COBSCOOK BAY TIDAL ENERGY PROJECT

2015 ENVIRONMENTAL MONITORING REPORT

FERC PROJECT NO. P-12711-005

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

ORPC Maine, LLC, a wholly-owned subsidiary of Ocean Renewable Power Company, LLC, (collectively, ORPC), is a Maine-based developer of hydrokinetic power systems and projects that harness the power of oceans and rivers to generate clean, predictable renewable energy. In partnership with coastal and river communities, ORPC works to create and sustain local jobs while promoting energy independence and protecting the environment.

ORPC received a pilot project license for the Cobscook Bay Tidal Energy Project (Project) from the Federal Energy Regulatory Commission (FERC) on February 27, 2012 (FERC Project No. P-12711-005). The purpose of the Project is to evaluate the potential for a new source of clean, renewable energy generation using tidal energy resources in Cobscook Bay, Maine. ORPC obtained a preliminary permit for the Project area in Cobscook Bay from FERC on July 23, 2007; FERC issued a successive preliminary permit on January 13, 2011. Feasibility studies, including environmental surveys, and pre-filing consultation were conducted, resulting in ORPC's filing of a draft pilot project license application with FERC on July 24, 2009 and subsequently, the final pilot project license application in September 2011. The FERC pilot project license boundary for the Project encompasses the proposed development area (Figure 1).

In March 2012, ORPC began construction of the Project off the coast of Eastport and Lubec, Maine (Figure 1). Following installation of the initial phase of the Project during the spring and summer of 2012, the Project began delivering electricity to the Emera Maine grid in September 2012. This is the first grid-connected installation of ORPC's TidGen® Power System.

TidGen® Power System

ORPC designed the TidGen® Power System to operate in water depths of 60 to 150 ft. The core component of the TidGen® Power System is ORPC's proprietary turbine generator unit (TGU). The TGU utilized four advanced design cross-flow (ADCF) turbines to drive a permanent magnet generator mounted between the turbines on a common driveshaft. The ADCF turbines rotated in the same direction regardless of tidal flow direction; rotational speed of the turbines was directly related to water flow speed. The TGU was 98 ft in length, 17 ft high and 17 ft wide. It was attached to a bottom support frame, which held the TGU in place approximately 15 ft above the sea floor. The bottom support frame was 98 ft long by 50 ft wide by 15 ft high. The bottom support frame was constructed of steel, and the TGU was constructed of steel and composite material. The coupled TGU and bottom support frame comprised the TidGen® device (Figure 2). The TidGen® device was connected to an underwater power consolidation module, which was then connected to an on-shore station through a single underwater power and data cable. The on-shore station was interconnected to the local power grid. The TidGen® device and the related cabling and on-shore station comprised a complete TidGen® Power System.

Figure 1. Cobscook Bay Tidal Energy Project location map.

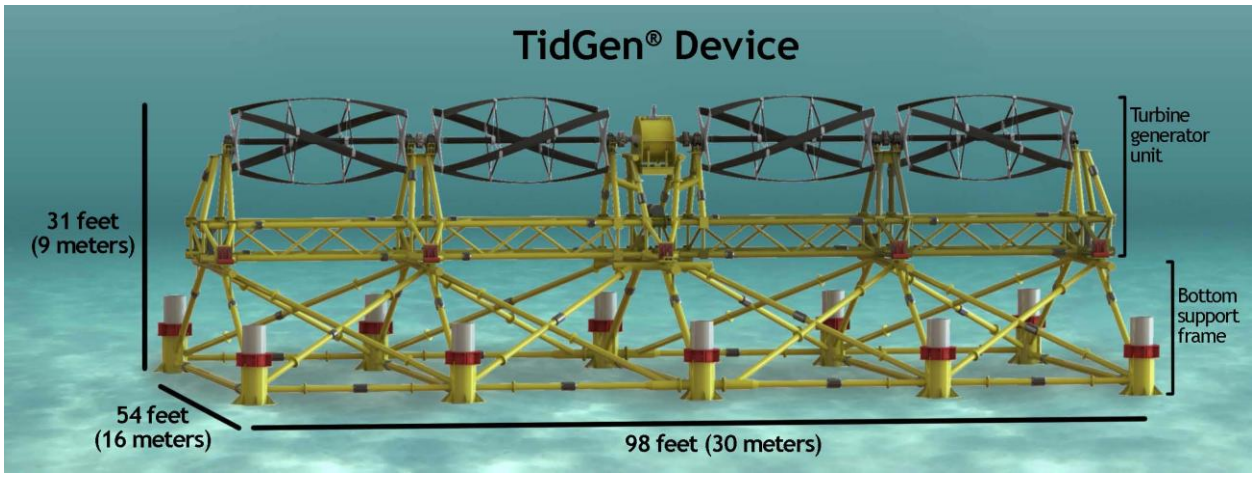

Figure 2. TidGen® device illustrating turbine generator unit (TGU) and bottom support frame

1.2 Technology Optimization Phase

The TidGen® TGU was retrieved from the Cobscook Bay Tidal Energy Project site in July 2013. Prior to retrieval, ORPC logged considerable operational time, achieved multiple milestones and gathered important lessons learned regarding deployment and retrieval procedures, and turbine operation, performance and environmental interactions. To take immediate advantage of the lessons learned, ORPC decided to proceed with significant engineering improvements to the TidGen® Power System while the TGU was out of the water. This approach allowed ORPC to properly address issues with the generator and identify and implement longer-term design and component part improvements for future versions of the TidGen® Power System. This effort will result in a greater technology gain over time and help sustain successful operations locally.

ORPC has focused our technical optimization strategy on leveraging lessons learned from multiple projects (Figures 3, 4 and 5) towards cross-platform designs and advanced design tools. Turbine, fairing structure and control system design improvements will improve performance of the power systems. To this end, the design of the tensioned mooring system deployed in 2014 in Cobscook Bay matured the OCGen® prototype system as expected. These advances, combined with the integration of new generator and driveline technologies scalable to 600kW rated power in high flow environments, will provide the basis for the optimized TidGen® Power System to be re-installed in Cobscook Bay. We anticipate improving the TidGen® TGU demonstrated efficiency to an onboard power output efficiency approaching 45%.

Figure 3. TidGen® Power System, deployed in 2012-2013 in Cobscook Bay, Maine

Figure 4. OCGen® module, deployed in 2014, Cobscook Bay, Maine

Figure 5. RivGen® Power System, deployed in 2015 in Igiugig, Alaska

To support the deployment of the optimized power system, ORPC will leverage component development work that contributes to the next generation ocean power system design. The U.S. Department of Energy (DOE) is sponsoring two major ORPC efforts at present:

> *Advanced Energy Harvesting Control Schemes for Marine Renewable Energy Devices* (DE-EE0006397) implemented turbine control system improvements on the RivGen® platform installed in Igiugig, Alaska, in the summer of 2015 using new acoustic flow measuring strategies that characterized turbulence and flow variation upstream and across the turbine profile. Based on analytical simulations, supported by scale model testing, we projected an 18% improvement in energy capture utilizing the innovative control schemes. Field testing of these improvements indicated that these performance enhancements were achieved.
>
> *Power Take-Off Systems for Marine Renewable Devices* (DE-EE0006398) focuses on both bearings and subsea generator designs. Through the use of advanced roller bearings, mechanical losses will be significantly reduced, improving overall driveline efficiency. In addition, ORPC is working on innovative generator designs, implementing multiple layers of leak prevention and mitigation while utilizing field-proven anti-corrosion and connector technologies. System availability is projected to approach 90%, and subsequent implementation of conditional monitoring systems will increase this further. A generator will be purchased upon successful completion of the critical design review in March 2016.

ORPC has based its next generation turbine system on an expanded two dimensional (2D) and three dimensional (3D) computational fluid dynamics (CFD) strategy developed by ORPC, and Maine-based Aerocraft, in collaboration with Sandia National Laboratories. Results from extensive 3D CFD simulations show a high degree of correlation between actual field data and analysis.

As part of the OCGen® Module Mooring Project, funded in part by DOE (DE-EE0002650) and Maine Technology Institute (DA2513), ORPC demonstrated the feasibility of a buoyant tensioned mooring system to operate in a reversing flow, tidal environment while maintaining proper position in the water column and within expected loading. More importantly, the project produced additional design tool validations, such as Maine Marine Composites' OrcaFlex models, which allow for the dynamic analysis of the orientation and attitude of the buoyancy pod system within varying flows and operational states. Such tools allow the next generation system to be designed for minimal weight and material costs.

A timeline of completed design elements and ongoing efforts is shown on Figure 6.

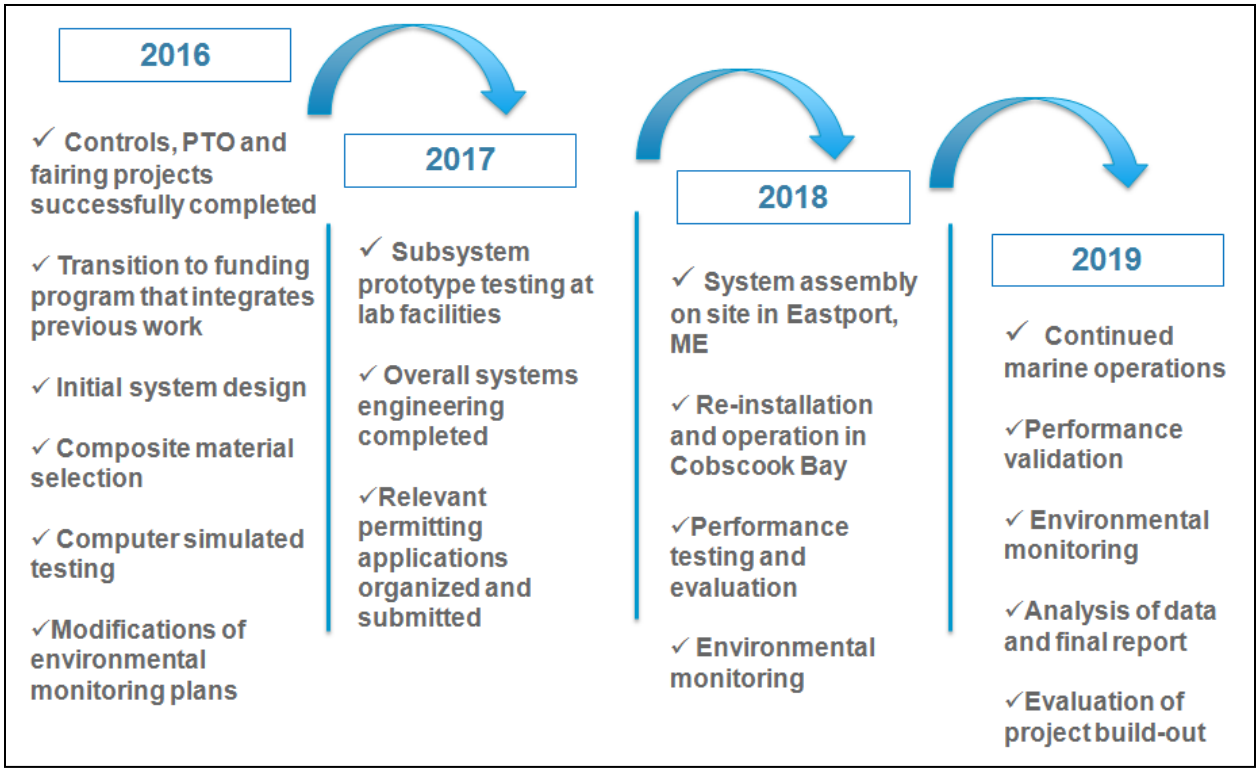

Figure 6. Technology optimization roadmap

1.3 Pilot License Extension

ORPC requested a two-year extension for the Cobscook Bay Tidal Energy Project pilot project license from FERC on June 5, 2015. This request resulted from the status of the Project and experimental nature of hydrokinetic technology development. ORPC, through consultations with FERC and the Project's Adaptive Management Team, concluded that requesting a license extension would be more appropriate than filing for a new license, including a Notice of Intent (NOI) and Pre-Application Document (PAD).

ORPC's pursuit of a pilot project license extension versus a new license was based on the following factors:

- ORPC is currently in a technology optimization phase, partially funded by DOEthat was not anticipated.
- Precedence exists for longer-term pilot project licenses for tidal energy projects (i.e., ten years).
- The extension would provide an opportunity to test alternative turbine designs.
- The tidal energy resource at the Project site in Cobscook Bay is not currently suited for commercial development.

Following a public comment period and consultation with resource agencies FERC issued an order on December 16, 2015 granting the two-year license extension.

1.4 Temporary Variance from Environmental Monitoring

The status of the TidGen® TGU led ORPC to consult with FERC and the Project's Adaptive Management Team to determine an appropriate level of environmental monitoring while the TGU was out of the water. This effort culminated with the issuance of a temporary variance from environmental monitoring from FERC on October 29, 2013. The essential elements of granting a variance were the following: an environmental, safety, hydrologic or third party issue that renders the license condition impracticable or counterproductive; a defined period of time and specific plan of action for the variance has been identified; no unreasonably adverse environmental impact is likely; and consent from the consulting agencies is documented.

ORPC continued some opportunistic environmental monitoring at the Project site in 2014 despite the temporary variance. These activities were associated with the deployment of ORPC's OCGen® Module Mooring Project at the site. Environmental monitoring included review of dive video for benthic growth on subsea components (Section 3.0 of this report). In addition, ORPC and the University of Maine School of Marine Sciences (UMaine) continued fisheries and marine life interaction research at the site in 2014 and 2015 through a separate UMaine funding award from DOE.

ORPC provided FERC and the Project's Adaptive Management Team updates during the temporary variance period in 2015 related to project activities and technology optimization progress. ORPC held an Adaptive Management Team meeting on November 19, 2015, which included further updates on the technology optimization phase and a request for feedback on the potential for an extension to the temporary variance to align with the engineering and design schedule. Based on feedback from the Adaptive Management Team, ORPC explored the option of requesting a two-year variance extension.

