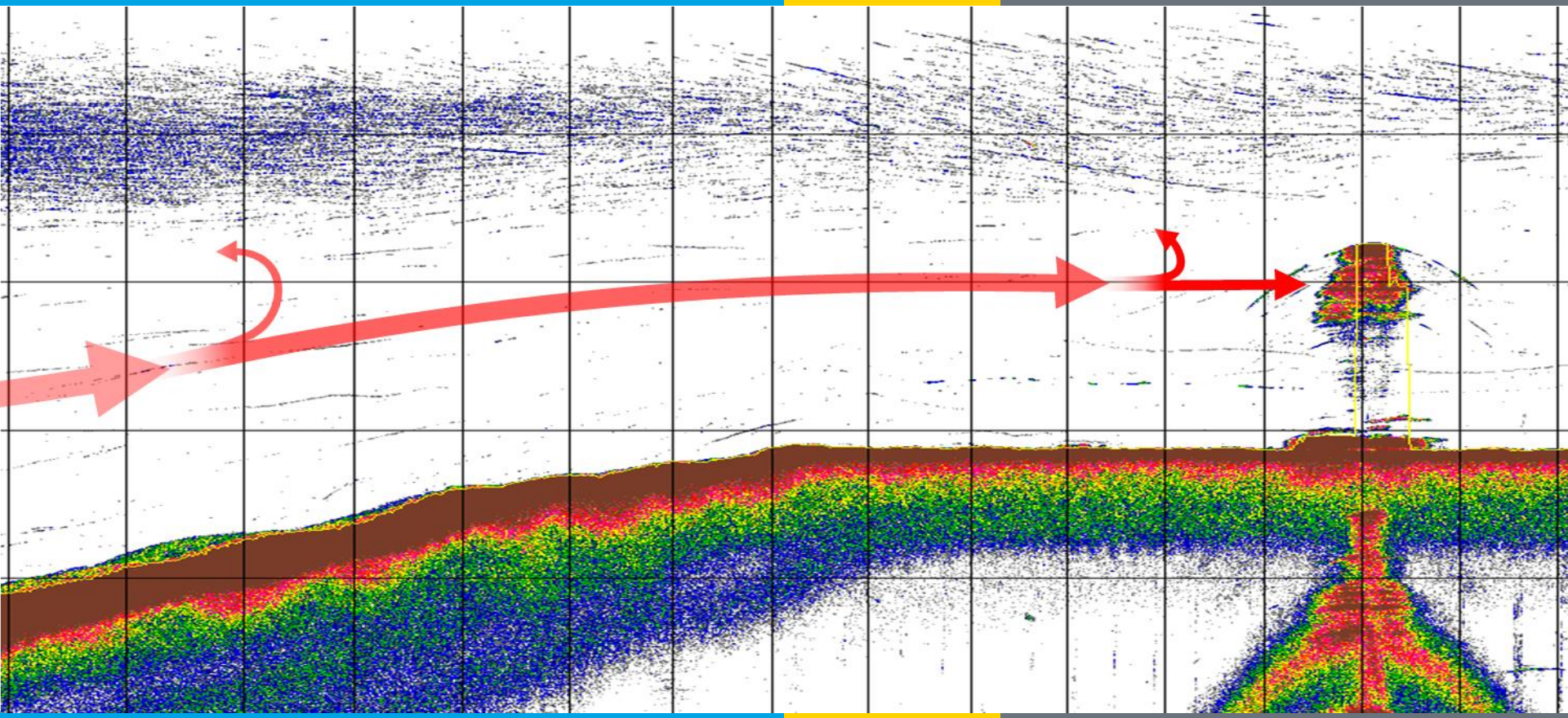
Water Power Technologies Office Peer Review
Marine and Hydrokinetics Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Interactions of Aquatic Animals with the ORPC OCGen in Cobscook Bay, Maine

Gayle Zydlewski
University of Maine
gayle.zydlewski@maine.edu - 207.581.4365
February 2017

Project Overview

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

Regulators of the growing tidal energy industry require information on its environmental effects in order to ensure its responsible development. The effects of these new devices on fish are of high concern to regulators, fishers, the scientific community, and other stakeholders. The goal of this project was to quantify aquatic animal behavior changes associated with the presence of a deployed marine and hydrokinetic (MHK) device.

The Challenge: This renewable energy technology is new and untested, and may affect fish and other marine life on a variety of spatial and temporal scales. No existing technology can monitor all of these scales simultaneously, and there are no established best-practices for evaluating effects of MHK devices on fish. Many different approaches must therefore be taken to evaluate the effects of an MHK device.

