COBSCOOK BAY TIDAL ENERGY PROJECT

2014 ENVIRONMENTAL MONITORING REPORT

FERC PROJECT NO. P-12711-005

March 17, 2015

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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.

<u>TidGen® Power System</u>

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.

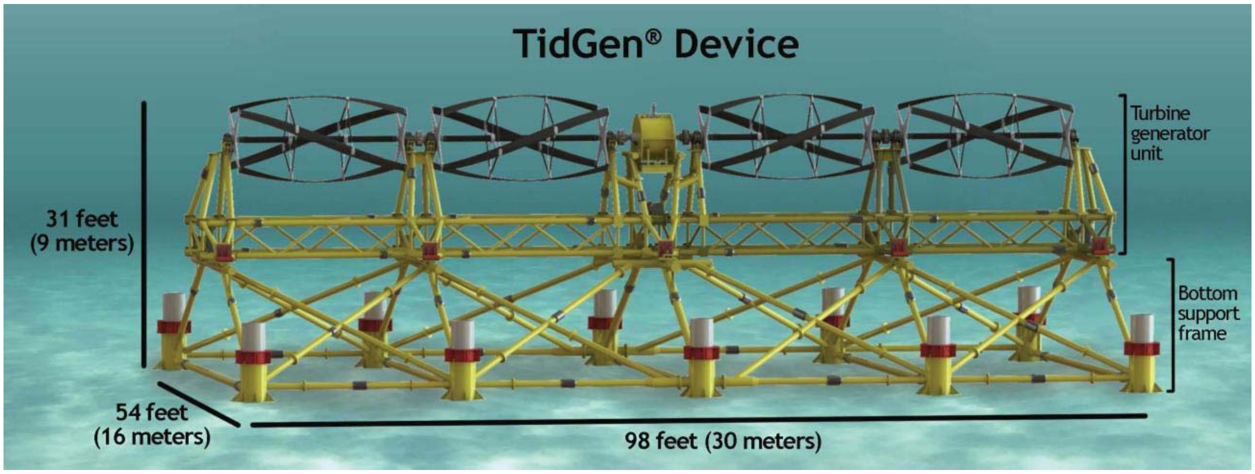


Figure 2. TidGen® device illustrating turbine generator unit (TGU) and bottom support frame.

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 2014 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) will implement turbine control system improvements on the RivGen® platform in the summer of 2015 using new acoustic flow measuring strategies that characterize turbulence and flow variation upstream and across the turbine profile. Based on analytical simulations, supported by scale model testing, we project an 18% improvement in energy capture utilizing the innovative control schemes.

Power Take-Off Systems for Marine Renewable Devices (DE-EE0006398) focuses on both bearings and subsea generator designs. Through the use of polycrystalline diamond 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 .

ORPC has based its next generation turbine system on an expanded computational fluid dynamics (CFD) two dimensional (2D) and three dimensional (3D) 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 the floating 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.

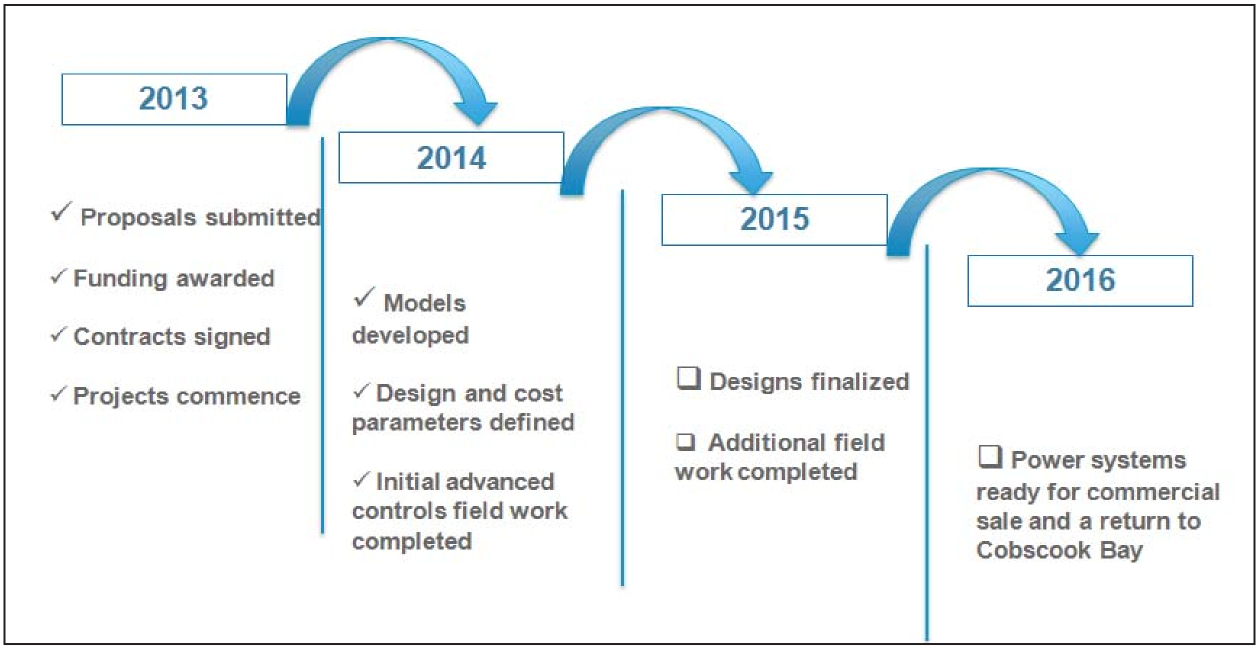


Figure 6. Technology optimization roadmap

1.3 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 Cobscook Bay Tidal Energy 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 through a separate University of Maine funding award from DOE.

ORPC provided FERC and the project's Adaptive Management Team updates during the temporary variance period in 2014 related to project activities and technology optimization progress. ORPC held an Adaptive Management Team meeting on October 15, 2014, which included further updates on the technology optimization phase and a request for feedback on the potential for a one-year extension to the temporary variance to align with the engineering and design schedule.

ORPC submitted a memo to the Project's Adaptive Management Team on November 5, 2014 that explained the temporary variance extension and requested concurrence. In addition, the temporary variance request was presented at the Project's Adaptive Management Team meeting on October 15, 2014.

Based on these discussions, ORPC requested a one-year temporary variance extension to environmental monitoring from FERC. 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.

FERC approved the request for an extension to the temporary variance for environmental monitoring from ORPC for the Cobscook Bay Tidal Energy Project, P-12711, on December 22, 2014.

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	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
To be determined	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 plan 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 2014 Adaptive Management Team Meetings

ORPC met with the AMT on October 15, 2014 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
  - Site and on-shore station inspection
  - Viability of pilot license extension
- Building the environmental interaction knowledge base
  - OCGen® prototype testing project in Cobscook Bay
  - UMaine fisheries monitoring
  - RivGen® demonstration project in Kvichak River, Igiugig, Alaska
- Temporary variance extension request
- Western Passage licensing and permitting update

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

Minutes from the October 15, 2014 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 involved 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 60 kW to 150 kW.	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

3.0 BENTHIC AND BIOFOULING MONITORING (License Article 406)

The primary goals of the Benthic and Biofouling Monitoring Plan are to evaluate the benthic community during the Project and study whether the structures introduced into the marine system contribute to biofouling accumulation that may alter the habitat within the deployment area. These goals will be accomplished by (1) characterizing the existing benthic community (pre-deployment); (2) examining the recovery of the benthic resources disturbed during the installation of the subsea cable; (3) examining the benthic community near the deployed TidGen® Power System; and (4) examining the presence and relative extent of coverage of biofouling organisms on the deployed TidGen® Power System. The Benthic and Biofouling Monitoring Plan will use the data gathered to evaluate the potential Project effects on the benthic community in accordance with the requirements of the FERC pilot license process.

A Phase I (post-deployment) benthic sampling survey was conducted in the subtidal and intertidal areas of the power and data cable route on August 7 and August 8, 2013. MER Assessment Corporation conducted habitat characterizations of the deployment areas and the subsea and intertidal cable routes. ORPC performed a biofouling assessment of the TidGen® TGU immediately following its retrieval and relocation to the Deep Cove pier on July 15, 2013. In addition, a biofouling assessment was conducted on the bottom support frame based on diver video collected in July 2013.

ORPC was not required to conduct benthic monitoring in 2014 based on the Temporary Variance order from FERC. However, the installation of the OCGen® Module Mooring Project at the Cobscook Bay Tidal Energy Project site in 2014 provided an opportunity to inspect the TidGen® bottom support frame, shore cable termination anchor, and the Simrad tower for benthic growth. The inspection was performed by divers on July 22, 2014 and dive video subsequently reviewed by ORPC staff.

Dive video indicated that the bottom support frame was relatively corrosion free, but the vast majority (~75%) of its surface is covered in blue mussels, which tended to be 5 to 6 in. thick. The face of the side-looking Simrad transducer was also covered in mussels, which were removed by divers. Sea urchins and sea stars were abundant on and in the vicinity of the bottom support frame and associated structures as shown in Figures 7, 8 and 9.

Direct comparison between the July 2014 and July 2013 diver video surveys was difficult due to video quality and the duration of the dives. Nevertheless, the July 2014 observations were generally consistent with those previously recorded and confirmed a continued presence of benthic organisms on subsea structures. These results were consistent with artificial reef effects observed with other subsea structures as well as a reduction in dragging activity for these commercially important species in the immediate project vicinity.

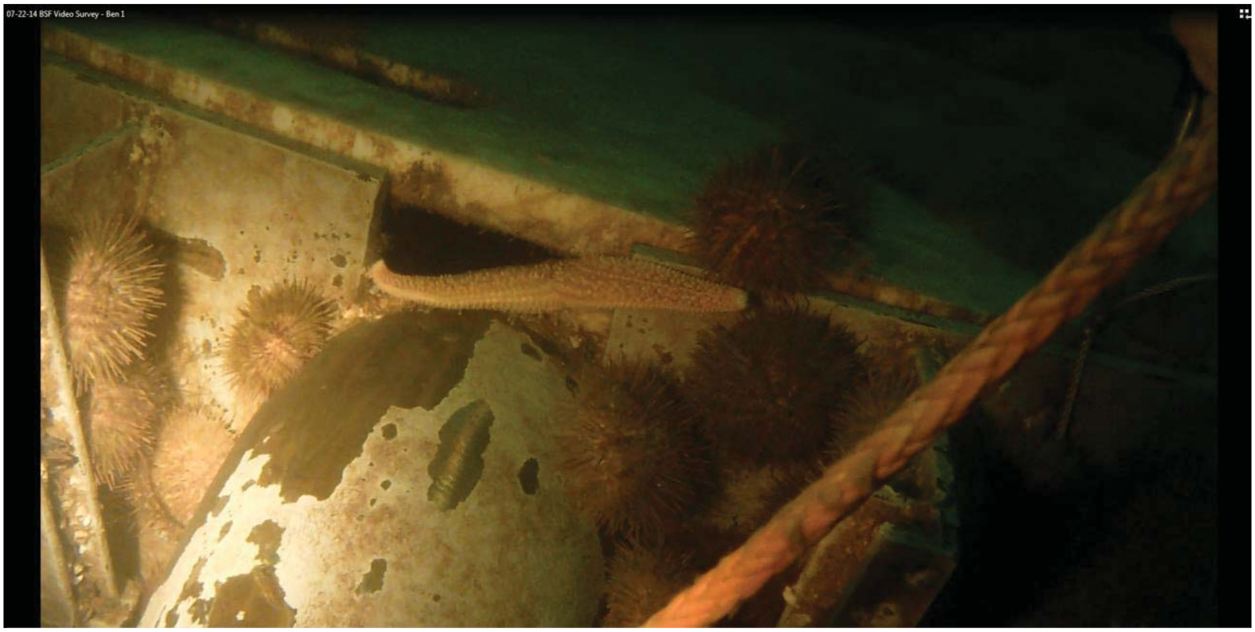


Figure 7. Sea urchins and sea star on shore cable termination anchor

Figure 8. Blue mussels on steel pile (center) and bottom support frame (lower left)

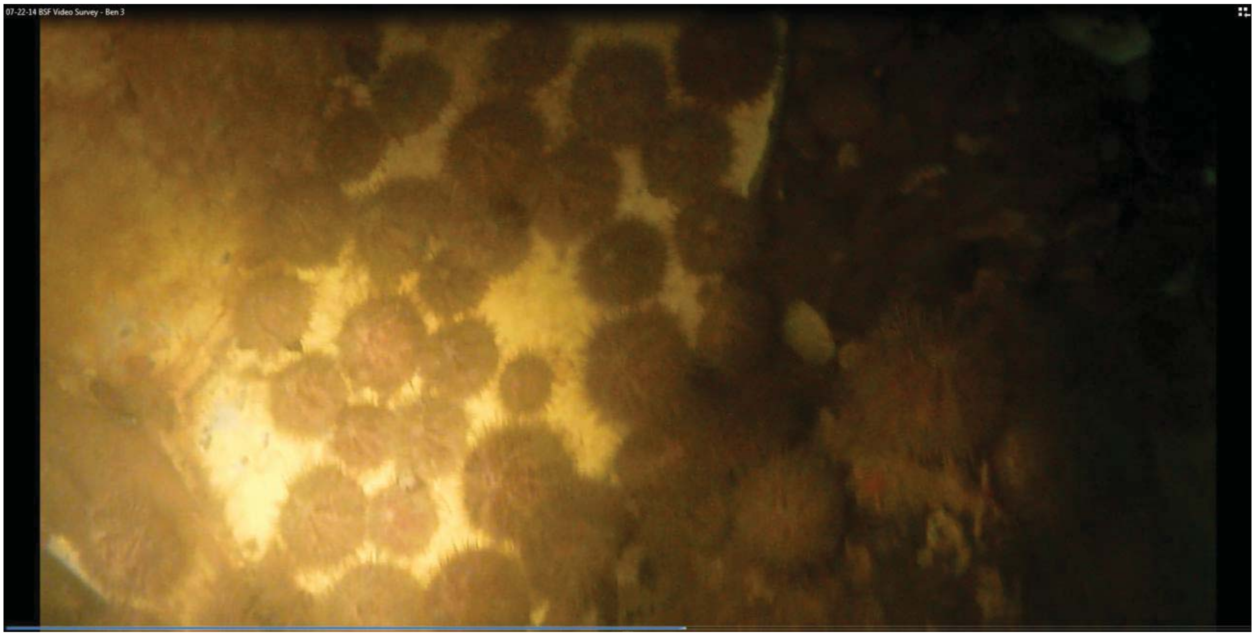


Figure 9. Sea urchins on bottom support frame pile skirt

4.0 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® devices(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 uses side-looking hydroacoustics collected at the Project site to assess the interaction of marine life with the TidGen® device. This monitoring focuses on the behavior of marine life (primarily fish) as they approach or depart

from the region of the TGU and attempts to quantify changes in behavior in response to the TidGen® unit.

4.1 2014 Activities in Cobscook Bay

UMaine's Fish Assessment Study Team continued research at the Cobscook Bay Tidal Energy Project site in 2014 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.*

ORPC's OCGen® Module Mooring Project provided an opportunity for UMaine to collect marine life interaction data around the OCGen® Module as well as continued data collection from the existing side-looking Simrad and inter-annual data from the Project Control Site (CB2). Figure 10 shows the location of UMaine surveys at the OCGen® location and Control Site.

Figure 10. Fisheries Monitoring Plan study area and down-looking hydroacoustic survey locations for 2010-2014. CB1 and CB2 are indicated by dashed ovals. CB1a and CB1b are indicated by small round points. CB1 current directions are averages provided by ORPC.

2014 activities conducted by UMaine's Fish Assessment Study Team are summarized below.

1. Continued long-term, down-looking hydroacoustic and trawl dataset .These data are used for analyses described below as well as describing seasonal patterns of relative abundance

and vertical distribution observed annually. Table 3 summarizes field activities associated with Activity 1.

Table 3. 2014 Activity 1 field data collections and associated conditions.

Date	Site(s)	OCGen® Present	Turbine Rotating	Lunar Stage
Mar 9, 2014	CB2	No	NA	1st qtr; neap
May 22, 2014	CB2	No	NA	3rd qtr; neap
Aug 5, 2014	CB1a, CB1b, CB2	Yes	Yes	1st qtr; neap
Aug 17. 2014	CB1a, CB1b, CB2	Yes	No	3rd qtr; neap
Aug 25, 2014	CB1a, CB1b, CB2	Yes	No	new; spring
Sep 20, 2014	CB1a, CB1b, CB2	No	NA	3rd qtr; neap
Nov 17, 2014	CB2	No	NA	3rd qtr; neap

2. Investigating methods to separate fish based on presence/absence of swimbladder and euphausiids using dB differencing processing techniques with down-looking hydroacoustic dataset (2011-2013) .Data collected from 2014 will be added to this analysis.

3. Investigating a probability of encounter model using three parameters:
   - (p_1) probability of fish being at the device depth when device is not present (down-looking hydroacoustic data 2011-2013)
   - (p_2) probability of behavior changes before being detected (down-looking hydroacoustic data 2011-2013)
   - (p_3) probability of behavior changes between being detected and reaching the device (mobile transect hydroacoustic data collected in 2014, Table 4 and Figure 11).

Table 4. 2014 Activity 3 Field data collections and associated conditions

Start time	End time	Tide	No. of transects
7/29/2014 14:00	7/29/2014 19:30	Ebb	29
7/29/2014 20:29	7/30/2014 1:10	Flood	27
7/30/2014 2:20	7/30/2014 7:40	Ebb	13
7/30/2014 8:50	7/30/2014 13:45	Flood	29
7/30/2014 15:00	7/30/2014 19:50	Ebb	29
7/30/2014 21:20	7/31/2014 2:05	Flood	16
7/31/2014 3:20	7/31/2014 8:00	Ebb	27
7/31/2014 9:30	7/31/2014 14:15	Flood	28
7/31/2014 21:20	8/1/2014 2:40	Flood	21
8/1/2014 9:50	8/1/2014 15:13	Flood	31
8/1/2014 22:20	8/2/2014 3:20	Flood	25
8/2/2014 10:50	8/2/2014 16:10	Flood	29
8/2/2014 23:00	8/3/2014 4:00	Flood	26

8/3/2014 11:30	8/3/2014 16:30	Flood	26
8/13/2014 21:10	8/14/2014 3:00	Flood	35
8/14/2014 22:00	8/15/2014 3:00	Flood	26
8/15/2014 10:00	8/16/2014 15:10	Flood	27
8/15/2014 23:00	8/16/2014 1:40	Flood	16
8/16/2014 11:20	8/16/2014 15:40	Flood	24

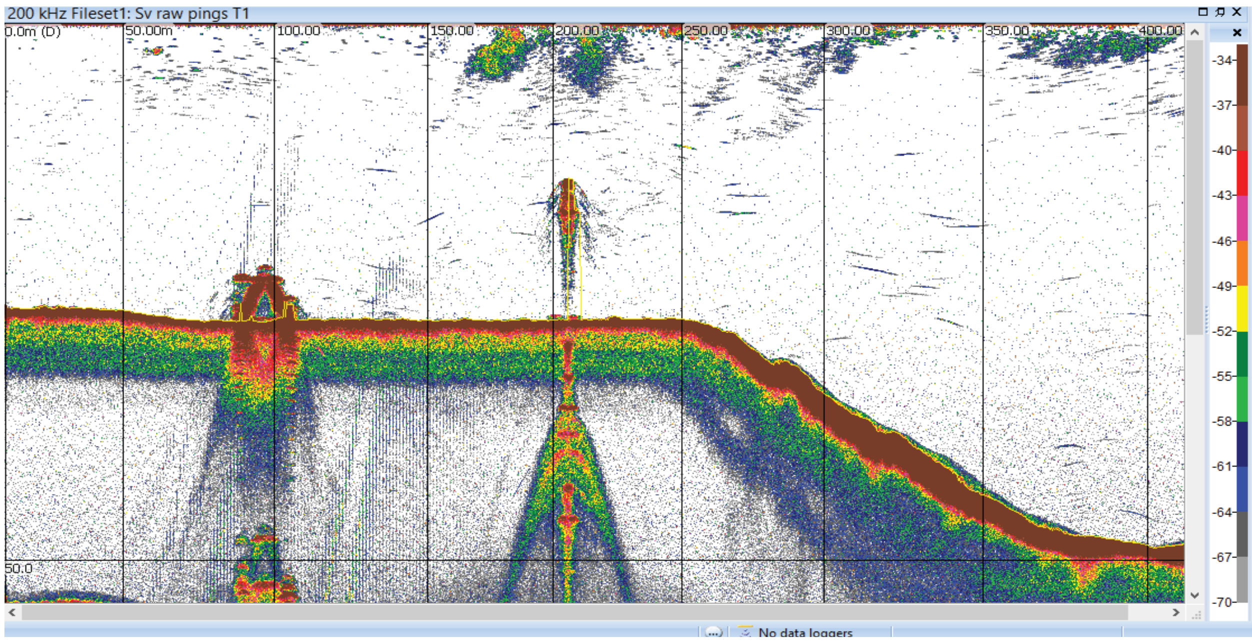


Figure 11. Sonar image showing TidGen® bottom support frame (left) and OCGen® Module (center). Image courtesy of UMaine.

4. Continued long term side-looking hydroacoustic dataset at TidGen® device location.
   - Investigate fish response to static device (TidGen® device braked) using side-looking data collected in April-July 2013.
   - Investigate long term temporal trends in fish densities using long-term, side-looking hydroacoustic dataset.

An update on fisheries and marine life interaction was presented to the Project's AMT on October 15, 2014. This presentation is included in Appendix B.

4.2 Development of Best Available Science

Data and analysis in 2014 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 hydro kinetic industry. This publically available information demonstrated significant progress in an industry where several years ago there was little to no information about environmental interactions of hydrokinetic devices.

The following products were completed by UMaine in 2014:

Viehman, H., Zydlewski, G.B., McCleave, J., & Staines, G .2014 .Using acoustics to understand fish presence and vertical distribution in a tidally dynamic region targeted for energy extraction .*Estuaries and Coasts*. Doi:10.1007/s12237-014-9776-7

Viehman, H., & Zydlewski, G.B .2014 .Fish interaction with a commercial-scale tidal energy device in a field setting .*Estuaries and Coasts*. doi:10.1007/s12237-014-9767-8

Zydlewski, G. B., Copping, A. & Redden, A. 2014. Special Issue: Renewable Ocean Energy Development and the Environment. *Estuaries and Coasts*.

Zydlewski, G.B., Viehman, H.S., Staines, G.S., Shen, H., & McCleave, J.D. 2014. Fish interactions with marine renewable devices: Lessons learned, from ecological design to improving cost effectiveness. Proceedings of the 2nd International Conference on Environmental Interactions of Marine Renewable Energy Technologies (EIMR2014), 28 April – 02 May 2014, Stornoway, Isle of Lewis, Outer Hebrides, Scotland. www.eimr.org.

ORPC presented at an Ocean Energy System (OES) Annex IV workshop held in Nova Scotia on November 1, 2014. The presentation, *Keys to Industry Advancement: Environmental Monitoring & Adaptive Management,* summarized findings from multiple ORPC power systems including the OCGen® module in Cobscook Bay and the RivGen® device in Igiugig, Alaska. Because the project in Igiugig, Alaska is located in a clear river environment, it allowed for alternative monitoring methods, most notably video cameras, which provided additional understanding of environmental interactions. ORPC presented initial findings from the Igiugig project to the Cobscook Bay Tidal Energy Project AMT at the October 15, 2014 meeting as well as at the Annex IV workshop. The final report for the 2014 environmental monitoring at Igiugig, completed by LGL, is included as Appendix C.

ORPC also continues to contribute project information to DOE's Tethys website which houses global data on ocean energy, available at : http://mhk.pnl.gov/.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In 2014 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 Report addresses opportunistic monitoring that occurred during project activities in Cobscook Bay.

5.1 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 Adaptive Management Team on October 15, 2014 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. An extension to the temporary variance from environmental monitoring was subsequently issued on December 22, 2014.

5.2 Environmental Monitoring Results

The 2014 environmental monitoring results continued to build an increased knowledge of marine life interaction with ORPC Power Systems and negligible environmental effects.

Benthic and Biofouling
Video collected by divers in July 2014 were generally consistent with those previously recorded and confirmed a continued presence of benthic organisms on subsea structures. These results were consistent with artificial reef effects observed with other subsea structures as well as a reduction in dragging activity for these commercially important species in the immediate project vicinity.

Fisheries and Marine Life Interaction
ORPC's OCGen® Module Mooring Project provided an opportunity for UMaine to collect marine life interaction data around the OCGen® Module as well as continued data collection from the existing side-looking Simrad and inter-annual data from the project control site. In addition, UMaine continued investigating methods to separate fish based on presence/absence of

swimbladder and euphausiids using dB differencing processing techniques as well as development of a probability of encounter model.

Development of Best Available Science
Data and analysis in 2014 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 hydro kinetic industry.

6.0 AGENCY REVIEW

6.1 Agency Review Period and Responses

The 30-day agency review period for the draft report ended on March 13, 2015. ORPC provided a reminder notice to the Adaptive Management Team on March 4, 2015.

Table 5 summarizes agency comments received and ORPC's response and/or action. ORPC was pleased to receive positive feedback on the Report and the value and benefit of the adaptive management process. ORPC has revised this report to address comments received where necessary.

Table 5. Adaptive Management Team Comments on 2012 Environmental Monitoring Report.

Name/Agency	Comment	ORPC Response/Action
Jim Beyer, Maine Department on Environmental Protection	Email comment (March 4, 2015) *I concur with your report.*	Comment noted.
Daniel Hubbard, U.S. Coast Guard	Email (March 4, 2015) Confirmed USCG representative for the Adaptive Management Team	Comment noted, Table 1 revised accordingly
Sean McDermott, NOAA NMFS, Habitat Conservation Division	Email comment (March 12, 2015) *We were pleased to see the progress of the project and data as presented in the October meeting. The monitoring has provided insight to many originally unanswered questions. Please keep us posted as the project progresses and as consultation is required. We remain interested in the development of tidal energy and the outcome of future studies.*	Comments noted.

6.2 Public Dissemination of 2014 Environmental Monitoring Results

In accordance with ORPC's Adaptive Management Plan, the 2014 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, October 15, 2014

COBSCOOK BAY TIDAL ENERGY PROJECT
ADAPTIVE MANAGEMENT TEAM
MEETING MINUTES
October 15, 2014

Attendance: Denis-Marc Nault, Maine Department of Marine Resources; Jim Beyer, Maine Department of Environmental Protection; Sean McDermott, NOAA/NMFS Essential Fish Habitat; Dave Bean, NOAA/NMFS Protected Species; Dan Hubbard - U.S. Coast Guard; Dr. Gayle Zydlewski - University of Maine School of Marine Sciences; Garrett Staines, University of Maine School of Marine Sciences; Suzanne Miller, Maine Department of Environmental Protection; Nathan Johnson, Ocean Renewable Power Company; John Ferland, Ocean Renewable Power Company

Participating by phone: Jay Clement, U.S. Army Corps of Engineers; Jocelyn Brown-Saracino, U.S. Department of Energy

Welcome and Introductions

The meeting began at 10:10 am. 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 OCGen® Module Mooring project and RivGen® Power System testing and relevance to industry
- Explain ORPC's technology optimization progress
- Discuss ORPC's temporary variance extension request
- Identify next steps and priorities

Cobscook Bay Tidal Energy Project Update

Mr. Johnson, ORPC, provided the following project update:

- ORPC submitted its 2013 Environmental Monitoring Report, with the Adaptive Management Team concurrence, on March 3, 2014.
- FERC issued a formal notice on May 13, 2014, stating that the report fulfilled the requirements of the applicable license articles.
- During the summer of 2014, ORPC conducted the OCGen® Mooring Module Project within the FERC-licensed site in Cobscook Bay and included benthic and scour monitoring as part of the project.
- University of Maine School of Marine Sciences continued its monitoring of fisheries interaction at the licensed site by collecting data at the OCGen® prototype and nearby Cobscook Bay Tidal Energy Project control site.
- FERC notified ORPC that the company must make a decision soon regarding seeking a commercial license at the Cobscook Bay site. Mr. Johnson noted that ORPC would like to request that FERC extend the existing Pilot Project License by two years, which would make its length the same as Verdant Power, which has a 10-year Pilot Project License for the East River in New York. Mr. Beyer, Maine DEP, recommended the group discuss this issue in more detail at the end of the presentation.