Based on these discussions, ORPC requested a two-year temporary variance extension to environmental monitoring from FERC on December 31, 2015. The request took the following factors into account:

- Comprehensive pre-deployment environmental studies have contributed to an understanding of inter-annual variability.
- Environmental monitoring results-to-date indicate negligible effects to marine life for ongoing operations.
- TGU operational status makes adherence to license condition impractical and will not advance the conditions purpose.
- No undue impacts or impedance of other license requirements are anticipated.
- ORPC plans to return to adherence of condition once TGU operation recommences.

The request for the two-year extension to the temporary variance for environmental monitoring was granted by FERC on March 2, 2016.

2.0 ADAPTIVE MANAGEMENT (License Article 404)

2.1 Adaptive Management Plan and Team

ORPC developed an Adaptive Management Plan (AMP) as required by the FERC pilot project license (P-12711-005, Article 404) for the Project. The AMP is an integral part of ORPC's implementation of the Project and provides a strategy for evaluating monitoring data and making informed, science-based decisions to modify monitoring as necessary. As required by Article 404, the AMP was drafted in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Coast Guard, Maine Department of Environmental Protection, and Maine Department of Marine Resources. ORPC also consulted with technical advisors, who were involved with the development of each of the elements of this Project. The AMP reflects the collaborative approach that has been an integral part of the Project since its beginning. Table 1 lists the members of the Adaptive Management Team (AMT) and their respective roles. Several former members of the AMT have changed positions within their organizations; therefore, ORPC is in the process of identifying appropriate replacements.

Table 1. Cobscook Bay Tidal Energy Project Adaptive Management Team

NAME	ORGANIZATION	ROLE	RESPONSIBILITY
Nathan Johnson	ORPC	Project Developer	Communication
Steve Shepard	U.S. Fish & Wildlife Service	Government Regulator	Compliance with established regulations
Sean McDermott	NOAA NMFS, Habitat Conservation Division	Government Regulator	Compliance with established regulations (Essential Fish Habitat)
David Bean/Jeff Murphy	NOAA NMFS, Protected Resources Division	Government Regulator	Compliance with established regulations (Endangered Species)
Denis-Marc Nault	Maine Department of Marine Resources	Government Regulator	Compliance with established regulations
Daniel Hubbard	U.S. Coast Guard, First District	Government Regulator	Compliance with established regulations
Jim Beyer	Maine Department of Environmental Protection	Government Regulator	Compliance with established regulations
Jordan Carduner	NOAA NMFS, Office of Protected Resources	Government Regulator	Compliance with established regulations (Marine Mammals)
ADVISORY			
Gayle Zydlewski	University of Maine	Technical Advisor	Fisheries Monitoring
Moira Brown	New England Aquarium	Technical Advisor	Marine Mammal Monitoring
Jay Clement	U.S. Army Corps of Engineers	Government Regulator	Advisory

The collaborative approach that was adopted for the AMP was first utilized for the 2009 memorandum of understanding (MOU) between the State of Maine and FERC, that included a working structure to develop and permit Maine's first hydrokinetic power project. An important component of the MOU was to develop appropriate and cost effective environmental studies and monitoring plans. It was clear from the onset that knowledge of the eco-system and its many facets potentially affected by this new hydrokinetic power project would require new methods of inquiry to collect, monitor and evaluate environmental data. Many of the new scientific methods that were developed for the Project have become a new basis for learning, and the scientific community has begun modifying approaches to environmental studies using these new methodologies in other programs. This learning has helped to bring the agencies and industry to a point where they have more tools to confidently address the needs of permitting of a commercial development. ORPC's AMP was designed to utilize not only the environmental studies at the Project site, but also environmental studies from other hydrokinetic projects and related studies from around the world.

ORPC's AMP recognized that many scientific uncertainties exist and that environmental conditions constantly change. The AMP, therefore, was designed to be modified within the Project time line and acknowledged that elements such as key environmental uncertainties, applied studies and institutional structure may evolve over time. The AMP has worked well for the agencies, stakeholders, and ORPC as the Project evolved from a concept to the first pilot installation and operation.

The AMP summarized the minor and major license modification process required to make changes to environmental monitoring. ORPC strongly supported the involvement and concurrence of the AMT in applicable license modification requests, and the AMP process establishes a path to proceed in this manner.

2.2 2015 Adaptive Management Team Meeting

ORPC met with the AMT on November 19, 2015 to provide an update on technology optimization as well as environmental monitoring and to seek concurrence on an extension to the temporary variance from environmental monitoring.

Specific agenda items included:

- Cobscook Bay Tidal Energy Project update
    - Technology optimization progress
    - Pilot project license extension request
    - Temporary variance extension request
- Building the environmental interaction knowledge base
    - UMaine fisheries monitoring and data analysis
    - 2015 RivGen® demonstration project in Kvichak River, Igiugig, Alaska
- Western Passage Permitting and Development Strategy

Monitoring results presented to the AMT continued to indicate negligible observed effects to the environment from ORPC power systems.

Minutes from the November 19, 2015 AMT meeting are included in Appendix A. The presentation to the AMT, which includes an update from the UMaine, is included as Appendix B.

2.3 Cobscook Bay Tidal Energy Project License Modifications

The Cobscook Bay Tidal Energy Project has successfully demonstrated the ability to modify license requirements based on knowledge gained, the engagement and concurrence of the AMT, and clear communication with FERC.

Table 2 summarizes license modifications completed since 2013. It should be noted that modifications related to rated capacity and inspection and maintenance did not involve the Project's AMT.

Table 2. Summary of 2013 Cobscook Bay Tidal Energy Project license modifications

Submittal/License Article(s)	Requested Modifications	FERC Order Date
Exhibit A, Project Description and Operation	Rated capacity of the TidGen® Power System revised from 60kW to 150kW.	February 21, 2013
FERC Division of Dam Safety and Inspection - Article 306. Inspection and Maintenance	Clarification of inspection and maintenance activities and frequencies	April 8, 3013
2012 Environmental Monitoring Report - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Modifications vary by license article but generally clarify monitoring plans or reduce frequency of monitoring surveys based on increased knowledge of species presence and environmental effects.	May 8, 2013
Temporary Variance Request - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Hiatus in environmental monitoring during technology optimization phase	October 29, 2013
Temporary Variance Extension Request - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Hiatus in environmental monitoring during technology optimization phase	December 22, 2014
Pilot License Extension	Two-year extension to existing 8-year pilot license	December 16, 2015
Temporary Variance Extension Request - Article 405. Acoustic - Article 406. Benthic & Biofouling - Article 407. Fisheries and Marine Life Interaction - Article 409. Hydraulic - Article 410. Marine Mammal - Article 412. Bird	Two-year hiatus in environmental monitoring during technology optimization phase	March 2, 2016

3.0 FISHERIES AND MARINE LIFE INTERACTION MONITORING (License Article 407)

The goal of the Fisheries and Marine Life Interaction Monitoring Plan was to collect pre-deployment and post-deployment information, provide an initial description of fish distribution and relative abundance within Cobscook Bay and supplement existing information for the general Passamaquoddy Bay area. Specific objectives included:

- Characterize fish presence and vertical distribution in Cobscook Bay with acoustic technologies
- Conduct stratified sampling to evaluate tidal cycle, diel, and seasonal trends
- Characterize fish distribution, species, and relative abundance and summer seasonal occurrence with multiple netting efforts in open-water pelagic and benthic areas, near-shore sub-tidal areas, and intertidal areas of outer, middle, and inner bays within Cobscook Bay
- Use data gathered to develop a preliminary assessment of the potential effects of the Project on fish populations in the Deployment Area and to the extent possible in Cobscook Bay
- Monitor indirect fish interactions with the TidGen® device(s) to evaluate potential Project effects
- Evaluate potential cumulative effects of the Project based on this comprehensive data set and the direct interaction monitoring data collected

The Project requires monitoring to assess potential effects of the TidGen® Power System on the marine environment. ORPC's monitoring plan regarding marine life has two parts: (1) Fisheries Monitoring Plan and (2) Marine Life Interaction Monitoring Plan.

Fisheries Monitoring Plan
The Fisheries Monitoring Plan is a continuation of research started by UMaine researchers in 2009. The study was designed to capture tidal, seasonal and spatial variability in the presence of fish in the area of interest (near the TidGen® device deployment site). The design involved down-looking hydroacoustic surveys during several months of the year, and examined the vertical distribution and relative abundance of fish at the project and control site (for relative comparison). Pre-deployment data were collected in 2010, 2011, and early 2012, and post-deployment data were collected from August 2012 through September 2013. Data from the Project site were compared to the control site to quantify changes in fish presence, density, and vertical distribution that may be associated with the installation of the TidGen® Power System.

Marine Life Interaction Monitoring Plan
As part of the Marine Life Interaction Monitoring Plan, ORPC used side-looking hydroacoustics collected at the Project site to assess the interaction of marine life with the TidGen® device. This monitoring focused on the behavior of marine life (primarily fish) as they approached or

departed from the region of the TGU and quantified changes in behavior in response to the TidGen® unit.

3.1 2015 Activities in Cobscook Bay

UMaine's Fish Assessment Study Team continued research at the Cobscook Bay Tidal Energy Project site in 2015 as part of their DOE award (DE-EE0006384), *Interactions of aquatic animals with the ORPC OCGen® in Cobscook Bay, ME: Monitoring behavior change and assessing the probability of encounter with a deployed MHK device.*

2015 Activities

1. Completed analyses of data collected in 2014 associated with the OCGen® deployment, which included testing for differences in relative fish density and vertical fish distributions around the device.

2. Completed research of dB differencing methods on down-looking hydroacoustics data to separate Atlantic mackerel from swimbladdered fish. Analyses included previous stationary, down-looking hydroacoustics data from 2011-13 and data collected in 2014. Resulting methods from this research were used to remove zooplankton from all relative fish density estimates for all stationary, down-looking hydroacoustics data (2011-2014).

3. Completed probability of encounter model and submitted manuscript. These analyses included stationary, down-looking hydroacoustics data from 2011-13, and 2014 data collected using stationary and mobile hydroacoustics.

4. Completed long-term, side-looking hydroacoustics data collection at TidGen® location. Analyses of fish response to a static device and long-term, temporal trends in fish densities are in progress and will be submitted for peer review.

5. A final report associated with this award is being prepared.

An update on fisheries and marine life interaction was presented to the Project's AMT on November 19, 2015. This presentation is included in Appendix B.

3.2 2015 Igiugig Hydrokinetic Project

ORPC deployed and operated its RivGen® Power System, a submerged hydrokinetic device, in the Kvichak River near Igiugig, Alaska, in July and August 2015. Despite being a smaller version of the same core TGU technology as the TidGen® Power System deployed in Cobscook Bay, the Adaptive Management Team has expressed a keen interest in learning about the results of environmental monitoring associated with the project in Igiugig.

Biological monitoring for the 2015 Igiugig Hydrokinetic Project was performed by LGL Alaska Research Associates, Inc., in accordance with the 2015 Monitoring Plan developed in March 2015 and Alaska Department of Fish and Game (ADF&G) Fish Habitat Permit FH 15-II-0038.

Fish movements at the RivGen® device were described using video footage collected from five underwater cameras mounted to the pontoons of the power system. Video footage was collected 24 hours/day July 19–25, 2015 and again August 19–27, 2015; review was done by watching the first 10 minutes of a selected hour from each of the four primary cameras (the fifth camera was a backup). Spatially, the camera field of view captured the port side of the RivGen® device, including upstream and downstream views of the port side turbine (only). In accordance with the Monitoring Plan, footage was reviewed to achieve partial temporal coverage during different categories of turbine operating status and daytime/nighttime conditions. At night, two underwater lights lit the viewing area. In addition, bird and marine mammal surveys were conducted for 15 minutes each morning of monitoring. Methods and the overall approach were similar to those used for the demonstration study conducted at the same site in 2014.

Blocks of video footage from portions of 238 different hours were reviewed in season in 2015. There were 359 events with fish, composed of approximately 1,202 individual fish from at least six species. The majority of fish observations were of solitary fish; the largest school was approximately 100 fish. Species composition varied from July to August and also from day to night. In particular, salmon smolt were almost exclusively seen at night and were more prevalent in July than August. Several instances of fish moving through the RivGen® turbine were noted and reported in season as part of the Adaptive Management Plan. No obvious physical injuries to fish were detected, and no altered behavior by wildlife near the RivGen® device observed. Cameras, lights, and power system components all operated reliably. All video footage was archived. A data analysis report for the 2015 environmental monitoring at Igiugig, completed by LGL, is included as Appendix C.

Due to the quantity and quality of fish monitoring data collected at Igiugig in 2015 DOE has allocated funding to the Pacific Northwest National Laboratory to conduct further analysis on the data set in 2016. The analysis will concentrate on fish presence, and interaction with the turbine. Visual analysis of the video will be undertaken and, in parallel, algorithm development to automate fish detection within the video data will be performed. The aim is to produce near real-time automated processing to identify potential fish interaction with the turbine. U Maine will also be involved in the data analysis and interpretation.

3.3 Development of Best Available Science

Data collection and analysis in 2015 by the ORPC team continued to grow the knowledge base of its power system interactions with the environment. This knowledge will inform the permitting and licensing process moving forward for ORPC's projects as well as the greater marine and hydrokinetic industry. This publically available information demonstrated significant

progress in an industry where several years ago there was little or no information about environmental interactions of hydrokinetic devices.

The following products were completed by UMaine in 2015:

Shen, H., Zydlewski, G. B., Viehman, H. S., Staines, G. J. *submitted – in review*. Encountering a Marine Hydrokinetic Device. Renewable Energy.

Shen, H., Zydlewski, G. B., Viehman, H. A., Staines, G. J., and McCleave, J. D. 2015. Estimating the probability of fish encountering a marine hydrokinetic device. Proceedings of the 3rd Marine Energy Technology Symposium (METS), Apr 27-29, Washington, D.C.

Staines, G. J., Zydlewski, G. B., Viehman, H. A., Shen, H., and McCleave, J. D. 2015. Changes in vertical fish distributions near a hydrokinetic device in Cobscook Bay, Maine, USA. Proceedings of the 11th European Wave and Tidal Energy Conference, Sep 6-11, Nantes, France.

