go directly to the six major tables, and use the subtending lists to establish general agreement or disagreement about the author’s calls.

The matrices have been adapted from the recent BOEM Environmental Protocols project (Boehlert et al. 2012), which summarizes diverse expert opinion, regulatory considerations, and stakeholder concerns to identify priority projects. The three project phases, siting and construction; operations and maintenance; and decommissioning are used to deconstruct their different information requirements. Some proxy activities that provide relevant data are listed, but as examples, not as an exhaustive compendium. Note that information needs are associated with the project phase that requires them, even though baseline or effects monitoring might take place during another phase (e.g., baseline monitoring for potential operational effects). Accordingly, baseline monitoring gaps for operations and maintenance are listed in that project phase, even though they will likely need to be initiated well prior to construction.

Assessing environmental effects in large marine ecosystems (LME) very much depends on ecological context. Hence, contextual information to support the following exposition and listing of data gaps has been provided separately in Part Two, as an [electronic appendix](#) to this document. It includes discussion of stressor-receptor interactions, and

some description of the character of the individual environmental stressors and the environmental receptors, as they are grouped in the matrices. The appendix is intended for readers who desire more specific information on a topic or broader general context and background for the issues addressed.

Explanation of Table Structure

The tables that follow are meant to provide information based on current literature that identifies the specific gaps that need to be addressed. Environmental stressor and receptor interactions are implicit in both the EPA’s Framework for Ecological Assessment (EPA 1998) and NOAA’s Driver-Pressure-State-Impact-Response (DPSIR; e.g., Levin et al. 2009) models. A preliminary stressor-receptor table was designed for the 2007 wave energy effects workshop hosted by Oregon State University (McMurray 2008), as modified from work done by the Scottish Executive (e.g., SEA 2007a). The stressor-receptor table groupings were modified into the more functional groups used here during the recent environmental baseline and monitoring protocols project for BOEM (Boehlert et al. 2012). Each intersection in the matrix is intended to represent an interaction by a stressor and a receptor or group of receptors. They are presented in relatively concise matrix format in order to provide a common currency for workshop participants to identify the gaps, and include separate wave and wind matrices each for project phase, including: siting and construction; operations and maintenance; and decommissioning.

Table 1. Key to the notations used in the stressor-receptor matrices.

Symbol	Meaning
(blank)	<u>Not applicable</u> . Not considered an ecologically important interaction between stressor and receptor.
A	<u>Accident related</u> . An impact of this interaction is likely to result from an accident related to construction, servicing or extreme weather (and may be temporary).
E	<u>Existing data</u> . Data and information exist to inform the interaction. Since MRE development is nascent in the U.S., most of these data are “once removed” in the following sense: 1) geographic – information from marine renewable energy development in Europe and Great Britain, primarily; or 2) other industrial activities and resource studies on the U.S. West Coast (offshore oil and gas development, and undersea cabling are activity examples; cetacean, seabird and fish studies are resource examples).
G	<u>Gap exists</u> . There exist significant gaps in our ability to assess this interaction.
M	<u>Mitigation exists</u> . There exists known mitigation for this interaction. Mitigation herein refers to avoidance or minimization of a direct or indirect ecological effect or impact on a receptor through engineering or operational

	modification of the project. Mitigation does not refer herein to so-called “offsite” mitigation or to compensatory mitigation (i.e., paying or compensating for environmental damage).
P	<u>Proxy data exist.</u> There exists information from other related activities worldwide that inform this interaction (that is, this information is twice removed from marine renewable energy development on the U.S. West Coast by both activity and by geography).
S	<u>Scaling effect.</u> The significance of this interaction is likely to be subject to the effects of scale.
T	<u>Temporary.</u> The effect or impact of this interaction is likely to be temporary.
?	<u>Uncertain or unknown.</u> There exists significant uncertainty about the resource or the character of the interaction.

It is realized that there are current studies, including those just getting underway, that should be referenced, and an objective of the early distribution of this paper was to solicit from workshop participants new information pertinent to these gaps, as well as information that may identify other gaps not identified here. More information about the stressor-receptor matrices, including those from Boehlert et al. (2012), may be found in the Appendix. At the workshop, participants added a receptor column for Air Quality and Meteorology to the matrix.

Acknowledgements

Acknowledgement for the content herein is most importantly due to the BOEM environmental protocols project (Boehlert et al. 2012) Protocol Development Team, principally George Boehlert, Sarah Henkel, Andrea Copping and Sharon Kramer. Thanks are also given for helpful feedback from the conference steering committee, including George Boehlert, Caren Braby, Ann Scarborough Bull, Mary Elaine Helix, Sarah Henkel, Paul Klarin, and Donna Schroeder. Any and all mistakes and omissions are solely the responsibility of the author.

This paper is respectfully dedicated to the memory of Dr. W. Scott Overton: statistician, professor, teacher and mentor at Oregon State University. Dr. Overton passed away in Philomath, Oregon, on July 2, 2012, at the age of 86. His course in Systems Ecology, and particularly his introduction to General Systems Theory, forever changed the author’s view of the world.

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Siting and Construction

Table 2. Stressor-receptor matrix for wave energy development siting and construction phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation (waves/currents)	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
A	Static devices		T,E	T,E		T,E			T,E											T	T
B	Moving devices		T	T		T			T												
C	Energy removal		T,S																		
D	Chemical release				A,T	A,T			T,E												
E	Noise and vibration											T,M	T,M	T,M	T,M	T,M	T,M	T,M			T,M
F	EMF																				
G	Boat traffic	T,E			T,E	T,E	T,E	T,E	T,E	T,E		TE	T,E	T,E	T,E	T,E	T,E	T,E			
H	Lights									T,E		TE	T,E	T,E	T,E	T,E	T,E	T,E		E,M	E,M

Key:

A - Accident-related, E - Existing data, **G - Gap exists**, M - Mitigation exists, P - Proxy data exist, S - Scaling effect?,
T - Temporary, ? - Uncertain or Unknown

Wave Energy Siting and Construction Table Explanation and Examples

- Static devices – Static and dynamic device design for wave energy development is evolving rapidly; data gaps related thereto are deferred to the operations and maintenance section. Direct sediment disturbance will be temporary, as will other effects of static device emplacement or deployment. Relevant existing information examples include marine construction of docks and jetties, offshore oil & gas platform construction and emplacement, and power and information cable jetting, trenching and burial. Oregon has numerous information cable landings, siting for which is coordinated by the Oregon Fisherman’s Cable Committee (OFCC).
- Moving devices – Moving devices, if present and exposed, are not expected to be operational during the siting and construction phase.
- Energy removal – Energy removal would likely be temporary and local during siting and construction, but could be scale related in the construction of a very large and dense wave energy project (see operations and maintenance). There is no directly relevant proxy for this potential scaling effect.
- Chemical release – Chemical release would likely be associated with spills or accidents linked to vessel traffic and would be temporary. Relevant existing information comes from marine construction activities as related to offshore structures; chemical release would most likely result from boat traffic (toxics contained in WECs are considered under the operations and maintenance phase).

- Noise and vibration – Siting would likely utilize acoustic devices (high resolution side-scan and sub-bottom profiling) that are low energy and used worldwide. Noise and vibration of construction activities would be temporary. Applicable information exists for hard bottom construction involving pile-driving, and mitigation by way of sound curtains is used by nearshore construction projects. Sound power level limits and distances are clearly established for sensitive groups of organisms.
- Electromagnetic fields – The projects are not expected to produce power during this phase, so EMF is not expected. There are few measurements of background EMF; for example, one for the Cape Blanco area is found in Clifton et al. (1991) and the Oregon Wave Energy Trust (OWET) has released a major report relating to EMF measurement (Slater et al. 2010).
- Boat traffic – Boat traffic is common in the California Current and offshore Oregon; there are existing data for OCS service boats and heavy lift boats and barges in marine industries, with the closest examples being the OCS oil & gas industry offshore Southern California; and for shipping in and out of major West Coast ports.
- Lights – Construction lighting will be temporary, and there are existing relevant data from marine construction projects in the United States (e.g., OCS oil & gas development).

Wave Energy Siting and Construction Data Gap Listing

- All stressors – The author sees no area where insufficient, critical information and data exist to inform the regulatory process.