Mr. Johnson then provided the following update regarding ORPC's OCGen® Module Mooring Project:

- The project was funded by the U.S. Department of Energy (DOE).
- The device had no generator; therefore it did not fall under the jurisdiction of FERC. ORPC re-used a set of earlier generation turbines (actually the set used in the 2010 Beta TidGen® project) to simulate load.
- The primary function was to test an alternative mooring and anchoring technology.
- The prototype device was installed from June 27, 2014 to September 17, 2014.
- The re-used turbines rotated between July 24, 2014 and August 10, 2014.
- Although the foils in the older turbines eventually failed as they had reached the end of their useful life, it did not impact the project's purpose, which targeted the mooring and anchoring technology.
- Regarding permitting of the project, ORPC had introduced the testing concept to the Adaptive Management Team at September 2013 AMT meeting.
- With guidance from the AMT, ORPC requested an Informal Staff Opinion from Maine DEP on October 17, 2013, seeking an exemption from the Natural Resources Protection Act (NRPA). Maine DEP granted approval on December 9, 2013.
- ORPC then sent a Section 10 General Permit application to the U.S. Army Corps of Engineers. The USACE issued the permit on March 31, 2014.
- Mr. Johnson noted that the AMT concurrence on the OCGen® project was a great example of how the agencies and ORPC work together to help create a growing knowledge base about tidal energy development and environment. This collaboration helps make the permitting process more efficient.
- Mr. Johnson also emphasized the rational of using the FERC-licensed site as the test site. It was already marked for navigation safety, the existence of the data cable enabled collection of various operational monitoring information, and ORPC consolidated marine operations in a specific location within the harbor, therefore reducing its footprint and avoiding commercial fishing conflicts.

Mr. Johnson then reviewed several slides that contained photographs and video of the project, including documentation of scour and benthic monitoring.

Mr. Beyer asked what filled the OCGen® modules buoyancy pod. Mr. Johnson said air. Mr. Bean asked if the project needed additional anchors other than the two used directly with the buoyancy pod. Mr. Johnson said no other anchors were used. Mr. Beyer asked about impact on the mooring system from turbulent waters. Mr. Johnson noted that they system moved only about a meter deviation from its vertical orientation. Mr. Beyer also asked if the mooring lines had suffered twisting in any way. Mr. Johnson said he could get more engineering input on the question if necessary, but it was his sense that twisting did not occur. Mr. Johnson then described the anchor photo in more detail, pointing out where markings were made that would assist divers with recognizing evidence of scour.
Regarding benthic monitoring, Mr. Johnson said divers inspected the bottom support frame used for the TidGen® project as well as the data transmission cable to shore. He said no cable was exposed and nothing indicated the cable was out of place from its desired location. Marine growth occurred on site due to the existence of fixed structures such as the bottom support frame and the fact there no dragging occurred in the project site.

Mr. Bean asked if ORPC used anti-fouling paint. Mr. Johnson replied that ORPC used traditional marine coatings without anti-fouling components. Mr. Johnson then showed a video of a diver inspection of a portion of the TidGen® bottom support frame. As per the project's benthic and biofouling environmental monitoring plan, divers removed some growth to help identify any significant changes to a structure, inspect the cathodic protection anodes and determine if growth affected hydrodynamics around the structure. Mr. Johnson noted that ORPC will continue to monitor benthic growth; to date the overall impact of marine growth has been insignificant.

Mr. Bean expressed his concern that over time, with a mooring and anchoring system similar to the OCGen® device technology, increased marine growth may contribute to degradation of the mooring and anchoring system. Mr. Johnson acknowledged his input and noted that research has been conducted by the University of New Hampshire, among other places, regarding bethic growth on offshore aquaculture moorings and that ORPC will continue to monitor progress in that regard.

Fisheries and Marine Life Interaction

Mr. Bean asked what the RPMs were. Mr. Johnson said the OCGen project upper limit was between 60 and 80 RPMS. Mr. Bean inquired about the use of video to record different stages of the tide and turbine rotation, which he said would help regulators better understand a device's interaction with marine life. He also asked if the rotating turbines created an inflection that caused marine life to avoid the foils. Dr. Zydlewski said there is no pressure similar to a traditional hydroelectric dam facility, and that part of the emphasis of her research was to measure how fish sense the device in the water column and how they avoid it.

Dr. Zydlewski reviewed the history of how her research over the summer, funded by DOE, utilized ORPC's OCGen® prototype. With ORPC's TidGen ® device out of the water, DOE agreed that the OCGen® project would help satisfy research requirements. In terms of her team's overall research goals for the Cobscook Bay Tidal Energy Project, Dr. Zydlewski explained that the goal of the project was to quantify aquatic animal behavior changes associated with the presence of a deployed marine hydrokinetic (MHK) device. Specific objectives included:

- Long-term seasonal hydroacoustic dataset near an MHK device
- New analytical methods to improve species identification
- Encounter probability model
- Side-looking hydroacoustics at the TidGen® device

Dr. Zydlewski reviewed where data was collected by month between 2011 and 2013, referencing the TidGen® project site and the control site closer to Shackford Head. The information also showed when data was collected with and without the TidGen® device in place.

In regards to seasonal patterns of relative abundance, the control site and the project site have similar data, although some evidence exists of the project site having lower density during construction of the TidGen® project, most likely because of avoidance due to installation activity on site. Seasonal patterns of relative abundance between the project and control sites are similar; both before and after the installation of the bottom support frame. Regarding distribution of fish in the water column, there does not appear to be significant differences in vertical distribution around the device.

Dr. Zydlewski then summarized the data gathering that had occurred during 2014 with the OCGen® Mooring Module project. Data was collected both while the turbines were turning and locked. UMaine continues to analyze the data.

One of the research challenges is separating out marine life by species as a way to get more detail about what fish use the Bay. UMaine's work will also help understand behavior by schooling fish. The challenge is how to separate out schools which have swim bladders. To address this question UMaine is using dB differencing methods on data previously collected.

Dr. Zydlewski noted that one of her master's degree students recently completed a thesis of what species are in the bay—46 different species were identified, with 60,000 individuals collected (sampling at multiple locations, trawling, seining, Fyke nets), and have since added two more species. Sticklebacks were most abundance, and no sturgeon were detected.

Dr. Zydlewski also explained the encounter probability model that they are developing. In the near field, it appears that fish are avoiding the turbine, and to the extent marine species interacted with the turbine; they were small and passed through it. UMaine is now focused on the mid-field area to try and determine how and when fish evade the turbine area. This work is in conjunction with Argonne National Laboratory and USACE.

Dr. Zydlewski summarized some preliminary results which indicated that 60 to 70 percent of the fish remained in the water column area between the ocean bottom and 9 meters above (the zone of the bottom support frame and the turbine). An estimated 8-9% of the fish were in the top 3 meters of that range which represented the turbine zone. This presented an understanding of the distribution of fish in the vicinity of the turbine which had the probability of being affected if they interacted with the turbine.

Dr. Zydlewski said that at each stage of the tide, ebb and flood, there were no major differences between the project and control sites, even when the turbine was operating. This was useful information, and the UMaine team is still verifying some of its models to finalize its data before publishing.

Mr. Bean asked if Dr. Zydlewski was comfortable that the control and project site are representative of the Bay. She said yes, but the key is to have a good control site. The existing control site is deeper than project site. UMaine is looking at other ways to address these differences, but key is that every time they have done work in the Bay, the same trends occur. Fish coming from the deeper area (to the east) near the control site become more concentrated in the water column due to the reduced depth near the project site. Fish also appear to congregate in the wake of the buoyancy pod.

Dr. Zydlewski reviewed the use of side-looking hydroacoustics at the TidGen® site. The use of hydroacoustics assists with determining sampling periodicity to represent variability over a month. A key question for researchers is: Are the 24-hour surveys that are conducted representative of what happens in the Bay over a monthly period? With the hydroacoustics tool, ORPC kept the system on and a UMaine PhD student collected and analyzed the data. This process was time consuming, and the student continues to analyze the data. An interesting component of the research was to determine proper periodicity, i.e., 12 hours, day/night, 14 days etc. A yearlong data set will help establish periodicity and determine if a 24-hour survey is valid or not. That process is currently underway.

Mr. Bean inquired if there were similarities in fish periodicity between existing literature in Chesapeake Bay and Cobscook Bay. Mr. Marc-Nault inquired about the correlation between fish peak presence and the stage of ebb or flood. Dr. Zydlewski indicated that both of the previous questions are being evaluated further as a result of their research.

Regarding next steps, Dr. Zydlewski outlined the following:

- In November 2014, UMaine will sample at the control site.
- The team is in the midst of analyzing 2014 data. Most data collected in the August/September time frame is still being processed.
- These tasks will add to existing work regarding:
  - Long-term dataset
  - Make correlations with trawl data
  - dB differencing
  - Probability of encounter
  - ELAM model
  - Free-spinning TidGen® device
  - Temporal analysis of fish presence for optimizing sampling

Dr. Zydlewski indicated that in addition to collecting and analyzing the data, an important priority for the UMaine work is to help industry determine the proper way to conduct long-term monitoring in a reasonable and effective manner.

OCGen Scour Monitoring

Mr. Johnson summarized the scour monitoring for the OCGen® project, noting the following:

- Minimal horizontal movement of anchors occurred (3-4 inches maximum)
- Localized sour occurred at one anchor corner location, at a depth of approximately one ft
- Both anchors settled to the height of the steel skirt (19 in.).

Mr. Beyer asked if the system experienced vibratory action in any way, and Mr. Johnson said he thought that impact was minimal if at all. Mr. McDermott of NOA/NMFS asked if it was possible to determine when settlement occurred, i.e., at deployment or was it gradual? And if it was gradual, was there a way to determine if the settle had finished or would continue. Mr. Johnson noted that the methodology used was to inspect for scour immediately after installation and just prior to removal therefore it was difficult to determine if the settling was gradual or punctuated.

In summarizing the OCGen project, Mr. Johnson made note of the following:

- ORPC successfully demonstrated OCGen® module installation, anchoring and retrieval
- The opportunity existed to further assess benthic growth on the TidGen® device bottom support frame
- UMaine's survey of fisheries interaction continued to build an industry knowledge base
- Scour monitoring indicated minimal movement of anchors

Mr. Johnson said the evolution of the OCGen® technology will be important for deep water areas, such as Western Passage and eventually ocean current sites.

Mr. McDermott asked if ORPC was developing the OCGen® in order to have flexibility in design of its products or would eventually be moving to this as a standard design. Mr. Johnson said the initiative helps in both ways as ORPC seeks less expensive installation solutions and also better siting of the turbine in the water column.

Mr. Johnson concluded the Cobscook Bay site portion of the meeting by explaining that ORPC has been receiving interest from other industry members regarding potential testing of devices and monitoring equipment at the site. He noted that the Cobscook Bay site has permitting and licensing data available, existing project infrastructure (support structure, power and data cable, on-shore station) and available environmental, bathymetric and resource data. Additionally, ORPC staff, local supply chain partners and regulators such as the AMT are experienced regarding the site both from a technology and an environmental monitoring standpoint. ORPC indicated the intent of this discussion was to make the AMT aware of the potential for testing if opportunities were to progress. Prior to proceeding, ORPC would communicate with the AMT and seek their concurrence. Use of the site as a test area would become a good opportunity for the local contractor community and provide the opportunity for additional monitoring research to occur.

Mr. Bean asked about the flexibility of the existing FERC pilot license regarding these activities. Mr. Johnson noted that FERC's jurisdiction occurs when electricity is being generated and delivered to the grid; if projects are not distributing electricity, or if a stationary test vessel is moored, the jurisdiction is under USACE. He said the recent experience with the OCGen® project is a good example of how a testing scenario can occur efficiently.

Mr. Bean asked if a testing initiative would be included in the variance request. Mr. Johnson said that would depend on how clear testing opportunities presented themselves at the time the request was made and emphasized that ORPC would not move the testing idea forward without concurrence from the AMT.

Mr. Hubbard from the Coast Guard asked if ORPC has had a positive experience with the navigation aids and if anything needed to be changed in that regard. Mr. Johnson said the aids have been useful and ORPC continues to meet with the local fishing community a couple of times a year. Mr. Hubbard suggested that over time both recreational and commercial fishermen may want to fish the project site during down time periods because marine life clusters in the area. He said this could become a future issue for the AMT. Mr. Johnson said that recreational fishing activity is minimal in the vicinity of the site due to species present and the velocity of the current. He said that the potential exists for commercial interest but the precautionary information noted on charts about it being a power project site helps to discourage underwater activities in the area. Mr. Hubbard asked how high the OCGen® pod was in the water column. Mr. Johnson said it was approximately 40 ft below the surface (dependent on tidal stage) and presented no navigation issues because there are no deep draft vessels using that portion of Cobscook Bay.

Mr. McDermott asked when ORPC was required to report again to FERC. Mr. Johnson said the end of the year 2014 environmental monitoring report would be due to FERC in March 2015. Mr. McDermott noted the AMT's interest in publications by Dr. Zydlewski, and she said she would keep them informed about when data was published, including in *Estuaries and Coasts.*

RivGen® Project Update

Mr. Johnson provided a summary of ORPC's RivGen® Power System project, recently concluded in Igiugig, AK. He emphasized that the project was applicable to ORPC's efforts in Cobscook Bay because it provided the opportunity to collect additional data regarding fish behavior in the vicinity of a rotating turbine. Mr. Johnson showed photos and video of the project. He said the fish monitoring was conducted by the Alaska firm LGL, and ORPC will share the fisheries report with the AMT when it is completed. He said that based on data analyzed to date no adverse or negative interactions between the RivGen® Power system and aquatic life were observed. Next steps for the project include a second deployment in Igiugig in 2015 with plans for a commercial system installation in 2016.

Technology Optimization

Mr. Ferland provided an overview of ORPC's technology optimization program, which features a variety of component improvements designed to increase power system efficiency and reliability, while reducing weight, product costs and the overall cost of electricity.

Mr. Ferland said ORPC's efforts are viewed as an industry development opportunity by DOE, which has re-invested significantly in ORPC to help accelerate the company's initiatives. He said the work is complex and national in scope, features partnerships with two national laboratories (NREL and Sandia), involvement of two universities (University of Washington and the University of Alaska) and multiple contractors with disciplines in engineering, computational fluid dynamics, generator design and power electronics. In addition to the technology improvement effort, DOE is also requiring ORPC to address cost breakdown structure and the long-term cost of energy. As such, the results will benefit and inform industry growth internationally.

Mr. Ferland said that an interesting opportunity in this effort has been the ability to use in-water project development activity in Alaska to benefit the company's work in Cobscook Bay. He then reviewed the individual projects within the optimization effort, the goal of each initiative, the cost and funding, who the partners are and the projected end date. The summary showed that ORPC anticipates returning an improved TidGen® Power System to Cobscook Bay in 2016. He then showed a time line illustrating how progress has occurred in the effort since 2013 and what tasks remain in order to complete the work.

Dr. Zydlewski inquired if the next generation of the TidGen® TGU would be installed on the existing bottom support frame. Mr. Ferland responded that it would. Mr. McDermott asked if multiple devices would be installed at the site in 2016. Mr. Ferland indicated that a single device would likely be installed but that other devices, including a single TGU OCGen® could be subsequently installed prior to deployment in Western Passage. Mr. Bean asked about the validity of diversion devices for fish. Mr. Ferland responded by explaining the early technology development in the industry and how ORPC's power systems are designed to minimize environmental effects (low RPM and percent solidity).

Temporary Variance Request

Mr. Johnson reviewed ORPC's temporary variance request regarding the Cobscook Bay Tidal Energy Project and noted the following chronology:

- FERC order issued on October 29 after the following:
    - ORPC memo to AMT on August 21, 2013

  - Discussion at AMT meeting on September 10, 2013
  - ORPC submittal to FERC on September 19, 2013
- ORPC provided project updates on May 22 and September 31, 2014.
- Based on the temporary optimization phase and continued monitoring in 2014, which continue to indicate negligible environmental effects, ORPC will request an extension to the variance.

With TidGen® scheduled to be re-installed in 2016 ORPC would like to minimize costs and effort associated with environmental monitoring and request an extension through next year. ORPC's request takes the following factors into account:

- Comprehensive pre-deployment and post-deployment environmental studies have contributed to an understanding of inter-annual variability.
- 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 will return to adherence of condition once TGU operation recommences.

Mr. Beyer, Maine DEP, said he was unconcerned regarding an extension to the temporary variance for another year. A discussion ensured about fisheries data. Mr. Bean asked if a full year of fisheries monitoring was available. Dr. Zydlewski said yes, because December this year will conclude a year's collection of data. Additionally, data exists back to 2011 regarding seasonal abundance. Mr. Bean added that it is also encouraging that ORPC is able to get data on salmon interactions from its RivGen® project.

Mr. Johnson noted that it is possible to keep the side looking SIMRAD running on the Cobscook Bay site as UMaine increases its ability to analyze the reams of data produced. Mr. Bean observed that at this stage of ORPC's work in Maine, it is not necessarily bad to have a one year gap in data, and Mr. Beyer indicated that other requirements in the environmental plan can be set aside as there is nothing to study right now. Mr. Bean asked if ORPC's technology optimization strategy would significantly alter the design of its turbines. Mr. Johnson replied that while size might change slightly and potentially some shape of individual components, the optimized power systems will resemble what ORPC has installed in the past.

Mr. Johnson thanked the AMT for its input and said that ORPC would draft a memo requesting concurrence with the extension to the temporary variance.

Western Passage

Mr. Johnson provided an update on the status of ORPC's efforts regarding the permitting and licensing of Western Passage. He noted that ORPC, with support from local stakeholders, requested a successive preliminary permit on January 1, 2014. FERC issued an order denying the application on July 2, 2014, citing lack of extraordinary circumstances. ORPC continues to work on its strategy for developing a project in Western Passage and will keep the AMT informed. There are potential alternative regulatory methods for obtaining site control, and ORPC and the AMT may discuss this at a later time.

ACTION ITEMS

Mr. Johnson reviewed the following action items from the meeting:

- ORPC will generate meeting minutes and distribute for review.
- AMT concurrence and/or questions on the temporary variance extension
- AMT concurrence and/or questions regarding pilot license extension
- ORPC will investigate alternative strategies related to Western Passage.

Please note that ORPC will be moving our office location in Portland by the end of November. Our new address will be:

66 Pearl St, Suite 301
Portland, ME 04101

Appendix B

Adaptive Management Team Presentation, October 15, 2014

Cobscook Bay Tidal Energy Project
Adaptive Management Team Meeting

ORPC
OCEAN RENEWABLE POWER COMPANY

October 15, 2014

Welcome and Introductions

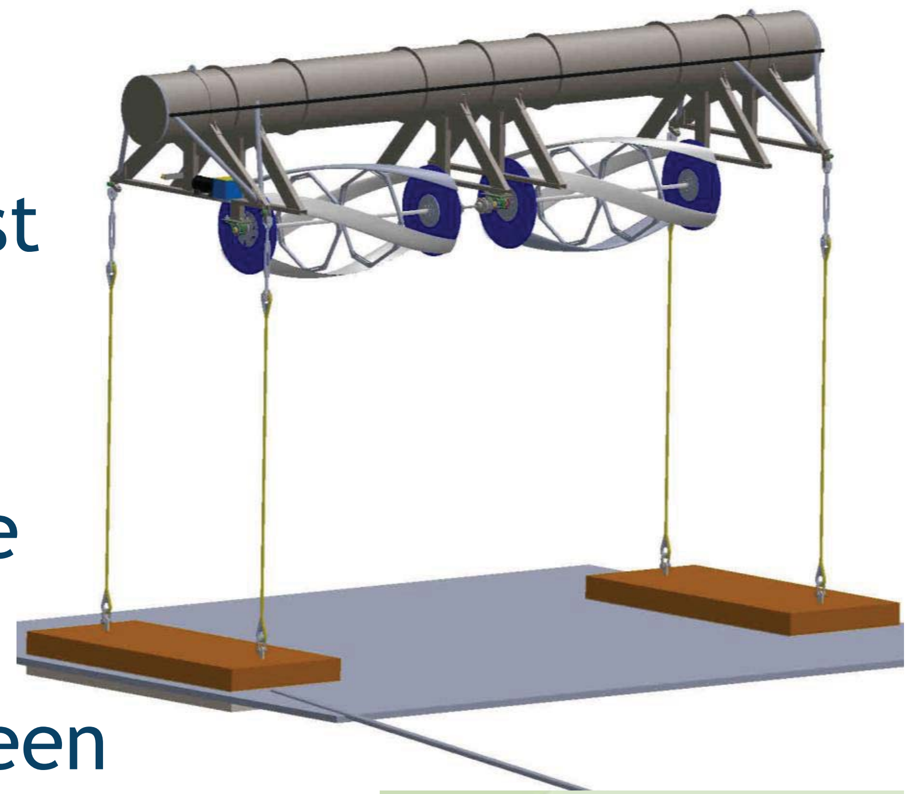
- Introduction of attendees
- Agenda
- Meeting objectives
  - CBTEP update
  - Summarize OCGen® Module Mooring and RivGen® testing and relevance to industry
  - Detail technology optimization progress
  - Discuss temporary variance extension request
  - Next steps and priorities

CBTEP Project Update

- 2013 Environmental Monitoring Report submitted to FERC on March 3, 2014
- FERC issued a formal notice on May 13, 2014 stating the report fulfills requirements of applicable license articles
- OCGen Module Mooring Project conducted within FERC licensed site (including benthic and scour monitoring)
- UMaine continued fisheries interaction work around the OCGen prototype and project control point
- FERC notice of commercial license timeframe

OCGen® Module Mooring Project

- Funded by the Department of Energy
- Primary function to test alternative anchoring technology
- Installed between June 27 and September 17
- Turbines rotated between July 24 and August 10



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OCGen® - Permitting

- Testing concept introduced prior to last fall's AMT Meeting
- Request to MaineDEP for Informal Staff Opinion (NRPA exemption) submitted on October 17, 2013. MaineDEP approval granted on December 9, 2013.
- USACE General Permit (Section 10) submitted with AMT concurrence on December 20, 2013. Permit issued on March 31, 2014.

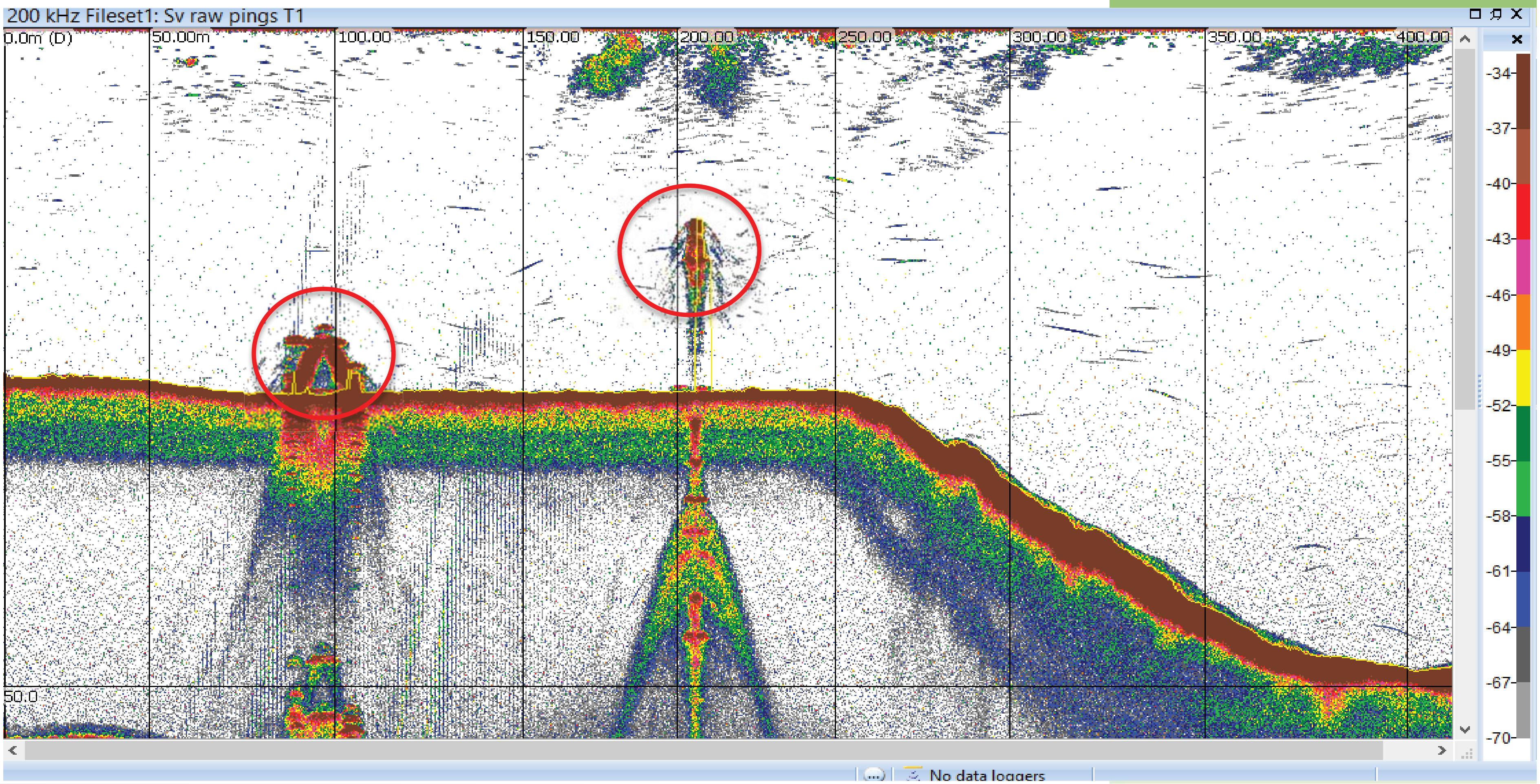
OCGen® Installation - Module

ORPC OCEAN RENEWABLE POWER COMPANY

OCGen® Installation - Anchors

ORPC OCEAN RENEWABLE POWER COMPANY

OCGen® Image (courtesy of UMaine)