Viehman, H. A., Zydlewski, G. B., McCleave, J. D., and Staines, G. 2015. Using hydroacoustics to understand fish presence and vertical distribution in a tidally dynamic region targeted for energy extraction. Estuaries and Coasts 38(S1): 215-226.

Viehman, H. A. and Zydlewski, G. B. 2015. Fish interactions with a commercial-scale tidal energy device in a field setting. Estuaries and Coasts 38(S1): 241-252.

Viehman, H. A. and Zydlewski, G. B. 2015. Using temporal analysis techniques to optimize hydroacoustic surveys of fish at MHK devices. Proceedings of the 11th European Wave and Tidal Energy Conference, Sep 6-11, Nantes, France.

Viehman, H. A. and Zydlewski, G. B. 2015. Altered fish behavior near a static hydrokinetic turbine. Oral presentation at the 145th meeting of the American Fisheries Society, August 16-20, Portland, Oregon.

Viehman, H. A., Zydlewski, G. B., Staines, G. J., and Shen, H. 2015. What about the fish? Studying effects of tidal power turbines in the USA. Oral presentation to zoology faculty and graduate students at the University of Aberdeen, September 17, Aberdeen, Scotland.

Zydlewski, G. B., Copping, A., and Redden, A. 2014. Special Issue: Renewable ocean energy development and the environment. Estuaries and Coasts 38(S1): 156-158.

Zydlewski, G. B. 2015. Environmental Effects of Marine Energy Development: State of the Science on MHK monitoring technology - Collision and Fish. Annex IV Plenary Session at European Wave and Tidal Energy Conference, Nantes, France, September 8-11.

Zydlewski, G. B., Staines, G. J., Viehman, H. A., Shen, H. 2016. Fish Behavior, Presence, and Distribution in a Tidally Dynamic Region, with and without a Tidal Energy Device. Poster presentation at the Ocean Sciences Meeting, New Orleans, LA, February 21-26.

Zydlewski, G. B., Staines, G. J., Viehman, H. A., Shen, H., McCleave, J. D., Vieser, J., and Jensen, A. 2016. Fish behavior, presence, and distribution in relation to the Cobscook Bay Tidal Energy Project. Oral Presentation at the Atlantic Salmon Ecosystems Forum, Orono, ME, January 6-7.

ORPC made the following presentation in 2015 and early 2016 related to environmental monitoring of our power systems and the adaptive management process:

Johnson, N.E. 2015. Marine and Hydrokinetic Environmental Panel. *Proceedings of the International Marine Renewable Energy Conference (IMERC) 29 April, Washington DC.*

Johnson, N.E. 2015. Adaptive Management Case Studies Round Table. *Proceedings of the U.S. Department of Energy's Marine and Hydrokinetic Workshop for State and Federal Regulators 6 May, Washington DC.*

Johnson, N.E. 2015. Marine and Hydrokinetic Environmental Panel. *Proceedings of the 10th Ocean Renewable Energy Conference International Marine Renewable Energy Conference (IMERC) July 17, Portland, Oregon.*

Johnson, N.E. 2016. Adaptive Management Webinar. *OES Annex IV, January 27.*

ORPC also continues to contribute project information to DOE's Tethys website, which houses global data on ocean energy (http://mhk.pnl.gov/). In addition, a recently release public review draft of the Annex IV 2016 State of Science Report (http://tethys.pnnl.gov/annex-iv-2016-state-science-report-public-review-draft) includes a case study on the Cobscook Bay Tidal Energy Project.

4.0 CONCLUSIONS AND RECOMMENDATIONS

In 2015 ORPC continued to focus on a technical optimization strategy that leverages lessons learned from multiple projects towards cross-platform designs and advanced design tools. Technological and operational experience gained through the OCGen® Module Mooring Project in Cobscook Bay, Maine, and the RivGen® Project in Igiugig, Alaska, will directly contribute to the optimized TidGen® Power System that is reinstalled in Cobscook Bay.

Despite the issuance of a temporary variance from FERC this Environmental Monitoring Report addresses continued data analysis conducted by UMaine for Cobscook Bay.

4.1 The Role of Adaptive Management

The Project continues to demonstrate the ability to modify license requirements based on the results of science based data collection, the engagement and concurrence of the AMT, and clear communication with FERC. This process has garnered international attention as a model for adaptive management.

ORPC met with the Project AMT on November 19, 2015 to provide an update on technology optimization as well as environmental monitoring and to seek concurrence on an extension to the temporary variance from environmental monitoring. A request for a two-year extension to the temporary variance from environmental monitoring was submitted to FERC on December 31, 2015.

4.2 Environmental Monitoring Results

The 2015 data analysis and environmental monitoring results continued to build an increased knowledge of marine life interaction with ORPC Power Systems and indication of negligible environmental effects.

Fisheries and Marine Life Interaction

In 2015 UMaine's Fish Assessment Study Team completed research related to marine life interaction data around the OCGen® Module deployed in 2014. In addition, research was completed on dB differencing methods to separate Atlantic mackerel from fish with swim bladders, a probability of encounter model finalized, and long-term side-looking hydroacoustic data collection at the TidGen® deployment location was completed with further analysis in progress.

Development of Best Available Science

Data and analysis in 2015 by the ORPC team continued to grow the knowledge base of its power system interactions with the environment. This knowledge will contribute to informing the permitting and licensing process moving forward for ORPC's projects as well as the greater marine and hydrokinetic industry.

Following a 30-day review and comment period from the AMT, this Report will be revised accordingly and submitted to FERC in accordance with the Project license.

5.0 AGENCY REVIEW

5.1 Agency Review Period and Responses

The 30-day agency review period for the draft report ended on March 25, 2016. ORPC provided a reminder notice to the AMT on March 16, 2015.

Table 3 summarizes agency comments received and ORPC's response and/or action.

Table 3. Adaptive Management Team Comments on 2015 Environmental Monitoring Report.

Name/Agency	Comment	ORPC Response/Action
Jeff Murphy, NOAA NMFS, Protected Resources Division	Email comment (February 24, 2016) *I have no comments.*	Comment noted.
Jordan Carduner, NOAA NMFS, Office of Protected Resources	Email comment (February 29, 2016) *I have no comments on the Agency Review Draft.*	Comment noted
Jay Clement, U.S. Army Corps of Eningeers	Email comment (March 16, 2016) *I have no comments or questions.*	Comments noted.

5.2 Public Dissemination of 2014 Environmental Monitoring Results

In accordance with ORPC's AMP, the 2015 Environmental Monitoring Report will be made available to the public. In addition to the Report being available on FERC's website, it will also be posted to ORPC's website. Hard copies of the full report will be provided to the municipal offices of the City of Eastport and the Town of Lubec, and ORPC will coordinate further dissemination with community organizations.

Appendix A

Adaptive Management Team Minutes, November 19, 2015

Agenda

Welcome and Introductions – Nathan Johnson

The meeting began at 1:10 pm. Participants introduced themselves, and then Nathan Johnson, ORPC, reviewed the agenda and the following meeting objectives:

- Provide an update on the Cobscook Bay Tidal Energy Project
- Summarize ORPC's technology optimization progress
- Dr. Zydlewski to present the results of the University of Maine School of Marine Sciences Analysis
- Summarize ORPC's Igiugig, Alaska RivGen® Power System testing, fish monitoring data, and relevance to industry
- Provide an update on ORPC's Western Passage permit application status
- Discuss ORPC's temporary variance extension request
- Identify next steps and priorities

Cobscook Bay Tidal Energy Project (CBTEP) Update – Nathan Johnson and John Ferland
Mr. Johnson and Mr. Ferland presented an update on ORPC's Cobscook Bay Tidal Energy Project. Given that there was no operating project in the water at the site over the past year,; Mr. Johnson updated the Management Team on the permitting and licensing process surrounding the Cobscook Bay Tidal Energy Project. Mr. Johnson notified the Management team that the 2014 Environmental Monitoring Report was submitted to FERC on March 17, 2015. During this time, the University of Maine continued fisheries interaction data analysis. Mr. Johnson then provided an update to the Management Team regarding ORPC's request for a two-year FERC pilot license extension. Mr. Johnson stated that on February 9, 2015, ORPC submitted a formal justification as to why ORPC did not apply for a commercial license. On June 5, ORPC submitted a request to FERC for a pilot license extension. Following the submittal, a public comment period was opened on July 14. Mr. Johnson noted that no motion has been made to date regarding the request. Mr. Johnson closed the update by noting that all Temporary Variance reports had been submitted on schedule.

Mr. Johnson paused for questions, to which Jeff Murphy responded by phone. Mr. Murphy notified Mr. Johnson that NMFS Protected Resources Division has not filed their final determination on the extension but would be doing so over the next several weeks. Mr. Johnson then introduced Mr. Ferland with an update on ORPC's Technology Optimization progress.

Mr. Ferland began the Technology Optimization overview by stating ORPC's targets for further technology design improvements, including increased efficiency, reduced weight, lower production cost, reduced cost of electricity, and lower cost of installation, retrieval and maintenance. Mr. Ferland noted that achieving these targets is seen as an industry development priority within the US DOE, which has significantly re-invested in ORPC.. Mr. Ferland added that these efforts are complex and national in scope. Mr. Ferland included that ORPC is currently utilizing many partnerships with national laboratories, universities, and contractors in order to advance development efforts.

Mr. Ferland notified the Adaptive Management Team that ORPC was awaiting a decision from the DOE regarding follow on technology development funding, which would be matched by Maine Technology Asset Fund (MTAF) funding in order to develop and improve the buoyant tension mooring system demonstrated during the OCGen® Module Mooring Project in 2014. Mr. Ferland added that ORPC is

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beginning to compile data regarding cost breakdown structure of the technology, as well as predictions of the long-term cost of energy.

Mr. Ferland gave an update of ORPC's progress under the following projects:

- DOE Forward Controls
- DOE Power Take-off
- USDA SBIR

Updates included increased competitiveness of the electrical power generating system and validation of the inclusion of a fairing to the 2015 RivGen® device, which significantly increased power production. Mr. Ferland added that ORPC's in-water experience in Igiugig has benefited ORPC's technology optimization effort regarding the TidGen® device that will be re-deployed in Cobscook Bay.

Mr. Ferland then presented a timeline of technology optimization milestones, including anticipated dates for resuming operations in Cobscook Bay. At this point in the meeting, the Adaptive Management Team then took a brief recess.

Mr. Johnson then resumed discussions with an update on ORPC's temporary variance request. Mr. Johnson began by stating that following the Adaptive Management Team meeting on October 15, 2014, ORPC submitted a temporary variance request to FERC on November 25, 2014, which was subsequently approved by FERC on December 22, 2014.

Mr. Johnson explained that the temporary variance request was based on the following considerations: pre and post project environmental studies' contributions to the understanding of inter-annual variability, and observed negligible effects to marine life for ongoing operations. Additionally, Mr. Johnson explained that the TGU operational status makes adherence to license condition impractical, and would not advance the condition's purpose. Mr. Johnson included that no undue impacts or impedance of other license requirements are currently anticipated, and that ORPC plans to return to adherence of conditions once TGU operation recommences. Mr. Johnson then outlined the temporary variance request process, indicating that ORPC would seek concurrence of the Adaptive Management Team before submitting the extension request to FERC.

Agency feedback and discussion on CBTEP Update

No clarification was needed on ORPC's decision-making process and there was a general consensus of support regarding ORPC's request for an extension to the temporary variance. Jim Beyer suggested that ORPC extend the temporary variance request to 2018, so that the duration of the license would coincide with the planned estimate for re-deployment. ORPC stated they would contact FERC regarding the potential for a two year extension to the temporary variance versus one.

UMaine School of Marine Sciences Data Analysis– Gayle Zydlewski

Dr. Gayle Zydlewski began by introducing her data analysis team, Garrett Staines and Haley Viehman, who have been working with the fish monitoring data from the Cobscook Bay site. Dr. Zyldeswski's team continues to analyze data on fish presence and behavior at the Cobscook Bay site. Dr. Zydlewski provided a brief outline of the project, indicating that the team used both side-looking (SIMRAD tower) and stationary down-looking hydro acoustic beams to conduct the majority of their research on turbine-fish interactions. Dr. Zyldeswki added that down-looking hydro-acoustic measurements were also collected at a control site, in order to compare data results.

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Dr. Zydlewski introduced the braked data collected by the side-looking split beam hydro-acoustics to collect braked data. The SIMRAD tower located 45.7 m from the turbine has collected data to be integrated with the downward-looking data to predict the probability of fish-turbine interactions.

Dr. Zydlewski presented the primary thesis of their research: do fish avoid the turbine, and/or do they aggregate in its wake. Dr. Zydlewski said that the data were collected from April-July 2013, stressing that during this time the turbine was not rotating. Using the acoustic monitoring equipment the team was able to constantly record fish numbers and to track the fish in 3D to better depict their movements in the turbine zone.

Dr. Zydewski then presented a slide depicting fish heading in the direction of the turbine at flood and ebb tides during the day and at night. The data showed that only at night did observable behavior changes occur, and that the greatest variations occurred at night during the flood tide.

Dr. Zydlewski concluded that temporal variances in fish abundance were observable, with patterns occurring based on tidal, day, and lunar cycles. Dr. Zydlewski added that these observations stressed the need for consistent and informed timing of environmental monitoring surveys, in order to depict accurate trends. Dr. Zydlewski pointed out that this would also lower the cost of environmental monitoring data collection, reducing the need for broad spectrum monitoring.

Dr. Zydlewski introduced the data collected by the down-looking hydro-acoustic monitors. Dr. Zydlewski informed the Adaptive Management Team that the turbine may have had an impact on the fish distribution throughout the water column, although the results did not show an immediate justification for the re-distribution.

Dr. Zydlewski demonstrated the Encounter Probability Model, explaining that this was used to aid in determining fish avoidance behavior during the approach and encounter of the turbine. Dr. Zydlewski's team concluded that the probability of a fish encountering the turbine at the height of one of the foils was approximately 6%.