Table 3. Stressor-receptor matrix for offshore wind energy development siting and construction phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation (waves/currents)	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
A	Static devices		T,E	T,E		T,E			T,E										T,E	T,E	
B	Moving devices																				
C	Energy removal																				
D	Chemical release				A,T	A,T			T,E												
E	Noise and vibration											T,M	T,M	T,M		T,M	T,M				
F	EMF																				
G	Boat traffic	T,E			T,E	T,E	T,E	T,E	T,E	T,E		T,E	T,E	T,E	T,E	T,E	T,E	T,E			
H	Lights									E		E	E	E	E	E	E	E	E	E,M	E,M

Key:

A – Accidents, E – Existing data, **G – Gap exists**, M – Mitigation exists, P – Proxy data exist, S – Scaling effect, T – Temporary, ? – Uncertain or Unknown

Offshore Wind Energy Siting and Construction Table Explanation and Examples

- Static devices – Static devices may be either monopiles or floating platforms, both of which have existing information, as they are deployed for wind (Europe). Sediment disturbance will be temporary, as will other effects of static device emplacement or deployment. Relevant examples include marine construction of docks and jetties, offshore oil & gas platform construction and emplacement, and power and information cable jetting, trenching and burial.
- Moving devices – Wind rotors are not expected to be operational during the siting and construction phase.
- Energy removal – Energy removal during the siting and construction of offshore wind arrays would be unlikely.
- Chemical release – Chemical release would likely be associated with spills or accidents linked to vessel traffic and would be temporary. (Toxics contained in wind devices are considered under the operations and maintenance phase.)
- Noise and vibration – Siting would likely utilize acoustic devices (high resolution side-scan and sub-bottom profiling) that are low energy and used on the U.S. West Coast. Noise and vibration of

construction activities would be temporary; for hard bottom construction involving pile-driving directly relevant information exists (e.g., for the Swedish Utgrunden project; see Ingemansson 2004.). Mitigation by way of sound curtains is used by nearshore construction projects; sound power level limits and distances are clearly established for sensitive groups of organism.

- Electromagnetic fields – These projects are not expected to produce power during this phase, so EMF is not expected.
- Boat traffic - Boat traffic is common in the California Current and offshore Oregon, and there are existing data for OCS service boats and heavy lift boats and barges in marine industries, for example, OCS oil & gas development offshore California.
- Lights - Construction lighting will be temporary, and there are existing relevant data from marine construction projects on the U.S. West Coast (e.g., oil & gas development).

Offshore Wind Energy Siting and Construction Data Gap Listing

- All stressors – The author sees no area where insufficient, critical information and data exist to inform the regulatory process.

Operations and maintenance

Table 4. Stressor-receptor matrix for wave energy development operations and maintenance phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation (waves/currents)	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
A	Static devices		G			G	?S	G,S	P			P				G,S	G,P		?	G,S
B	Moving devices										G				G	G	G	G		G
C	Energy removal		G,S	G,S		G,S	G,S													
D	Chemical release		S?		A,T	A,T		A,T	S?		S?									
E	Noise and vibration					E	E					G	G	G	G	G				
F	EMF		P			P	P	G	G			G	G	G,P	G					
G	Boat traffic	T,E	E	E	E	E	E	E	E	E	E	E	E	E	E	E,A	E	E	E	E
H	Lights									E		E	E	E	E	E	E	E	E,M	E,M

Key:

A - Accident-related, E - Existing data, **G - Gap exists**, M - Mitigation exists, P - Proxy data exist, S - Scaling effect, T - Temporary, ? - Uncertain or unknown

Wave Energy Operations and Maintenance Table Explanation and Examples

- Static devices – There is a general lack of information on farfield effects that may be scale-related. Directly relevant information on fish attraction device (FAD) and artificial reef effects comes from BOEM studies in the Gulf of Mexico and Southern California OCS oil & gas programs program (e.g., Love and Schroeder 2006; Bull et al. 2008).
- Moving devices – little known.
- Energy removal – Energy removal is likely to be strongly scale- and technology-dependent (spacing among wave energy conversions devices will likely be in the range of 10s to 100s of meters).
- Chemical release – This stressor has two components: continuous, long-term release of ablated antifouling particles, and accidental spills resulting from either failure of the wave energy conversion devices and leakage of toxics (likely hydraulic fluid, if present), and accidents during servicing. Spills will have temporary effects; long-term buildup of toxic particles ablated from the antifouling coatings seems highly unlikely due to strong advection, but could also be subject to scaling.
- Noise and vibration – Background noise was documented by Navy studies, and is presently under study by NNMREC.
- Electromagnetic fields – The background is generally described; there are some proxy data for trenched/buried power cabling.
- Boat traffic – There is continuous boat traffic in the California Current and offshore Oregon; and also data for OCS service vessels in the California Bight.

- Lighting – There are applicable existing data from vessel traffic and lighted buoys along the U.S. West Coast.

Wave Energy Operations and Maintenance Data Gap Listing

- Static devices – There is a lack of technology-related information on structures and anchoring systems, lack of site-specific information on bottom types, habitats and benthos; lack of ecosystem models and local fish attraction device and artificial reef effects data, and cetacean and seabird collision models, the latter three of which may be subject to scaling effects. Also, there is a lack of data on seabird habitat utilization and behavior nearshore.
- Moving devices – Data gaps are largely the lack of technology-related information on moving parts and the likelihood of damage by contact or entrapment on pelagic biota, from soft-bodied plankton (e.g., medusae) to diving seabirds.
- Energy removal – Data gaps are related to the need for scale-dependent site-specific modeling (also documented as a challenge in DOI 2009).
- Chemical release – no apparent data gaps.
- Noise and vibration – For sensitive species, there is a lack of technology-specific noise and vibration data, generally and in situ.
- Electromagnetic fields – Gaps are the complete lack of in situ EMF measurements for the wave energy conversion devices themselves, and lack of sensitivity and effects information on the four groups listed, including the applicability of European data (much of which is equivocal) on closely related species offshore Oregon.
- Boat traffic – no apparent data gaps.
- Lighting – no apparent data gaps.

Table 5. Stressor-receptor matrix for offshore wind energy development operations and maintenance phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation waves/currents	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
A	Static devices					G	S?	G,S								G,S				G	G,E
B	Moving devices	E																		G	G
C	Energy removal		E,S	E,S		E,S	E,S													G	G
D	Chemical release		S?		A,T	A,T		A,T													
E	Noise and vibration					E	E					G	G	G	G	G				G	G
F	EMF		P			P	P	G,S	E,M					G,P	G						
G	Boat traffic	T,E	E	E	E	E	E	E	E	E	E	E	E	E	E	E,A	E?	E	E	E	E
H	Lights									E		E	E	E	E	E	E	E	E	E,M	E,M

Key:

A - Accident-related, E - Existing data, **G - Gap exists**, M - Mitigation exists, P - Proxy data exist, S - Scaling effect?, T - Temporary, ? - Uncertain or Unknown

*Offshore Wind Energy Operations and Maintenance Table
Explanation and Examples*

- Static devices – Effects on sediment and farfield and ecosystem interactions are likely to be scale dependent (spacing among wind energy conversion devices will likely be in the range of 100s to 1000s of meters, e.g. Cape Wind spacing is 630m by 1000m).
- Moving devices – Moving devices have only above-water effects; some directly applicable data on seabird interactions are available from European developments (e.g., Horns Rev and Nysted wind farms: see Petersen et al. 2006).
- Energy removal –Energy removal is likely to be scale dependent for water column energy (spacing among wind energy conversion devices will likely be in the range of 100s to 1000s of meters, e.g. Cape Wind spacing is 630m by 1000m).
- Chemical release – This stressors has two components: continuous, long-term release of ablated antifouling particles, and accidental spills resulting from either failure of the wave energy conversion devices and leakage of toxics (likely hydraulic fluid, if present), and accidents during servicing. Spills will have temporary effects; long-term buildup of toxic particles ablated from the antifouling coatings seems extremely unlikely due to strong advection, and the lower density of wind arrays.
- Noise and vibration – Background noise offshore Oregon has been extensively documented by Navy studies (though much data may still be classified), and is presently under study by NNMREC. Directly applicable noise information for offshore wind development is available from European wind farms (e.g., Horns Rev and Nysted wind farms: see Teilman et al. 2006).

- Electromagnetic fields – EMF is assumed to be limited to the cabling as generation is not conducted underwater; proxy data exist for cables.
- Boat traffic – There is continuous boat traffic in the California Current and offshore Oregon; and also data for OCS service vessels in the California Bight.
- Lights – There are relevant proxy data on effects and mitigation from marine industries worldwide. Directly applicable data come from active wind energy fields in Europe; see discussion in the Cape Wind FEIS (MMS 2009).