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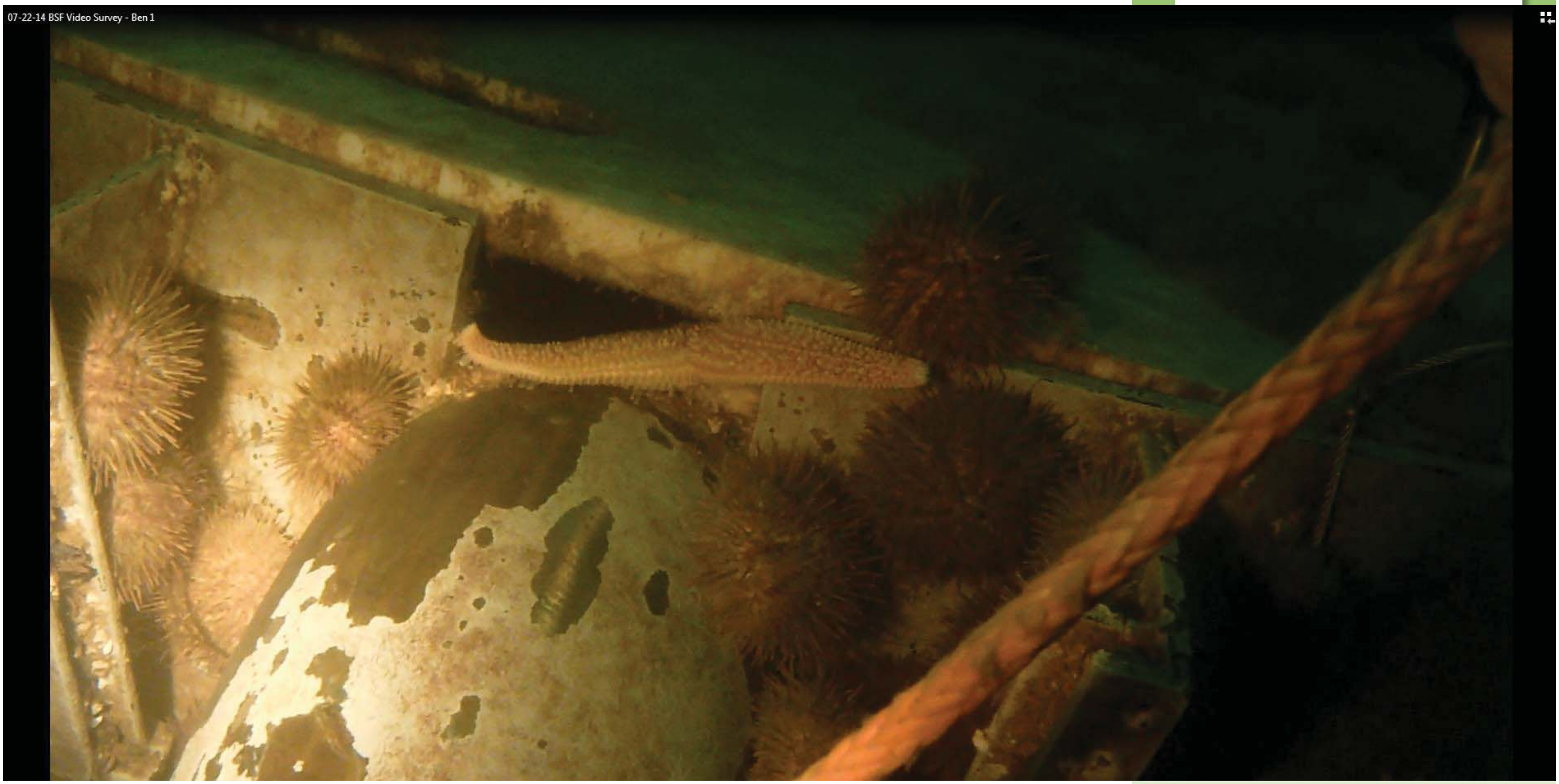
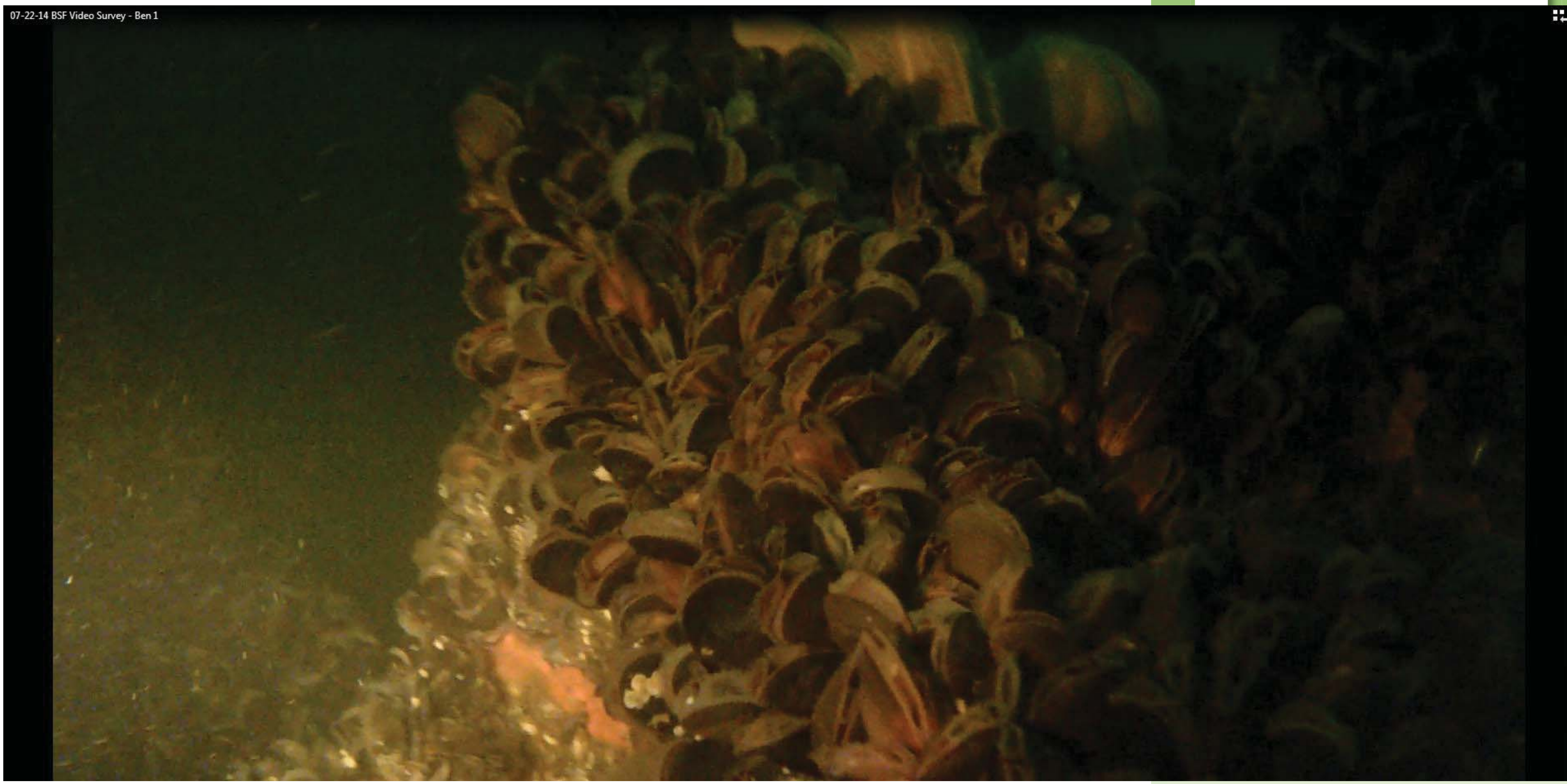
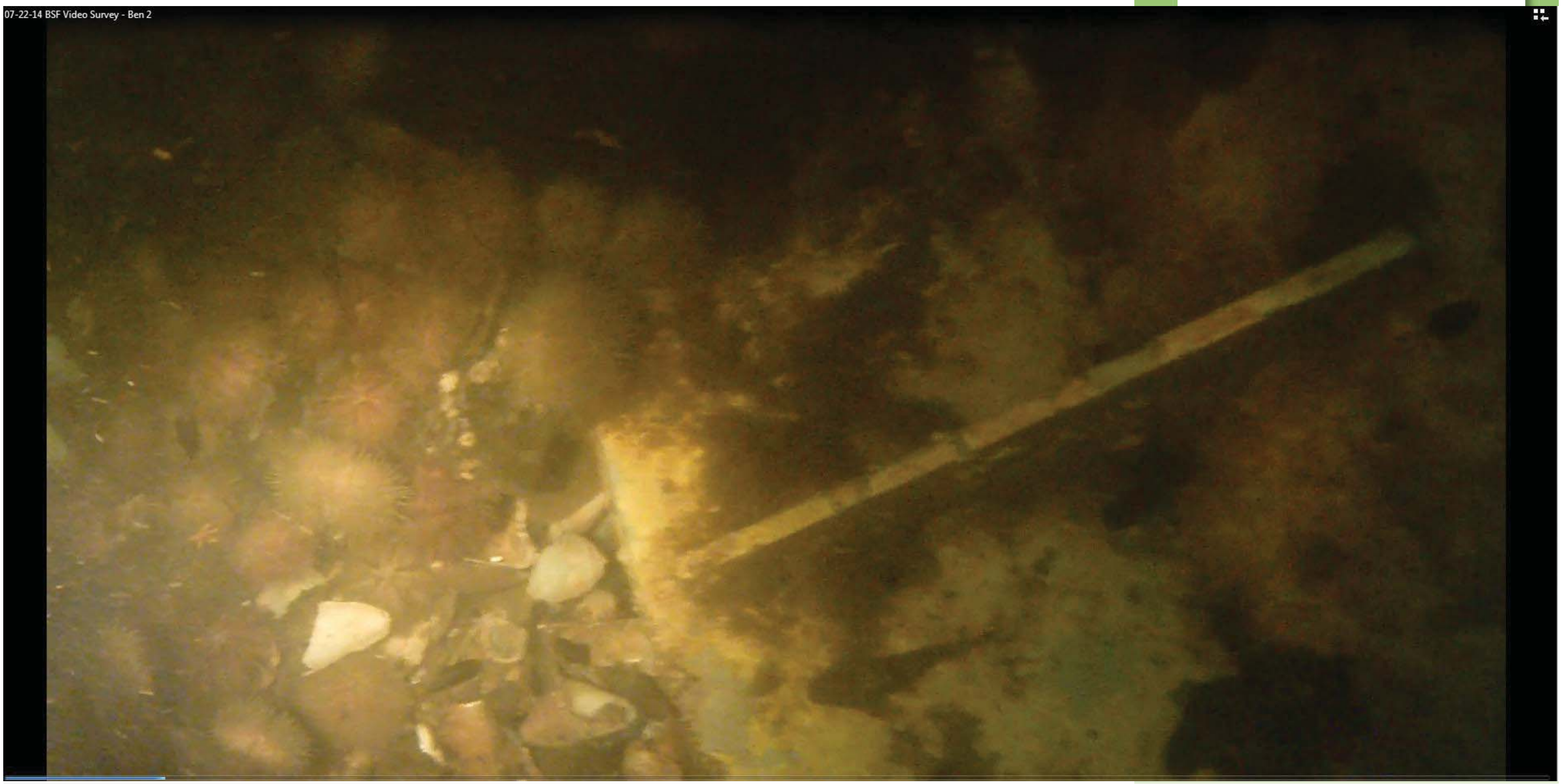
Benthic Monitoring



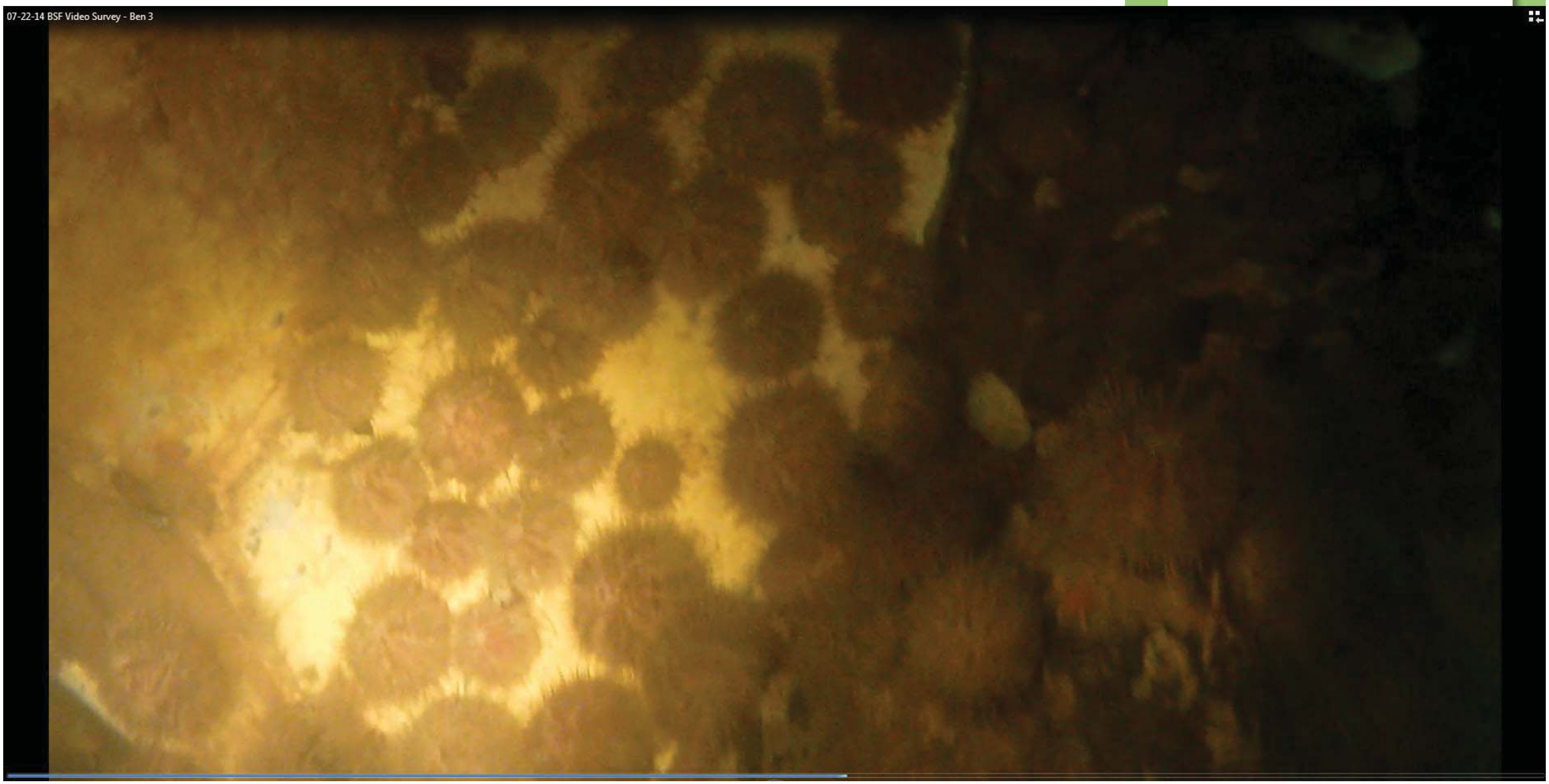
Benthic Monitoring



Benthic Monitoring



Benthic Monitoring



ORPC OCEAN RENEWABLE POWER COMPANY

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1865 THE UNIVERSITY OF MAINE
School of MARINE SCIENCES

MTPI
Maine Tidal Power Initiative
environment · resource · community · engineering

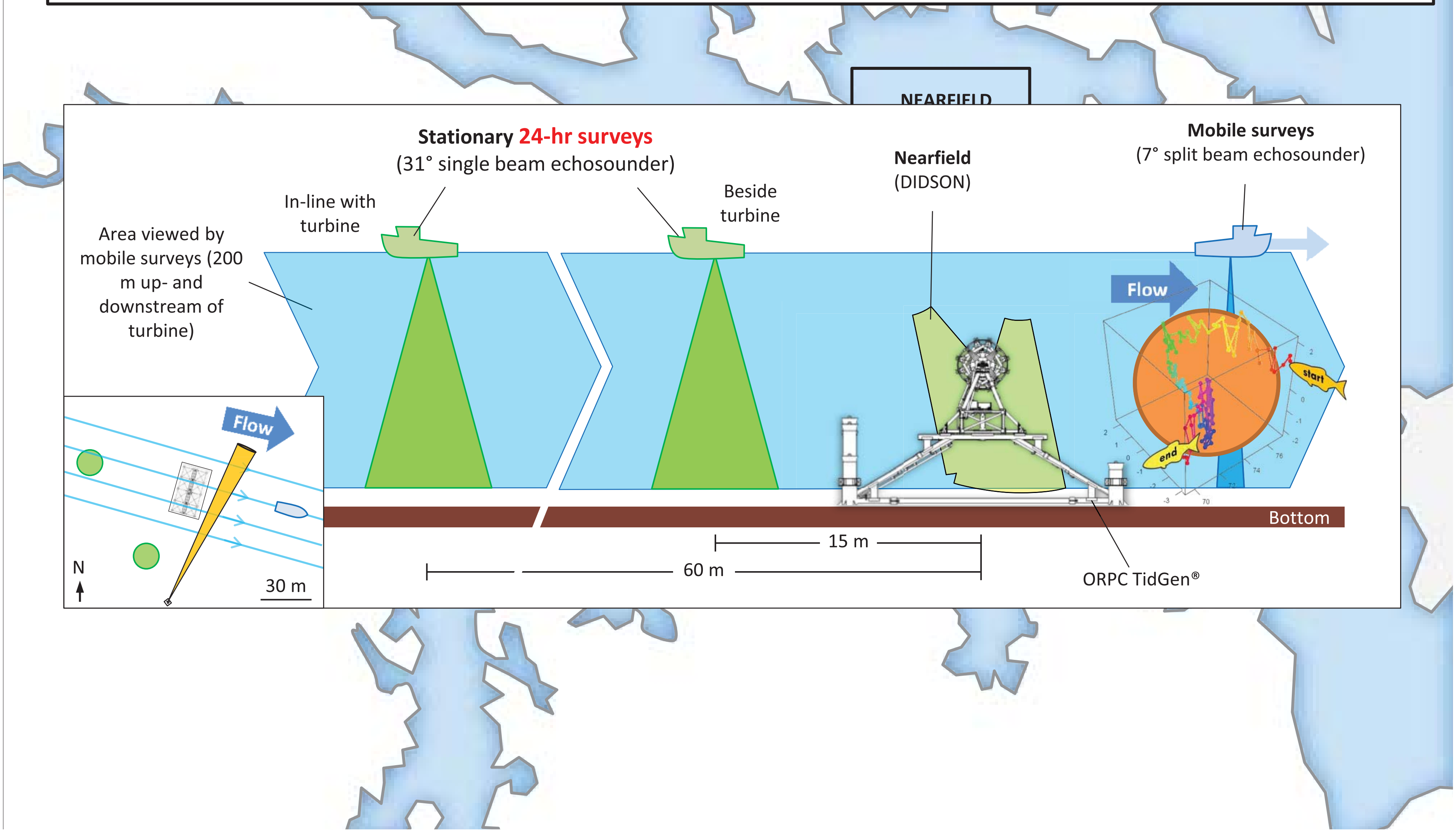
Cobscook Bay Tidal Energy Project: Fisheries and Marine Life Interaction

Gayle Zydlewski, Jim McCleave
Haley Viehman, Garrett Staines, Jeff Vieser
Haixue Shen, Megan Altenritter

U.S. DEPARTMENT OF ENERGY

DE-00006384

Study design and additions in 2014



DOE funding started in January 2014:

Interactions of aquatic animals with the ORPC OCGen® in Cobscook Bay, Maine: Monitoring behavior change and assessing the probability of encounter with a deployed MHK device

The **goal** of this project is to quantify aquatic animal behavior changes associated with the presence of a deployed marine hydrokinetic (MHK) device.

Specific objectives:

(i) long-term seasonal hydroacoustic dataset near an MHK device;

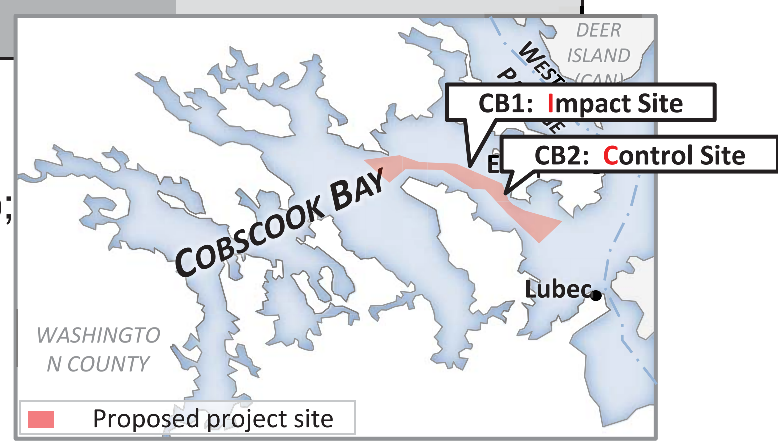
(ii) new analytical methods to improve species identification;

(iii) an encounter probability model;

(iv) side-looking hydroacoustics at TidGen®

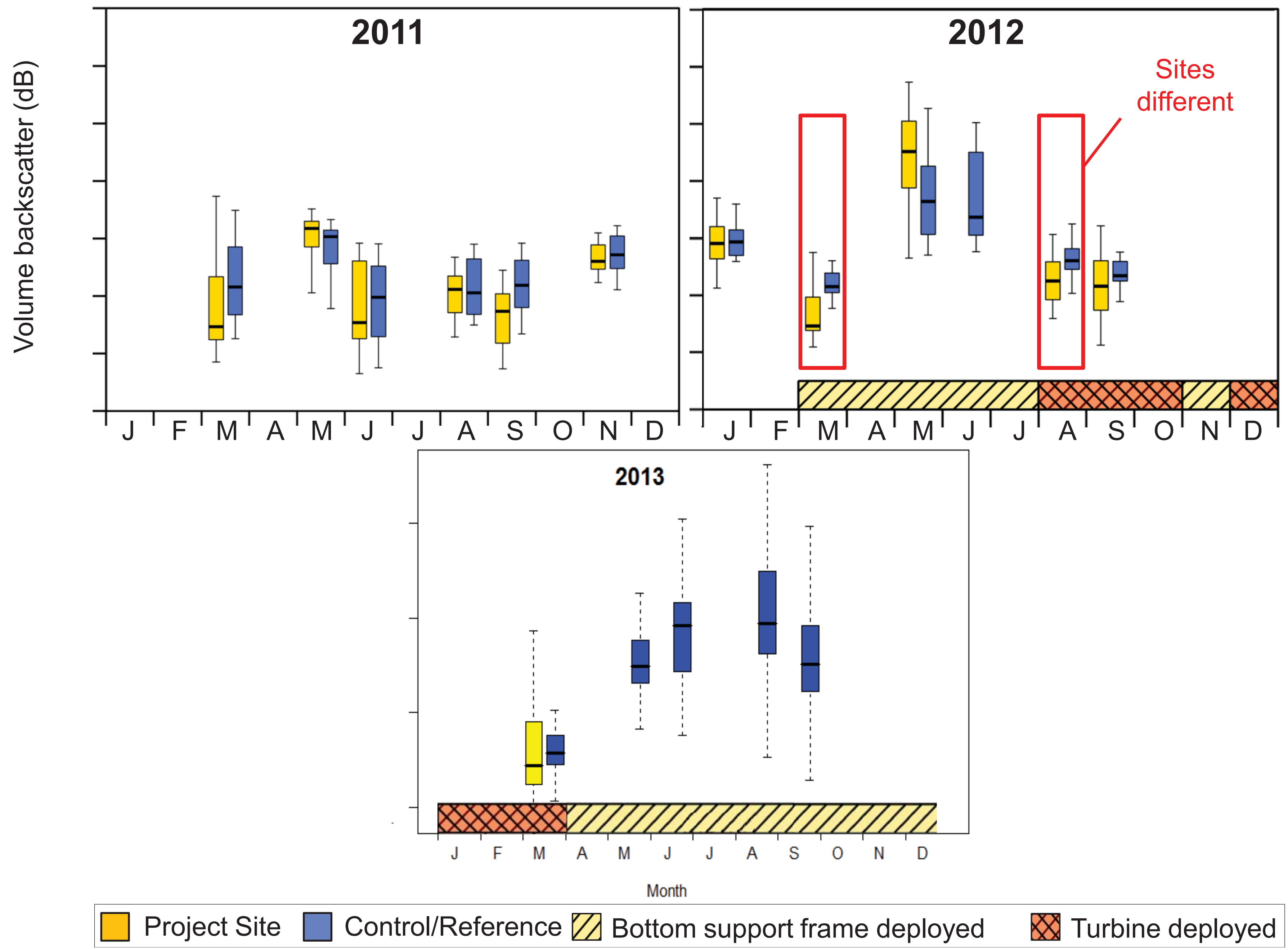
(i) Long-term dataset: 2011-2013

Month	Year 2011	Year 2012	Year 2013
Jan		1, 2	
Feb			
Mar	1, 2	1, 2	1a, 1b, 2
April			
May	1, 2	1a, 1b, 2	2
June	1,2	2	2
July			
Aug	1, 2	1a, 1b, 2	2
Sept	1, 2	1a, 1b, 2	2
Oct			
Nov	1, 2		
Dec			

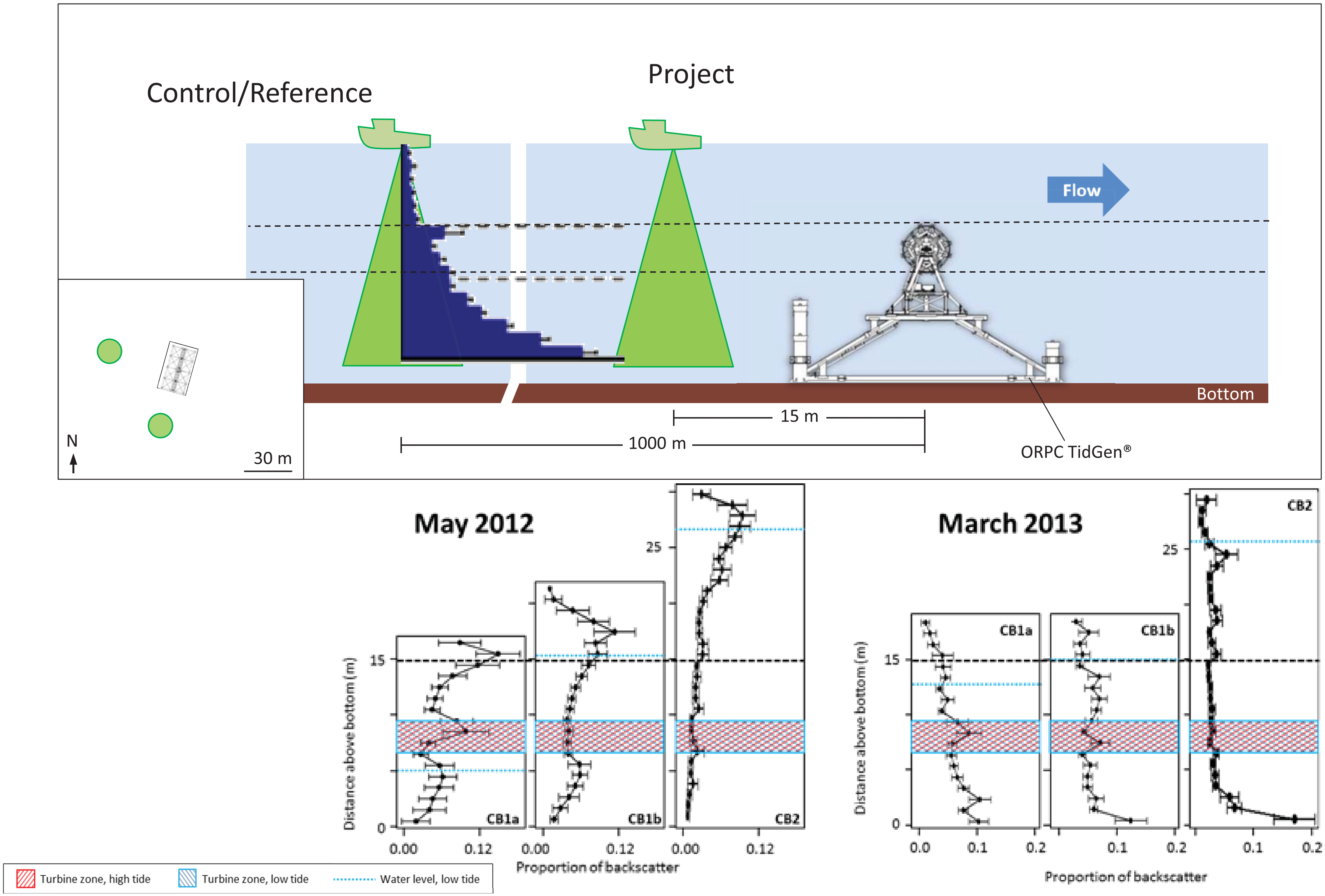


1 = project site (a = beside turbine, b = in-line with turbine);
2 = control site.
White = pre-deployment;
Light grey = TidGen® bottom frame deployed;
Dark grey = TidGen® turbine deployed.