Dr. Zydlewski concluded by alerting the Management Team to continuing and upcoming research efforts by her team. Dr. Zydlewski highlighted an upcoming State of the Science Report, The Environmental Effects of Marine Energy Devices, to be published in April 2016. Dr. Zydlewski, the Pacific Northwest National Laboratory, and others are acknowledged as contributors to the report. Dr. Zydlewski added that she will be participating in the Environmental Effects Monitoring Programs for 2015-2020 at the Fundy Ocean Research Center for Energy. Dr. Zydlewski will also be working with the Pacific Northwest National Laboratory's video algorithms for RivGen® data collected during 2015 in Igiugig, Alaska.

Agency Feedback and Discussion on UMaine Work – Group

A discussion occurred regarding the interpretation of monitoring data over multiple years. References were made to yearly temperature variations that had been observed to affect other marine life along the coast of Maine.

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2015 RivGen® Commercialization Project - Nathan Johnson
Mr. Johnson began by giving a recap of project details for the RivGen 2015 installation in Igiugig, Alaska. Mr. Johnson highlighted that ORPC successfully demonstrated device improvements and grid integration, and that comprehensive environmental monitoring equipment observed no injuries or mortalities to fish.

Mr. Johnson then gave an overview of the permitting process for the RivGen Project, including permits and/or consultation from the following federal and state agencies: U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, U.S. Department of Energy (National Environmental Policy Act), U.S. Coast Guard, Alaska Department of Fish and Game, and Alaska Department of Natural Resources.

Mr. Johnson then introduced the environmental monitoring data collected by ORPC and its consultant, LGL Alaska.. Mr. Johnson informed the Adaptive Management Team that extensive data was already available regarding spatial and temporal presence of fish in the Kvichak River, being that it is home to the largest sockeye salmon run in North America. Mr. Johnson presented the data regarding spatial presence of salmon and smolt, temporal presence of different fish species, and the 2015 Sockeye Salmon escapement in number of fish. Mr. Johnson noted that the salmon run for 2015 was exceptionally large and late, presenting an opportunity to collect data while the RivGen® Power System was deployed and operational. Using additional data from Alaska Department of Fish and Game's fish counting tower, ORPC concludes that nearly two million adult sockeye salmon entered the vicinity of the turbine during the first week of operation.

Mr. Johnson then presented a slide showing the camera positioning on the RivGen for the purpose of viewing fish interactions from various angles on the turbine. Mr. Johnson explained that the cameras only recorded observations during the first ten minutes of every hour in order to cut down on data analysis efforts. The results of the monitoring displayed over Mr. Johnson's concurrent slides showed the number of hours of monitoring data that was reviewed over July and August, with the majority of hours reviewed falling between 9:00 a.m. to 12:00 a.m. Mr. Johnson indicated that most of the fish events occurred 12:00 a.m. and 3:00 a.m. The Adaptive Management Team concurred that this data supports the conclusion of Dr. Zydlewski's team that temporally-sensitive monitoring efforts are the most cost-effective way to collect data on fish interactions.

Mr. Johnson showed the Adaptive Management Team videos of salmon and salmon smolt interactions with the turbine at night. Mr. Johnson said that the video of the salmon smolt showed them entering the turbine from upstream direction and exiting the turbine also on the upstream side.

Mr. Johnson then showed three consecutive videos showing a Lamprey-turbine interaction, from three cameras positioned in different locations along the pontoon support structure. The videos showed the Lamprey approaching the turbine from the direction of the flow, passing through the braked turbine, and exiting downstream after showing indications of wake effects.

Mr. Johnson then summarized conclusions of the 2015 Igiugig monitoring which included no obvious evidence of fish passage delay was observed. In addition, there was no observed evidence of animal attraction to the turbine, although some avoidance behavior was recorded.

Mr. Johnson informed the management team that ORPC will be collaborating with the Pacific Northwest National Laboratory regarding further analysis of the data collected by the RivGen® cameras. The project is to be funded by the U.S. DOE, and will combine the efforts of ORPC, University of Maine

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School of Marine Sciences, and the University of Washington. The project objectives include the completion of a comprehensive analysis of 2015 Igiugig data set, and the development of video automation tools. The project is anticipated to be completed by Q4 2016.

Agency Feedback on RivGen® Power System testing results
The Adaptive Management Team appreciated the update on the RivGen® Power System project in Igiugig, Alaska and recognized its value to the overall understanding of marine life interactions with ORPC power systems.

Western Passage Permitting and Development Strategy – John Ferland
Mr. Ferland provided a recap of the current status of ORPC's project development efforts in Western Passage. Mr. Ferland stated that ORPC requested a successive preliminary permit on January 1, 2014, in accordance with the support of local stakeholders. FERC issued an order denying the application issued on July 2, 2014, citing a lack of extraordinary circumstances. Mr. Ferland noted that the agency has strict protocols regarding the issuance of successive preliminary permits. Given the elapsed time and aims of the technology roadmap, Mr. Ferland explained that ORPC will pursue applying for a new FERC Preliminary Permit by January 2016.

Agency Feedback on Western Passage Project

There was a general consensus of support among the Management Team and agency partners on ORPC's plan to pursue a new preliminary permit for Western Passage.

Action Items and Assignments - Nathan Johnson

Action Item	Status
ORPC will generate meeting minutes and distribute for review. AMT concurrence and/or questions on the temporary variance extension will be requested.	**Distributed to AMT on December 4, 2015**
ORPC will contact FERC regarding the potential for a two year extension to the temporary variance	**ORPC spoke with FERC on December 2, 2015 and they indicated they were not opposed to a two-year extension pending their review of the request.**
ORPC will send fish monitoring videos to participants who attended by phone	**Sent on November 20, 2015**
ORPC will continue to update the AMT on technology optimization and development progress.	**Ongoing. ORPC will submit a new preliminary permit application permit to FERC for the Western Passage site on December 4, 2015**

Adjourn Meeting – Nathan Johnson

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Appendix B

Adaptive Management Team Presentation, November 19, 2015

Cobscook Bay Tidal Energy Project
Adaptive Management Team Meeting

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November 19, 2015

Welcome and Introductions

- Introduction of attendees
- Agenda
- Meeting objectives
  - CBTEP update
  - University of Maine School of Marine Sciences Analysis
  - 2015 RivGen® Power system testing in Alaska
  - Western Passage status
  - Next steps and priorities

CBTEP Permitting and Licensing Update

- 2014 Environmental Monitoring Report submitted to FERC on March 17, 2015
- UMaine continued fisheries interaction data analysis
- FERC license extension
  - February 9 submittal justifying why ORPC did not apply for commercial license
  - June 5 submittal requesting extension
  - July 14 – comment period opened
  - No motion made to date
- Temporary variance reports submitted on schedule

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Technology Optimization Overview

- **Overall goals**
  - **Higher efficiency, less weight, lower production cost, reduced cost of electricity, lower costs of installation, retrieval maintenance**
- **Seen as industry development priority within US DOE**
  - **Significant re-investment in ORPC by DOE**
  - **A complex effort that is national in scope:**
    - **Two national laboratories (NREL and Sandia)**
    - **Four universities (Maine, Montana, Washington and Alaska)**
    - **Multiple contractors (engineering, CFD, generator design, power electronics)**
  - **In addition to technology improvement, DOE requires data regarding cost breakdown structure and long-term cost of energy**
  - **Results will inform industry growth internationally**
- **In-water work in Alaska benefits Cobscook Bay efforts**

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Technology Optimization Summary

Project Focus	Project Cost & Funding Sources	End Date	Status
Forward Controls: Optimize energy harvesting capability	$2.2 m •DOE: $1.7m • Cost share: $475K	Dec 2015	Control scheme improved competitiveness of ORPC MHK electrical power generating system. Impact Analysis provided economic analysis of impacts of system performance advancements (SPAs) proposed by this project. On schedule; on budget.
Power Take Off: Next generation driveline, bearings couplings, generator	$3.8m •DOE: $2.8m • Cost share: $928K	Jan 2016	Improvements to components are expected to improve the cost competitiveness of the ORPC MHK electrical power generating system. Impact Analysis will provide an economic analysis of impacts of SPAs proposed within this project. On schedule.
Fairing and foil design, support structure and testing: Ability to harness slower moving current	$1.55m •USDA SBIR Phase I: $100K •Phase II: $450K • MTI:$1m	Aug 2016	2015: Validated that fairing system provided significant gains in power production required by remote communities, including those residing along rivers with slower currents. 2016: Complete final design of commercial RivGen® Version 2.0. On schedule.
Durability: Develop an integrated buoyant TidGen® Power System	$8mm •DOE $4.1m (pending) •MTAF $900K	Jul 2019	Develop an integrated and innovative buoyant MHK system, based around the company's TidGen® Power System, which will significantly reduce installation costs, improve performance, and prove more reliable.

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Technology Optimization Progress

2016

✓ Controls, PTO and fairing projects successfully completed

✓ "Durability Project" begins integrating previous work

✓ Initial system design

✓ Composite material selection

✓ Computer simulated testing

✓Modifications of environmental monitoring plans

2017

✓ Subsystem prototype testing at lab facilities

✓ Overall systems engineering completed

✓Relevant permitting applications organized and submitted

2018

✓ System assembly on site in Eastport, ME

✓ Re-installation and operation in Cobscook Bay

✓Performance testing and evaluation

✓ Environmental monitoring

2019

✓ Continued marine operations

✓Performance validation

✓ Environmental monitoring

✓Analysis of data and final report

✓Evaluation of project build-out

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Temporary Variance Request

- FERC order issued on December 22, 2014 after the following:
  - Discussion at AMT meeting on October 15, 2014
  - ORPC submittal to FERC on November 25, 2014
- ORPC provided project updates on:
  - January 30, 2015
  - June 2, 2015
  - October 1, 2015
- Based on temporary optimization phase schedule ORPC is requesting an extension to the variance

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Temporary Variance Request

ORPC's request takes into account the following:

- Comprehensive pre-deployment and post-deployment environmental studies have contributed to an understanding of inter-annual variability
- Results-to-date indicating negligible effects to marine life for ongoing operations
- TGU operational status makes adherence to license condition impractical and will not advance the conditions purpose
- No undue impacts or impedance of other license requirements are anticipated
- ORPC plans to return to adherence of condition once TGU operation recommences

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Temporary Variance Request

Request process:

- ORPC is presenting request at November 19 Adaptive Management Team
- AMT concurrence will be sought following meeting discussion
- Extension request, with support from the AMT, will be submitted to FERC

UMaine Data Analysis

- See following slides

Thanks to:

People

- The Fish Assessment Study Team
  James McCleave, Garrett Staines, Haley Viehman, Jeffrey Vieser, Megan Altenritter, Haixue Shen, Brittney Fleenor, Alex Jensen
- Captain Butch Harris and crew
- Steve Brown and crew
- Chris Bartlett
- The Maine Tidal Power Initiative
- Ocean Renewable Power Company
- Community participants

Funding

U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

NSF

MAINE EPSCoR

Award EPS-0904155

Sea Grant Maine

SSI maine's sustainability solutions initiative

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THE UNIVERSITY OF MAINE School of MARINE SCIENCES

Outline

Continuous data of fish presence and behavior

Side-looking split beam hydroacoustics

1. Braked data
2. Long-term temporal analysis

Seasonal data on vertical distributions of fish

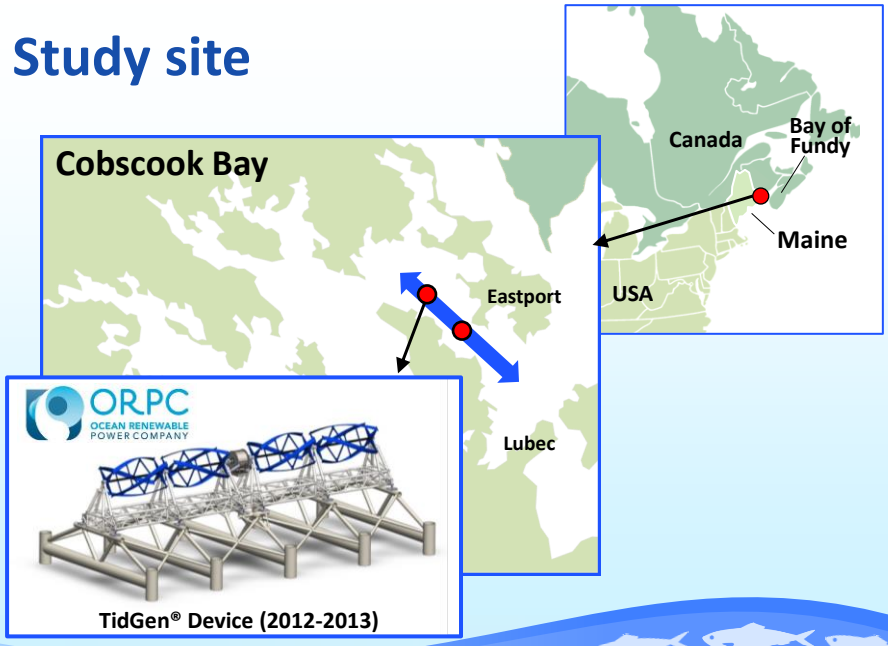
Down-looking hydroacoustics

Probability of Encountering a turbine

Integration of down-looking with mobile transects

2

Study site



3

Fish responses to turbine

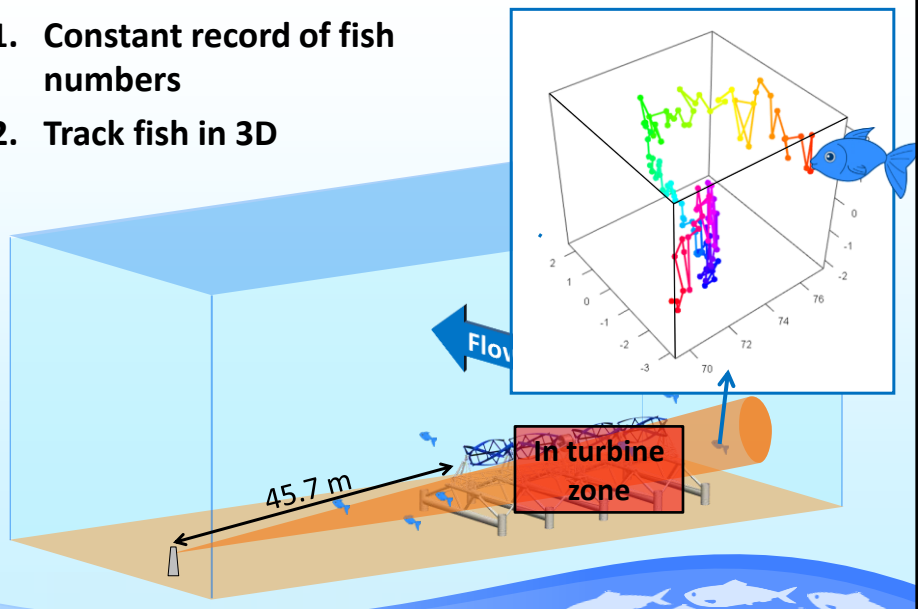
Q: Do fish avoid the turbine?
Do they aggregate in its wake?