Offshore Wind Energy Operations and Maintenance Data Gap Listing

- Static devices – Data gaps include offshore distribution and habitat utilization for bats and seabirds at adequate resolution and for specific sites.
- Moving devices – Data gaps include offshore distribution and habitat utilization for bats and seabirds at adequate resolution and for specific sites.
- Energy removal – no apparent data gaps.
- Chemical release – no apparent data gaps.
- Noise and vibration – Data gaps exist for noise and vibration in the area of in situ acoustic signatures, and the site-specific habitat utilization of sensitive species.
- Electromagnetic fields – This is considered a data gap in some cases for lack of consistent, well-documented effects.
- Boat traffic – no apparent data gaps.
- Lights – no apparent data gaps.

Decommissioning

Table 6. Stressor-receptor matrix for wave energy development decommissioning phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation waves/currents	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
A	Static devices		G,E		T	T			G,P			G,E									
B	Moving devices																				
C	Energy removal																				
D	Chemical release				A,T	A,T			T,E												
E	Noise and vibration											T	T	T	T	T	T	T			T
F	EMF																				
G	Boat traffic	T,E			T,E	T,E	T,E	T,E	T,E	T,E		T,E	T,E	T,E	T,E	T,E	T,E	T,E	T,E		
H	Lights										T,E		T,E	T,E	T,E	T,E	T,E	T,E	T,E	T,E	E,M

Key:

A - Accident-related, E - Existing data, **G - Gap exists**, M - Mitigation exists, P - Proxy data exist, S - Scaling effect?, T - Temporary, ? - Uncertain or Unknown

Wave Energy Decommissioning Table Explanation and Examples

- Static devices – It is assumed that static devices projecting into or above the water column will be removed during decommissioning. Relevant proxy data come from the large number of decommissioned OCS oil & gas platforms in the Gulf of Mexico (e.g., Kaiser et al. 2007), especially BOEM's *Rigs to Reefs* program, and also from other artificial reef studies utilizing metal (e.g., purposely sunken ships) or concrete. Existing data come from decommissioned platforms offshore California.
- Moving devices – All moving devices are expected to be removed during decommissioning.
- Energy removal – Energy removal is expected to become negligible when energy absorbing structures in the water column are removed.
- Chemical release – Chemical release could occur due to accidental spills from leakage of toxics (likely hydraulic fluid, if present), and accidental spills during removal of devices; spills will have temporary effects. No biologically available or toxic chemicals are expected to be left in place after decommissioning.
- Noise and vibration – Noise and vibration will be temporary during decommissioning.
- Electromagnetic fields – Projects will not produce power during the decommissioning phase, hence EMF are not expected.

- Boat traffic - Boat traffic is common in the California Current and offshore Oregon, and there are proxies for OCS service boats and heavy lift boats and barges in marine industries worldwide.
- Lights - Construction lighting will be temporary, and there are existing relevant data from marine decommissioning projects in the United States (e.g., West Coast boat traffic and California oil & gas development).

Wave Energy Decommissioning Data Gap Listing

- Static devices – There is a gap on our knowledge about the long-term effect of artificial reefs; though there are data on arrays of oil platforms 10s of kilometers apart, there are no data on arrays of anchors spaced on the order to 10s to 100s of meters. This data gap would likely be addressed during operational phase.
- Moving devices – no apparent data gaps.
- Energy removal – no apparent data gaps.
- Chemical release – no apparent data gaps.
- Noise and vibration – no apparent data gaps.
- Electromagnetic fields – no apparent data gaps.
- Boat traffic – no apparent data gaps.
- Lights – no apparent data gaps.

Table 7. Stressor-receptor matrix for offshore wind energy development decommissioning phase environmental data gaps.

	Stressor	Air Quality/ Meteorology	Sediment characteristics	Water circulation (waves/currents)	Water chemistry	Nearfield habitat	Farfield habitat	Ecosystem interactions	Benthic invertebrates	Nektonic invertebrates	Plankton	Resident fishes	Migratory fishes	Elasmobranchs	Sea turtles	Cetaceans	Pinnipeds	Mustelids	Bats	Birds	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
A	Static devices		G,E		T	T			G,P			G,E									
B	Moving devices																				
C	Energy removal																				
D	Chemical release				A,T	A,T			T,E												
E	Noise and vibration											T	T	T	T	T	T	T			T
F	EMF																				
G	Boat traffic	T,E			T,E	T,E	T,E	T,E	T,E	T,E		T,E	T,E	T,E	T,E	T,E	T,E	T,E	T,E		
H	Lights										T,E		T,E	T,E	T,E	T,E	T,E	T,E	T,E	T,E	E,M

Key:

A - Accident-related, E - Existing data, **G - Gap exists**, M - Mitigation exists, P - Proxy data exist, S - Scaling effect?,
T - Temporary, ? - Uncertain or Unknown

Offshore Wind Energy Decommissioning Table Explanation and Examples

- Static devices – It is assumed that static devices projecting into or above the water column will be removed during decommissioning; anchors may remain from floating platforms and monopiles may be severed at the substrate surface. Relevant data come from existing studies on the FAD and artificial reef effects from decommissioned oil & gas platforms in the Gulf of Mexico.
- Moving devices – All moving devices are expected to be removed during decommissioning
- Energy removal – Energy removal is expected to become negligible when energy absorbing structures in the water column are removed.
- Chemical release – Chemical release could result from accidental spills from leakage of toxics (likely hydraulic fluid, if present), and accidental spills during removal of devices; spills will have temporary effects. No biologically available or toxic chemicals are expected to be left in place after decommissioning.
- Noise and vibration – Noise and vibration will be temporary during decommissioning.
- Electromagnetic fields – These projects will not produce power during the decommissioning phase, hence EMF are not expected.
- Boat traffic - Boat traffic is common in the California Current and offshore Oregon, and there are proxies for OCS service boats and heavy lift boats and barges in marine industries worldwide.

- Lights - Construction lighting will be temporary, and there are existing relevant data from marine decommissioning projects in the United States (e.g., West Coast vessel traffic and California oil & gas development).

Offshore Wind Energy Decommissioning Data Gap Listing

- Static devices – There is a gap on our knowledge about the long-term effect of artificial reefs; though there are data on arrays of oil platforms 10s of kilometers apart, there are no data on arrays of anchors or monopiles spaced on the order of 100s of meters to a few kilometers. This data gap would likely be addressed during operational phase.
- Moving devices – no apparent data gaps.
- Energy removal – no apparent data gaps.
- Chemical release – no apparent data gaps.
- Noise and vibration – no apparent data gaps.
- Electromagnetic fields – no apparent data gaps.
- Boat traffic – no apparent data gaps.
- Lights – no apparent data gaps.

Summary and Conclusions

This gap analysis was compiled for the express purpose of stimulating thought and dialog at the conference breakout sessions. The various gaps identified herein are intended to be debated and deleted, modified or augmented by the participating subject matter experts at very specific and technical levels. Generally, it appears that siting and construction practices for other ocean and marine industries worldwide provide adequate information for understanding potential environmental effects well enough to support regulatory decision-making and the design of appropriate environmental studies. Operations and maintenance for both wave and offshore wind involve a significant number of gaps, related to: 1) static devices; 2) moving devices; 3) sound and vibration; and 4) electromagnetic fields. Data gaps for decommissioning appear to be related only to decisions about which of each energy project's physical elements will be left in place as artificial reefs, and the ecological ramifications of those artificial reef effects in situ and as potentially related to scaling.

In compiling the preceding information, the author notes some generalities that may be of value to the breakout dialogs and subsequent consideration and prioritization or ranking of gaps. With no ordering for importance or priority:

1. Many gaps in this analysis are driven by the simple lack of *in situ* environmental monitoring data on deployed systems of any kind, but especially on commercial-scale systems in the United States' LMEs;
2. There is a serious lack of information on the stressor signals and signatures of evolving technologies in the wave energy sector;
3. Many gaps are related to the scaling factors concerning the magnitude of wave and wind ocean renewable energy developments, both in terms of array size and numbers of arrays;
4. There are many information needs related to site or locale-specific information for proposed or future projects;
5. Some gaps might be addressed by data mining/harvesting from existing sources that may not meet some metadata or data assimilation criteria, but are nonetheless of high value; and
6. Many data gaps (or, more correctly, needs for data supporting high levels of certainty) are driven by the need to sufficiently inform the regulatory requirements for agency decisions about necessary protections for special status species and habitats.