Seasonal patterns of relative abundance



Proportion of fish at different depths

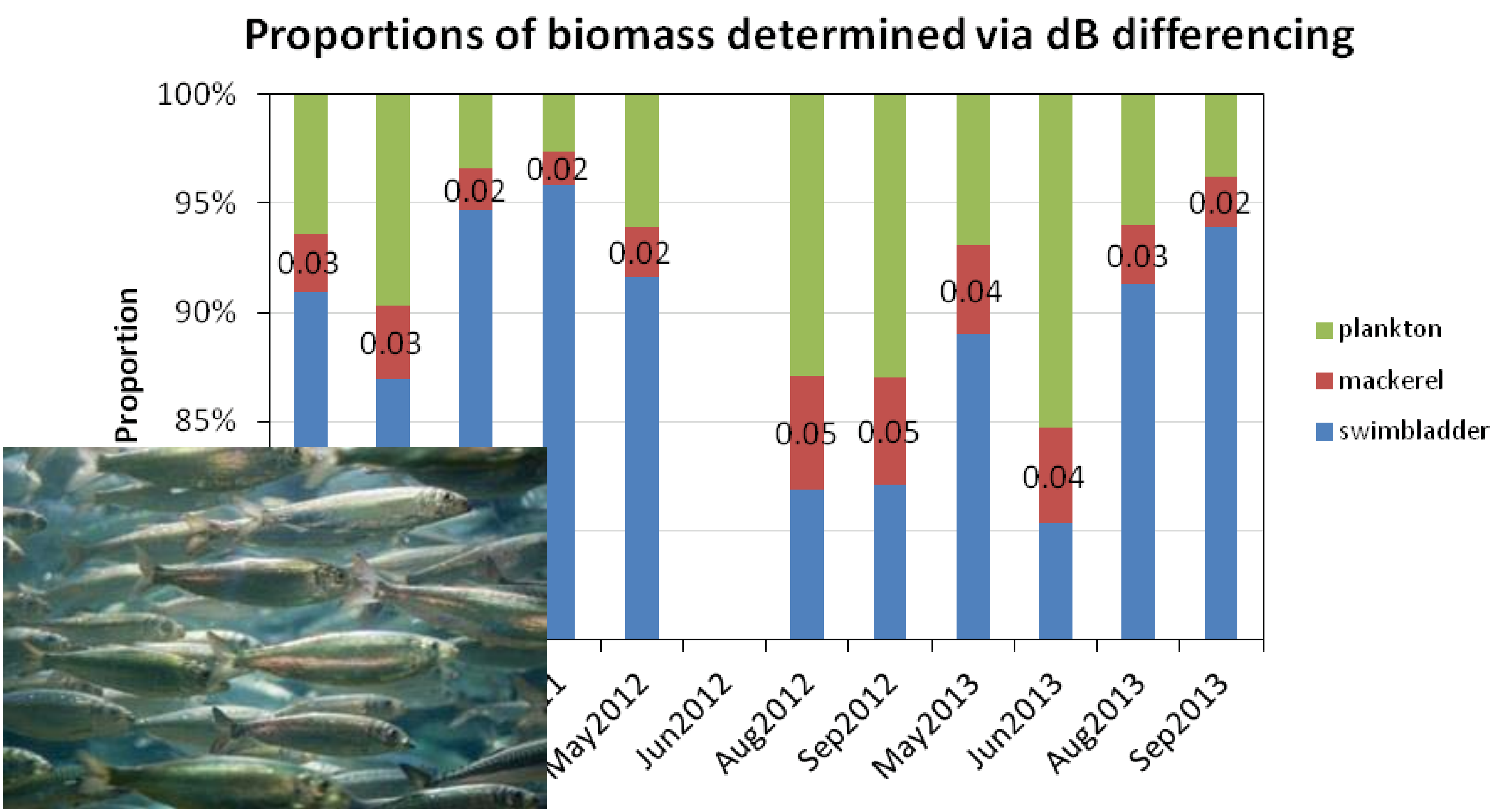


2014 downlooking data collection

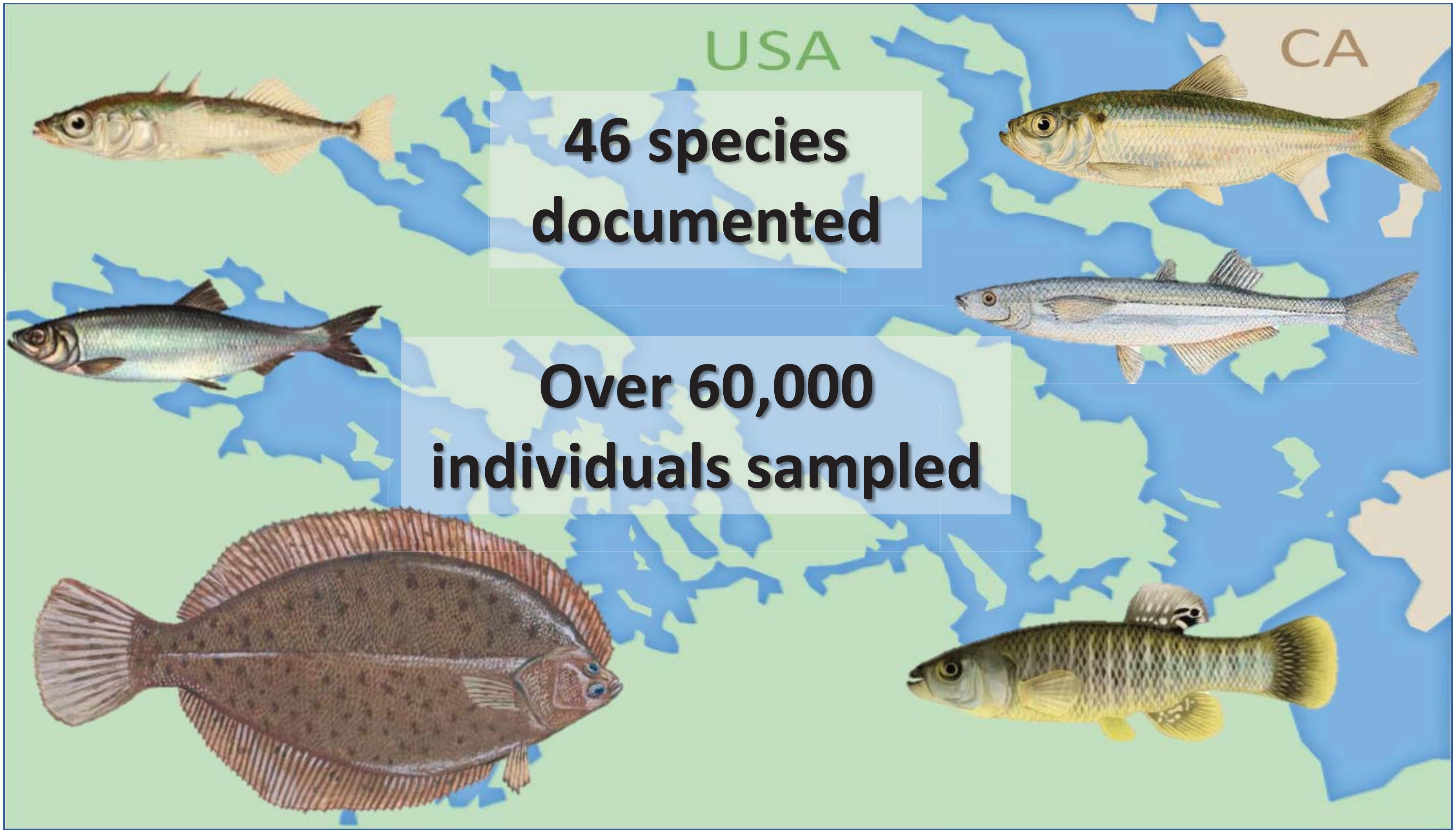
Date	Site(s)	OCGen® Present	Turbine Rotating	Lunar Stage
Mar 9, 2014	CB2	No	NA	1st qtr; neap
May 22, 2014	CB2	No	NA	3rd qtr; neap
Aug 5, 2014	**CB1a, CB1b, CB2**	**Yes**	**Yes**	**1st qtr; neap**
Aug 17. 2014	CB1a, CB1b, CB2	Yes	No	3rd qtr; neap
Aug 25, 2014	CB1a, CB1b, CB2	Yes	No	new; spring
Sep 20, 2014	CB1a, CB1b, CB2	No	NA	3rd qtr; neap
Nov 17, 2014	CB2	No	NA	3rd qtr; neap

ii. New methods for improving species identification

Objective: *Develop dB differencing methods for down-looking hydroacoustic data*



What is in the Bay? – Vieser MS thesis
& data collected in 2014

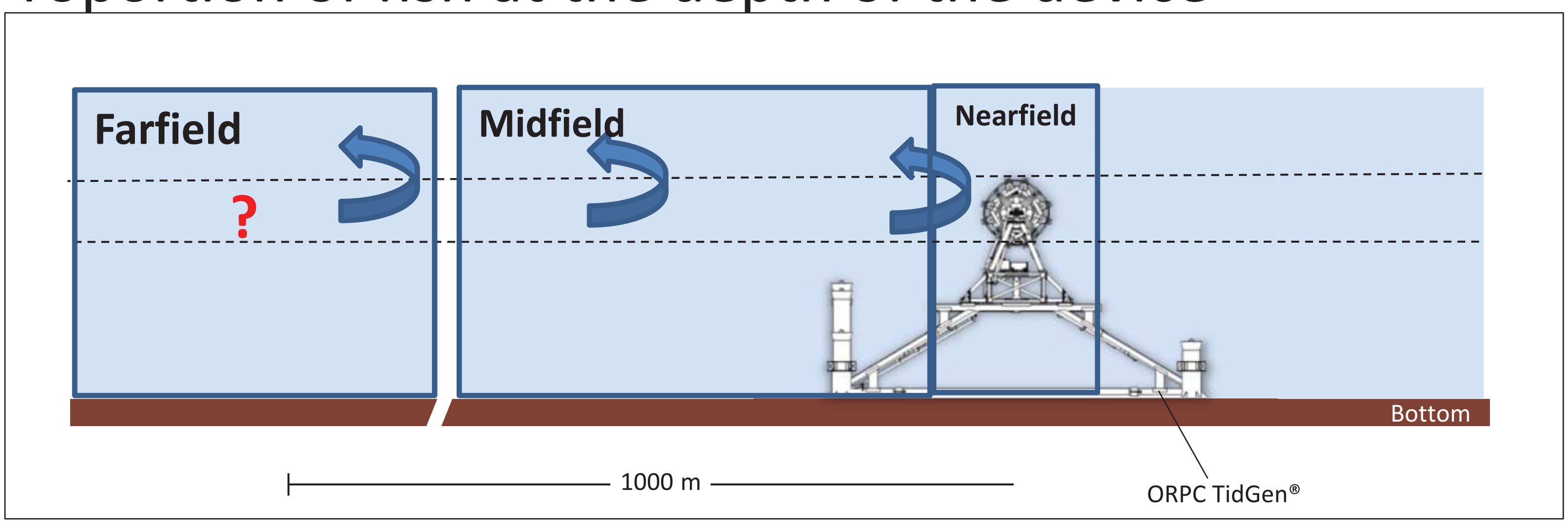


(MacDonald et al. 1984, Jung and Houde 2003)

(iii) Encounter probability model

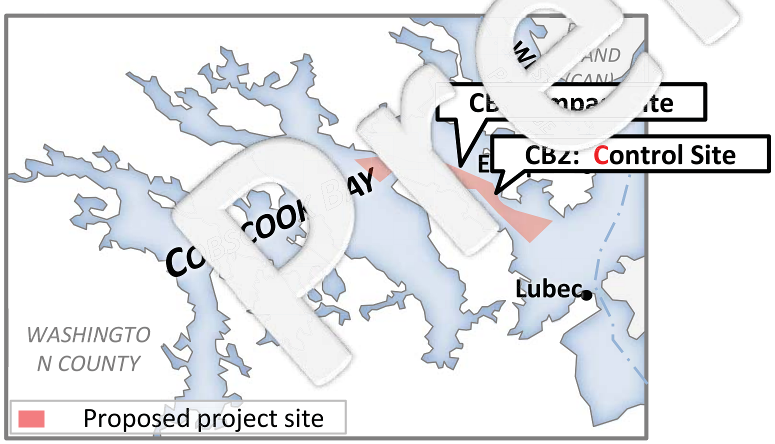
What is the probability that a fish will encounter an MHK device?

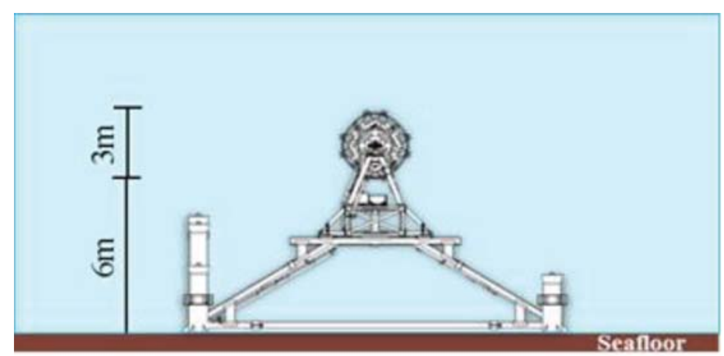
1. **Near-field** – within 5 m of a blade
   – DIDSON (Viehman and Zydlewski 2014)
2. **Far-field** –no expected effects of the device
   – Abundance & distribution (Viehman et al. 2014)
3. **Mid-field** – within the hydrodynamic effects, 100s m
   – Proportion of fish at the depth of the device



Probability of fish at the depth spanned by the entire device ([illegible]-9 m) and the depth spanned by the turbine blades ([illegible])

Location	Year	Probability at 0-9m above seafloor	Probability at 6-9m above seafloor
Project site	2011	79.3% (75.0% - [illegible]3.6[illegible])	8.32% (6.43% - 10.3%)
	2012	65.2% (54.3% - 7[illegible]%)	8.97% (6.86% - 11.3%)
Control site	2011	78.3% ([illegible]% - [illegible]0%)	8.43% (7.23% - 9.72%)
	2012	6[illegible].4% ([illegible]1.5% - 73.1%)	8.63% (6.73% - 10.6%)
	2013	65.[illegible] (61.4% - 70.1%)	9.31% (8.11% - 10.5%)

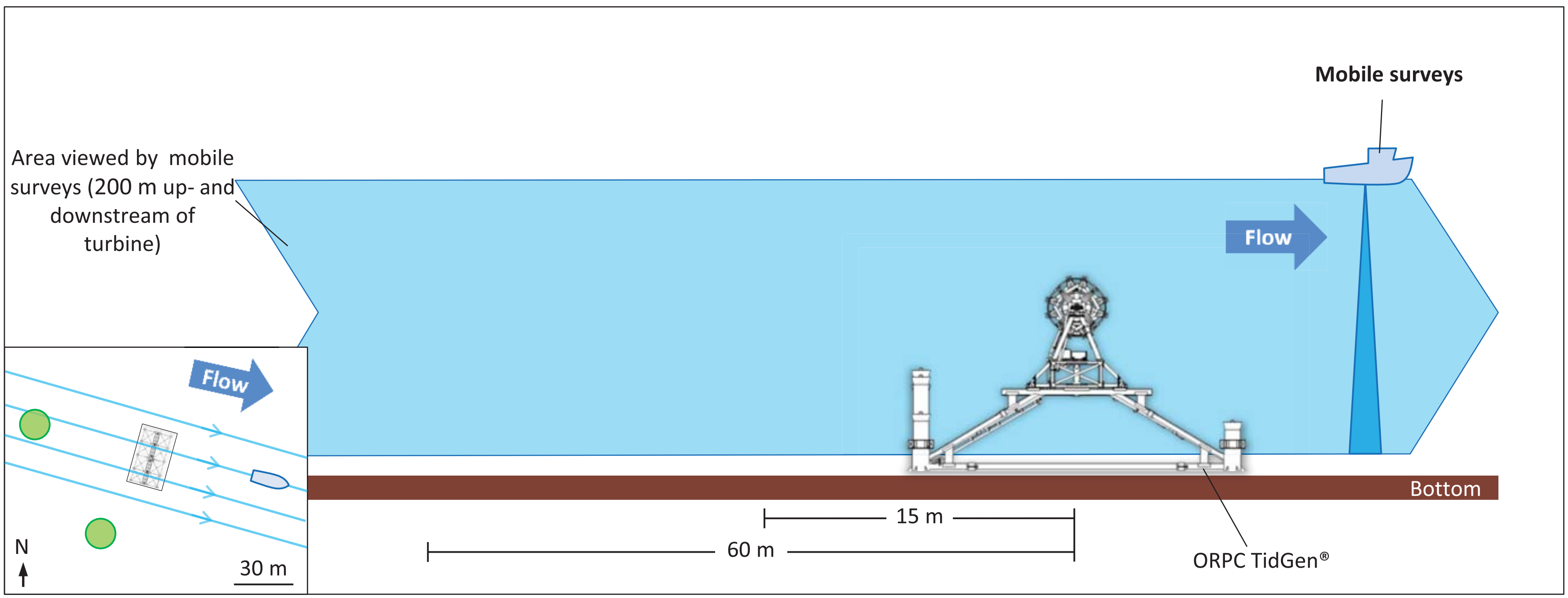




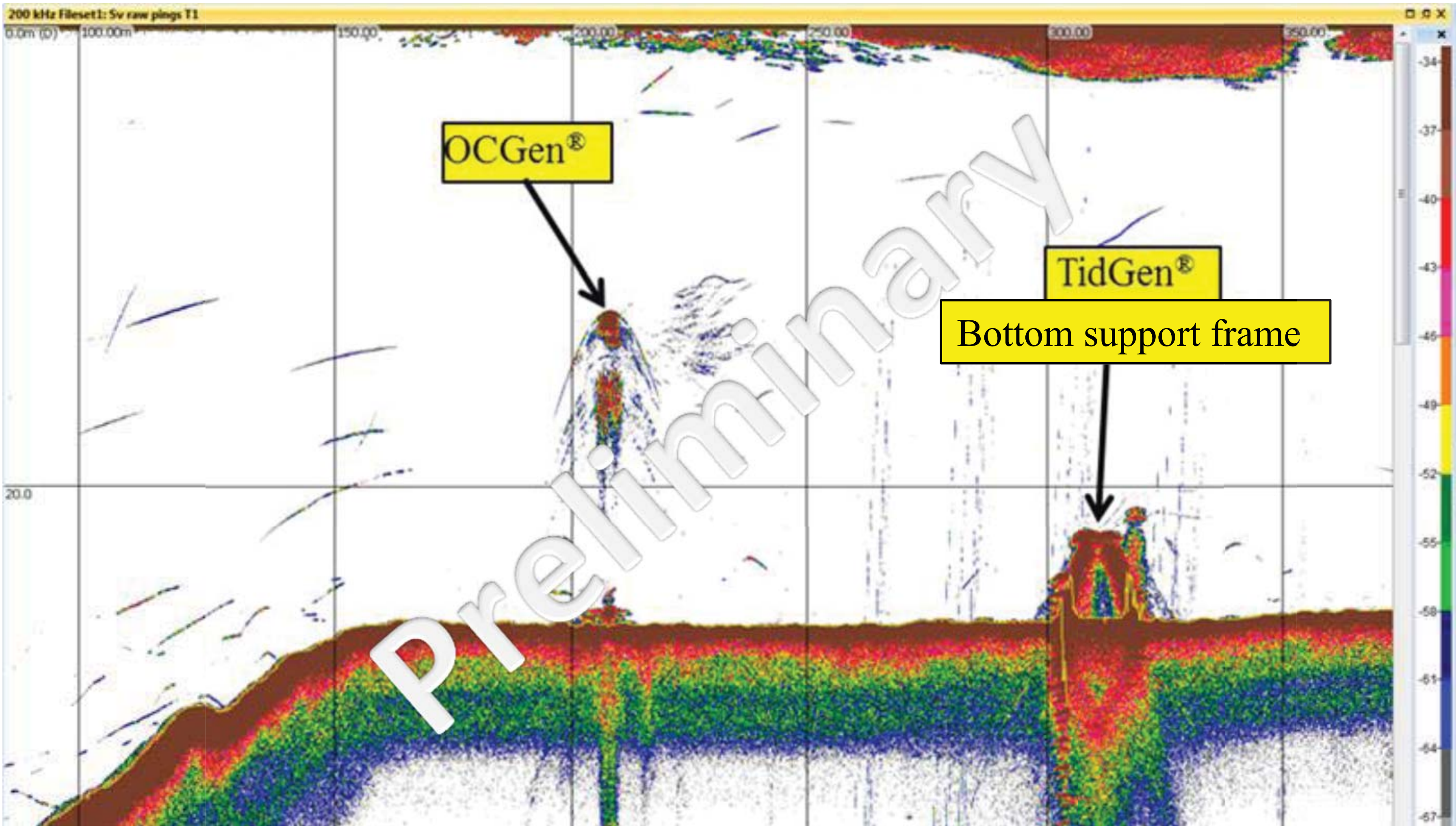
Comparison of fish vertical distribution between project and control sites

Year	Month	Tide stage	p-value
2012	Mar	Ebb	0.279
		Flood	0.362
	May	Ebb	0.381
		Flood	0.522
	Aug	Ebb	0.145
		Flood	0.515
	Sep	Ebb	0.594
		Flood	0.559
2013	Mar	Ebb	0.279
		Flood	0.362

Midfield: 100s m

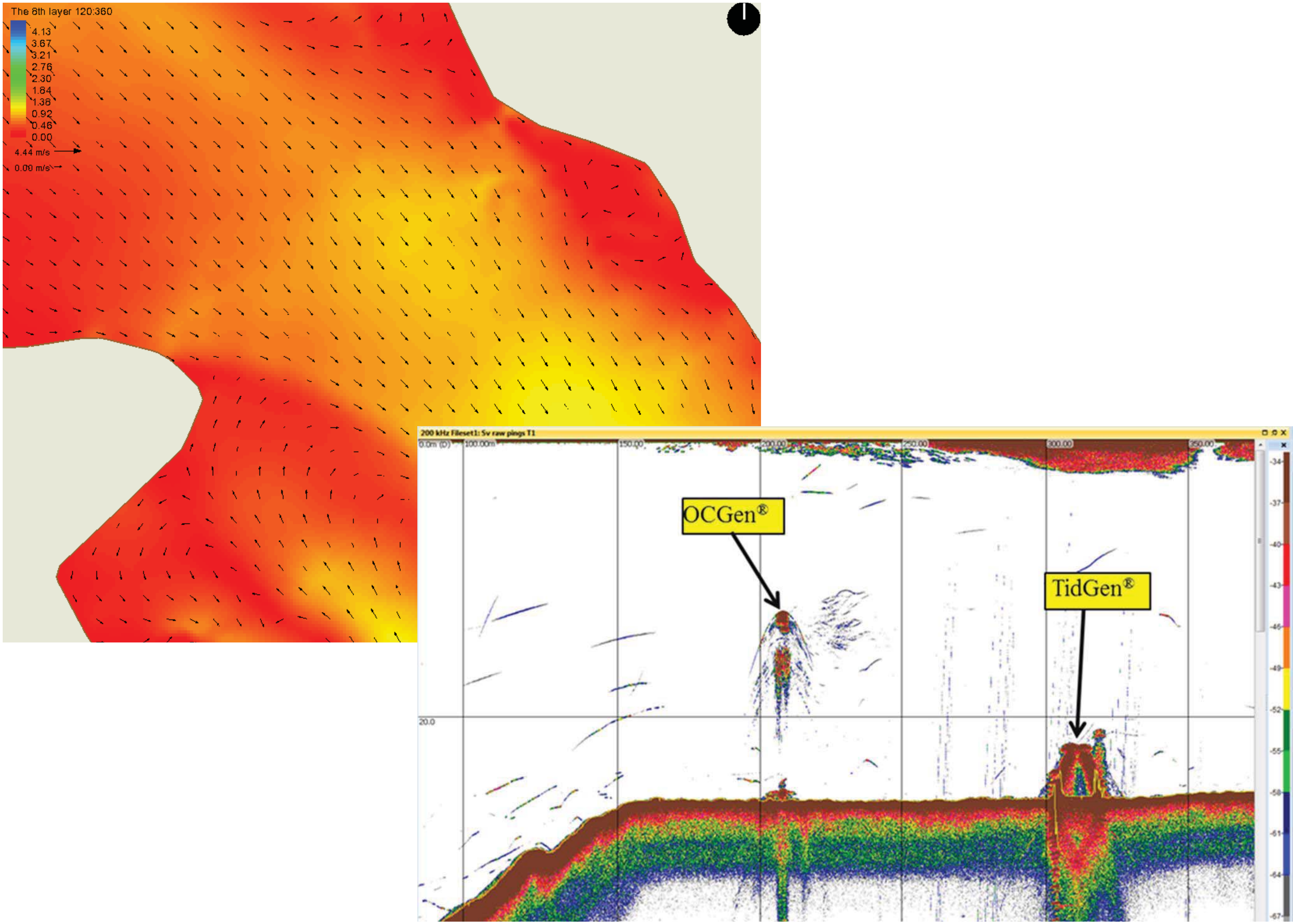


Example of mobile transect



Mobile transects

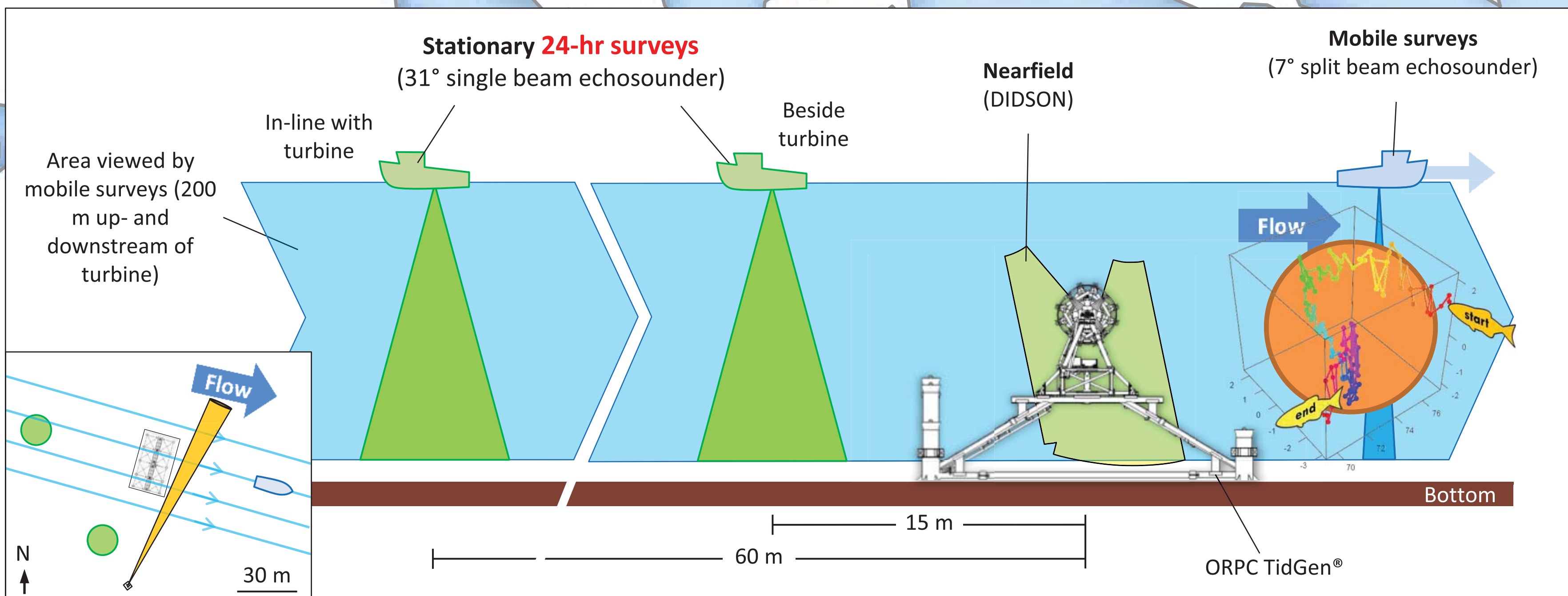
Start time	End time	Tide	No. of transects
7/29/2014 14:00	7/29/2014 19:30	Ebb	29
7/29/2014 20:29	7/30/2014 1:10	Flood	27
7/30/2014 2:20	7/30/2014 7:40	Ebb	13
7/30/2014 8:50	7/30/2014 13:45	Flood	29
7/30/2014 15:00	7/30/2014 19:50	Ebb	29
7/30/2014 21:20	7/31/2014 2:05	Flood	16
7/31/2014 3:20	7/31/2014 8:00	Ebb	27
7/31/2014 9:30	7/31/2014 14:15	Flood	28
7/31/2014 21:20	8/1/2014 2:40	Flood	21
8/1/2014 9:50	8/1/2014 15:13	Flood	31
8/1/2014 22:20	8/2/2014 3:20	Flood	25
8/2/2014 10:50	8/2/2014 16:10	Flood	29
8/2/2014 23:00	8/3/2014 4:00	Flood	26
8/3/2014 11:30	8/3/2014 16:30	Flood	26
8/13/2014 21:10	8/14/2014 3:00	Flood	35
8/14/2014 22:00	8/15/2014 3:00	Flood	26
8/15/2014 10:00	8/16/2014 15:10	Flood	27
8/15/2014 23:00	8/16/2014 1:40	Flood	16
8/16/2014 11:20	8/16/2014 15:40	Flood	24