* Data collected while turbine NOT rotating, April - July 2013

4

1. Fish behavior at the BRAKED TidGen®

1. Constant record of fish numbers
2. Track fish in 3D



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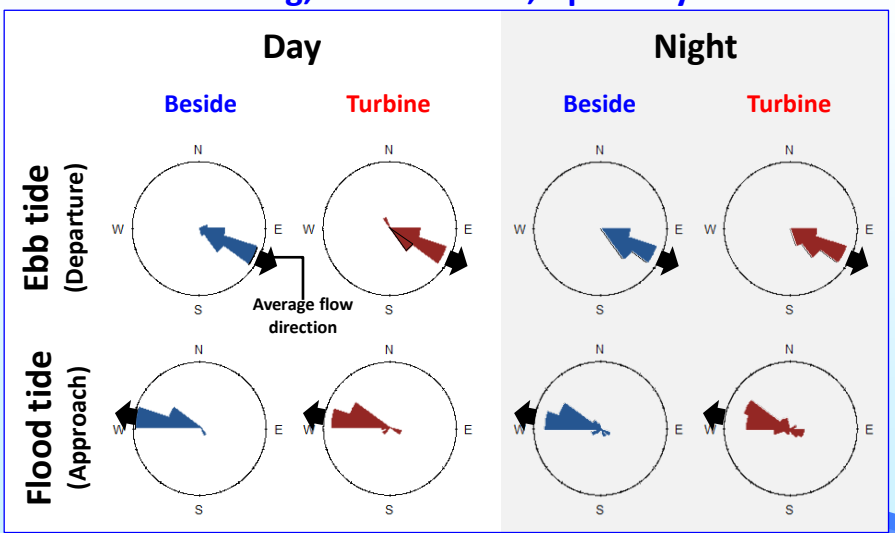
Fish responses to turbine

Fish heading, static turbine, April-July 2013



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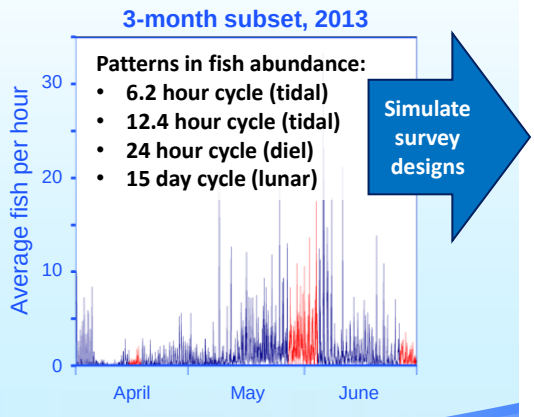
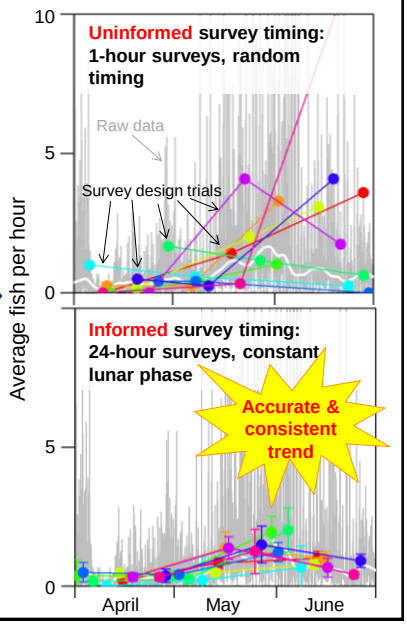
2. Temporal patterns in fish abundance

Q: How can we time surveys of fish at a site for accurate long term monitoring and lowest cost?





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Outline

Continuous data of fish presence and behavior

Side-looking split beam hydroacoustics

1. Braked data
2. Long-term temporal analysis

Seasonal data on vertical distributions of fish

Down-looking hydroacoustics

Probability of encountering a turbine

Integration of down-looking with mobile transects

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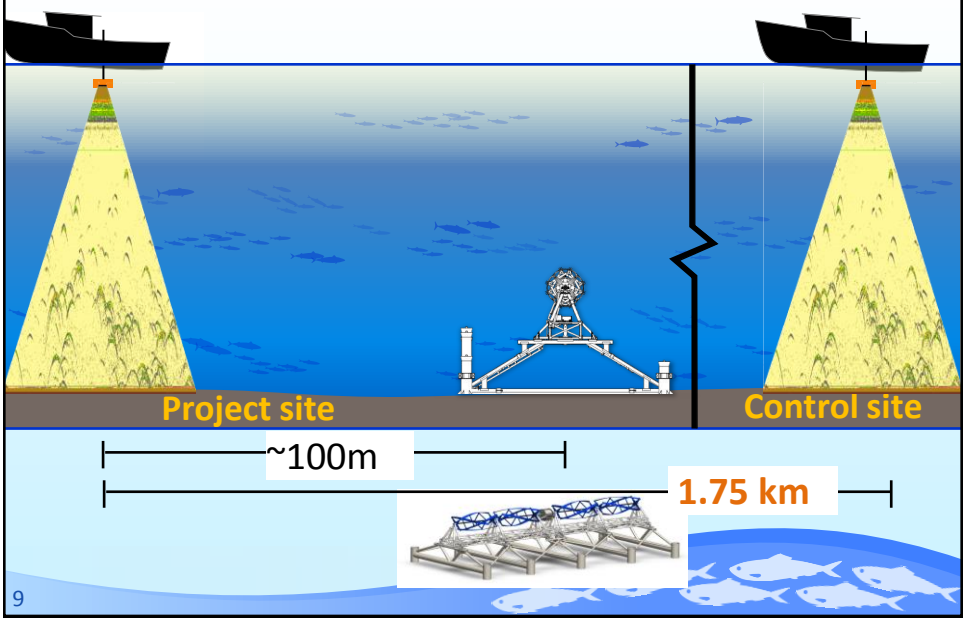
Stationary down-looking hydroacoustics for TidGen®



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Before/After Comparisons with Control Site (BACI)

Before/After		
Month/Year	**Site**	**Significance**
Aug 2011/12	**Impact**	**p = 0.003**
	Control	-
Sep 2011/12	Impact	-
	Control	-
Mar 2012/13	**Impact**	**p < 0.001**
	Control	-

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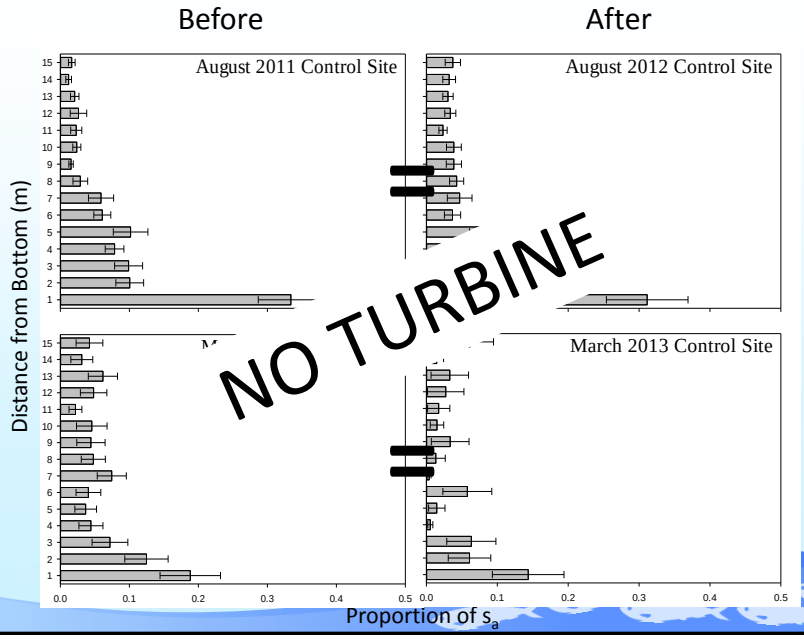
Results for **Control Site**



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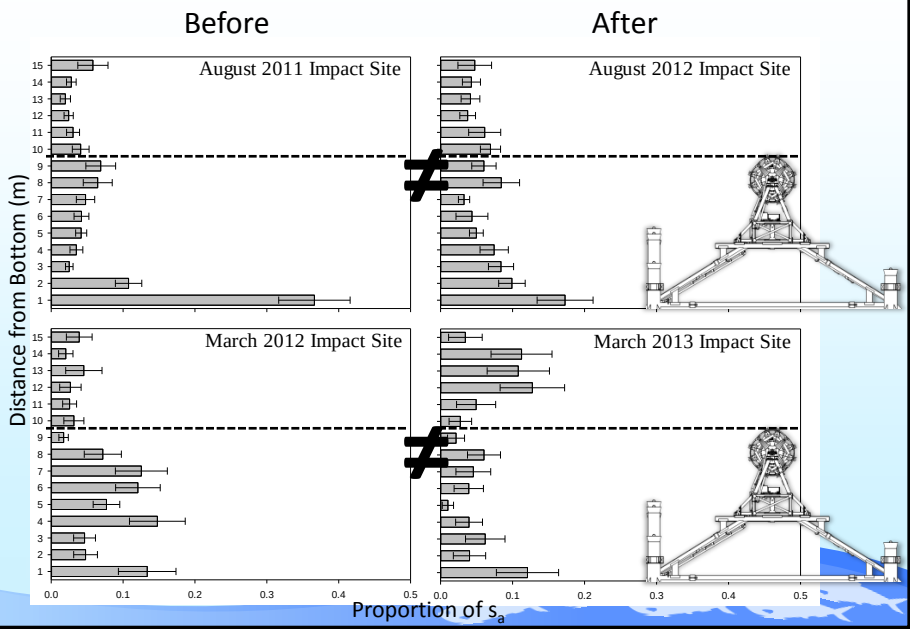
Results for **Impact Site**



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Outline

Continuous data of fish presence and behavior

Side-looking Simrad Tower – split beam hydroacoustics

- Braked data
- Long-term temporal analysis

Seasonal data on vertical distributions of fish

Down-looking hydroacoustics

Probability of encountering a turbine

Integration of down-looking with mobile transects

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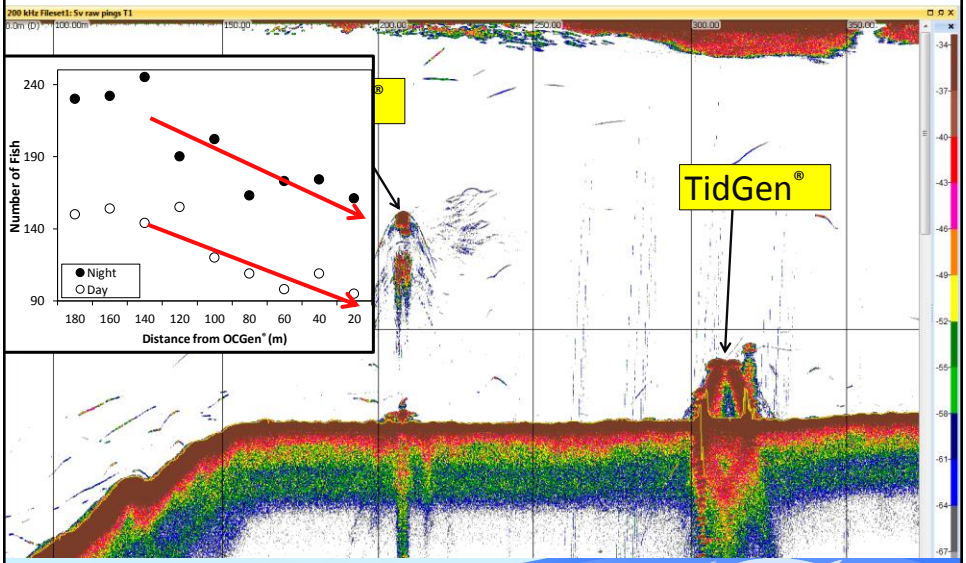
Transect over OCGen®



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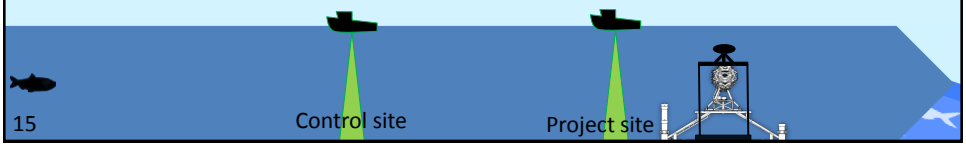
Encounter Probability Model

$$p = p_1 * (1 - p_2) * (1 - p_3)$$

p_1: probability of fish being at the device depth when the device was not present

p_2: probability of fish behavior changing to avoid the device before being detected by stationary surveys at project site when TidGen® was present

p_3: probability of fish behavior changing to avoid the device between the location of stationary survey and OCGen®



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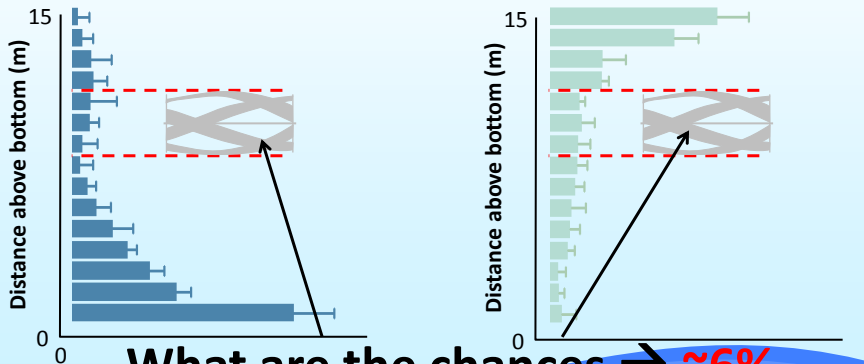
What is the probability of encounter?