These generalities are perceived by the author, but are again intended to initiate an informed and robust dialog at the conference.

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APPENDIX C
CONTRIBUTED POSTER ABSTRACTS

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Marine Spatial Planning for Offshore Wind Energy Projects in the North Sea

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A desire for new domestic sources of clean renewable energy is driving national governments and private enterprises to look beyond their shorelines and into territorial waters for new sources of sustainable energy. Addressing spatial conflicts among offshore renewable energy projects and other resource users is a relatively new issue for both government regulators and the emerging industry in the United States and around the world. Federal, state, and regional governing bodies in the United States are using Marine Spatial Planning (MSP) as a means to create management plans that takes into account the multiple objectives (i.e., ecological, social, economic) of the multiple activities that are taking place within a management area. MSP is also increasingly being referenced as a tool for reducing spatial conflicts among resource users. Several European Union (EU) Member States have engaged in MSP to address spatial conflicts arising among offshore wind energy production projects and competing ocean uses. Experience from offshore wind energy developers, government officials, and environmental non-government organizations from the Netherlands, Germany, and the UK indicates that national-level marine spatial planning on the North Sea proved to be a valuable mechanism for addressing conflicts between competing or conflicting resource users and offshore wind energy project installations. While the collection of the best-available science is one necessary component of MSP, resources and planning efforts should focus on underlying process and participation to promote dialogue among all resource users and manage human expectations.

Wave Energy: Design for the Environment

Adam Brown

NNMREC

The potential of the world's oceans for commercial energy extraction has driven the development of many concepts for Wave Energy Converters (WECs). In most cases these concepts do not adequately consider the intricacies of the ocean environment. Many designs assume that reliability and survivability may be built-in as the design progresses. This is a flawed philosophy that will lead to systems being grossly over-designed just to endure the ocean. The design of commercially competitive wave energy converters must consider the environmental operating conditions early in the design process.

This paper presents the results of an analysis of spectral data from NDBC buoy 46050, off the coast of Newport, Oregon. The analyses will be used to provide insight into the ocean design environment. A focus has been placed on presenting the results of the analysis and information pertinent to system design in a compact, meaningful, and user-friendly format. Additional simulations and discussions provide information pertinent to engineers entering the field of wave energy with the hope that an increased understanding of the ocean as a design environment will lead to the development of robust, cost-competitive WECs.

Annex IV: International Collaboration on the Environmental Effects of Ocean Energy Devices

*Andrea Copping, Luke Hanna, Simon Geerlofs
Pacific Northwest National Laboratory*

Annex IV is a collaborative project among member nations of the International Energy Agency's (IEA) Ocean Energy Systems (OES) initiated in 2010 to examine the environmental effects of ocean energy devices and projects. Lead by the U.S., the Department of Energy is the operating agent, working in cooperation with BOEM, FERC and NOAA. The project strives to facilitate efficient government oversight of the development of ocean energy systems by expanding the baseline knowledge of environmental effects and monitoring methods. Two expert workshops have been held in Dublin, Ireland (September 2010 and October 2012) to guide and review Annex IV progress, and to make suggestions for future Annex IV efforts. To help disseminate information and data across the various member nations and marine and hydrokinetic (MHK) projects, Pacific Northwest National Laboratory has been tasked with developing an online knowledge base to house and organize Annex IV monitoring information and research results. Metadata survey forms have been used to collect information from MHK developers and researchers from around the world. These completed Annex IV metadata forms and associated literature are located within the Annex IV website (http://mhk.pnnl.gov/wiki/index.php/Annex_IV_Knowledge_Base) and will become publically accessible early in 2013. To review Annex IV progress and activities carried out from 2010-2012, a draft report has been written to provide a summary of the current science and understanding for three potential impacts of ocean energy technologies: physical interactions between animals and tidal turbines; the acoustic impact of ocean energy devices; and the effects of energy removal on physical systems. This report will be finalized within the next month and will be publically available on the Annex IV website.

DOE's Marine Sciences Laboratory: Pacific Northwest National Laboratory

*Andrea Copping, Simon Geerlofs, Luke Hanna
Pacific Northwest National Laboratory*

This poster presents an overview of Pacific Northwest National Laboratory's Marine Science Laboratory (MSL) in Sequim, WA, where researchers are working to understand and address challenges facing sustainable, ocean renewable energy development. MSL is a unique facility within the Department of Energy's national laboratory system, with 90 marine scientists and engineers delivering science and technology solutions for issues critical to the nation's energy, environmental and security future. The poster will describe opportunities for environmental monitoring and potential future device testing at MSL, as well as linkages with composite research occurring along Washington state's Northern Olympic Peninsula.

Monitoring and Mitigation Alternatives for Protection of North Atlantic Right Whales during Offshore Wind Farm Installation

*Andrea Copping, Tom Carlson, Shari Matzner, Michele Halvorsen, Jessica Stavole
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The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) has recently proposed potential sites for offshore wind (OSW) development along the Atlantic Coast. The North Atlantic Right Whale (NARW) ranges along the Atlantic coast and the population is highly endangered, with only 300-600 left. Since 1980, the NARW population has been declining rapidly mainly due to collisions with shipping vessels and fishing gear entanglements. Studies from the oil and construction industries have shown that underwater sound puts these and other marine animals at risk. Installation of offshore wind turbines on the Atlantic coast will be accomplished by driving piles into the seabed, an activity that generates loud noises throughout construction. Ensuring the safety of the NARW from the acoustic challenges of pile driving will require real time monitoring and mitigation, which must be integrated into construction planning. Researchers from Pacific Northwest National Laboratory are developing a system of monitoring and mitigation activities that will be integrated into the flow of construction. Monitoring can be done in one or a combination of three ways: Marine Mammal Observation (MMO), Passive Acoustics Monitoring (PAM), and Active Acoustics Monitoring (sonar). In addition to further developing monitoring techniques, mitigation for acoustic challenges to NARW during offshore wind installation requires: 1) understanding the distribution of the animals throughout the year to mitigate the intersection of the NARW and construction activities; 2) developing performance specifications for marine mammal monitoring systems; and 3) deploying those systems at a cost that is acceptable to the industry.

Seabird Associations with the Columbia River Plume off Oregon and Washington Determined Using Airborne Hyperspectral Radiometry

Jonathan Felis¹, Jennifer Broughton², Josh Adams¹, John W. Mason³, Jeff N. Davis⁴, Sherry Palacios², Raphael Kudela², David M. Pereksta⁵, and John Y. Takekawa¹

¹U. S. Geological Survey, Western Ecological Research Center, ²University of California Santa Cruz, Ocean Sciences, ³Environment International, ⁴Moss Landing Marine Laboratories, ⁵Bureau of Ocean Energy Management, Pacific Outer Continental Shelf Region

Marine spatial planning, including the designation of important marine bird areas and potential site selection for offshore energy development, requires the quantification and description of species-specific patterns in distribution with measurable habitat features. Such relationships can aid predictive models to refine population estimates at sea and delineate important habitats outside surveyed areas. In the northern California Current System, seasonal upwelling and the Columbia River plume create oceanographic structure. This structure includes enhanced phytoplankton growth and formation of physical frontal boundaries that can aggregate prey near the surface, thereby increasing availability for top-level predators. To relate patterns of seabird abundance to physical and biological characteristics of ocean habitats, we conducted aerial seabird surveys during January and June 2011 along strip-transects spanning continental

shelf and slope waters off Washington and Oregon. We installed a hyperspectral radiometer and a radiation pyrometer on board the aircraft to collect simultaneous remotely-sensed reflectance and sea surface temperature, respectively. We used along-transect gradients in three ocean habitat variables (sea surface temperature, synthetic salinity, and fluorescence line height) to 1) identify frontal features associated with, and independent of, the Columbia River plume and 2) examine relationships between these features and the distribution and abundance of common marine birds. In the past, aerial seabird surveys have relied on satellite-derived products of ocean optical properties that are coarse in scale or temporally-averaged to produce better spatial coverage. Herein, we couple the ability of aerial surveys to obtain rapid coverage of large geographic areas with high-resolution, instantaneous oceanographic information.