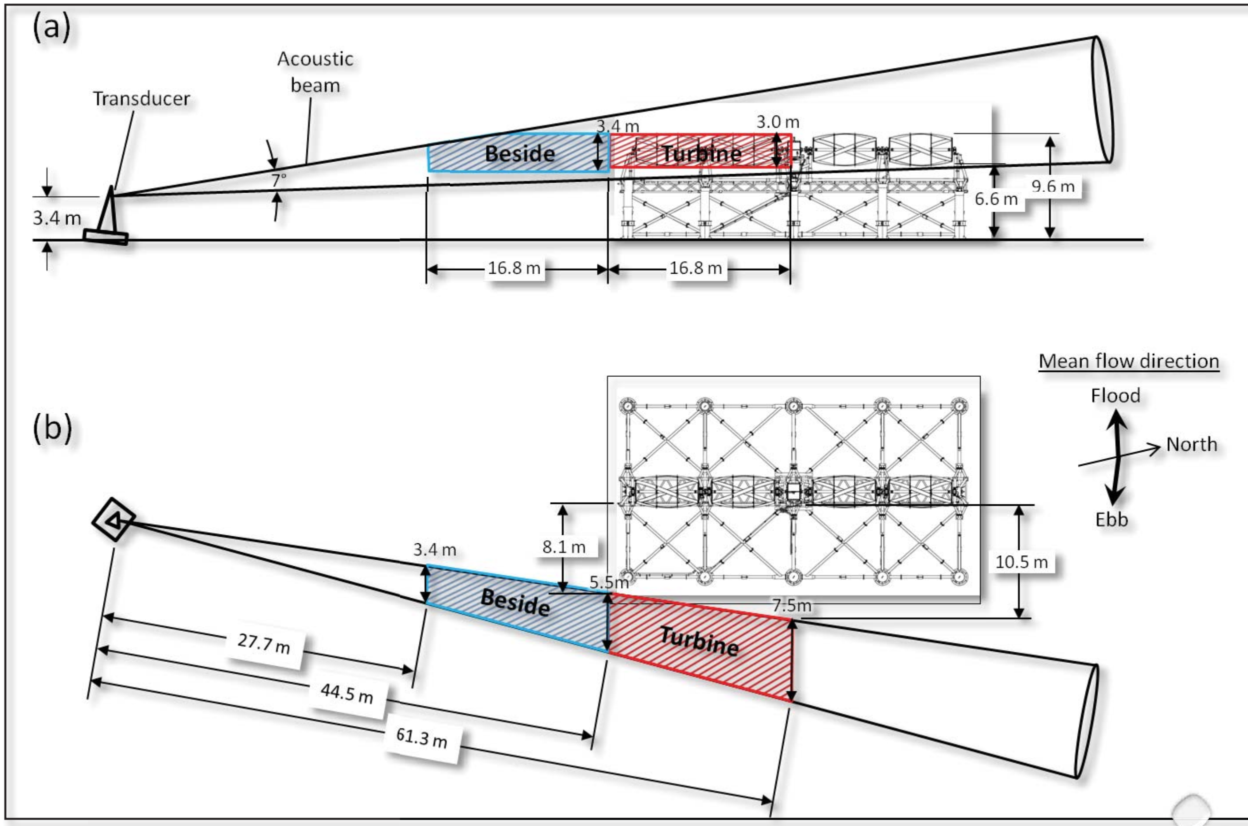
The 8th layer 120:360
4.13
3.67
3.21
2.76
2.30
1.84
1.38
0.92
0.46
0.00
4.44 m/s
0.00 m/s
200 kHz Fileset1: Sv raw pings T1
OCGen®
TidGen®
20.0

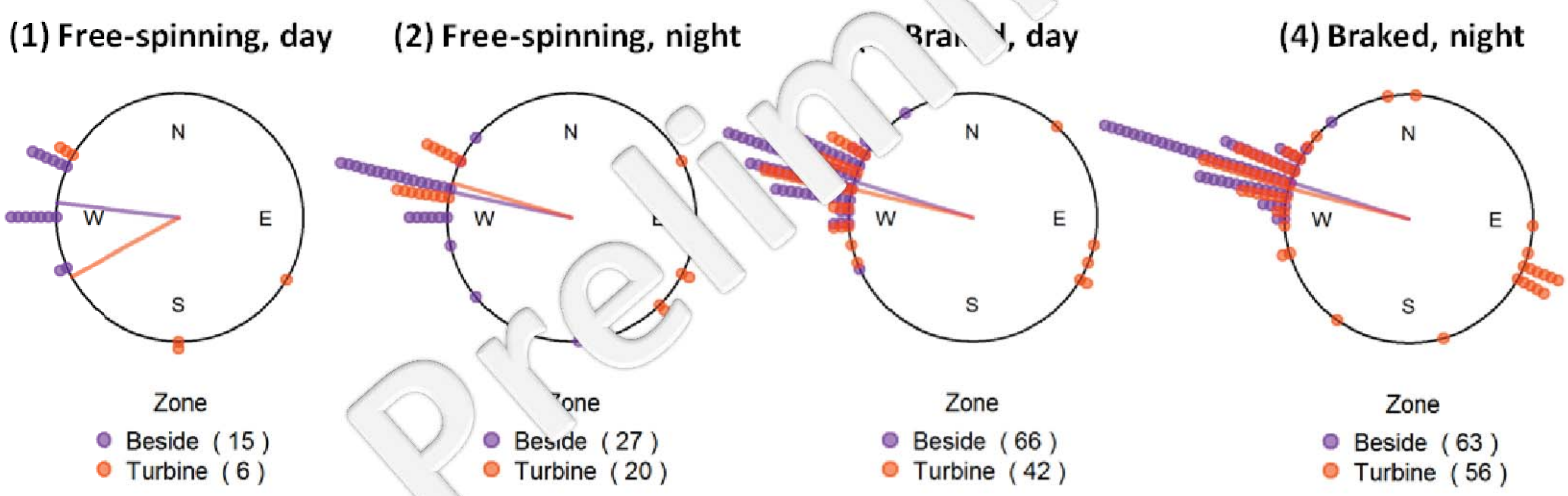
(iv) Side-looking hydroacoutics at TidGen®

Determine sampling periodicity to represent variability over a month

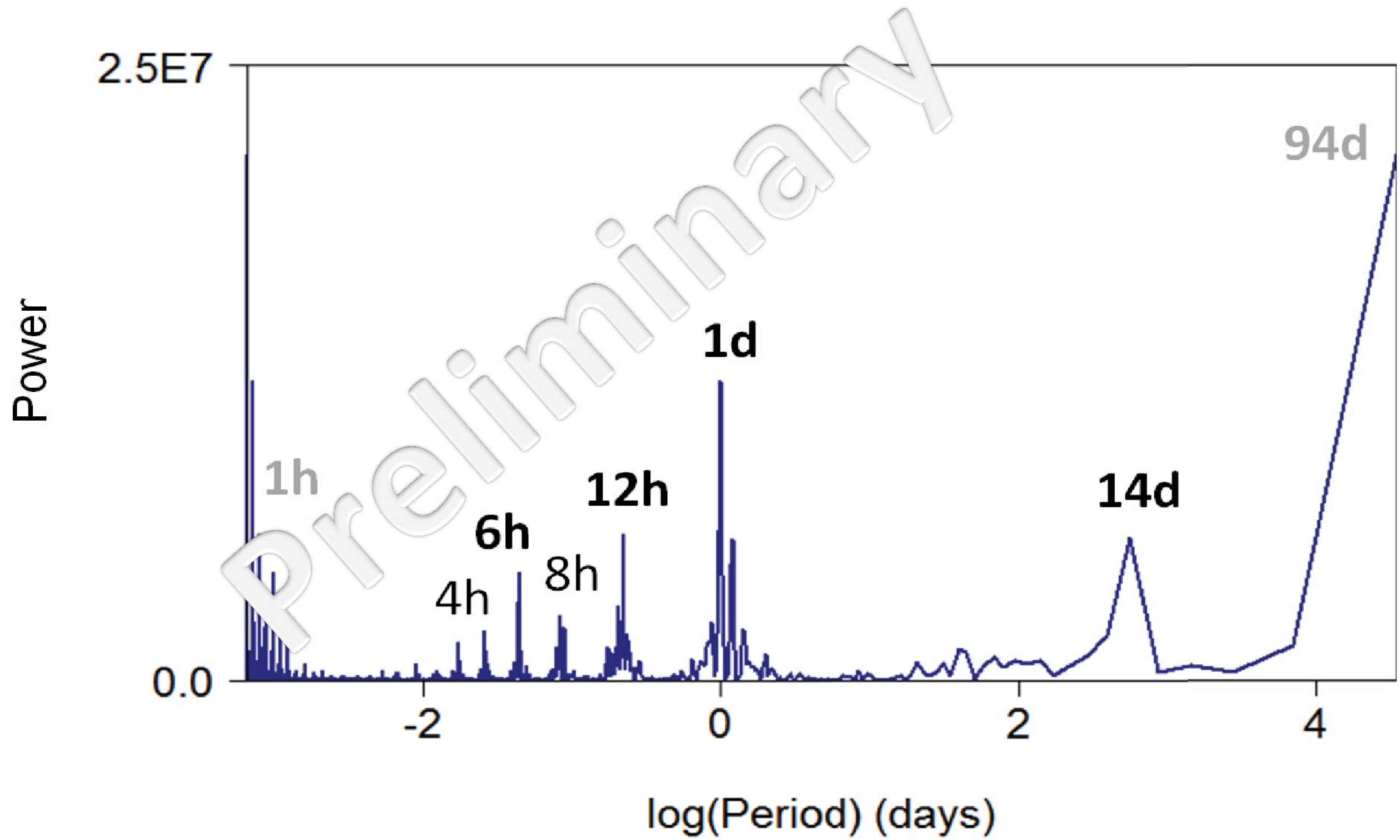


Turbine status	Data collection (between gaps)	Amount of side-looking acoustic data collected
Operational	During slack tide only	76 d, 5.8 hr
Free-spinning	Continuous	4 d, 0 hr
Braked	Continuous	33 d, 16 hr
Absent	Continuous	257 d, 18.4 hr


(a)
Transducer
Acoustic beam
7°
3.4 m
Beside
Turbine
3.4 m
3.0 m
6.6 m
9.6 m
16.8 m
16.8 m
(b)
Mean flow direction
Flood
North
Ebb
3.4 m
8.1 m
5.5m
7.5m
10.5 m
27.7 m
44.5 m
61.3 m


(1) Free-spinning, day
(2) Free-spinning, night
(4) Braked, night
N
S
E
W
Zone
Beside (15)
Turbine (6)
Beside (27)
Turbine (20)
Beside (66)
Turbine (42)
Beside (63)
Turbine (56)

Temporal analysis

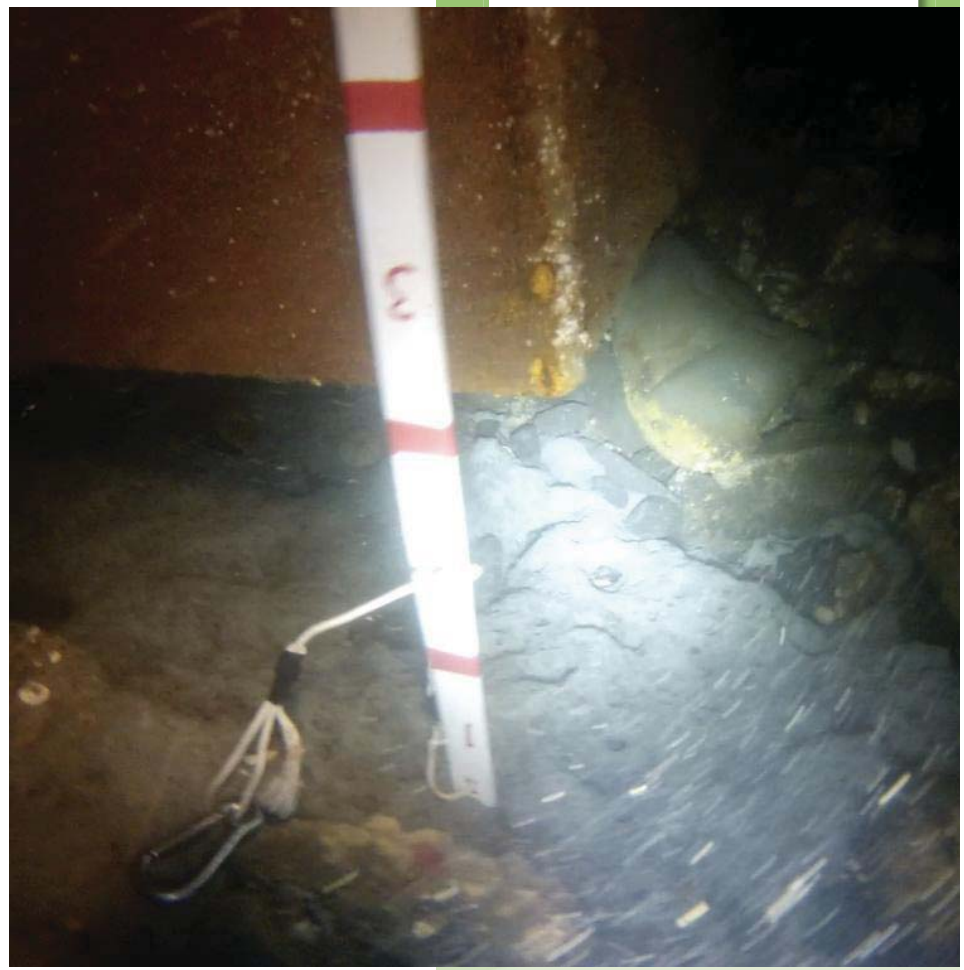


Future

- November control sample
- 2014 data analysis
  - Most data collected in Aug/Sep is being processed
  - Add to
    - Long-term dataset
    - Make correlations with trawl data
    - dB differencing
    - Probability of encounter
    - ELAM model
    - Free-spinning TidGen®
    - Temporal analysis of fish presence for optimizing sampling

OCGen® - Scour Monitoring

- Minimal horizontal movement of anchors (3-4 inches maximum)
- Localized scour at one corner location, maximum depth approximately 1 ft
- Settling of both anchors occurred to height of steel skirt (19 inches)



OCGen® Retrieval

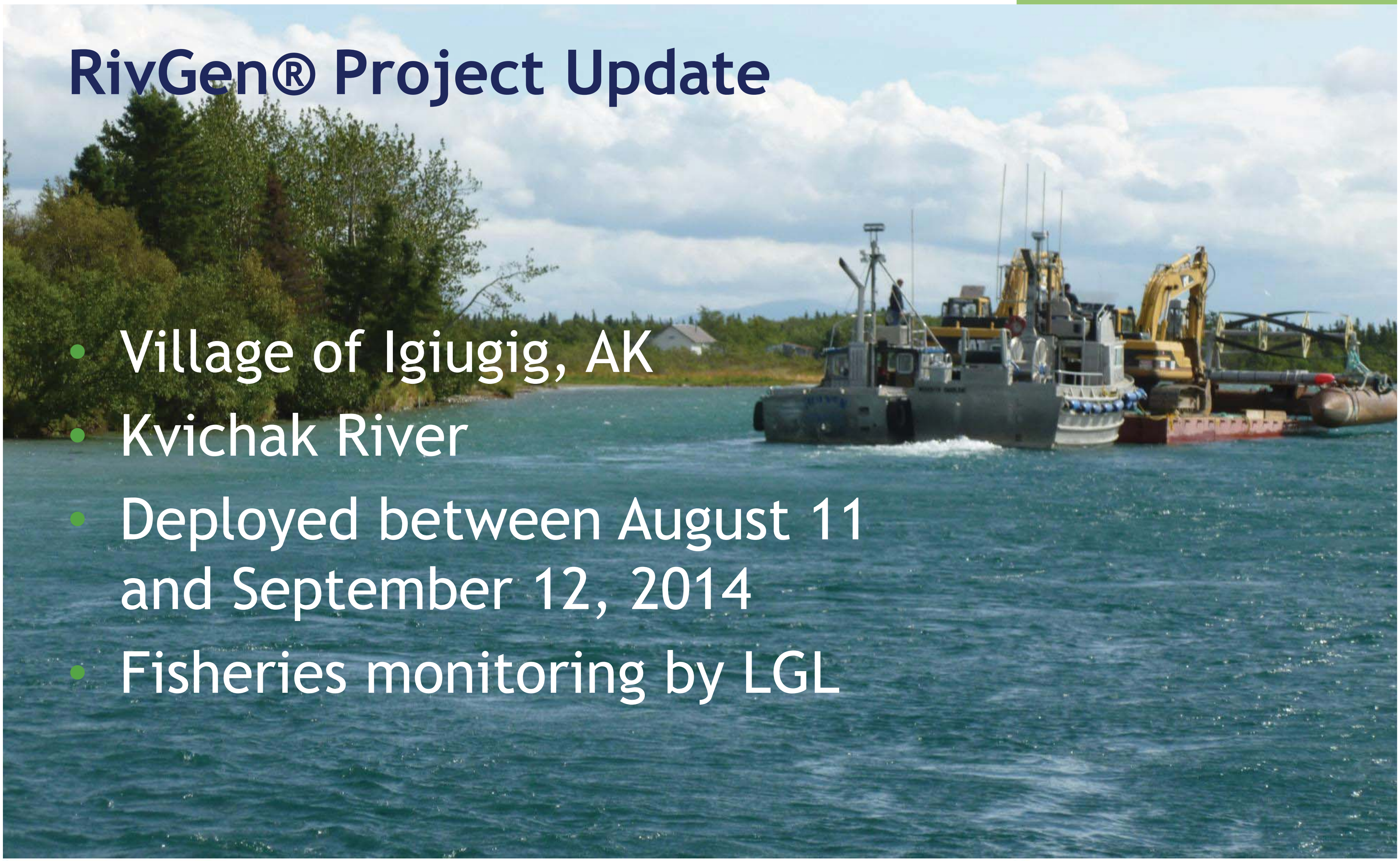
Relevance of Results

- Successful demonstration of OCGen® module installation, anchoring and retrieval methods
- Opportunity to assess benthic growth on BSF, further evidence of reef effect
- UMaine survey of fisheries interaction contributes to knowledge base
- Scour monitoring indicates minimal movement of anchors

Potential Testing Opportunities

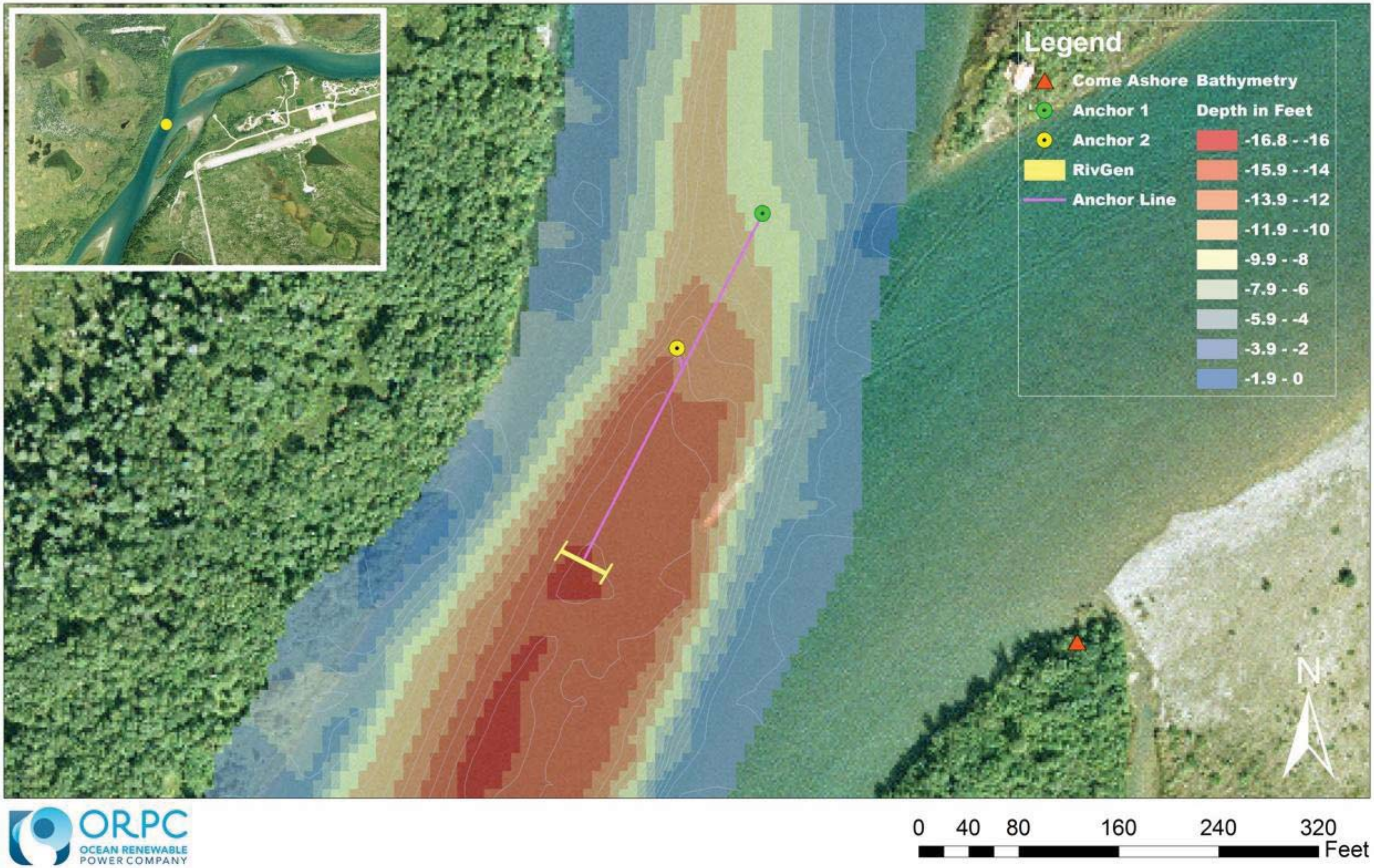
- ORPC's Cobscook Bay site has gained interest from other industry partners for the following reasons:
  - Demonstrated permitting and licensing process
  - Existing infrastructure (support structure, power and data cable, shore station)
  - Environmental, bathymetric and resource data
  - Experienced staff, local partners and regulators