- Encounter probability: $p = p_1*(1-p_2)*(1-p_3)$

  Entire device: 0.498 (95% CI: [0.371, 0.619])

  Turbine blade: 0.058 (95% CI: [0.043, 0.073])



What are the chances → ~6%

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Continuing work

- Annex IV *State of the Science Report: the Environmental Effects of Marine Energy Devices*
- Bay of Fundy work
  - Environmental Effects Monitoring Programs 2015-2020 at the Fundy Ocean Research Center for Energy (FORCE)
- PNNL video algorithms for RivGen® data collection

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Annex IV: State of the Science Report April 2016

Chapter Number	Title	Primary Responsibility
1	Introduction	PNNL
2	Interactions of Marine Energy Devices with the Marine Environment	PNNL, Aquatera
3	Collision Risk for Animals Around Tidal Turbines	Ben Wilson Carol Sparling Gayle Zydlewski
4	Risk to Marine Animals from Underwater Sound from Wave and Tidal Devices	PNNL
5	Changes to Physical Systems (energy removal and changes in flow)	PNNL
6	Risk from Electromagnetic Fields	Andrew Gill
7	Effects on benthic habitats and reefing patterns among marine animals	PNNL
8	Spatial planning for fishing and conservation, as it interacts with marine energy development	Anne Marie O'Hagan
9	Case studies that examine siting and permitting/consenting of marine energy devices	Teresa Simas Juan Bald
10	Marine energy monitoring and research	PNNL, Aquatera

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2015 RivGen® Project

- Igiugig, Alaska
- Installed between July 13 and September 22, 2015
- Successfully demonstrated device improvements and grid integration
- No observed injuries or mortalities to fish

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2015 RivGen® Project: Permits

Agency	Permit/Consultation
U.S. Army Corps of Engineers	Nationwide Permit No.52
FERC Consultation	Project conducted under the guidelines of the "Verdant Exemption"
U.S. Department of Energy, NEPA	Biological Evaluation and Essential Fish Habitat (NMFS and USFW)
U.S. Coast Guard	Navigation Safety Plan
Alaska Department of Fish and Game	Fish Habitat Permit
Alaska Department of Natural Resources	Land Use Permit, Water Use Permit

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2015 RivGen® Project

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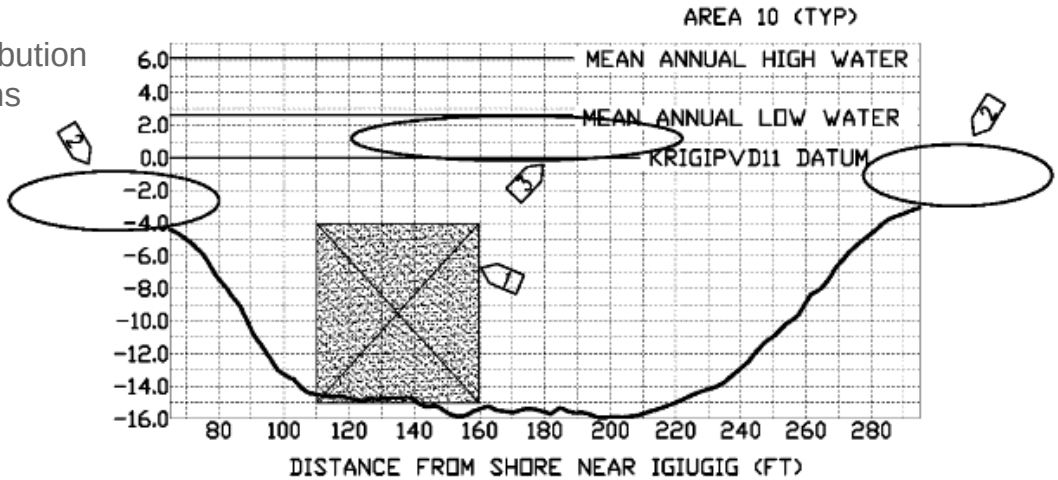
Fisheries – Spatial Presence

- Smolt distribution
- Adult returns



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Fisheries – Temporal Presence

- Smolt
- Adult sockeye
- Chinook and coho
- Fall rainbow trout

S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
	FEBRUARY						1	2	MARCH					1	2	APRIL						
5	3	4	5	6	7	8	9	3	4	5	6	7	8	9		1	2	3	4	5	6
12	10	11	12	13	14	15	16	10	11	12	13	14	15	16	7	8	9	10	11	12	13
19	17	18	19	20	21	22	23	17	18	19	20	21	22	23	14	15	16	17	18	19	20
26	24	25	26	27	28			24	25	26	27	28	29	30	21	22	23	24	25	26	27
								31							28	29	30				

MAY							JUNE							JULY							AUGUST						
			1	2	3	4							1		1	2	3	4	5	6							
5	6	7	8	9	10	11	2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	8	9	10
12	13	14	15	16	17	18	9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17
19	20	21	22	23	24	25	16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24
26	27	28	29	30	31		23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30	31
							30																				

SEPTEMBER							OCTOBER							NOVEMBER							DECEMBER						
1	2	3	4	5	6	7				1	2	3	4	5						1	2	1	2	3	4	5	6	7
8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14
15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21
22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28
29	30						27	28	29	30	31			24	25	26	27	28	29	30	29	30	31				

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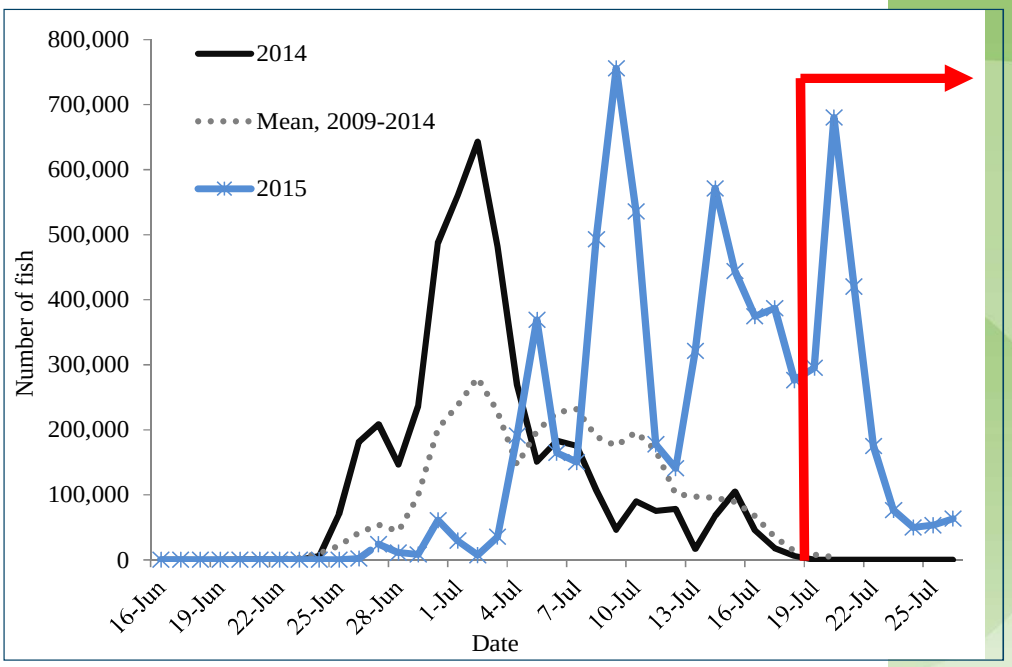
2015 Sockeye Salmon Escapement



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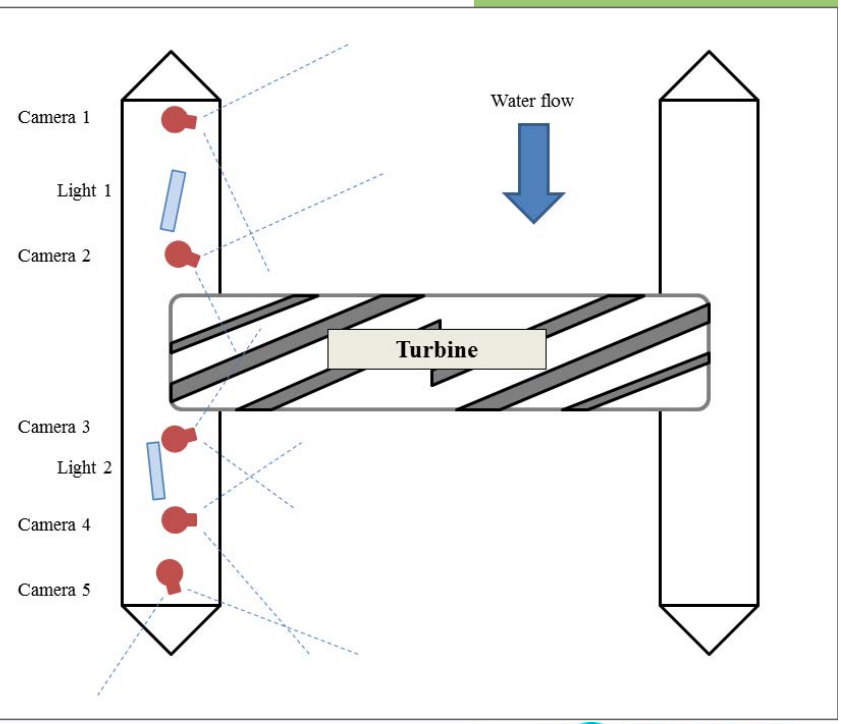
Igiugig (Camera Locations)

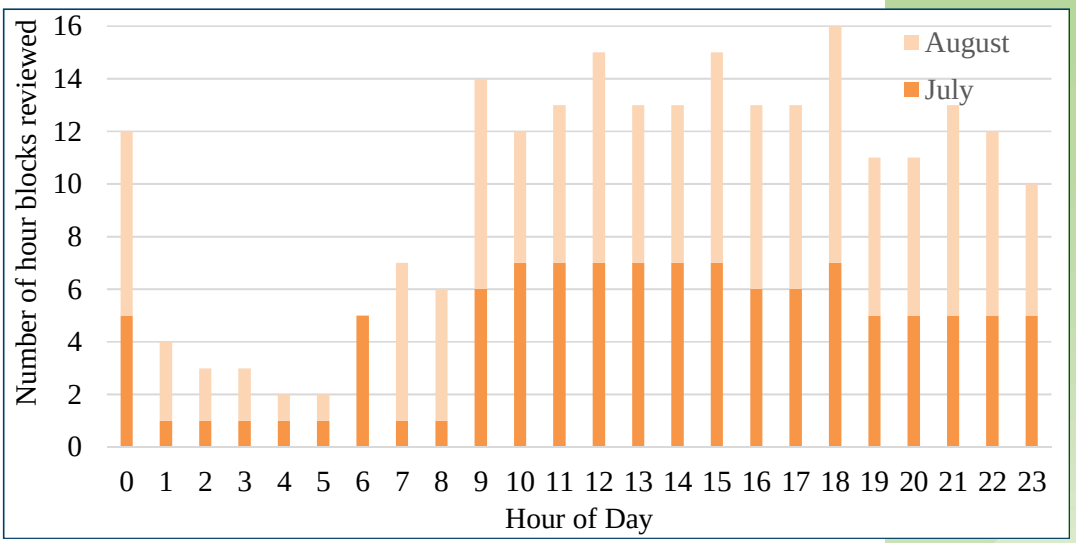


Igiugig Monitoring Results

- Total number of fish by species during day/night and month, 2015

	July		August			
Species	Day	Night	Day	Night	Total	Total %
Chum salmon (adult)			14	12	26	2.2%
Coho salmon (adult)			5	2	7	0.6%
Pink salmon (adult)				2	2	0.2%
Sockeye salmon (adult)	259	51	1	1	312	26.0%
Unidentified adult salmon			9	8	17	1.4%
Unidentified juvenile salmonid		773	1	52	826	68.7%
Rainbow trout			1		1	0.1%
Lamprey spp.	1		1	1	3	0.2%
Unknown species	1	2	1	4	8	0.7%
Total	261	826	33	82	1,202	100.0%

Igiugig Monitoring Results



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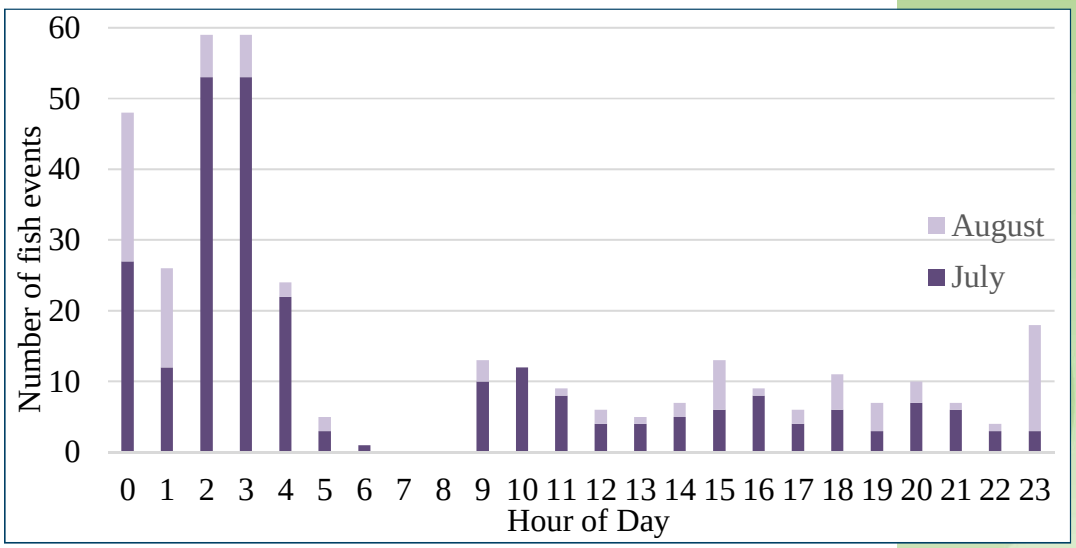
Igiugig Monitoring Results