Monitoring and Mitigation Strategies for Marine Mammals and Tidal Power

Simon Geerlofs, Andrea Copping

Pacific Northwest National Laboratory

Southern Resident Killer Whales (SRKW) inhabit Washington state's Puget Sound in the summer months, foraging for their preferred prey species, Chinook salmon. These whales are an iconic marine mammal and listed as endangered under the Federal Endangered Species Act. Snohomish Public Utility District (SnoPUD) is in the process of obtaining a Federal Energy Regulatory Commission (FERC) pilot license for a tidal power test project to deploy two six meter diameter OpenHydro turbines in Admiralty Inlet, the entrance to Puget Sound. Regulatory and stakeholder concern has focused on monitoring and mitigating potential impacts to SRKW that could result from operation of these two turbines. Pacific Northwest National Laboratory has developed specifications for a passive and active acoustic monitoring system that can classify, range, and localize SRKW within the vicinity of a tidal power turbine. Researchers from PNNL and Sandia National Laboratory have also carried out an analysis of the effects of a worst-case scenario: an OpenHydro blade striking an adult male SRKW in the head. Results from both of these projects are being used to inform FERC licensing and are an example of targeted collaborative scientific investigation to resolve a critical regulatory issue where tolerance for risk is very low. This poster will briefly describe both of these projects and facilitate discussion on appropriate monitoring and mitigation strategies for wave and tidal power going forward.

Gorgonians as a Potential Indicator for Assessing Seafloor Condition in Marine Spatial Planning

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Gorgonians are sessile and structure-forming macroinvertebrates that attract other invertebrate and fish species. Gorgonian species can be slow-growing and fragile and thus susceptible to seafloor disturbances. This life history characteristic makes gorgonian species potential indicators of marine spatial planning effects on the Pacific Northwest continental shelf. Remotely Operated Vehicle (ROV) Hammerhead 2011 and 2012 surveys provide the most recent

video of macroinvertebrate communities in this region. Video taken in 2011 at Siltcoos Reef, Oregon, and Gray's Bank, Washington, was compared with video taken from the Delta submersible at those sites in 1993 and 1995, respectively. Invertebrate species were identified and associated seafloor substrates were recorded as primary and secondary grain size and relief. All surveys found gorgonians growing in the majority of seafloor substrates, including flat rock and boulders. ROV Hammerhead stations had higher densities of gorgonians than the previous Delta submersible surveys. These increases occurred in high-relief substrata as well as low-relief covered sediments. The greater prevalence of gorgonians from 1995 to 2011 could be the result of commercial fishing gear restrictions, which went into effect between these surveys, and suggest that some sites are recovering and are currently more protected from anthropogenic activities. However, almost nothing is known about the life history of gorgonians on the Pacific Northwest continental shelf; other explanations for gorgonian abundance increases include changes in oxygen concentration and nutrient availability. Although policy changes may be improving seafloor habitat for gorgonians and their associated fish communities, a better understanding of gorgonian species is needed to more accurately assess and improve management decisions.

Bayesian Siting Model for Marine Spatial Planning

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With so many spatial planning and decision support tools available today, all of which claim to solve a multitude of problems, why introduce another tool? Virtually all spatial planning and analysis tools today are built around the power of Geographic Information System (GIS) software applications. These systems exist, are in wide use, and adapting them for planning tasks seems an attractive and straightforward path. Despite their ease of use and spatial intelligence, GIS systems alone fall short for decision support: they (1) do not explicitly account for or propagate uncertainties in the underlying data or models, (2) do not handle temporal and multidimensional data well or at all, and finally (3) they do not really help the user make a decision or find common ground.

Bayesian analysis methods, however, provide a way to incorporate uncertainties (model or measurement), disparate and patchy data, or even missing data into a robust analysis system. This type of system not only provides an outcome but also reports the certainty of the outcome as well as the sensitivity of the outcome to any particular piece of data.

The Bayesian decision support system allows the user to discover which data are important, which can be ignored, and which are needed to make an optimal decision. The system treats all data probabilistically, combining probabilities in conceptually the same way a GIS combines layers, but Bayes Theorem replaces the ad-hoc map algebra methods used in typical GIS analysis. The Bayesian system can also be used in the final stage of decision-making, allowing users to engage in "what if" scenarios by permitting them to input their subjective values into the decision process. For non-subjective values, the system calculates an initial and final suitability

value as a means of evaluating change or impact to a given environmental measure. Lastly, since the problems addressed here are spatial and the analysis has been applied to spatial datasets, the output can be visualized in a GIS system so that the users can view the outcomes, the underlying data, and the analysis results in an intuitive way. By having all cards on the table, with a robust science based foundation, consensus building is simplified.

Predicting Benthic Invertebrate Distribution: GIS-linked Bayesian Belief Networks for Marine Spatial Planning

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Relatively speaking, compared to charismatic or commercially valuable fauna, little is known about the distribution of marine benthic invertebrate species and the factors that influence their distribution. Drawing upon recent invertebrate and seafloor habitat surveys a Bayesian Belief Network-Geographic Information System linked (BBN-GIS) framework for predicting and visualizing potential benthic invertebrate habitat is being developed for the West Coast of North America, from Ft. Bragg, California to the southern boundary of the Olympic Coast National Marine Sanctuary, Washington. The BBN-GIS system supports marine spatial planning, particularly the assessment of wave energy siting alternatives, by providing information useful for determining site suitability, identifying hotspots, and for drawing attention to potential environmental impacts.

BOEM-funded benthic mapping and sampling surveys at six shallow to mid-Continental Shelf study sites provided information for developing surficial geologic habitat (SGH) maps and for examining habitat preferences. We compared several Bayesian learning techniques to associate observed species abundance with environmental variables and measured their relative influence as predictors of species distribution. Results revealed that regardless of modeling technique, environmental variables describing sediment properties and water depth were most influential while those variables describing water properties (temperature and dissolved oxygen concentration) were consistently less influential as predictor variables. SGH proved to be a suitable grain size proxy for prediction over minimally characterized areas. We conclude that the BBN-GIS framework is a practical tool for rapid prediction and visualization of probabilistic species distribution even with very small, incomplete data sets.

Therefore Bayesian learning extracts information contained in survey data that is useful for characterizing habitat preference and for predicting habitat suitability outside of the study area. Additionally, BBN models are transparent and easily updated with new information. BBN-GIS tools such as this can support marine spatial planning by allowing interactive visualization and comparison of alternative scenarios and are thus well-suited for adaptive marine management.

The West Coast Regional Data Framework

Todd Hallenbeck

West Coast Governors Alliance Sea Grant Fellow

The West Coast Governors Alliance on Ocean Health (WCGA) was launched in 2006 by the governors of California, Oregon, and Washington with the goal of advancing regional ocean governance to protect and restore the health of West Coast ocean and coastal resources and the economies that depend on them. The WCGA identifies regional ocean issues for the California Large Marine Ecosystem and addresses these issues through sharing common strategies, leveraging resources, and coordinating regionally with its federal, state, and tribal partners. Priority issue areas include providing strategies for the reduction of marine debris on our coasts as well as community adaptation to rising sea levels. As a cross-cutting issue area, the WCGA identified access to regionally relevant geospatial data and information products as critical to addressing its priorities and supporting implementation of the National Ocean Policy (NOP) and created the Regional Data Framework (RDF) Act to serve as a multi-state institution for regional data management, sharing, and coordination. This effort encompasses both the establishment of a Human Network, comprised of the people, existing networks, and communication mechanisms necessary for linking data managers and users as well as the development of a Data System including the hardware, software, and data necessary for linking the existing technological infrastructure on the West Coast. This dual mission recognizes the importance of human and technological elements inherent in increasing data access and discovery for regional marine planning, policy development, and resource management.

Acoustic Measurements from a Wave Energy Conversion Ocean Test Facility off the Central Oregon Coast

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A year-long experiment (March 2010 to April 2011) measuring ambient sound at the Northwest National Marine Renewable Energy Center's (NNMREC) shallow water site (50 m) off the central Oregon coast provides important baseline information and insight for future evaluation of acoustic impacts associated with marine hydrokinetic power testing and development along the inner Continental Shelf of the Pacific Northwest. Time-averaged and cumulative distributions of the received acoustic power spectral levels characterize the site as a high-energy end member for shallow water in the northeast Pacific, largely influenced by locally generated ship noise, breaking surf, and baleen whale vocalizations. Additionally, a broad increase in time-averaged spectral levels originating from far-field commercial ship noise along the Outer Continental Shelf is observed between 35 and 75 Hz. Root mean square sound pressure level (SPL_{rms}) estimates during the year-long deployment taken across the 1Hz–1kHz frequency band and calculated from one-minute intervals reveal minimum, mean, and maximum values of 90 dB, 113 dB, and 148 dB re 1 μ Pa respectively. Additionally, measurements of the acoustic output transmitted by a wave energy conversion device (WET-NZ) at the NNMREC facility during a recent test will be discussed in the context of these baseline measurements.