RivGen® Project Update



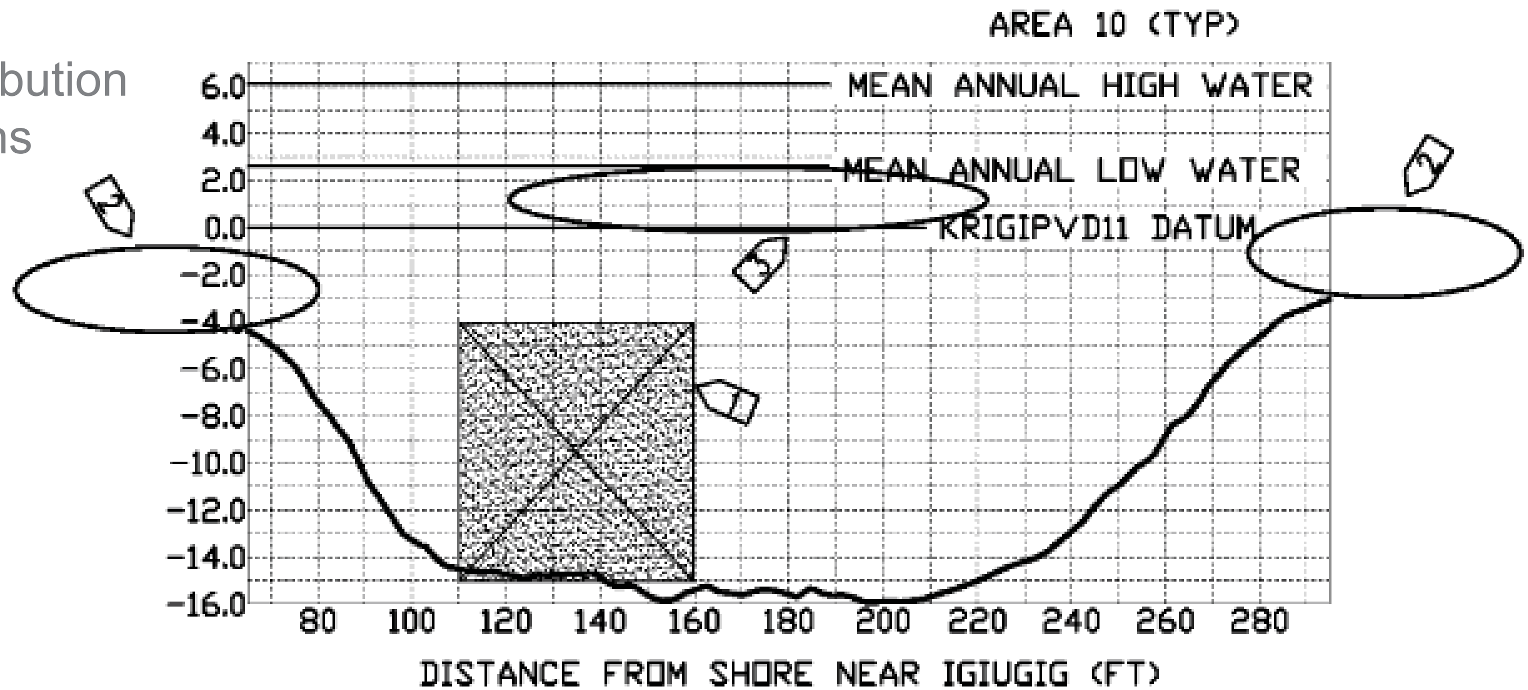
- Village of Igiugig, AK
- Kvichak River
- Deployed between August 11 and September 12, 2014
- Fisheries monitoring by LGL

ORPC OCEAN RENEWABLE POWER COMPANY


Legend
Come Ashore
Anchor 1
Anchor 2
RivGen
Anchor Line
Bathymetry
Depth in Feet
-16.8 - -16
-15.9 - -14
-13.9 - -12
-11.9 - -10
-9.9 - -8
-7.9 - -6
-5.9 - -4
-3.9 - -2
-1.9 - 0
N
0 40 80 160 240 320
Feet

Fisheries - Spatial Presence

- Smolt distribution
- Adult returns



Fisheries - Temporal Presence

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

S
5
12
19
26

FEBRUARY

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

MARCH

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17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

APRIL

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28	29	30				

MAY

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26	27	28	29	30	31	

JUNE

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30						

JULY

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28	29	30	31			

AUGUST

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11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

SEPTEMBER

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15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

OCTOBER

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		1	2	3	4	5
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20	21	22	23	24	25	26
27	28	29	30	31		

NOVEMBER

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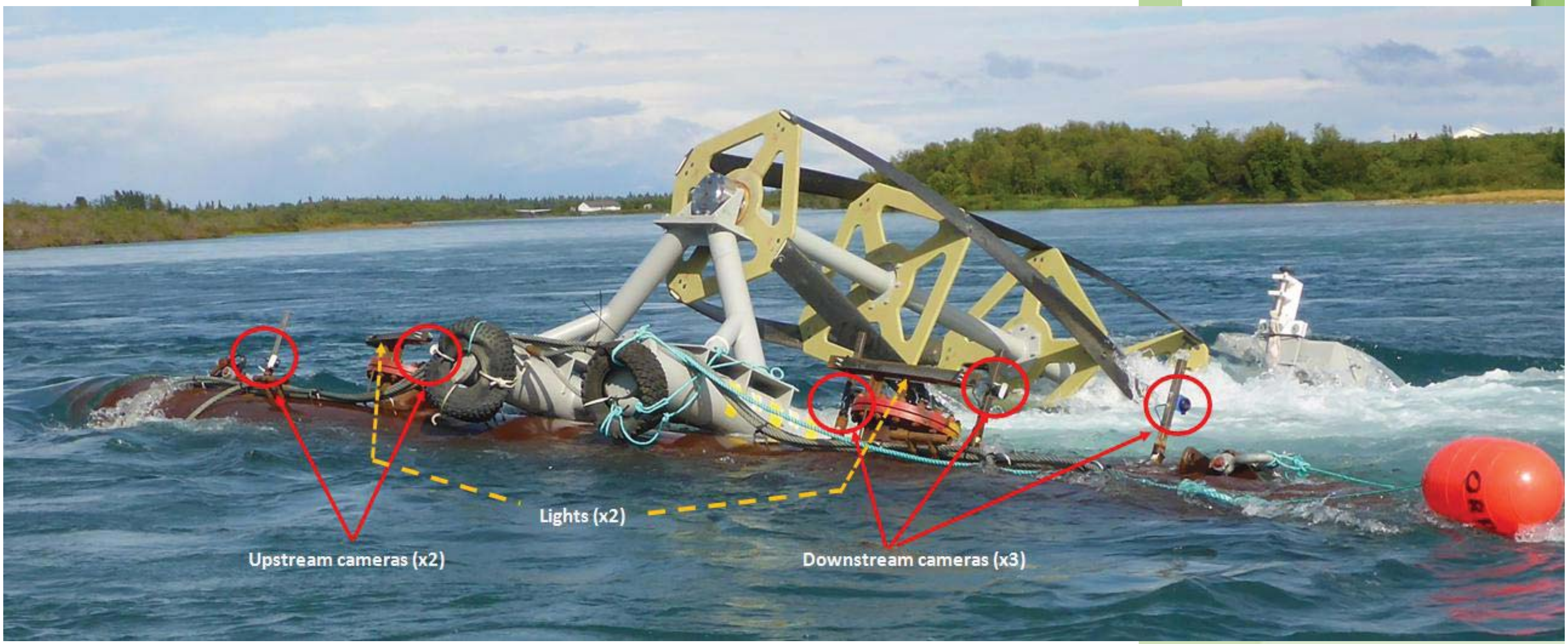
17	18	19	20	21	22	23
24	25	26	27	28	29	30

DECEMBER

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

OCEAN RENEWABLE POWER COMPANY

RivGen® Installation



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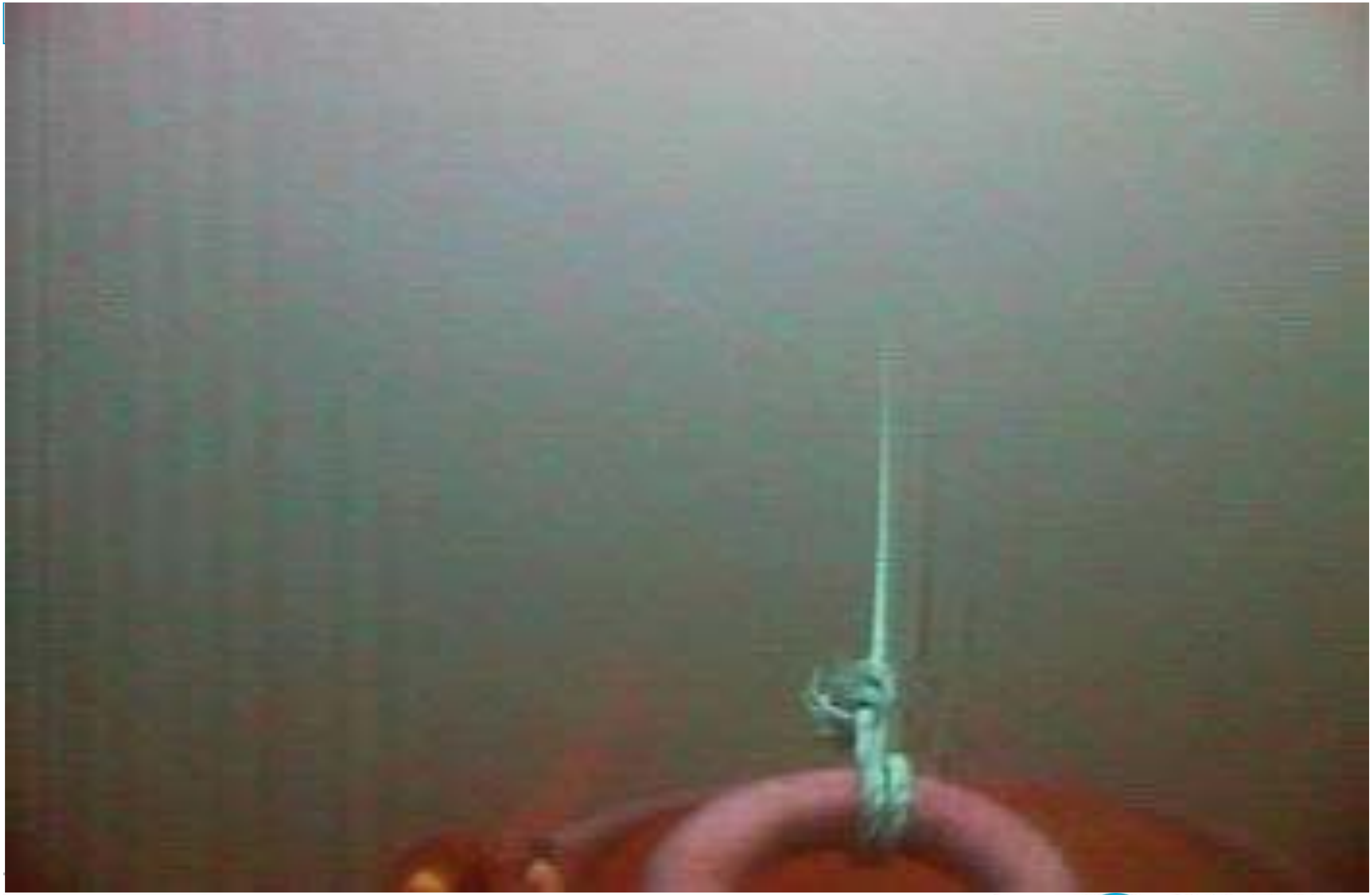
OCEAN RENEWABLE POWER COMPANY



OCEAN RENEWABLE POWER COMPANY

[redacted]

RivGen® Next Steps

- USDA Phase II Project
- 2015 demonstration in Igiugig
- 2016 commercial installation in Igiugig (pending AEA funding)

Technology Optimization Overview

- **Overall goals**
  - Higher efficiency, less weight, lower production cost, increased reliability, reduced cost of electricity
- **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)
    - Two universities (U. Washington and U. 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 and visa versa**

Technology Optimization Summary

Project Focus	Goal	Cost	Funding Source	Partners	End Date
Advanced Forward Controls	Optimize energy harvesting capability	$2.2 m	• US DOE: $1.7m • Cost share: $475K	• U of Wash • NREL	Dec. 2015
Power Take Off	Next generation driveline, bearings couplings, generator	$3.8m	• US DOE: $2.8m • Cost share: $928K	• U of Alaska • Aero Craft • RCT Systems • NREL	Jan. 2016
Fairing and foil design, support structure and testing	Ability to harness slower moving current	$1.55m	• USDA SBIR Phase I: $100K Phase II: $450 K • MTI:$1m	• BluSource Energy • Marsh Creek • Aero Craft • Sandia Nat'l Lab	March, 2016

Technology Optimization Progress

2013

- ✓ Proposals submitted
- ✓ Funding awarded
- ✓ Contracts signed
- ✓ Projects commence

2014

- ✓ Models developed
- ✓ Design and cost parameters defined
- ✓ Initial advanced controls field work completed

2015

- ❑ Designs finalized
- ❑ Additional field work completed

2016

- ❑ Power systems ready for commercial sale and a return to Cobscook Bay

Temporary Variance Request

- FERC order issued on October 29 after the following:
  - ORPC memo to AMT on August 21, 2013
  - Discussion at AMT meeting on September 10, 2013
  - ORPC submittal to FERC on September 19, 2013
- ORPC provided project updates on May 22 and September 31, 2014.
- Based on temporary optimization phase and continued monitoring in 2014 ORPC is requesting an extension to the variance

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

Temporary Variance Request

Request process:

- ORPC is presenting request at October 15 Adaptive Management Team
- AMT concurrence will be sought following meeting discussion
- Extension request, with support from the AMT, will be submitted to FERC

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
- ORPC has developed a strategy to continue developing the Western Passage site

ORPC Priorities

- TidGen® Optimization
- RivGen® Commercialization Project
- Western Passage permitting
- ORPC Solutions
  - Governor's Energy Office Hydropower Study
  - Wave energy project
  - Feasibility studies

Action Items and Assignments

- ORPC will generate meeting minutes and distribute for review
- AMT concurrence and/or questions regarding pilot license extension
- AMT concurrence and/or questions on the temporary variance extension
- Notice of new address: 66 Pearl St, Portland

Thank you from the ORPC Team!

For more information:

Nathan Johnson
Director of Environmental Affairs
njohnson@orpc.co
207-772-7707
visit www.orpc.co

Appendix C

Nemeth, M. J., Priest, J.T. & Patterson, H.M. 2014. Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014.

Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014

Prepared for

Gray Stassel Engineering, Inc.
P. O. Box 111405,
Anchorage, Alaska 99511-1405

December 2014

Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014

by

Matthew J. Nemeth, Justin T. Priest, and Heather M. Patterson

LGL Alaska Research Associates, Inc.
2000 W. International Airport Road, Suite C1
Anchorage, Alaska 99502

for

Gray Stassel Engineering, Inc.
P. O. Box 111405,
Anchorage, Alaska 99511-1405

December 2014

Suggested format for citation:

Nemeth, M. J., J. T. Priest, and H. M. Patterson. 2014. Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014. Final report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for Gray Stassel Engineering, Anchorage, AK. 28 pp. + appendices.

EXECUTIVE SUMMARY

Two river instream hydrokinetic (RISEC) devices were installed in the Kvichak River, Alaska in 2014 to demonstrate the ability to generate hydroelectric power. Fish and wildlife were monitored nearby to describe their presence and to document any negative effects from the devices. Fish were monitored using underwater video cameras and lights mounted to each device; wildlife (birds and mammals) were monitored using shore-based surveys by trained biologists and technicians. Both devices were installed near the village of Igiugig, submerged in the river until sitting on the river bottom, and operated intermittently in August and September.

Fish were present at each device and were seen travelling upstream, travelling downstream, and milling. Most observed fish were salmon and salmonids (*Oncorhynchus* spp.) and moved freely around each device. No fish were detected moving through the turbine part of the larger device, which was manufactured by the Ocean Renewable Power Corporation. At the smaller device, manufactured by Boschma Research, Inc., one lamprey (*Lampetra* spp.) was detected moving downstream through the part of the device housing the turbine. Overall, salmon were clearly less abundant at the devices than along the edges of the river nearby and showed no negative effects from the devices. Wildlife consisted almost entirely of birds, had no contact with or negative effects from the devices, and showed no behavioral changes when nearby.

The fish monitoring design was also meant to test the ability to use underwater cameras to monitor fish in the type of conditions found on the Kvichak River. Cameras were able to detect fish from 10 to 15 feet away, depending on water clarity; this range allowed coverage of 1/3 of the ORPC device and of the entire entrance and exit of the BRI device. In the daytime, ambient light was sufficient for fish detection; at night, lights placed nearby allowed video recording to continue with no loss of effectiveness. All cameras and lights were fixed directly to the devices in a design finalized once on site, and were powered from shore. Cameras and lights were able to be started within 1 to 12 hours after deployment of each device, and operated effectively thereafter with no breakdowns.

Camera images were recorded on shore at a temporary recording station, where footage could be viewed in real time during daily site visits by trained technicians. Imagery was then transferred to a laptop computer and reviewed nearby in Igiugig. A subsample of 10 minutes was reviewed from each hour of video footage (from each camera); most of these 10-minute blocks were able to be reviewed within two days of original recording. Video imagery was recorded during all operation time by the ORPC device and 72% of the operating time by the BRI device.

Overall, fish were seen at rates of less than one fish per 10-minute block of video reviewed at each device. This rate was likely a function of the device placement (relatively far offshore, in water that was deeper and faster than other parts of the river channel), and timing (after the peaks of both the juvenile and adult sockeye salmon [*O. nerka*] run). More detailed aspects of fish presence and behavior are reported below.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF APPENDICES

INTRODUCTION

Two river instream conversion (RISEC) devices were operated underwater on the Kvichak River, near the village of Igiugig, Alaska, during a demonstration period in 2014. The ultimate goal of the demonstration was to test the efficiency and feasibility of the devices and gather information in preparation for a 5-year pilot license application to be submitted to the Federal Energy Regulatory Commission (FERC). Permission to operate the devices in 2014 required a Fish Habitat Permit (a "Title 16" permit) from the State of Alaska, Department of Fish and Game (ADF&G), granting permission for project activities in anadromous streams (AS 16.05.841-71). For the Title 16 permit, a monitoring plan (LGL 2014) was developed in consultation with ADF&G before deployment, to monitor fish and protect their passage. Although fish were the focus of the monitoring plan, terrestrial and aquatic wildlife were also monitored near the devices.

This report describes monitoring efforts used to fulfil these requirements, including methods, fish and wildlife detections, and any detected effects (positive, negative, indifferent) on fish or wildlife from the devices. Results presented here are intended to also help refine future monitoring methods and passage protection needed during any subsequent licensing phases.

The two RISEC devices monitored in 2014 were the RivGEN Power System manufactured by the Ocean Renewable Power Company (ORPC; Portland ME) and the BRI Cyclo-Turbine™ manufactured by Boschma Research Inc. (BRI; Brownsboro AL). Detailed designs for both devices were presented in the preseason monitoring plan (LGL 2014).

OBJECTIVES

The overall goal of this study was to monitor fish and wildlife in the vicinity of the RISEC devices while assessing the viability of an underwater camera system to monitor fish. The specific objectives in 2014 were as follows:

1. Document and classify any encounters of fish and wildlife with two RISEC devices.
2. Describe behavioral responses to any encounters with the devices, as well as subsequent effects on any fish or wildlife.
3. Assess whether the devices visibly alter in-stream habitat nearby.
4. Evaluate the viability of an underwater camera system to monitor fish at the devices.

STUDY AREA

Kvichak River Landscape and Fish Resources

This project was located on the Kvichak River, near the outlet of Iliamna Lake at the village of Igiugig. The watershed flows from glacially-turbid headwater streams down into Lake Clark, then southwesterly down the Newhalen River and into Iliamna Lake, the largest lake in Alaska. The Kvichak River then drains Iliamna Lake, running 106 km to the west and emptying into Bristol Bay in southwestern Alaska (Figure 1). The entire drainage is thus large (16,830 km^2) and is characterized by two large lakes that support enormous runs of sockeye salmon (*Oncorhynchus nerka*) that drive much of the region's economy. These lakes help trap glacial sediment, allowing the Kvichak River to be a relatively clearwater stream at Igiugig. Mean annual water discharge (1968 – 1986) for the Kvichak River near Igiugig was 503 m^3/s (17,763 ft^3/s), with annual peaks in August, September, and October (USGS 2008).

The Kvichak River is one of nine main rivers producing sockeye salmon targeted in Bristol Bay commercial, subsistence, and sport fisheries. Sockeye salmon return to the Kvichak River at Igiugig from mid-June to mid-July (Figure 2). The area near the RISEC demonstration sites in 2014 is important for managing the sockeye salmon fishery; part of ADF&G's inseason management of the Kvichak sockeye salmon stock comes from data collected at the salmon counting tower located just downstream of the village of Igiugig (~2 km). The average annual count of sockeye salmon at this tower was 3 million fish from 2005 through 2014 (calculated from annual count data provided by ADF&G). The Kvichak River at Igiugig is classified as Essential Fish Habitat (EFH) for anadromous fish by NOAA (2011).

The Kvichak River also supports a variety of other fish species of important socioeconomic value, with habitat use that ranges from seasonal migration corridors to year-round presence (Table 1). In addition to the other four species of Pacific salmon (*O.* spp.) found in Alaska, these include seven non-salmon species that Krieg (2003) estimated to be harvested by at least 25% of the households in the village of Igiugig. Overall, the study area is one in which a rich assemblage of fish species results in high subsistence, sport, commercial, and socioeconomic importance to local and regional residents.

Study Site Characteristics

Both RISEC devices were anchored and submerged on the bottom of the river, at or near 2 of the 11 sites originally surveyed by Terrasond (2011) to determine suitability. The ORPC device was located between Sites 9 and 10, approximately 1,000 m downstream of the public boat launch at the village of Igiugig and 125 m downstream of the end of Flat Island (Figure 1). Estimated water depth was 5.8 m, water velocity was 1.5 to 2.5 m/s, and river bed substrate was small cobble with very coarse, coarse, and medium gravel, and no significant amounts of finer material (TerraSond 2011). Final placement was approximately 100 m off the west bank (river right when facing downstream). The top of the device was approximately 1.25 m below the surface of the water during deployment in 2014 (R. Tyler, ORPC, personal communication).

The BRI device was installed at Site 6, approximately 100 m upstream from the boat launch and 1 km upstream from the ORPC device (Figure 1). Estimated water depth was 3 m, velocity was 1.8 to 2.5 m/s, and river bed substrate was primarily small cobble and coarse gravel with a small proportion of fines (TerraSond 2011). Final placement was approximately 75 m off the south bank (river left, facing downstream) with a substrate mix that included some large cobbles (personal observation by report author MJN) in addition to the substrate documented by Terrasond in 2011. Based on water depth (3 m) minus device height (2 m), the top of the device sat approximately 1 m underwater when resting on the river bottom.

Other hydraulic and bathymetric characteristics of the Kvichak River at Igiugig were described by TerraSond (2011).

METHODS

Fish Monitoring

Fish presence near each device was monitored using underwater video cameras that recorded and stored imagery. Video recordings were reviewed to document the following events, if any:

1. The number of fish, by species, encountering the device.
2. The basic behavioral response of fish encountering the devices (e.g., attraction, avoidance, change of course).
3. Any direct contact of fish with the device turbines.
4. Any visible evidence of negative effects from a contact event, such as physical exertion, injury, or death.

Video system design

Underwater cameras used at the RISEC devices were powered from shore, where data was also then collected and stored in a digital video recorder (DVR) for analysis. Underwater lights were placed near some cameras to illuminate the area and collect video images at night. All cameras and lights were manufactured by IAS systems (North Vancouver, British Columbia). Cameras were customized SeeMate ™ color to monochrome units with a F2.9 wide angle lense. Lights were SeeBrite ™ omnidirectional model 24L-SS-LED-350. Each light had four circuit boards, each with 24 light-emitting diodes (LEDs). DVRs were 16-channel units with a frame rate of 480 pps, manufactured by Dedicated Micros (Chantilly, WA).

Five cameras and two lights were used to monitor the ORPC device (Figure 3; Photo 1). Two cameras and one light were used to monitor the BRI device (Figure 4; Photo 2) Cameras and lights were affixed directly to the devices.

Data collection and management

Underwater cameras were operated whenever the device was operating (i.e., the turbine was spinning), as well as other times when the device was installed but not operating (i.e., the turbine was not spinning). Lights were used on a portion of the nights that the device operated. Each day, a field biologist downloaded video imagery from the shoreside power station.

For review, video imagery was separated into one-hour blocks of data. Imagery was then reviewed for the first 10 minutes of each hour, from each camera. Imagery was subsampled from all hours when the devices were operating, as well as a portion of the time when the device was not operating. Most subsamples of the imagery were reviewed inseason, on site in Igiugig, to detect any undesirable effects of the devices on fish (as specified in the Adaptive Management portion of the Monitoring Plan filed with the permitting process; LGL 2014).

Any fish detected were classified by species or group (e.g., salmonids), and placed into one of the three size classes: small fish less than 125 mm long (corresponding to the size of juvenile salmon); medium fish 125 – 250 mm long (smaller than adult salmon); and large fish longer than 250 mm (the size of large adult trout and adult salmon). Thereafter, all detections were classified as follows:

1. Movement direction (downstream, upstream, milling, or undetermined);
2. Evidence of passage delay, i.e., fish struggling to pass the device;
3. Contact with the device;
4. Evidence of injury or mortality; and,
5. Any other negative impacts.

Additionally, reviewers described each fish detection event for follow-up analyses.

Datasheets and then electronic entries were reviewed for quality assurance/control (QA/QC). Video imagery was archived on hard drives.

Visual verification of camera imagery and signs of streambed scour

The original monitoring also called for an alternate method to verify imagery seen by the cameras, and to report any signs of streambed scour downstream of the devices. This alternate method was to be developed *in situ*, based on site characteristics (LGL 2014). At the ORPC device, the safest and most reliable alternate method identified once on site was to use sonar buoy-based video footage collected by the University of Washington as part of a separate study of the device. These drifts consisted of multiple drifts that started upstream of the device and ended downstream, with a surface-mounted video camera pointed vertically towards the streambed. This footage was collected independently of and concurrent to the fish monitoring study, and provided postseason by the University of Washington (Dr. Brian Polagye).

At the BRI device, Camera 2 had a view of the substrate for the first 3-5 m downstream of the device.

Wildlife monitoring

Visual surveys for wildlife were conducted from shore each day the devices were operational. At each device, an observation site was chosen nearby based on proximity to the device, the field of view, and access. The surrounding riverbanks, islands, and stretches of water were divided into zones delineated by natural landmarks, and enabled the technicians to place animal sightings into specific areas that were consistent through the season.

Each wildlife survey was for 10 minutes. During the survey, the technician continuously scanned the zones both by eye and with the aid of Fujinon 7x50 binoculars. At the beginning of each survey, the observer noted the following: time, date, presence and operational status of the RISEC device, percent cloud cover, wind speed, rain, any potential visual impediments (e.g. glare, smoke, fog), and any other operations being conducted (e.g., sonar surveys, maintenance of RISEC device). Each 10-minute survey was preceded by a 5-minute "calming" period to offset any unintentional disturbance of wildlife by the observers as they arrived; this 5-minute period was not an official part of the survey.

For each bird and mammal sighting, the following were recorded:

- Species, or group if the species was not apparent.
- Count (noting juveniles, if present)
- Sighting cue (audio or visual)
- Location area / zone
- Habitat type (Air, Water, Vegetation, Ground)
- Movement relative to device (Towards, Away, Neutral)
- Reactions to device presence (e.g., looking at the device, changing course, splits in groups, changes in behavior)
- Interactions with the device (e.g., landing on the device itself, circling the device either on the water or in the air)
- Comments

Each sighting was also categorized by whether the animals arrived at the survey area, left the survey area, transited through the survey area, or remained in the survey area throughout the survey.

RESULTS

Camera, lights, and recording equipment were tested prior to deployment (Photo 5). Once deployed, the equipment functioned reliably, with no breakdowns of camera gear or lighting. Inseason progress reports were delivered on July 10 and August 5, and a season summary was delivered September 30 (Appendix B). Final effort and results are summarized by device, below.

ORPC device

Operations

The ORPC device was deployed on the river bottom on August 13, 2014 at approximately 1600, with the turbine starting to operate (spin) shortly thereafter. The turbine operated intermittently until September 10; the device was removed from the river on September 13. Camera operations matched the turbine schedule, operating intermittently from August 13 at 17:43 through September 10 at 15:00.

The five cameras and two lights all operated as planned. Video was recorded during all 87 hourly blocks when the turbine was operating. Lights were operated during most hours of nights when the device was operating.