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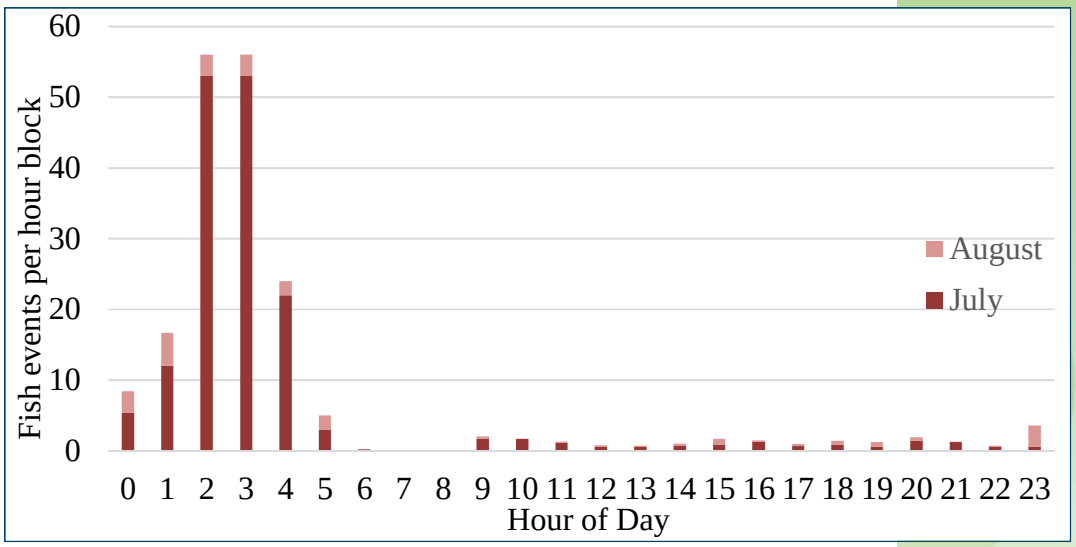
Igiugig Monitoring Results



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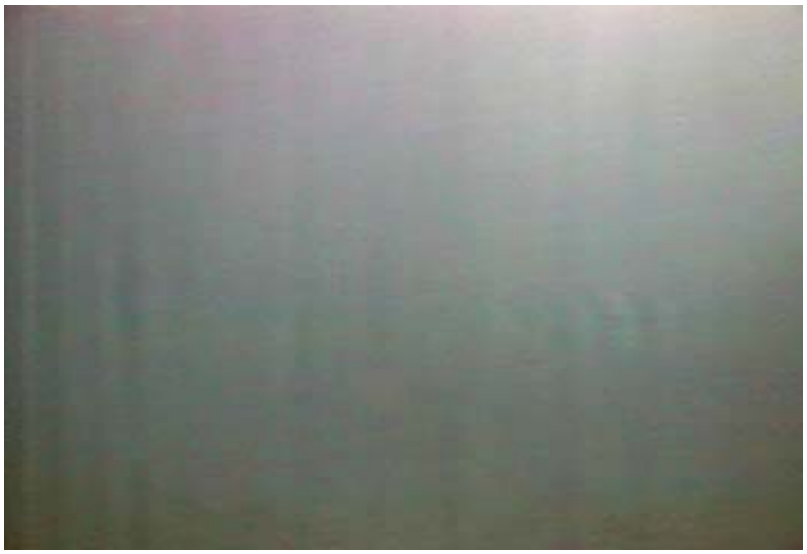
Igiugig Monitoring Results

- July 20, 2015. Adult Sockeye Salmon



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Igiugig Monitoring Results

- July 23, 2015. Salmon smolt

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Igiugig Monitoring Results

- August 25, 2015. Lamprey

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2015 Igiugig Monitoring Conclusions

- Presence, timing, and characterization of movement of fish (and wildlife) were documented. Nearly 2 million adult sockeye were counted on the river during the first week of operation.
- No obvious evidence of passage delay was observed
- No evidence of animal attraction. Some avoidance behavior was recorded
- No obvious indication of injury or mortality. Some potential disorientation by salmon smolt

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Pacific Northwest National Laboratory (PNNL) Fish Monitoring Analysis

- Funded by U.S. Department of Energy
- Project partners include ORPC, University of Maine School of Marine Sciences, University of Washington
- Objectives are a comprehensive analysis of the 2015 Igiugig data set and development of video automation tools
- Work to be completed by Q4 2016

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Western Passage Update

- ORPC, with support from local stakeholders, requested a successive preliminary permit on January 1, 2014
- FERC order denying application issued on July 2, 2014, citing lack of extraordinary circumstances
- Given elapsed time and technology roadmap, ORPC will pursue applying for a new FERC Preliminary Permit

Action Items and Assignments

- ORPC will generate meeting minutes and distribute for review
- AMT concurrence and/or questions on the temporary variance extension will be requested
- ORPC will continue to update the AMT on technology optimization and development progress.

Thank you from the ORPC Team!

For more information:

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Director of Environmental Affairs
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207-772-7707
visit *www.orpc.co*

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Appendix C

LGL Alaska Research Associates, Inc., Data Analysis for Monitoring of the RivGen® in the Kvichak River, 2015.

Alaska Research Associates, Inc.

LGL Alaska Research Associates, Inc.
2000 W International Airport Road Suite C1
Anchorage, Alaska 99502 USA
Tel: (907) 562-3339 Fax: (907) 562-7223

To: Nate Johnson and Monty Worthington, Ocean Renewable Power Company
From: Justin Priest and Matt Nemeth, LGL Alaska Research Associates, Inc.

Re: Data Analysis for Monitoring of the RivGen® in the Kvichak River, 2015

Date: November 11, 2015

This memo summarizes the preliminary data analyses from fish and wildlife monitoring at the RivGen® Power System, a submerged hydrokinetic device operated by the Ocean Renewable Power Company (ORPC) in the Kvichak River in July and August 2015. Monitoring was performed by LGL Alaska Research Associates, Inc., in accordance with the 2015 Monitoring Plan developed in March 2015 and Alaska Department of Fish and Game (ADF&G) Fish Habitat Permit FH 15-II-0038. Data presented here are preliminary and may change after final QA/QC. Interim results and figures were also presented in monthly progress reports at the end of July and August.

Fish movements at the RivGen® device were described using video footage collected from five underwater cameras mounted to the pontoons of the power system. Video footage was collected 24 hours/day July 19–25 and again August 19–27, 2015; review was done by watching the first 10 minutes of a selected hour from each of the four primary cameras (the fifth camera was a backup). Spatially, the camera field of view captured the port side of the RivGen® device, including upstream and downstream views of the port side turbine (only). In accordance with the Monitoring Plan, footage was reviewed to achieve partial temporal coverage during different categories of turbine operating status and daytime/nighttime conditions (Figure 1). At night, two underwater lights lit the viewing area. In addition, bird and marine mammal surveys were conducted for 15 minutes each morning of monitoring. Methods and the overall approach were similar to those described for the demonstration study conducted at the same site in 2014.

Blocks of video footage from portions of 238 different hours were reviewed inseason in 2015. There were 359 events with fish, composed of approximately 1,202 individual fish from at least six species. The majority of fish observations were of solitary fish; the largest school was approximately 100 fish. Species composition varied from July to August and also from day to night. In particular, salmon smolt were almost exclusively seen at night, and were more prevalent in July than August. Several instances of fish moving through the RivGen® turbine were noted and reported inseason as part of the Adaptive Management Plan. We did not detect any obvious physical injuries to fish, and saw no altered behavior by wildlife near the RivGen® device. Cameras, lights, and power system components all operated reliably. All video footage has been archived.

Preliminary results are presented in more detail below, organized by each Objective from the 2015 Monitoring Plan. Where appropriate, data are also presented in Tables and Figures below.

Data analyses listed by 2015 monitoring objective:

1) Summary of monitoring effort.
   a) Video review effort, by RivGen® device status and time group.
      (1) Table 1. Review effort by RivGen® device status and month.
      (2) Figure 1. Daily schedule of RivGen® device operations and data review effort.

2) Presence and timing of fish and wildlife at the RivGen® device (Objective 1 from Monitoring Plan).
   a) Fish monitoring observations.
      (1) Table 2. Number of fish observation events and number of fish, by month, day/night status, and RivGen® device operating status.
      (2) Table 3. Species and number of fish observed, by month and day/night status.
      (3) Table 4. Fish per reviewed hour block, by species, month, and day/night status.
      (4) Figure 2. Hourly summary of review effort, raw observations, and observations standardized by review effort for fish.
   b) Wildlife monitoring observations.
      (1) Table 5. Bird and wildlife observations by species group.

3) Characterize fish movements past the RivGen® device (Objective 2).
   a) Basic movement type.
      (1) Table 6. Movement classification/direction by species, day/night, and RivGen® status.
   b) Movements in relation to the RivGen® device.
      (1) Table A (to be determined): Movement of fish under, over, or through the turbine area.
      (2) Evidence of passage delay: We saw no obvious evidence of passage delay. Adult salmon were clearly able to move around the device, both going upstream (mostly in the daytime), or downstream (mostly at night). Adult salmon also showed general milling behavior that did not appear to be repeated attempts to move past the device. Finally, juvenile salmon were seen transiting past the device, usually travelling downstream. Juvenile salmon sometimes held downstream of the turbine briefly.

4) Describe the behavioral response of fish or wildlife contacting the RivGen® device (Objective 3).
   a) Table B (to be determined): Number of fish showing obvious attraction to, avoidance of, or sheltering at the RivGen® device in 2015, by species and day/night status.

b) Evidence of avoidance or attraction by fish: We saw no obvious evidence of attraction to the RivGen® device. Any such attraction would likely have only been detected as fish markedly altering course to move directly towards the RivGen® device; we saw no instances of this. We did see instances of avoidance by fish moving downstream, which sometimes altered course to move either over or under the turbine. Avoidance by upstream-moving fish (i.e., fish that avoided the RivGen® device altogether by moving away from it before coming into camera view) would not be easily detectable because the fish would have already altered their course before being able to be observed.

c) Evidence of avoidance or attraction by wildlife: There was no evidence of attraction or avoidance by wildlife during the study; all animals observed showed no behavioral changes near the RivGen® device. No marine mammals were observed in 2015.

5) Describe any acute effects from contact with the RivGen® device (Objective 4).

a) Evidence of disorientation, injury, or mortality: Acute effects of fish moving through the RivGen® device, including any potential adverse effects were documented and reported in four Adaptive Management Reports delivered within 48 hours of the incident. We saw no obvious indication of moribund or inert behavior that might indicate injury or mortality. We did see some potential disorientation by juvenile salmon moving downstream. In these events, schools of fish dispersed as they approached the RivGen® device from upstream; afterwards, downstream of the RivGen® device, these fish milled or moved around abruptly in the eddy behind the turbines, before resuming downstream movement.

Table 1. Summary of the review effort during all RivGen® device operational statuses, 2015. "Partial" hours were when turbines only operated during part of an hour block. "Spinning Whole Hour (Stbd turbine only)" hours were operations when only the starboard turbine was operational.

	July		August		Total	
Device Status	Not Reviewed	Reviewed	Not Reviewed	Reviewed	Not Reviewed	Reviewed
Day						
Not Spinning	26	39	25	11	51	50
Partial	1	16		4	1	20
Spinning Whole Hour		44		69	0	113
Spinning Whole Hour (Stbd turbine only)				17	0	17
Day Subtotal	*27*	*99*	*25*	*101*	*52*	*200*
Night						
Not Spinning	32	6	24	3	56	9
Partial		3			0	3
Spinning Whole Hour		1	20	18	20	19
Spinning Whole Hour (Stbd turbine only)			2	7	2	7
Night Subtotal	*32*	*10*	*46*	*28*	*78*	*38*
Total	59	109	71	129	130	238

Table 2. Summary of the total number of fish events and individuals during all device statuses, 2015. A "Fish Event" is defined as an observation of at least one fish during subsampling review. "Spinning Whole Hour (Stbd turbine only)" was when only the starboard turbine was operational.

	July			August			Total	
Device Status	# Fish Events	Total Fish Seen		# Fish Events	Total Fish Seen		# Fish Events	Total Fish Seen
Day								
Not Spinning	17	26		2	3		19	29
Partial	16	39		1	1		17	40
Spinning Whole Hour	57	196		19	19		76	215
Spinning Whole Hour (Stbd turbine only)				10	10		10	10
Day Subtotal	*90*	*261*		*32*	*33*		*122*	*294*
Night								
Not Spinning	150	736		5	5		155	741
Partial	16	75					16	75
Spinning Whole Hour	4	15		49	64		53	79
Spinning Whole Hour (Stbd turbine only)				13	13		13	13
Night Subtotal	*170*	*826*		*67*	*82*		*237*	*908*
Total	260	1,087	0	99	115	0	359	1,202

Table 3. Total number of fish by species during day/night and month, 2015.

	July		August			
Species	Day	Night	Day	Night	Total	Total %
Chum salmon (adult)			14	12	26	2.2%
Coho salmon (adult)			5	2	7	0.6%
Pink salmon (adult)				2	2	0.2%
Sockeye salmon (adult)	259	51	1	1	312	26.0%
Unidentified adult salmon			9	8	17	1.4%
Unidentified juvenile salmonid		773	1	52	826	68.7%
Rainbow trout			1		1	0.1%
Lamprey spp.	1		1	1	3	0.2%
Unknown species	1	2	1	4	8	0.7%
Total	261	826	33	82	1,202	100.0%

Table 4. Number of fish detected per reviewed hour block by species, 2015. Data are standardized to 10-minute review blocks.