Utilizing Online Tools to Facilitate Data and Information Sharing Within the Offshore Renewable Energy Community

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To maximize the benefits of ocean renewable energy research efforts, it is critical to gather, organize, and make available pertinent information and data to stakeholders. To that end, Pacific Energy Ventures (PEV) created the Advanced H2O Power (AWP) knowledgebase to provide information about and access to research products and resources in an interactive environment that fosters communication and collaboration. Similarly, Pacific Northwest National Laboratory (PNNL) developed the Tethys database and knowledge management system (http://mhk.pnnl.gov/wiki/index.php/Tethys_Home) to provide access to information, research and data pertaining to potential environmental effects of marine and hydrokinetic (MHK) and offshore wind developments.

To help ensure the information and resources provided by Tethys and AWP are successfully shared and utilized, PEV, in cooperation with PNNL, conducted an outreach assessment in fall 2011. The project team developed a combination of open- and close-ended questions to determine online resource use patterns and general communication preferences among ocean renewable energy stakeholders. Close-ended questions were integrated into an online survey, and one-on-one and small group discussions were held to gain further insight into information needs, preferred formats, and most effective communication channels. Over 180 stakeholders participated; the majority of respondents represented industry, academic/research institutes, and the federal government.

Analysis of the survey responses was utilized to develop and implement a targeted outreach plan to optimize the content, features, and functionality of Tethys and AWP to better meet stakeholders' information needs and communication preferences. The AWP knowledgebase was transferred to a new platform, Ocean Renewable Energy (www.oceanrenewableenergy.com), that provides the features and functionality identified as most important (e.g., ease of navigation, export to PDF) and highlights the topic areas that stakeholders seek information about most often (e.g., potential environmental effects, regulatory processes). The new Ocean Renewable Energy (ORE) platform also functions as a forum to enable stakeholders to share not only data and information, but also experience, knowledge, and advice.

The targeted outreach plan also involved several changes to the Tethys knowledgebase, including enhancing site search capabilities and improving database organization. Information, data and research literature housed within Tethys is now available in both a tabulated spreadsheet format and a map view, which displays geo-referenced MHK projects, documents, and research studies. Additionally, data export options are being configured to enable users to easily export information from Tethys in a variety of formats.

Both knowledgebase systems have been (and will continue to be) updated to ensure timeliness, relevance, and quality of content. Most recently, we began the process of interfacing Tethys and ORE to increase accessibility to the data and resources provided by each knowledgebase and provide additional context for that information. Finally, both Tethys and

ORE now feature blogs and discussion forums to facilitate ongoing coordination and communication about data needs and ensure these tools and the resources they provide are effectively utilized to advance ocean renewable energy.

Biological Monitoring of the Water Column at Marine Renewable Energy Sites

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Biological monitoring is an integral part of marine renewable energy site selection, installation, and operation. Spatial and temporal variability in aquatic animal communities decreases the ability to detect biological impacts. An optimal monitoring program will detect impacts by combining cost-effective placement of instrument packages with cogent data analysis that quantifies measurement uncertainty. Increasing the ability to detect biological change is accomplished by increasing monitoring density in both instruments and measurements, and by increasing monitoring duration and range. At present, there is a glaring lack of standard approaches to monitoring biology at marine renewable energy sites. Objective procedures and quantitative tools are not available to identify instruments, measurement variables, sample densities, or to scale point measurements to a corresponding spatiotemporal domain. A baseline description of community attributes at a proposed marine renewable energy site in Puget Sound will be used to demonstrate the feasibility of an acoustics-based monitoring program. Concurrent spatial and temporal surveys quantified density distributions of fish and macrozooplankton in May and June 2011. A suite of metrics was used to quantify sample resolution, facilitate comparison between spatially- and temporally-indexed data, and to estimate the scaling between point and areal samples. Our ultimate goal is to optimize the monitoring scope of any sampling program, which can then be used to streamline permitting, maximize data collection, and reduce monitoring costs.

Invasions of an Intertidal Sponge: Climate Change or Natural Cycle?

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Although sponges can be superior competitors in cryptic habitats under continuous submersion, they are typically sparse in rocky intertidal habitats. For example, the sponge *Halichondria panicea* is typically present in low intertidal habitats, but is usually at low abundance and limited to crevices, holes, and other cryptic habitats. Unusually, since 2007, abundance of *H. panicea* at Fogarty Creek on the central Oregon coast has increased from $7.3 \pm 1.3\%$ cover (mean \pm 1SE) to $25.6 \pm 3.7\%$ cover in 2012. Similar changes have been observed at another site, Yachats Beach. Such change could result from processes associated with climate change, with normal climatic or other cycles, or their interaction. We examined change in phytoplankton abundance and temperature, and found no comparable trend in either factor. Another alternative is the 18.6 year lunar phase known as the Metonic Cycle, which can alter tidal ranges and temperature patterns with impacts on intertidal community structure. We found that the increase in sponge abundance coincides with average yearly increases in mean low low

water, suggesting that time of submergence of low zone sponges has increased, thereby providing reduced thermal stress and more feeding time. Although long-term phases such as the Metonic Cycle should be considered when evaluating the impact of climate change, we did not observe similar changes in the mid-1990s, suggesting that other factors may also be in play.

Protocols Framework for Baseline and Monitoring Studies for Ocean Renewable Energy

Justin Klure

Pacific Energy Ventures

To ensure that environmental baseline and monitoring studies produce scientifically valid and comparable data to inform offshore renewable energy development, standard protocols and formats for data collection and comparison are needed. Beginning in 2010, Pacific Energy Ventures (PEV) led a team of experts to develop the Protocols Framework (Framework), a tool that screens ocean renewable energy technologies and environmental site characteristics to identify baseline and effects information needs and applicable protocols to obtain that information. Application of the Framework involves nine steps, beginning with Step 1, describing the technology and the site where it is to be deployed.

Descriptions of the technology and project site (from Step 1) are used to identify the high priority stressor/receptor interactions (Step 2), describe the spatial and temporal scale of the stressor (Step 3), and define exposure due to overlap of stressor-receptors (Step 4). Step 5 involves applying the scientific and regulatory thresholds to assess the levels or durations of effects. Next, the information needed to establish baseline conditions (Step 6) and measure the effects of a stressor on a receptor (Step 7) is identified. Finally, protocols to collect the baseline (Step 8) and effects (Step 9) information are identified.

Case studies of real and hypothetical ocean renewable energy projects were used as the proof of concept and to test the utility of the Protocols Framework. Because the Framework is predicated on prioritizing environmental interactions, the project team conducted an integrated analysis that applied scientific expert opinion, regulatory requirements, and stakeholder opinion to rank potential stressor–receptor interactions. Of 144 possible interactions, the number ranked medium or high totaled 41 for wave energy, 29 for tidal energy, and 32 for offshore wind energy. The greater number of high and medium priority interactions for wave energy reflects the diversity of technologies and the associated uncertainty in related environmental stressors. Across technologies, the stressor with the most high- and medium-priority rankings was the presence of static devices, reflecting the variety of interactions that could occur when new structures are introduced in open waters.

Application of the Protocols Framework demonstrated that it can successfully screen many potential environmental interactions to identify those that require substantial baseline and/or effects monitoring and provide specific protocols to guide the monitoring. While the priority interactions identified include those most likely to require monitoring, the relative importance of the issues may vary with specific technologies and locations, acquisition of additional or more accurate data, or changes within the regulatory regime. Similarly, the ability of the tool to deliver specifically applicable protocols or information needs depends on the specificity of the data available about the particular technology, as well as the populations, communities, and habitats.

Given the strong variability in physical and biological conditions, users should expect to fine-tune or adapt a selected protocol to the particular project and site characteristics.