Partners: Ocean Renewable Power Company (tidal turbine deployment, site access, bottom-mounted echosounder deployment)

Program Strategic Priorities

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for Innovative MHK components
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- **Support research focused on retiring or mitigating environmental risks and reducing costs**
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets
- Exchange of data information and expertise

Project Strategic Alignment

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- **Support research focused on retiring or mitigating environmental risks and reducing costs**
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

The Impact

- Identification of methods and strategies to understand risk to fish in these environments
- Streamline environmental monitoring protocols and costs
- Outcome: low probability of encounter, identification of environmentally-informed sampling designs for minimizing costs while maximizing accuracy of environmental information

Technical Approach

Hydroacoustic echosounders were used in a variety of deployment configurations to assess potential interactions of fish with the MHK device on multiple spatial and temporal scales.

This work sought to inform our predictions of the effects of MHK devices on fish by monitoring several of the potential scales of interaction, and by improving our understanding of the natural presence of fish at tidal energy sites.

This was some of the first information gathered at a site with MHK devices deployed.

Technical Approach

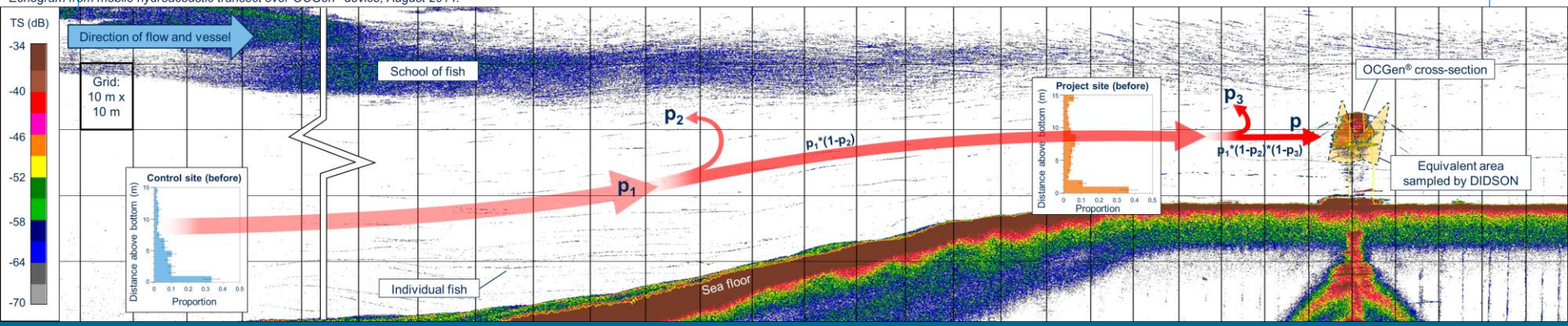
(1) Down-looking transects using hydroacoustic technology to detect individual fish, then models of fish distribution and presence.

What were the probabilities of fish encountering an MHK device based on fish vertical distribution, diel and tidal cycles, and behavior near the device?

- Maximum probability of fish encountering the whole TidGen® Power System: 0.432 (95% CI: 30.5, 55.3)
- Probability of fish encountering only the device foils: 0.058 (95% CI: 4.3, 7.3)

Echogram from mobile hydroacoustic transect over OCGen® device, August 2014.

Shen et al. In review. Renewable Energy.



(2) Hydroacoustics data processing to separate animal groups.

Animals in the ocean reflect sound differently depending on species and size. There are techniques for detecting these differences.

We improved confidence in our hydroacoustic data by using dB differencing to remove zooplankton from relative fish density estimates.

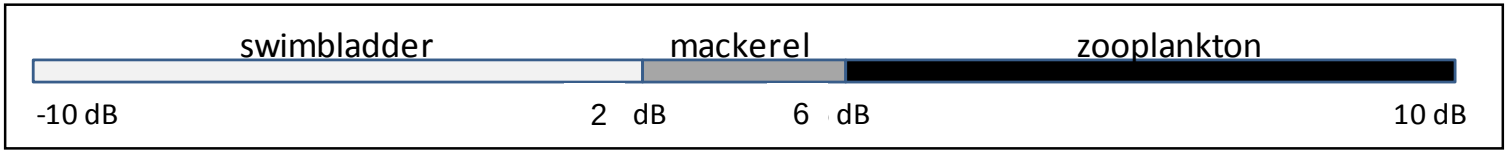


Figure 10. The frequency response, r(f), value line for dB differencing methods. Note that the mackerel r(f) is between the swimbladder and zooplankton r(f)s.