Visibility was consistent across cameras: reviewers could see an estimated 10–15 ft from each camera, based on background markings, with good resolution. Water was more turbid after rain events, and turbidity increases noticeable to the human eye at the water surface were also noticeable on imagery from the cameras at the river bottom. The downstream view on Camera 5 was most difficult to review for fish because there was little contrast in the background view; the other four cameras had partial views of the device structure, which provided contrast that helped discern fish during video review.

Imagery collection and review effort

The device was operated intermittently on all or parts of 17 days from August 14 through September 10. We separated the 696 potential hours during this time into the following four categories (Table 2):

1. Group A: 87 hours while the device was submerged and operating. We recorded all 87 of these hours, then reviewed the 83 (95%) for which water visibility was acceptable. Across all five cameras combined, this totaled 415 hours of coverage.
2. Group B: 471 hours while the device was submerged but not operating. We recorded 117 of these hours, then reviewed 28 of them (24%), which totaled 140 hours combined among all five cameras.
3. Group C: 55 hours while the device was on the surface and not operating. We recorded none of these hours.
4. Group D: 83 miscellaneous hours while the device was submerged and either operating briefly or not at all. We recorded and archived all 83 of these hours, and reviewed none.

In total, 10-minute subsamples were thus reviewed from 111 hourly blocks of data per camera, or 555 hours for all cameras combined (Table 2). Exactly 75% of these were while the device was submerged and operating. These represented 95% of the time the device operated.

Fish detections

Fish were detected on 32 separate events, representing 52 fish. Fish detection events were spread over 9 days; the most were on August 22, with 12 events representing 31 fish (pink salmon, chum salmon, and coho salmon; *O. gorbuscha, O. keta*, and *O. kisutch;* Table 3). The 52 fish detected consisted of 32 pink salmon, 2 chum salmon, 2 coho salmon, 14 fish of uncertain species, and 2 events that may not have even been fish. Uncertain species were usually juvenile-sized salmonids or adult-sized fish that were hard to distinguish between salmon and trout. 80% of sightings were at Camera 1.

After standardizing for effort, sightings translated to 0.09 fish per hourly block at the device (52 fish divided by 555 hourly blocks among all cameras combined; Table 2). Sightings peaked between 1600 and 1800, accounting for over half of the sighting rate (Figure 5).

Fish behavior

All behavior by live fish was milling, or traveling up- or downstream (Table 4). Milling was the most common behavior and was a mix of movements. A typical view was for the fish to drift down from above, or to emerge from the substrate along the pontoon. Many pink salmon showed this behavior. Dead fish drifted with the current and were easily differentiated from live fish.

Direct, sustained movement upstream or downstream was less frequent than milling behavior. A group of four pink salmon moved upstream (Camera 1) on Aug 22. These fish were not detected on the other cameras. Four fish, all of which were pink salmon, were detected moving downstream. All of these were seen upstream of the turbine; two were dead or torpid, one was unknown, and one was a pink salmon that appeared to move downstream and over the device.

Several fish were seen on Cameras 4 and 5, downstream of the turbine; these were all three of the coho or potential coho salmon seen, and all were classified as milling.

There were no detections of fish contact with the turbine itself and no evidence of passage delay (while the device was operational or not). A few fish appeared to use the pontoon eddy as a velocity shelter, but not the turbine structure. Qualitatively, there was no evidence of device status (turbine spinning vs. stationary) or diel timing (day vs. night) on fish presence; sample sizes were too small to compare quantitatively.

BRI device

Operations

The BRI CycloTurbine was installed on August 29, 2014 at 21:30. The turbine operated from this time until August 31 at 20:30. Cameras operated from August 30 at 0900 through September 2 at 10:25, thereby recording images both while the turbine operated and after it had stopped. The device stopped before a light could be installed; therefore, no imagery was collected at night.

The downstream view from Camera 1 was better at night (with the light) than during the day. The reflection of the aluminum, sometimes coupled with direct sunlight, reduced image quality at times. Camera 2 was better for viewing because it had less reflective glare and because it viewed fish in cross section (i.e., looking laterally across river).

Imagery collection and review effort

The device was operated intermittently on all or parts of four days from August 29–September 5. The 86 potential hours during this time were separated into the following two categories (Table 2):

1. Group A: 47 hours while the device was submerged and operating. We recorded 34 of these hours, and reviewed 10-minute subsamples from all of them. Across both cameras, this totaled 68 hourly blocks reviewed.
2. Group B: 39 hours while the device was submerged but not operating. We recorded all 39 of these hours and reviewed none of them.

In total, 10-minute subsamples were thus reviewed from 34 hourly blocks of data per camera (from 68 hourly blocks total), all of which were while the device was submerged and operating. These represented 72% (34 of 47) of the time the device operated (Table 2).

Fish Detections

Fish were detected fish during 48 separate events, totaling 53 fish. These sightings were 19 pink salmon, two chum salmon, five sockeye salmon, two lamprey, and 25 unspeciated salmonids (likely whitefish or trout; Table 3). All but four of the fish detected were at Camera 2 (the downstream camera).

Fish at the BRI site were spread more evenly throughout the day than at the ORPC site. Despite the relatively short deployment time, fish were seen every hour from 0700–2000. After standardizing for effort, sightings translated to 0.78 fish per hour of review time at the device (53 fish seen over 68 hours; Table 2); no single hour accounted for more than 15% of this sighting rate (Figure 5).

Fish Behavior

All fish detected on Camera 2 were milling (30 fish) or moving upstream (18 fish; Table 4). A typical milling behavior was fish appearing downstream of the device and holding downstream of the device, before moving sideways and/or downstream. The fish were usually an unidentified species of salmonid. A typical upstream behavior was for fish to approach the device, hold briefly, and then move upstream and around or to swim under the downstream edge of the device. We saw no adverse effects on these fish, most of which were pink salmon.

The four fish seen on Camera 1 were all traveling downstream. Four pink salmon migrated around the BRI device, one lamprey migrated above it, and one lamprey moved downstream through the device. This fish entered the device from the top, on the downstream portion of the debris guard; either the guard had broken here, or the sinuous body shape of the lamprey allowed it to pass through the guard's barrier cables. This fish presumably moved through the device and could have had contact with the turbine. Further effects on the fish could not be evaluated because the event was at night (0500 hrs), before a light had been installed on the downstream end of the device.

Visual verification of camera results, and indications of scour

The buoy-based video footage from University of Washington came from camera drifts over the ORPC device multiple times from August 21 through August 24. Each drift lasted approximately three to five minutes. Imagery was reviewed footage from all drifts; no fish were seen within the field of view of our fixed underwater cameras, either because no fish were there during drifts, or because it was at the limit of the drifted camera's range. The drifted camera was able to see fish elsewhere (water depth approximately 6–8 feet), and was able to see the turbine and some substrate at the device (approximately 20 feet deep); without further assessment of this camera, however, it can't be known whether the absence of fish was a true negative. This footage also showed no indication of gravel disturbance or other forms of scour downstream of the device.

At the BRI device, Camera 2 had an effective view of the substrate for 3 –5 m downstream of the device and showed no signs of scour. The short operation time (Aug 29 – Aug 31) prevented using any secondary methods to view fish.

Wildlife monitoring – both devices

A total of 28 wildlife surveys were conducted from August 15 through September 10; of these, 25 were at the ORPC site and 3 were at the BRI site. No animals came into physical contact with, interacted with, or otherwise reacted to either device. No animals exhibited changes in behavior or course of travel while in close proximity (within 30 m) of a device.

There were a total of 68 sightings of 151 individual animals. The sole mammal sighting was of a red squirrel (*Tamiasciurus hudsonicus*). All other sightings were of birds, the majority of which were gulls (Table 5).

Most bird sightings consisted of individuals or groups flying over the river corridor; the remaining were birds that landed in view during the survey, or that were already in view at the time of the survey (Table 6).

DISCUSSION

Presence of fish and wildlife near the devices

There was no evidence of effects on fish and wildlife at the ORPC device during the deployment period of August 13 to September 10. Notably, there were no sightings of birds swimming or diving at the device; only three groups were seen within viewing distance during the 25 surveys at this site. Fish encountered the device at low levels through the period, mostly holding near the pontoons upstream of the turbine; no fish were seen entering the turbine, and only one appeared to pass over (an adult salmon, moving downstream). Although there was space for fish to migrate underneath the turbine, we did not see this. Most sightings were adult-sized salmonids. Smaller fish would have been harder to see but still detectable within five feet, so their relative scarcity in the camera views was at least somewhat representative.

There was also no evidence of effects on wildlife at the BRI device, but observed higher rates (fish/hr) than at the ORPC site (with the caveat of a shorter sampling period). The most notable fish behavior was migration of pink salmon upstream and around the device; these fish thus showed some avoidance behavior, but the device did not appear to hinder fish passage and fish did not move upstream into the device. Fish also appeared to use the device as a velocity shelter, holding and milling slightly downstream of the device. The two pink salmon seen moving downstream both went around the device, perhaps due to the fish guard. One lamprey went through both the guard and the device; unfortunately, a light had not yet been installed downstream and the status of this fish could not be assessed when it exited the device.

The placement of the both devices ~ 100 m from shore may have helped reduce salmon presence by putting them outside of the main migration corridor of salmon. Differences in physical conditions between the study sites may have also helped contribute to differences in fish presence between the devices. Anecdotal evidence from ADF&G (R. Regnart, personal communication), supported by field observations during this project, is that most sockeye salmon migrate within 30 feet of each river bank, and approximately 60–70% of the run migrates up the left bank. Assuming this is also representative of pink salmon (weaker swimmers than sockeye salmon), both devices may have been out of the main migration corridor of the two most abundant salmon species. Although the peak of the run had passed, many salmon were still being seen along the shoreline through August by project biologists, in densities that were (qualitatively) higher than seen on the cameras at the devices.

The ORPC site was also high energy relative to the rest of the river cross section, which had eddies and much slower water velocities near each bank. These environmental conditions meant that fish had easier migration corridors further away from the device, and may have helped further reduce fish presence at the device. Although the design of the ORPC device would have also allowed fish to pass unobstructed below the turbine, no fish were seen doing so.

Wildlife sightings consisted almost entirely of birds, none of which showed a behavioral response (attraction or avoidance) to the device.

Equipment operation

There was a demonstration component to the fish monitoring portion of this project, given that it was the first such design used to monitor these types of devices in Alaska. The equipment operated effectively, with no breakdowns of gear once it passed shoreside testing. The specifications of the two main pieces of equipment worked well together, in that the lights were able to illuminate an area exceeding the cameras' effective views. Placement of lights behind the cameras worked well, with no glare problems. There were no apparent problems from vibration, such as from water current or mounting structures. One drawback to the video is that because it was designed for motion imagery, still images captured from the video are unrepresentatively poor and thus not reproduced here. Video samples are archived by the project (Appendix A) and available for distribution with this report.

Water turbidity and image background influenced the ability to interpret images. The effective range (distance) also changed depending on the question asked – cameras generally needed to be within 6 feet to identify juvenile salmon or speciate adult salmonids, within 10 feet to speciate adult salmon, and within 15 feet to characterize fish behavior and distinguish adult fish from debris. These distances allowed us to effectively address whether fish were entering the entire BRI device or the nearest 1/3 of the ORPC turbine, for example, but would have been less effective for differentiating behavior among trout species. Fish were more distinguishable against backgrounds with contrast (such as the ORPC turbine in the background) than without (such as with only the riverbed in the background).

Although the underwater imagery at the ORPC site was partial, it is likely representative for several reasons. Temporally, the subsampling approach (a ten-minute count each hour) is common for salmon in Alaska in general and on the Kvichak in particular (Anderson 2000; Reynolds et al. 2007), and should be sufficiently representative over time. Spatially, the one-third of the device visible in the cameras seems reasonably representative of the rest of it, given the uniform design of the device and the consistency of the water conditions at that site. Finally, the imagery was collected on 17 days spread across a 28-day time period, increasing the likelihood that a major change in run behavior or distribution would have been seen. The two cameras at the BRI device were able to capture 95 – 100% of the entry and exit.

Visual verifications with a secondary method were originally intended to ground-truth the primary cameras, and meant to be developed on site once characteristics were known. The backup method chosen (camera drifted over the device as part of a separate study) was the best available option, but the need for it became reduced when the primary cameras proved to function effectively and see fish clearly. This secondary validation method should be retained in the future in case any questions develop with the main camera system. Verification surveys at the BRI device were not possible due to the short deployment time.

CONCLUSION AND RECOMMENDATIONS

Fish seen during the study period did not seem negatively impacted by the devices, either because of the design or the placement location (or both). When present, upstream-moving salmon were able to migrate around the devices. Downstream fish appeared able to migrate around the ORPC device on their own, and the fish guard on the BRI device appeared effective for salmonids, although perhaps less so for lamprey.

The study identified a number of monitoring features to retain or adapt for future work, depending on objectives. The underwater video effectively monitored fish behavior around hydrokinetic devices on the Kvichak River, and worked for nighttime operation when paired with lights. Improvements may be needed to scale the effort up to larger sampling intervals, analyze more imagery, or refine fish identification. Depending on future objectives, some potential improvements are as follows:

1. Retain the fixed mounting system eventually selected for both cameras and lights in 2014.

2. Replace battery banks with 110 v power.

3. Describe fish during times of higher inriver fish abundance to determine if the distribution and behavior at the devices in 2014 was representative.

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TABLES

Table 1. List of fish species known or suspected to use the Kvichak River near site of this study. Subsistence use is from Krieg et al. (2003).

Common name[a]	Scientific name	Subsistence use	Habitat use at study site[b]	Seasonal timing
Alaskan brook lamprey	*Lampetra alaskense*	No	Migrant	unknown
Arctic-Alaskan lamprey	*L. camtschatica/alaskense*	No	Migrant	unknown
longnose sucker	*Catostomus catostomus*	Yes	Migrant	Spring
northern pike	*Esox lucius*	Yes	Migrant/Resident	Spring/Fall
Alaska blackfish	*Dallia pectoralis*	Yes	non-typical	year-round
rainbow smelt	*Osmerus mordax*	Yes	Migrant	Spring/Fall
broad whitefish	*Coregonus nasus*	Yes	non-typical	Fall
humpback whitefish	*Coregonus pidschian*	Yes	Migrant	Fall
least cisco	*Coregonus sardinella*	Yes	Migrant	Fall
pygmy whitefish	*Prosopium coulteri*	Yes	Migrant	unknown
round whitefish	*Prosopium cylindraceum*	Yes	Migrant	unknown
Arctic grayling	*Thymallus arcticus*	Yes	Migrant/Resident	Spring/Summer/Fall
pink salmon	*Oncorhynchus gorbuscha*	Yes	Migrant	Summer
chum salmon	*Oncorhynchus keta*	Yes	Migrant	Summer
coho salmon	*Oncorhynchus kisutch*	Yes	Migrant	Summer/Fall
rainbow trout	*Oncorhynchus mykiss*	Yes	Migrant/Seasonal	Spring/Fall
sockeye salmon	*Oncorhynchus nerka*	Yes	Migrant	Spring/Summer
Chinook salmon	*Oncorhynchus tshawytscha*	Yes	Migrant	Summer
Arctic char	*Salvelinus alpinus*	Yes	Migrant/Seasonal	unknown
Dolly Varden	*Salvelinus malma*	Yes	Migrant/Seasonal	Spring/Fall
lake trout	*Salvelinus namaycush*	Yes	non-typical	year-round
burbot	*Lota lota*	Yes	non-typical	year-round
threespine stickleback	*Gasterosteus aculeatus*	No	Resident	year-round
ninespine stickleback	*Pungitius pungitius*	No	Resident	year-round
slimy sculpin	*Cottus cognatus*	No	Resident	year-round

[a]Alt et al. 1994 a,b; Fall et al. 2010; Gryska 2007; Groot et al. 1991; Hauser 2007; Hubartt 1994; Krieg et al. 2003; Mansfield 2004; Mecklenburg et al. 2002; Minard et al. 1992; Morrow 1980; Quinn 2005; Salomone et al. 2009; Woody et al. 2007

[b] Migrant - utilize study site seasonally as a migratory corridor
Seasonal - May reside in study site
non-typical - rarely encontered in study site
Resident - Majority of life cycle could occur in study site

Table 2. Image recording, review effort, and fish detections by device and operational status in 2014.

	Hourly blocks			Review hours[a]		Events		Fish	
Device Status	Hourly intervals	Hourly blocks with video recording	Hourly blocks with video review	Number of cameras	Total hourly blocks reviewed, all cameras combined	Fish detection events	Events / hourly review block	No. of fish	Fish / hourly review block
ORPC									
Floating on surface	55	0	0		0				
Submerged, not spinning	471	117	28	5	140	4	0.03	14	0.10
Submerged, spinning	87	87	83	5	415	28	0.07	38	0.09
Various/Intermittent	83	83	0		0			0	
Total	696	287	111	5	555	32	0.06	52	0.09
BRI									
Floating on surface	0	0	0		0				
Submerged, not spinning	39	39	0	2	0				
Submerged, spinning	47	34	34	2	68	48	0.71	53	0.78
Various/Intermittent	0	0	0		0				
Total	86	73	34	2	68	48	0.71	53	0.78

[a] Each hourly block reviewed consisted of a 10-minute subsample

Table 3. Fish species detected by device status and operational status in 2014.

Device	Device operating?	Hourly blocks reviewed[a]	No. of fish detected: Pink salmon	Chum salmon	Coho salmon	Sockeye salmon	Lamprey	Unidentified spp.	Total
ORPC	Yes	415	19	2	2	0		15	38
	No	140	13					1	14
BRI	Yes	68	19	2	0	5	2	25	53
	No	0							0

Table 4. Fish behavior by species for each device in 2014.

Behavior	Chum salmon	Coho salmon	Pink salmon	Unidentified	Sockeye salmon	Lamprey	Total	Comments
ORPC								
Drifting			2	2			4	2 dead/dying pinks; 1 unidentified; 1 juv
Milling	2	2	26	7			37	Variety of behaviors
Travel, down				4			4	All upstream of turbine; 1 fish might go over
Travel, up			4	2			6	All upstream of turbine
Undetermined				1			1	
Subtotal, ORPC	2	2	32	16	0	0	52	
BRI								
Milling	1		2	23	4		30	Variety of behaviors
Travel, down			2			2	4	2 pinks around; 2 lamprey go over, thru
Travel, up	1		15	1	1		18	15 went around/under
Undetermined				1			1	
Subtotal, BRI	2	0	19	25	5	2	53	
Grand Total	4	2	51	41	5	2	105	

Table 5. Total number of wildlife sightings (number of individuals) by taxonomic group seen during wildlife surveys at the hydrokinetic devices in 2014. Device status during each survey is described as Operating (submerged and rotating, n=16), Not Operating (submerged and not rotating, n=10), or At Surface (not submerged and not rotating, n=2).

	Device Status			
Taxonomic Group	Operating	Not Operating	At Surface	Total
Small Mammals	0	0	1 (1)	1 (1)
Waterfowl	0	4 (24)	0	4 (24)
Bald Eagle	2 (2)	0	0	2 (2)
Other Raptors	0	1 (1)	0	1 (1)
Shorebirds	1 (1)	1 (7)	0	2 (8)
Gulls	30 (56)	1 (28)	4 (4)	35 (88)
Corvids	2 (2)	2 (2)	1 (1)	5 (5)
Passerines	12 (14)	3 (4)	3 (4)	18 (22)
Total Birds	47 (75)	12 (66)	8 (9)	67 (150)

Table 6. Movement behavior by number of sightings (number of individuals) for the wildlife in areas nearest (~ 200 m) the hydrokinetic devices in 2014. Movements categorized as Arrived (animal entered area during sighting), Departed (animal exited area during sighting), Remained (animal stayed within area throughout the duration of the sighting), Transited (animal entered and exited area during sighting), and Unknown (unable to determine, applies to animals detected by audio cue). Data excludes the 5-minute calming period before each survey.

	Movement of Animals in Areas Nearest Device					
Taxonomic Group	Arrived	Departed	Remained	Transited	Unknown	Total
Small Mammals	0	0	0	0	1 (1)	1 (1)
Waterfowl	0	0	0	1 (5)	0	1 (5)
Bald Eagle	0	0	0	0	0	0
Other Raptors	1 (1)	0	0	0	0	1 (1)
Shorebirds	0	0	0	2 (8)	0	2 (8)
Gulls	1 (2)	0	0	17 (40)	0	18 (42)
Corvids	1 (1)	0	0	1 (1)	1 (1)	3 (3)
Passerines	0	3 (3)	4 (6)	1 (1)	2 (2)	10 (12)
Total Birds	3 (4)	3 (3)	4 (6)	22 (55)	3 (3)	36 (72)

Areas not recorded for surveys 1-4

FIGURES

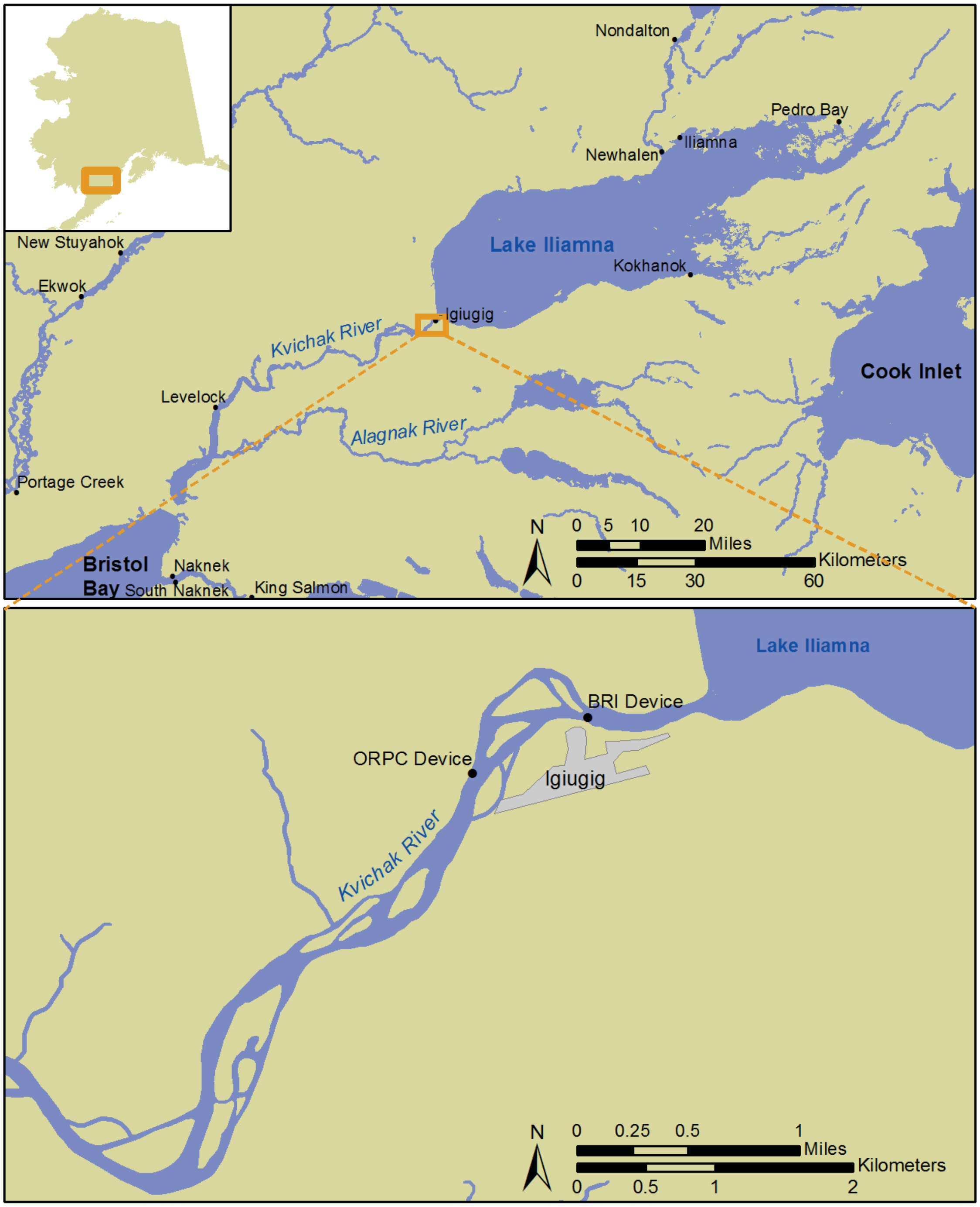

Figure 1. Map of the Kvichak River in southwestern Alaska, showing locations of the hydrokinetic devices built by ORPC and BRI and operated near the village of Igiugig in 2014.

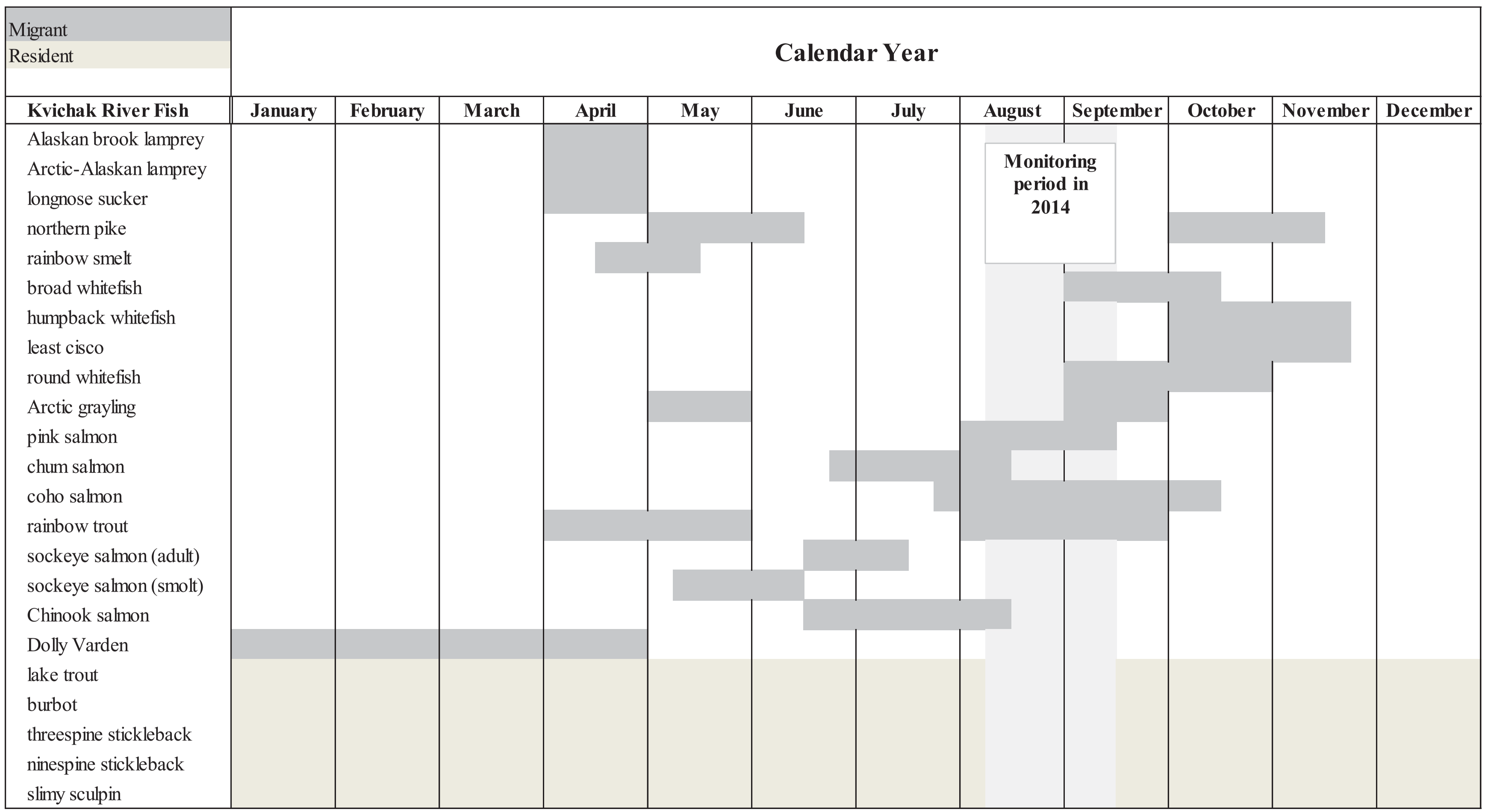

Figure 2. Approximate temporal peaks in fish presence, by species, in the Kvichak River near Igiugig relative to the 2014 monitoring period of August 13 – September 10 (multiple sources; see Table 1).