Temporal and Spatial Variation of Bivalve Molluscs

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Identifying and tracking temporal and spatial changes in benthic infaunal community composition and species abundance provides baseline data for prospective wave energy sites and future environmental impact assessments. This study utilized two benthic infaunal invertebrate data sets with sample sites along the Continental Shelf of the Pacific Northwest: a 2003 survey by the Environmental Protection Agency (EPA) and a 2010 survey covering select sites in the same region conducted by the Henkel lab at Oregon State University (OSU), funded by the Bureau of Ocean Energy Management (BOEM). EPA sample sites (June 2003) ranged from northern California to Washington, while BOEM sample sites (late August through mid-October 2010) were grouped into six stations over the same range. For each sample site, both surveys recorded temperature, salinity, dissolved oxygen, silt/clay % of sediment, and total organic carbon. In addition, the EPA survey recorded chlorophyll *a* concentration and the BOEM survey recorded fluorescence. EPA samples were retrieved using a double Van Veen grab, whereas BOEM samples were retrieved using a box core, which can result in a deeper grab depth, depending on the sediment type. Benthic grabs of 0.1 m² for both surveys were sieved through a 1.0 mm mesh.

The main change observed between the data sets was an increase in relative and absolute molluscan abundance. This was especially pronounced in Newport, where molluscs comprised approximately 80% of collected infaunal invertebrates in the 2010 BOEM survey. The increase in mollusc density (#/0.1 m²) was due primarily to an increased abundance of bivalves. For Newport specifically, the two most prominent bivalve species were *Axinopsida serricata* and *Nutricula lordi*.

BOEM sample sites (from the six stations sampled in 2010) were grouped using non-metric multidimensional scaling based on the similarity of bivalve species present and their abundance. The environmentally similar sites of Newport and Nehalem would be expected to have similar bivalve communities and therefore group together. However, different abundances of *Axinopsida serricata* largely drove these sites to form separate groups. Within the BOEM data set, spatial variation of bivalve presence/absence and abundance between sites provides information regarding habitat suitability, particularly in regards to sediment type. Often sites that fall into a certain sediment category (sand, silt, gravel) would be expected to contain similar benthic infaunal communities. However, a large difference in bivalve abundance between Newport and Nehalem, despite similar sediment proportions indicates finer partitioning among bivalve-suitable habitats within a single sediment group than previously considered. These results should be considered when conducting baseline research: despite conventional practice, infaunal community results from one site are not necessarily applicable to another site which falls in the same sediment group.

Time Series Observations on the Oregon Shelf at NH-10

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College of Earth, Ocean & Atmospheric Sciences, Oregon State University

Time series observations from moorings have been made since 1999 (with some significant gaps) 10 nautical miles off Newport, Oregon on the Newport Hydrographic Line (NH-10) through NANOOS (Northwest Association of Networked Ocean Observing Systems) and GLOBEC (Global Ocean Ecosystem Dynamics) programs. The mooring instrumentation has varied over the years, but typically consists of sensors measuring water temperature (15 depths), salinity (5 depths), and velocity (every 2 meters) at 2 minute sampling intervals. In addition a meteorological package is often deployed. The mooring is recovered and redeployed twice a year and can be used as a platform of opportunity for testing modest-sized instrument packages. This 80 m deep location on the shelf is often well-mixed vertically for 2 to 3 months during winter. Then the stratification of the water column begins in the spring and intensifies into summer, as the upper ocean warms due to solar heating and the deeper water cools due to upwelling circulation. The northward currents in the winter tend to be barotropic (uniform with depth) while the southward currents in the summer tend to be baroclinic (vary with depth).

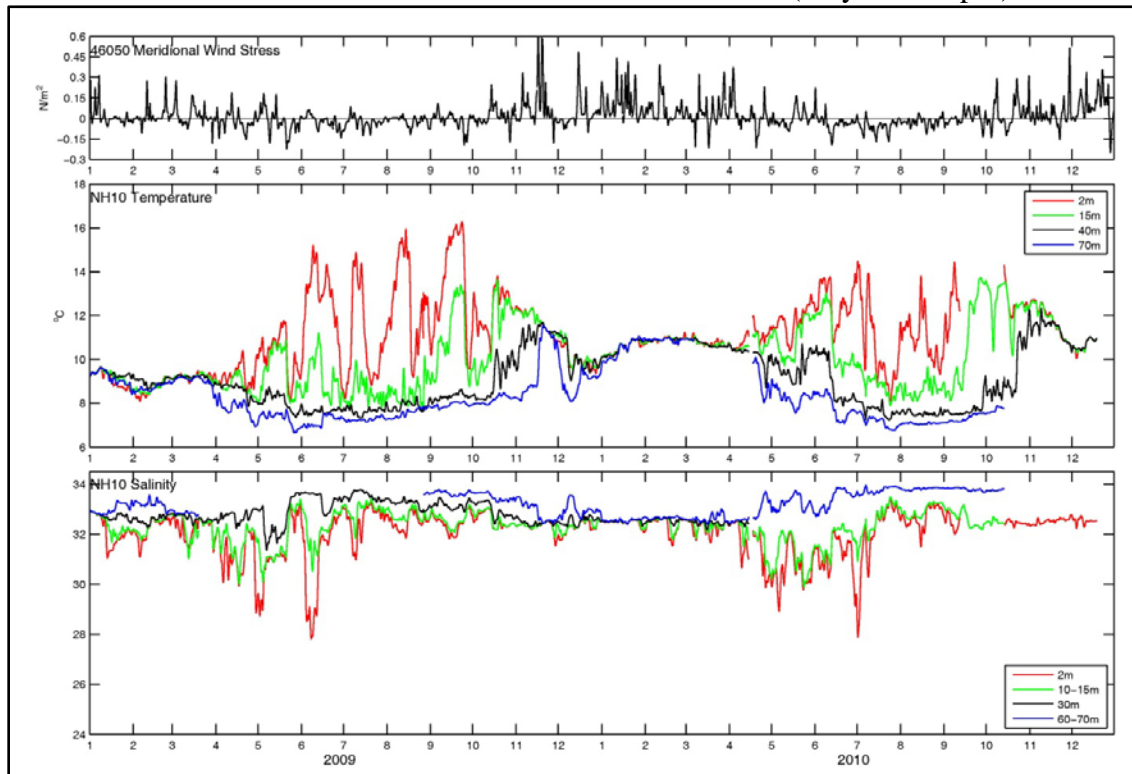


Figure A1: A sample of the NH-10 time series of temperature, salinity and wind stress

Development of Epibenthic Invertebrate Assemblages: Responses to Copper Anti-Fouling Paint and Water Flow

Page, M., J. E. Dugan, and C.C. Culver

Marine Science Institute, University of California, Santa Barbara

The performance of vessels, moorings, and other constructions can be negatively affected by the accumulation of fouling invertebrates on submerged surfaces. Variation in selectivity and strength of larval responses to surface characteristics and the local flow environment can affect development and composition of the invertebrate assemblage. For example, some boat hull-fouling species, including non-native taxa, are more tolerant of toxic copper-based coatings than others, making these coatings less effective and potentially favoring these species. In addition, the local flow environment may influence fouling assemblage development through effects on recruitment and subsequent growth of different taxa. Here we summarize results of field experiments conducted in two harbors in southern California that explore the influence of surface coating (copper anti-fouling vs. base gel coat) and flow environment on the rate and trajectory of fouling assemblage development. In the first experiment, plates treated with copper anti-fouling paint commonly applied to boat hulls were submerged, along with untreated plates, for 1, 3, and 12 months at marinas in the inner and outer reaches of Shelter Island Yacht Basin, San Diego Bay. Development of the fouling assemblage differed significantly between locations and treatments. A cryptogenic tube dwelling amphipod and cryptogenic and non-native encrusting bryozoans dominated the assemblage on the copper treated plates after 3 months. Over 12 months, these same species, plus two additional non-native species, comprised the majority of fouling on the plates. In the second experiment, submerged plates were exposed to artificially enhanced or ambient flow in Santa Barbara Harbor for 3 months. Development of the fouling assemblage differed significantly between treatment and control with a non-native solitary ascidian and encrusting bryozoans showing negative and positive responses, respectively, to enhanced flow. Observations of populations of the encrusting bryozoan *Watersipora* in harbors, on natural reefs, and on offshore oil platforms suggest that the local environment, including flow regime, may greatly influence the growth of this non-native species. Taken together, our results and observations suggest that interactions between anti-fouling coating and water flow likely exist that might favor the development of certain taxa, leading to substantially different assemblages (e.g., higher bryozoan cover) depending on the combination of these factors, at least up to 12 months. Additional field experiments that cross coating type and flow within one location are needed to develop a better understanding of interactions between flow and antifouling coatings on man-made surfaces in the sea.