Technical Approach

(3) Using long-term datasets of environmental conditions in tidal areas of MHK-interest to understand changes in fish behavior

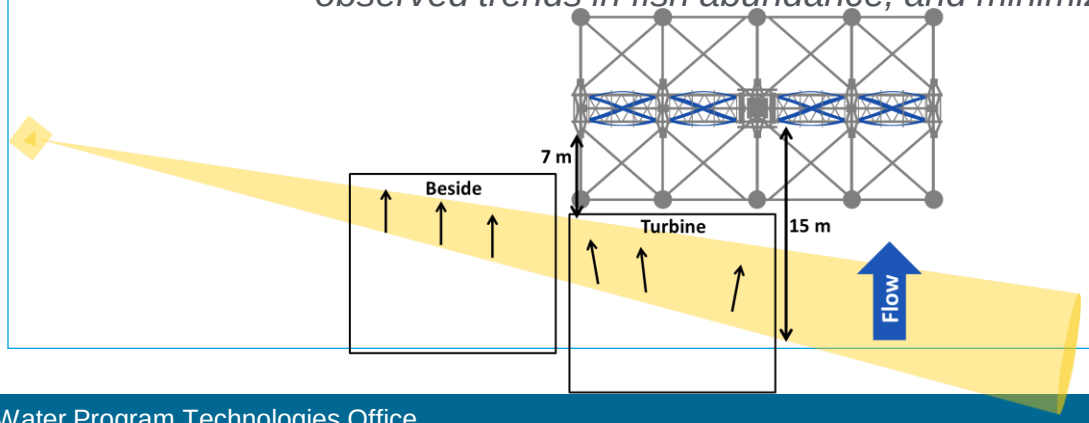
a) What were *individual fish behaviors* in front of and in the wake of the TidGen® module?

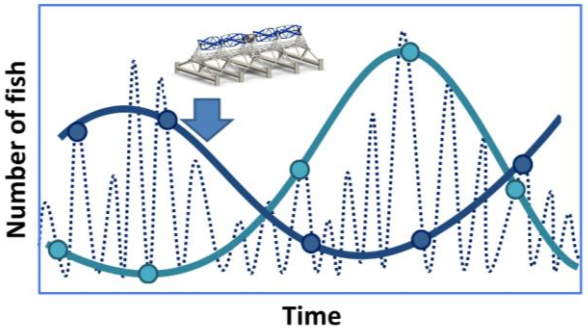
The presence of the static turbine affected fish movement upstream of the turbine relative to the water current.

a) Can a long-term hydroacoustic record of *fish abundance* be used to determine an ideal sampling strategy at this and similar tidal energy sites?

Survey timing can affect how long-term trends in fish abundance are observed and documented at a tidal energy site

Survey timing can be adjusted to account for natural cycles, improving accuracy of observed trends in fish abundance, and minimizing cost of surveys.





Accomplishments and Progress

Most important technical accomplishments achieved 2014, 2015, 2016 and their significance:

- Continuation of long-term hydroacoustic dataset on fish presence at project and control sites
- Probability of encounter model
- Patterns in fish presence at turbine depth
- Optimum survey design for long-term monitoring

Project Plan & Schedule

- Project initiation: 1/1/2014
  - Project end date: 6/30/2016
- Schedule adjustments
  - OCGen® vs. TidGen®
    - Goals remained the same → Different device
  - Foils stopped rotating
    - First survey: operational
    - 2nd and 3rd: not rotating
  - TidGen® bottom support frame proximity
    - Removed some data, but results were not statistically different.
- Go/No-Go decision points
  - March 2014: OCGen deployment
  - September 2014: Project performance and cost share

Project Budget

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$257.366k	$69.179k	$98.631k	$12.081k	$2.659k	$5.402k

- Variances from planned budget: None
- Portion expended to date: All
- Cost-share provided by UMaine and ORPC

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators:

Ocean Renewable Power Company (Partner)

Communications and Technology Transfer:

Presentations:

- Ocean Sciences 2016
- European Wave and Tidal Energy Conference 2015
- National Oceanic and Atmospheric Administration National Hydropower Meeting 2015
- Marine Energy Technology Symposium 2015

Seminars:

- Hirosaki University, Japan, 2015
- University of Aberdeen, Scotland, 2015.

Publications:

- Shen, H., G.B. Zydlewski, H. A. Viehman, G. Staines. 2016. Estimating the probability of fish encountering a marine hydrokinetic device. Renewable Energy 97: 746-756.
- 3 others submitted, 1 in progress.

Next Steps and Future Research

FY17/Current research: None associated with this funding mechanism

Proposed future research: Determining array-level effects will require techniques for measuring fish movement and behavior to be adapted from techniques used in this study: mobile, down-looking hydroacoustics and Before-After-Control-Impact design.

Continued interaction with ORPC and local and federal regulators of MHK development.