	July		August		
Species	Day	Night	Day	Night	Total
Chum salmon (adult)	-	-	0.1	0.4	0.1
Coho salmon (adult)	-	-	0.0	0.1	0.0
Pink salmon (adult)	-	-	0.0	0.1	0.0
Sockeye salmon (adult)	2.6	5.1	0.0	0.0	1.3
Unidentified adult salmon	-	-	0.1	0.3	0.1
Unidentified juvenile salmon	0.0	77.3	0.0	1.9	3.5
Rainbow trout	-	-	0.0	0.0	0.0
Lamprey spp.	0.0	0.0	0.0	0.0	0.0
Unidentified species	0.0	0.2	0.0	0.1	0.0
Total	2.6	82.6	0.3	2.9	5.1

Table 5. Summary of bird and wildlife observations near the RivGen® device, 2015. Data are standardized to the 15-minute sampling periods.

Taxonomic Group	Sightings	Number of individuals sighted	Number of individuals within 15 m of device	Number of individuals per sample period
Passerines	34	41	4	2.7
Bald Eagles	6	7	0	0.5
Other Raptors	1	1	0	0.1
Waterfowl and Loons	8	11	0	0.7
Gulls, Jaegers, and Terns	53	133	0	8.9
Corvids	3	3	0	0.2
Shorebirds	10	12	0	0.8
Terrestrial mammals	0	0	0	0
Marine mammals	0	0	0	0

Table 6. The number of fish events classified by movement type for each species, 2015. Proportions are per subtotaled day and night.

Movement Type	Chum salmon (adult)	Coho salmon (adult)	Pink salmon (adult)	Sockeye salmon (adult)	Unidentified adult salmon	Unidentified juvenile salmon	Rainbow trout	Lamprey spp.	Unidentified species	Total	Subtotal %
Day											
Milling	5	3		33	5				1	47	38.5%
Travel down	4			8	4	1		2	1	20	16.4%
Travel up	2	1		33			1			37	30.3%
Travel, other	2	1		12						15	12.3%
Undetermined				3						3	2.5%
Day Subtotal	*13*	*5*	*0*	*89*	*9*	*1*	*1*	*2*	*2*	*122*	*100.0%*
Night											
Milling	2	1	2	6	2	20			1	34	14.3%
Travel down	9	1		30	6	142		1	4	193	81.4%
Travel up				3		2				5	2.1%
Travel, other						1				1	0.4%
Undetermined				2		2				4	1.7%
Night Subtotal	*11*	*2*	*2*	*41*	*8*	*167*	*0*	*1*	*5*	*237*	*100.0%*
Total	24	7	2	130	17	168	1	3	7	359	100.0%

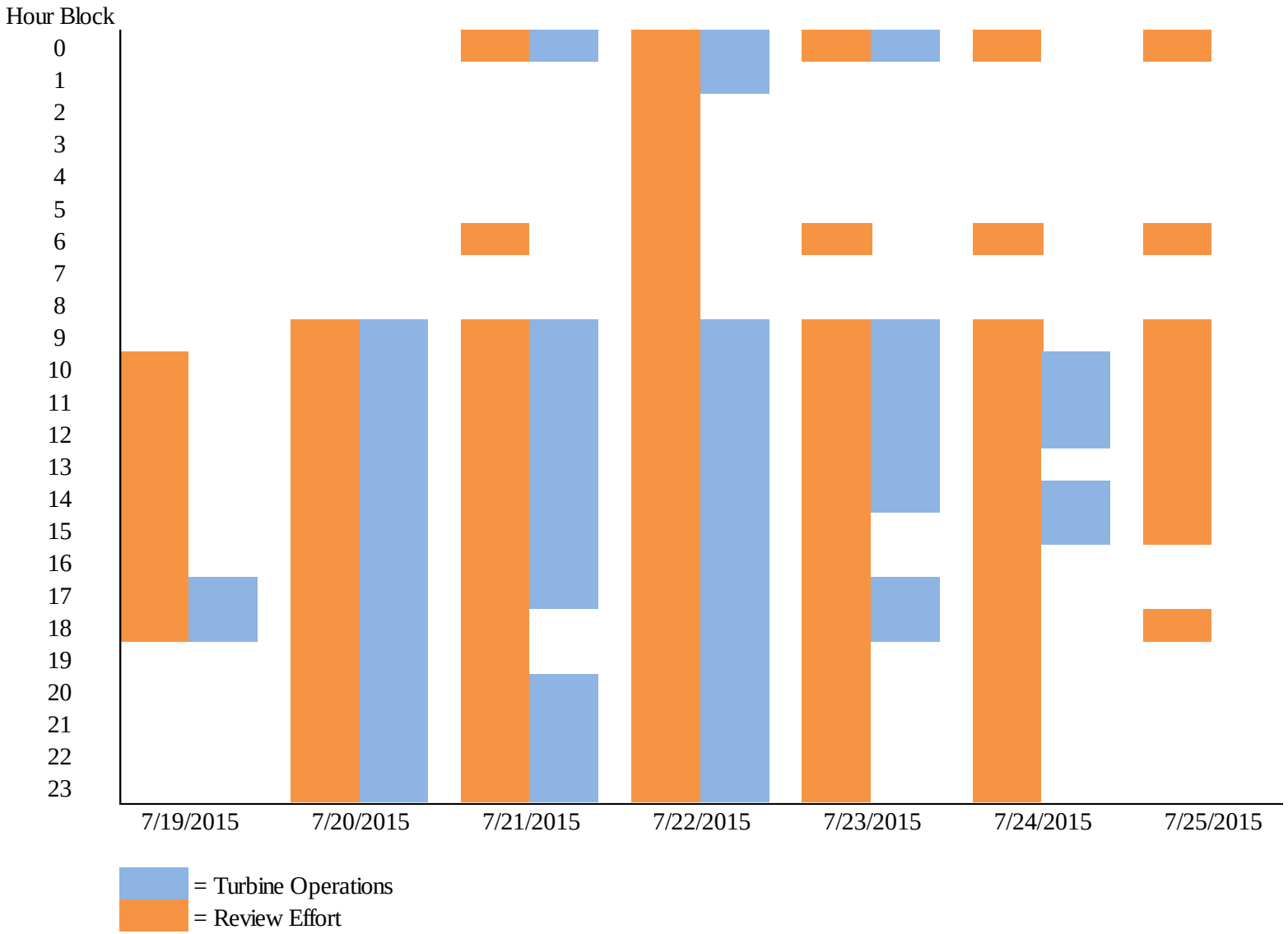

Figure 1A. Summary of turbine operations and review effort of the video system, July 2015. "Half" hours were operations when only one of the two turbine sides was operational.

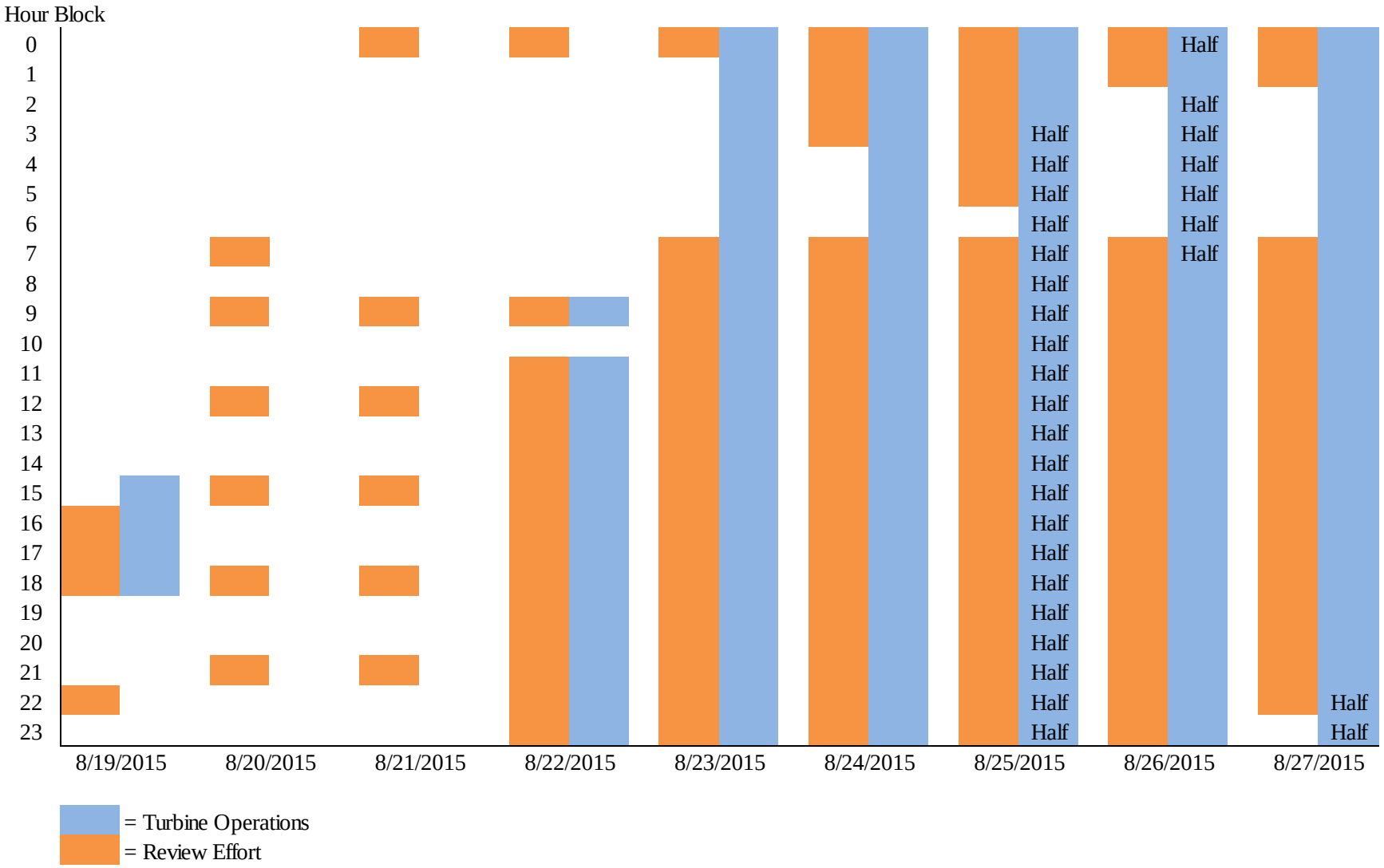

Figure 1B. Summary of turbine operations and review effort of the video system, August 2015. "Half" hours were operations when only the starboard turbine was operational.

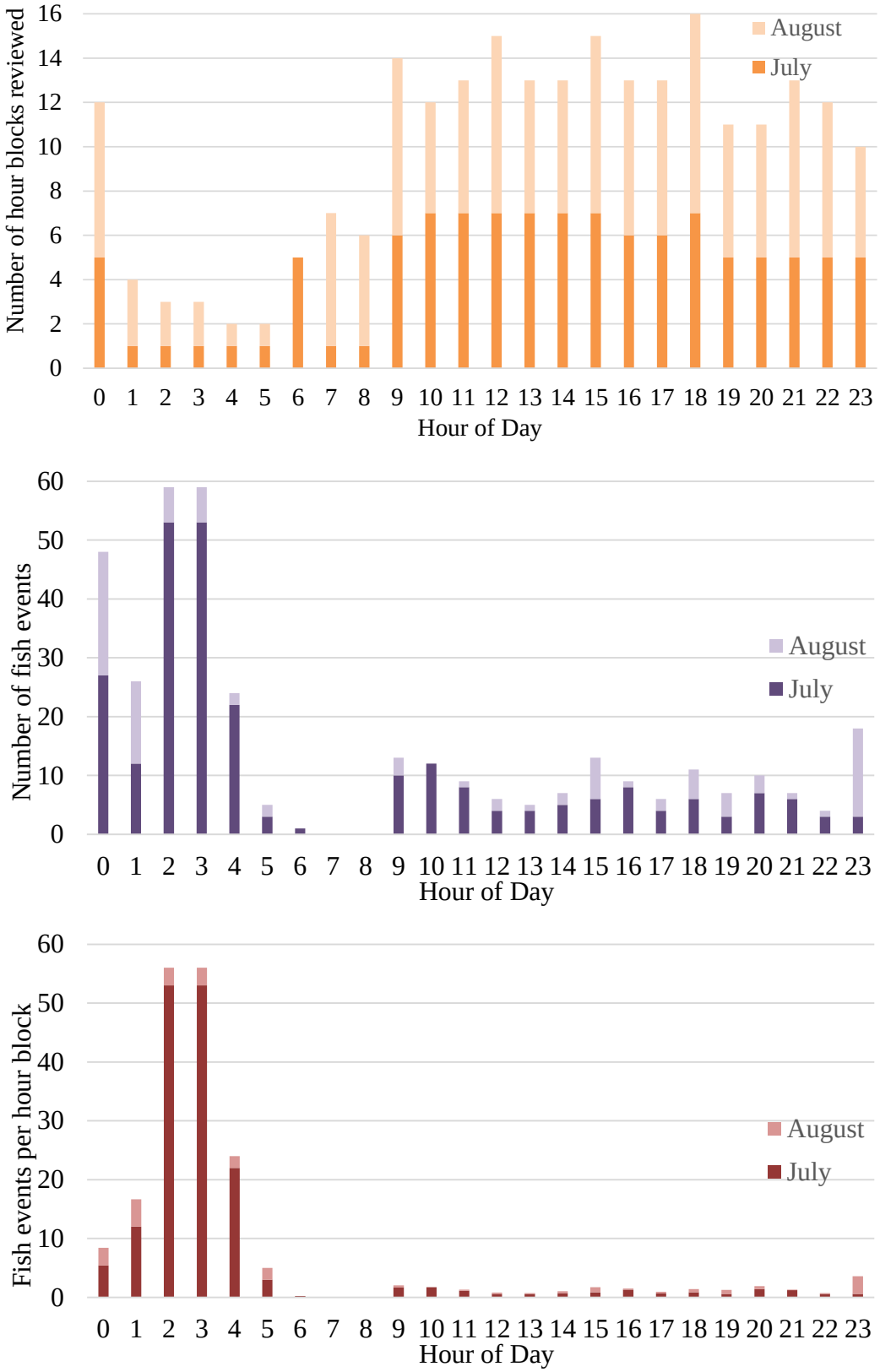

Figure 2A, 2B, 2C. Review effort by hour of day, number of fish events by hour of day, and fish events per hour, by hour of day.