Marine Bird Colony and At-Sea Distributions along the Oregon Coast: Implications for Marine Spatial Planning and Information Gap Analysis

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Increasingly diverse interests in commercial and recreational use of marine resources are creating new challenges for coastal ocean management. One concern of increased offshore use and development off the Oregon coast is the potential impact on marine bird populations. We summarized the primary surveys of seabird breeding colonies and at-sea distribution along the Oregon coast to describe spatial patterns in species distribution and identify gaps where additional data are needed. The abundance of breeding birds during the summer (over 1 million in total, primarily Common Murre, *Uria aalge*, and Leach's Storm-Petrel, *Oceanodroma leucorhoa*) is greatest in northern and southern Oregon due to the availability of breeding habitat on large offshore rocks and islands. While there are fewer breeding colonies along sandy shorelines, adjacent coastal waters are still frequented by breeding birds and nonbreeding migrants, but generally in lower densities during summer. Seabird density, and likely potential interaction with offshore structures, is greatest nearshore and steadily declines to lowest levels beyond the Outer Continental Shelf. Dynamic soaring species, however, which have a greater potential to interact with taller structures such as wind turbines, tend to be more common on the middle to outer shelf. Species composition also changes dramatically among seasons. Low flying (< 30 m above sea level) diving species dominate in most seasons, however, which has potential conservation implications for interactions with structures above and below the water's surface. Given the abundance of storm-petrels, increased light pollution is also a concern for these and other nocturnal, phototactic species. Dramatic declines or redistributions have occurred at some breeding colonies, indicating long-term planning should consider changing habitat requirements. The greatest data needs currently include fall/winter/spring at-sea distribution, summer distribution off southern Oregon, and more accurate estimates and monitoring of burrow-nesting seabirds. Oregon's coastal waters provide habitat for a large portion of breeding and nonbreeding marine birds along the U.S. West Coast and a thorough knowledge of their spatial distribution, seasonal abundance, and migration corridors is critical for well-informed marine spatial planning.

Data to Support a Review of Essential Fish Habitat for Pacific Coast Groundfish

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In this poster, we provide a summary of data used to support Phase I of a five-year review of Essential Fish Habitat (EFH) for 91 species of groundfish off the Pacific Coast of the U.S. We highlight some of the key products developed for this review that are now available to the public. Initial EFH designations were based on best available data developed from 2002 to 2005; NOAA's National Marine Fisheries Service (NMFS) approved these designations in May 2006. Beginning in 2010, the Pacific Fisheries Management Council (PFMC), Northwest and Southwest Fisheries Science Centers, and the NMFS Regions initiated the first mandatory five-year review for EFH provisions of the groundfish Fishery Management Plan. In Phase I of this process, we evaluated the extent of new information available for the review and for potential modifications of current EFH designations. Sources of information included published scientific literature and unpublished scientific reports; solicitation of data from interested parties; and the review of previously unavailable or inaccessible data sets. Coast-wide maps were updated for (1) bathymetry and interpreted groundfish habitat types; (2) the distribution and extent of groundfish fishing effort (as potential impact to EFH); (3) the distribution and relative abundance of biogenic habitat (i.e., sponges and corals); and (4) spatial management boundaries (as potential mitigation of impacts). This poster emphasizes geospatial datasets though additional new information has been identified, e.g., habitat associations for the 91 groundfish species, modeling efforts relevant to the determination and designation of EFH, non-fishing activities that may affect EFH, and new information on prey species. This complete body of information, in the form of a written report and supporting internet database, was presented to the PFMC, its advisory bodies, and the public, at the Council's September 2012 meeting, and adopted by the Council (PFMC's Essential Fish Habitat Review Committee Phase I Report: <http://www.pcouncil.org/groundfish/background/document-library/pacific-coast-groundfish-5-year-review-of-efh/>; online data catalog: <http://efh-catalog.coas.oregonstate.edu/overview/>). Phase II of the process is now underway and includes a six-month public review period. NMFS is currently conducting an analysis of the information in the Phase I Report, and will deliver a synthesis to the Council in April 2013. As part of Phase II, the Council will solicit proposals to modify EFH and Habitat Areas of Particular Concern (HAPC). If the Council decides to amend EFH, Phase III of the process will begin and may require an amendment to the groundfish Fisheries Management Plan. This five-year review represents a major update of the groundfish habitat assessment for the California Current and will have research and management applications well beyond satisfying the regulatory guidelines associated with EFH.

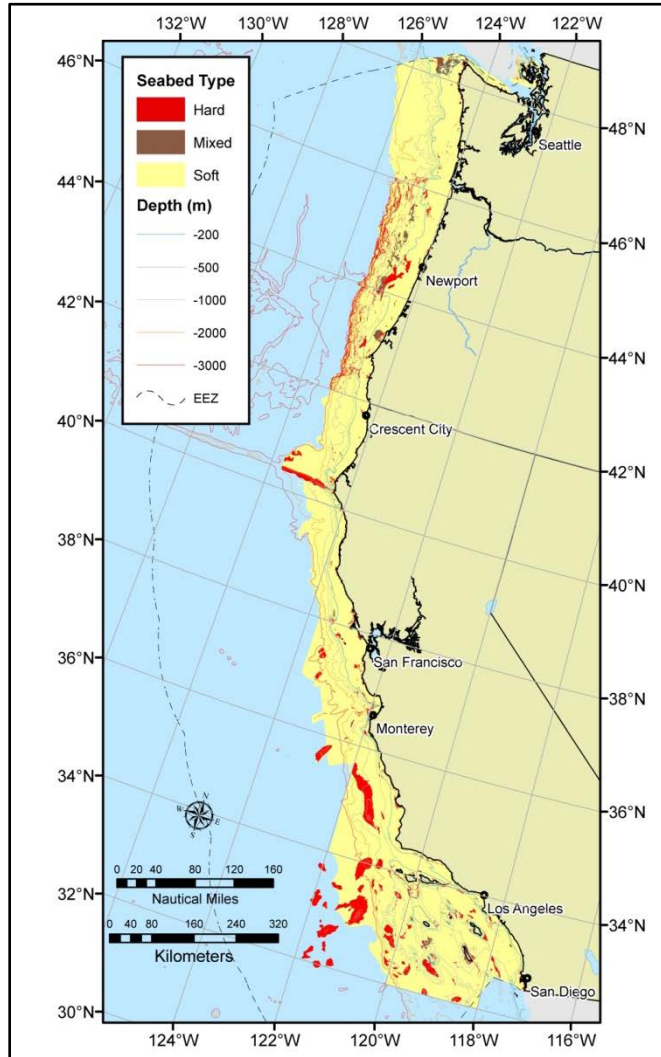


Figure A2: Map of seabed type (hard, mixed and soft) for the Pacific coast; developed for the Pacific coast groundfish 5-year review of Essential Fish Habitat.

Effects of Electromagnetic Fields on Marine and Estuarine Fish and Invertebrates

J.A. Ward, D.L. Woodruff, and A.E. Copping

Pacific Northwest National Laboratory

Electrical power from tidal currents, waves, and offshore wind represents an important new source of renewable energy and technical job creation for coastal communities. Because over 50% of the United States' population lives in a coastal county, the future need and potential resource are co-located. The creation of large-scale tidal, wave, and offshore wind systems could significantly contribute to renewable energy goals at the federal and state level and provide new energy alternatives for coastal tribes, coastal communities, and the U.S. military. Unfortunately, little is known about the environmental effects of electromagnetic field (EMF) emissions from devices or cables leading to shore or their effects on electro-sensitive fish and invertebrate species present in marine or estuarine ecosystems. Because uncertainties related to environmental effects could significantly influence device permitting and operation, fundamental questions related to exposure and effects on potentially sensitive species need to be addressed. This poster will describe the issues and challenges associated with ocean energy development; provide examples of laboratory research conducted at PNNL to better understand EMF effects on marine and estuarine fish and invertebrates; and discuss future actions and activities that will enable responsible development of tidal, wave, and offshore renewable energy sources in the United States.

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APPENDIX D
CONFERENCE PARTICIPANTS

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Oregon Marine Renewable Energy Marine Science Conference
28 – 29 November, 2012
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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.



The Bureau of Ocean Energy Management Mission

As a bureau of the Department of the Interior, the Bureau of Ocean Energy Management's (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEM Environmental Studies Program Mission

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.