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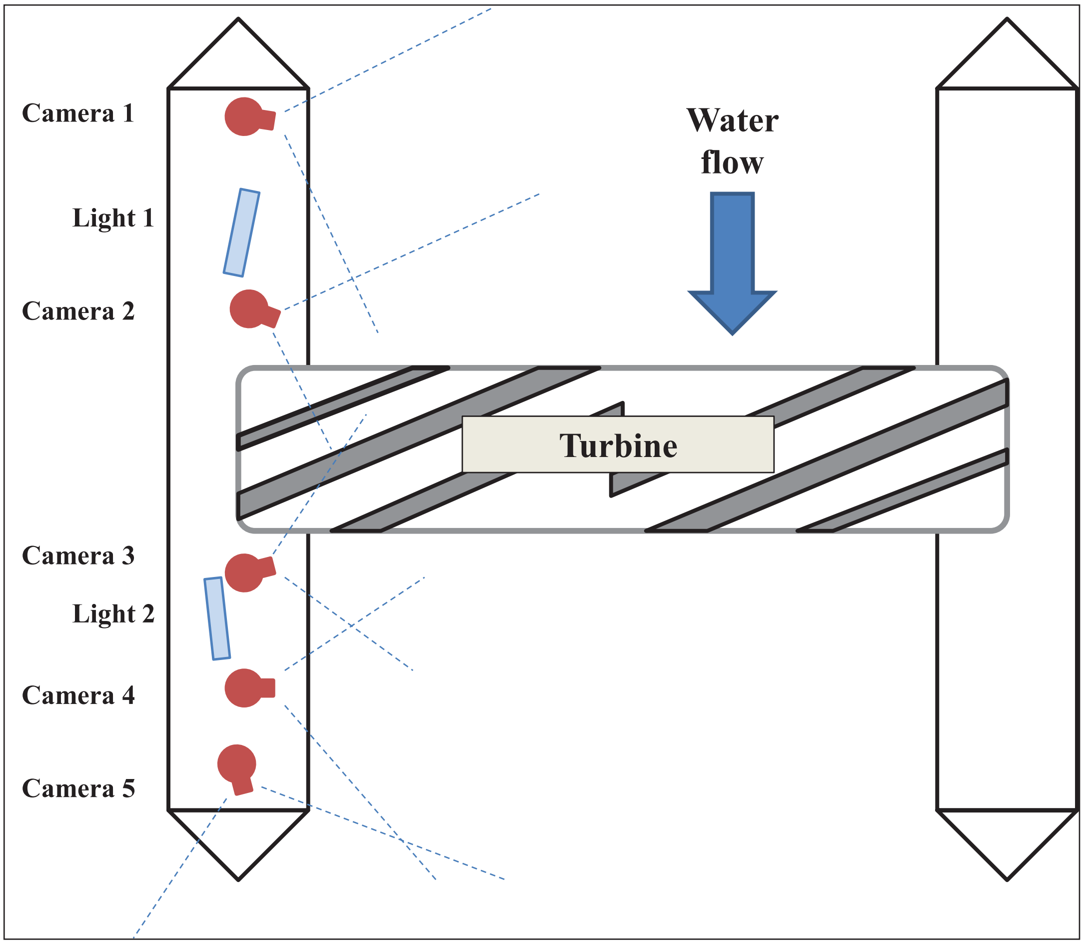


Figure 3. Schematic of ORPC device once submerged, showing final location of cameras and lights along the port side pontoon of the device. Dashed lines model the field of view from each camera. Schematic is not to scale.

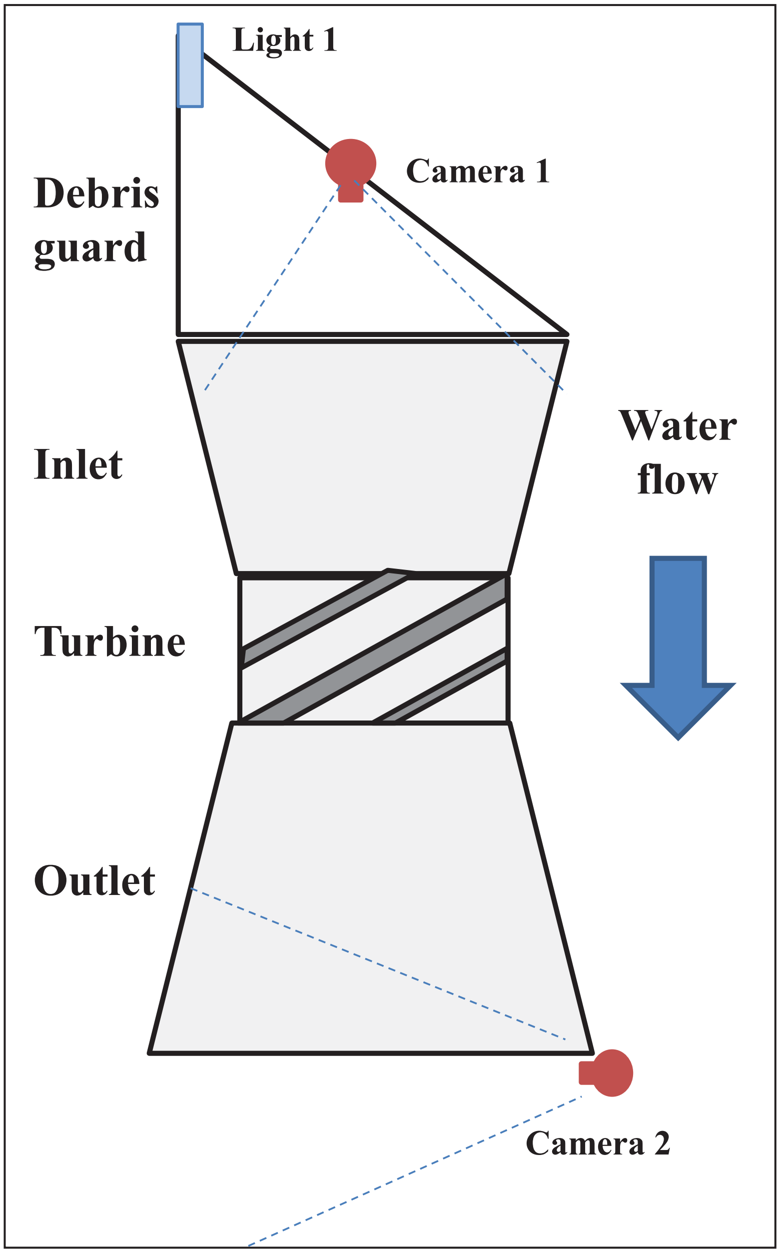


Figure 4. Schematic of BRI device once submerged, showing final location of cameras and lights. Dashed lines model the field of view from each camera. Schematic is not to scale.

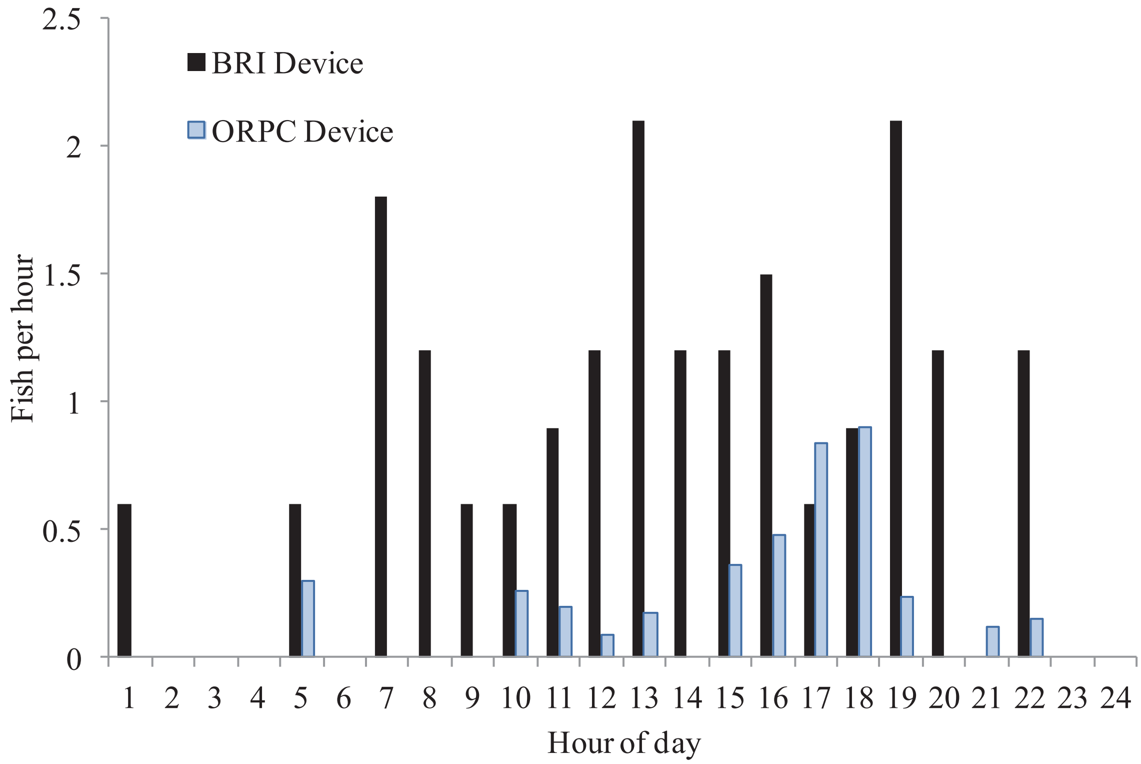


Figure 5. Fish detections by hour of the day at each RISEC device, standardized for review effort.

PHOTOS

Photo 1. ORPC device before deployment, showing approximate mount locations of underwater cameras (C1 – C5) and lights (L1 – L2) in 2014. Water would flow from left to right.

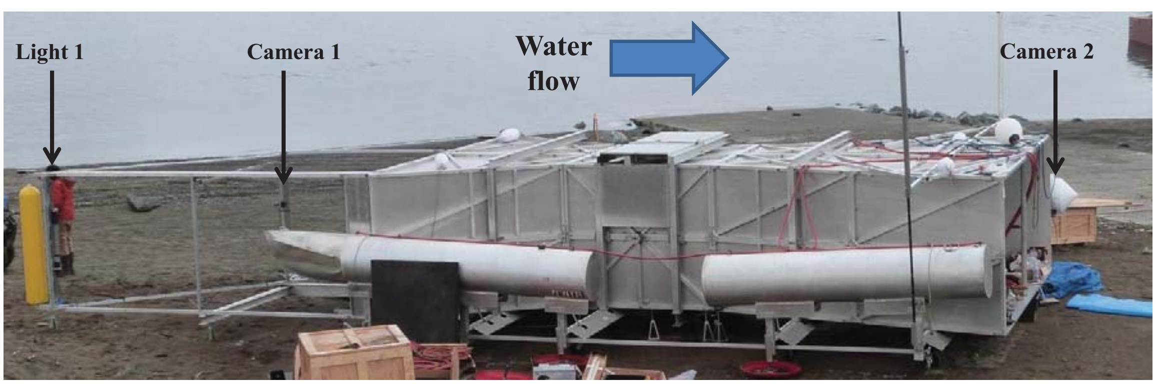


Photo 2. BRI device before deployment, showing mount locations of underwater cameras and light used during deployment in 2014. Water would flow from left to right.

Photo 3. Surface view of the BRI device while submerged on September 1, 2014. Water flowing from right to left; device is the white object visible in right center of photo.

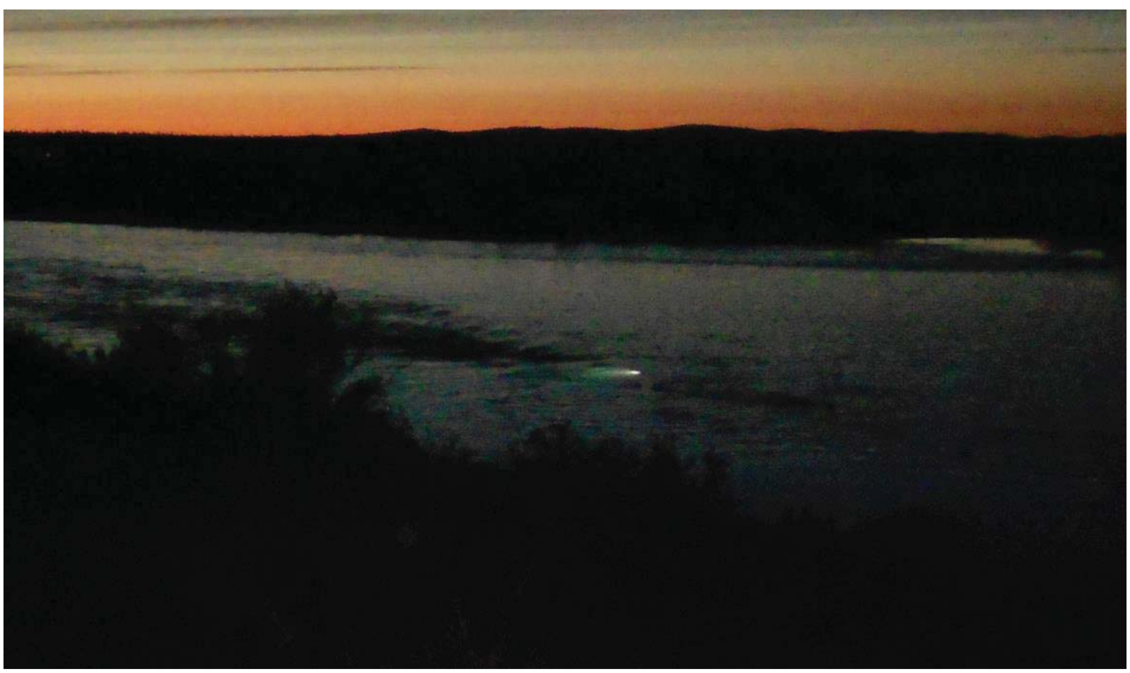


Photo 4. Surface view of the BRI device at night while submerged on August 30, 2014 at 11:00 pm. Illumination from underwater light attached to device is visible in right center of photo. Water flowing from right to left.

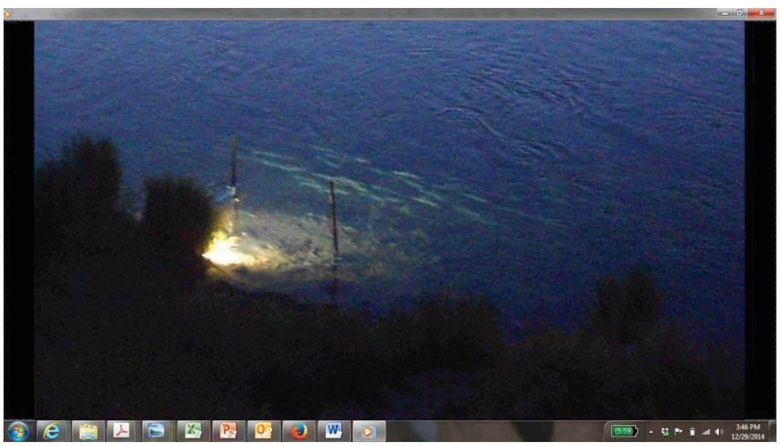
Photo 5. Surface view of pre-deployment testing of the underwater lights at 1:00 AM on July 3, 2014. Approximately ten sockeye salmon are seen migrating within the illumination field, at the top center of photo. Image is from a conventional (not underwater) camera, from about 20 m away.

Photo 6. Shoreside cabinetry that housed the video recording system and power link for the BRI RISEC device in 2014. Marker buoys for the submerged device can be seen at top left of photo.

APPENDIX A – SAMPLE VIDEO IMAGERY

Video clips available for distribution upon request.

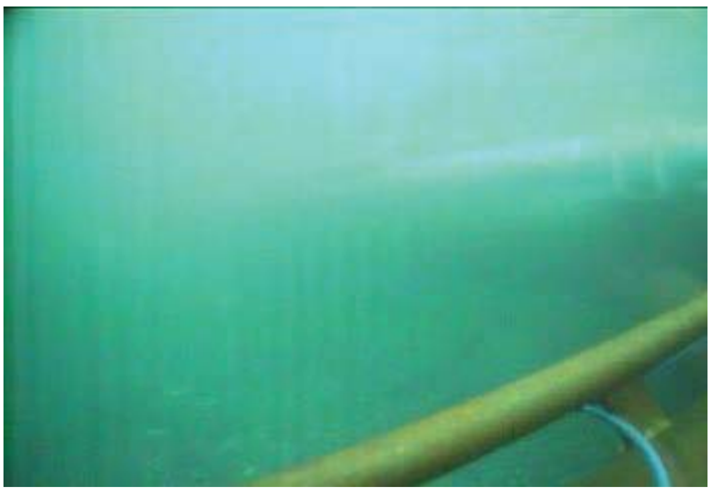
A1. Sockeye salmon migrating past test site during pre-deployment testing of underwater lights, 7/3/2014. Video taken from above the water surface using a conventional camera.



A2. Coho salmon video clip from the ORPC device, 8/21/2014.

A3. Chum salmon video clip from the ORPC device, 8/25/2014.

A4. Pink salmon video clip from the ORPC device 8/21/2014.



APPENDIX B –2014 PROGRESS REPORTS

Progress reports filed during the monitoring study in 2014.

B1 – Inseason Update #1, July 10th 2014

B2 – Inseason Update #2, August 5th 2014

B3 – Season Summary, September 30**th** 2014

Fish and Wildlife Monitoring of Kvichak RISEC devices

In-season Progress Report #2014 - 1

TO: Bill Price, Gray Stassel Engineering, Inc.	**DATE: 7/10/14**
RE: Fish & Wildlife Monitoring	**REPORTING PERIOD: Through July 3**
Prepared by: Matt Nemeth, LGL Alaska Research Associates, Inc. **cc: Priest, Patterson, Funk, Cr. Ziolkowski (LGL)**	

This report summarizes progress through July 3rd by LGL Alaska Research Associates, Inc. (LGL) for fish and wildlife monitoring of the RISEC devices on the Kvichak River. July 3rd marked the end of the first field trip.

Overall status

Neither RISEC device has been deployed, so LGL's work to date has consisted of preparation and designs. The BRI device has been outfitted with two specialized underwater cameras and one light, fastened directly to the device on "fixed mounts." Once the device is ready for deployment, we will need approximately one day to make the electronics operational. The ORPC device has been outfitted with fixed mounts for six cameras and two lights. Two to three days will be needed to install the electronics on these mounts, route the cables, assemble the shoreside power bank, and deploy the cables from the device to the power bank. These steps must be coordinated with other work on the device (non-LGL), and won't be started until the device deployment schedule(s) are firmed up.

Summary of field efforts through July 3

Preparation

Most work in June was spent preparing for our (LGL's) June 25 departure to Igiugig. Materials needed for mounts were generally shipped unassembled, partly for logistical reasons and partly to help accelerate the potential deployment schedule. Overall, this appeared to have been the correct approach. Assembling in Igiugig helped get bulk items such as cement and steel sent earlier and more cost effectively, and gave us greater flexibility once on site and able to assess the devices in coordination with BRI and ORPC staff. The last shipment of cameras and lights was received June 27th.

Camera and light designs

Upon arrival in Igiugig, we prioritized work on the BRI device to support a potential deployment as soon as June 28. One camera (BRI-1) was attached halfway along the debris guard that forms the bow (upstream end) of the device. This camera faced downstream, positioned to view fish moving towards the device mouth from approximately 20 feet upstream (Figure 1). A second camera (BRI-2) was attached to the stern (downstream end) of the device at its exit. This camera faced sideways but slightly downstream, positioned to capture fish downstream of the device (moving either upstream or downstream). One light was fixed approximately 10 feet upstream of camera BRI-1 (Figure 1), and a second will be added using mobile mounts, near camera BRI-2. One to two additional cameras will be added using mobile mounts (i.e., not attached to the device); these will be added after the device's deployment, in a way that best completes the intended fields of view described in the monitoring plan.

The ORPC designs were finalized such that mounts for six cameras and two lights were attached along the port side pontoon, split evenly upstream and downstream of the turbine that spans the pontoon centreline. This arrangement seem superior to the prior, tentative plan of having only up to three cameras mounted on the pontoon. The six camera mounts (ORPC 1-6) are positioned to collectively show an approximate 180-degree field of view from the bow of the device (ORPC-1, looking sideways) to the stern of the device (ORPC-6, looking directly downstream), and should provide most of intended fields of view described in the monitoring plan. Fish moving between the bow and stern can be captured synoptically by the different cameras; the fields of view may overlap or have blind spots, depending on distance from camera.

One challenge with the ORPC device is that we can't know camera performance *in situ* until the device is sunk, after which it can't be re-floated just to adjust cameras. Therefore, we may remove one camera (ORPC-2) beforehand and reserve it for a mobile placement after seeing how the fixed cameras perform. This camera would be used to complete the intended field of view in described in the monitoring plan.

Field testing

Fourth lights, nine cameras, and both DVRs tested correctly in Igiugig. The tenth camera works only in low light. A number of smaller glitches have been, or are still being, troubleshot. The full system was used successfully to identify sockeye salmon swimming near the BRI site, day and night, from a distance of 10 to 15 ft from the camera, in water 2 to 3 ft deep.

Future field work

Both device makers are revising their deployment schedules the week of July 7, with little work we can do on site in the interim without exposing the gear to surface damage while not being watched. We've therefore removed our staff from Igiugig for the time being.

Once the BRI device is floated onto its anchor and pulled to shore, we will inspect the electronics attached in June, deploy our cables between the shore and deployment site, and install shoreside electronics and temporary power lines at the optimal site between the device and the BRI power source. This will allow us to begin monitoring using the two fixed cameras. The two mobile cameras will then be phased in, where needed. Our cabling will be independent of BRI's.

Once the ORPC schedule is determined and further float tests are complete, we will attach the cameras and lights. The device will then be floated onto its anchor and all cabling (ORPC and

LGL) will be run to shore. We will then install the shoreside power supply and electronics and begin monitoring. Our cabling will be independent of ORPC's.

July work will be summarized in the next progress report on August 4th.

Table 1. Overview of location, view direction, and testing status of lights and cameras as of July 3. Some camera locations may be further rearranged.

Gear	Code	Location	Direction of view	Tested
Camera	BRI-1	Starboard bow, midway up debris guard	Down	OK
Camera	BRI-2	Starboard stern, at device exit	Across and down	OK
Camera	BRI-3	Mobile	TBD	OK
Camera	TBD	Mobile	TBD	Problems
Light	BRI	Center, bow, upstream end	Downstream	OK
Light	BRI	Mobile	TBD	OK
Camera	ORPC-1	Port side, bow, upstream	Across	OK
Camera	ORPC-2	Port side, bow, midway	Across	OK
Camera	ORPC-3	Port side, bow, near turbine	Across and down	OK
Camera	ORPC-4	Port side, stern, near turbine	Across and up	OK
Camera	ORPC-5	Port side, stern, midway	Across	OK
Camera	ORPC-6	Port side, stern, downstream	Downstream	OK
Light	ORPC	Port side, bow, midway	Across and down	OK
Light	ORPC	Port side, stern, midway	Across and up	OK

Figure 1. Location of mounts for two cameras (white arrows) and one light (red oval) on the BRI device. Water would flow from left to right.

Figure 2. Location of mounts for six cameras (white arrows) and two lights (red ovals) on the ORPC device. Water would flow from left to right.

Fish and Wildlife Monitoring of Kvichak RISEC devices

Inseason Progress Report #2014 - 2

TO: Bill Price, GSE	**DATE: 8/5/14**
RE: Fish & Wildlife Monitoring	**REPORTING PERIOD: July 3 – Aug 3**
Prepared by: Matt Nemeth, LGL Alaska Research Associates, Inc. **CC: Priest, Patterson, Funk, Cr. Ziolkowski (LGL)**	

This report summarizes efforts by LGL Alaska Research Associates, Inc. (LGL) for fish and wildlife monitoring of the RISEC devices on the Kvichak River from July 3 through August 3.

Overall status

There is relatively little to report for this period. Deployment of both RISEC devices was delayed for various reasons unrelated to fish monitoring, and LGL's effort was primarily to remain prepared and sufficiently staffed during these delays. The ORPC device is presently at the barge landing in Igiugig and is outfitted with cameras and lights. The BRI device is presently downstream of the deployment site, with the damaged cameras and light removed. New ones will be installed just prior to the next deployment date. There are no substantial changes to camera designs or approach from last month.

The new plan is for deployment the week of August 4 (BRI) and August 11 (ORPC). As noted last month, we will need approximately one to two days to make the electronics operational once the devices are deployed. LGL will have 1-2 staff on site during deployment.

Summary of fish and wildlife monitoring of hydrokinetic devices on the Kvichak River in 2014

For update to FERC 9/30/14

From Matt Nemeth, LGL 9/26/14

All results are preliminary and subject to additional analysis

LGL Alaska Resources Associates, Inc. implemented the fish and wildlife monitoring plan in support of two hydrokinetic devices deployed on the Kvichak River in the summer of 2014. The overall goal was to monitor potential fish and wildlife interactions with the devices; implicit in this was testing the feasibility of using underwater video to detect, record, and quickly relay any undesirable interactions. The use of underwater cameras was made possible by the relatively clear water of the Kvichak River. Notable results include the following:

- Cameras were continuously operated for Device 1 (Boschma Research Inc.) on August 30 and 31, and for Device 2 (Ocean Renewable Power Corp) intermittently from August 14 through September 10 (operated during all hydrokinetic operations).
- The methodology was successful: cameras were able to be deployed near each device, were reliable for the duration of deployment, and effectively detected fish as far as 10 to 15 feet away. Images were able to be recorded shoreside and archived digitally. Underwater lights also allowed effective nighttime operation.
- No adverse fish or wildlife interactions were seen.
- Inseason, subsamples of underwater video were reviewed daily to continuously monitor fish interaction with the hydrokinetic devices.
- Inseason, wildlife surveys for mammals and birds were conducted on all days that the hydrokinetic devices operated. Combined with underwater video review, these surveys supported the inseason adaptive management plan guiding potential mitigation actions.
- The effectiveness of future video monitoring will be influenced by site characteristics (water depth and velocity, turbidity, substrate, distance from shore), the organisms to monitor, season, and the design of the devices. Other monitoring techniques could be used as needed.

Full results, conclusions, and recommendations will be included in a final report due December 15, 2014.