ENVIRONMENTAL MONITORING FOR MHK ENERGY: A LOOK AT FISH INTERACTION

Genevra Harker-Klimeš[1], Garrett Staines, Colleen Trostle and Shari Matzner
Pacific Northwest National Laboratory
Marine Sciences Laboratory,
1529 W Sequim Bay Road, Sequim,
WA 98382

[1]Corresponding author: genevra.harker@pnnl.gov

INTRODUCTION

Marine and hydrokinetic (MHK) energy generation is a new industry, and consequently has a high number of uncertainties. Amongst these are unknown environmental effects, which need to be addressed through the deployment and observation of devices. Unfortunately, the lack of knowledge of the environmental effects is one of the barriers to deployment, as regulators are reluctant to permit device installation without a better understanding of the consequences, and well-defined management measures.

One of the key areas of concern is how animals interact with devices in the water: when do they detect the device, how do they avoid it, and how often is there a collision? This can be approached from an observational perspective or behavioral modeling, and for future assessments, a combination of the two will probably be required. As observations improve our understanding, the modeling will be more accurate, with increasing application for a wider range of conditions.

This presentation will discuss how fish collision has been monitored in the past, what the limitations are with different techniques, and how we can use this information to improve fish collision monitoring in the future. It will specifically focus on a continuing study to quantify fish collision that is being undertaken at the Pacific Northwest National Laboratory, and a future study to assess collision rates, refine software analysis and assess the effectiveness of different sensors when used in combination.

FISH INTERACTION

Existing Studies

While there are several techniques for measuring animals underwater, no single process provides the information to address regulatory concerns related to fish interaction. To date, both acoustic and optical imaging techniques have been used to detect animals near a device and to determine avoidance, evasion and collision rates [1].

The collision rate for fish with current turbines is of particular concern, both in rivers and in the marine environment. Permits often require the monitoring of fish to establish how they are affected, focusing on protected species.

Previous studies of fish collision have been undertaken around the Verdant turbines deployed at the Roosevelt Island Tidal Energy (RITE) site in New York, using both a stationary and a mobile, vessel mounted DIDSON system in 2006 and 2007 [2], as well as a series of BioSonics split beam echosounders. There were also studies around the Ocean Renewable Power Company (ORPC) deployment of their TidGen® Power System in Cobscook Bay, Maine in 2012, which again combined several acoustic sensors [3]. For fish detection, a downward looking Simrad single-beam echosounder was used from a stationary research vessel at the turbine site and a control site, before and after installation. A Simrad split-beam echosounder was deployed 44.5 m from the turbine looking horizontally seaward of the device, covering a distance of approximately 80 m. In addition, during a pre-deployment test of their Turbine Generator Unit on a research barge, two DIDSON acoustic cameras were deployed for 22 hours looking at areas immediately adjacent to the turbine on both sides [4]. Both these projects demonstrate the use of acoustic sensors for baseline measurement, far-field detection, and close interaction.

Subsequently, in July/August 2015, ORPC deployed a similar turbine, their RivGen® Power System, in the Kvichak River in Alaska, near the village of Igiugig. On that occasion, five video cameras were used to monitor the turbine, with lights at night to improve fish detection. Several days of these video data have been manually analyzed to establish how many fish interacted with the turbine (Figure 1) and note any distinct behavior. This analysis has highlighted the difficulties of undertaking manual analysis, and has a series of learning points concerning how the analysis is undertaken, what parameters can be identified, and also the importance of the type of video equipment used.

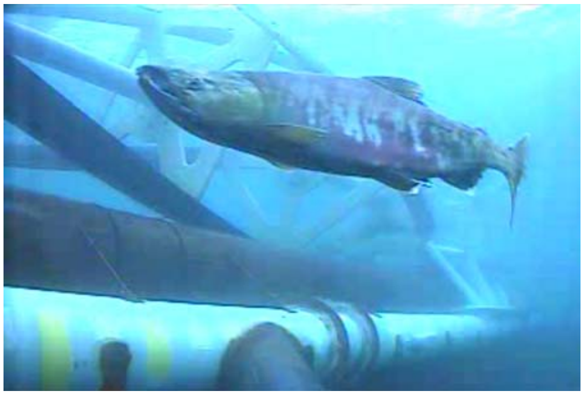

FIGURE 1. FISH BESIDE TURBINE AT IGIUGIG.

The limitations associated with these different deployments, and the nature of the locations that are likely to be used for turbine deployment (e.g., fast flowing, turbid water bodies), highlight the need to combine different sensors. When designing the monitoring program, a number of factors need to be considered, and compromises reached, including:

- Range observed (device itself, near-field, far-field)
- Resolution of image
- Turbidity
- Light availability
- Boundaries and interference within signal
- Background 'noise' within signal: the signal to noise ratio (SNR)
- Distinction between fish and debris
- Amount of data to be collected and labor intensive analysis

This last point is particularly relevant to image-type monitoring, as it is not feasible for a person to study video or sonar images 24 hours a day and detect all that is shown. The events that are of most interest (such as collision) are extremely rare, and it is likely that an observer would miss these events when viewing a long dataset.

Consequently, automated image analysis is a priority for animal interaction monitoring. This has its own set of limitations in detecting fish against a moving background, successfully distinguishing fish from other 'blobs', and reducing false positives.

A further difficulty with all these techniques is to establish actual collision or strike. Even in video footage it is likely to be difficult to separate a fish beside a blade from one that hits a blade, as a change in behavior may be due to the turbulence around a blade rather than an impact itself. This leads to the consideration of additional sensors within the blades to detect stresses that may represent a strike [5,6].

Future Study

Given the uncertainties surrounding the most effective approach, a fieldwork study is planned that will combine a number of different techniques. These include passive acoustics, fish tagging with hydrophones to monitor the tracks of individual fish, far-field (e.g., 30-50 m) sonar/echosounder sensors, near-field (e.g., <10 m) acoustic cameras, and immediate interaction (e.g., face of turbine) optical cameras.

The aim of this study is both to add data for model parameters that consider fish behavior, and to determine which methods of observation provide the most appropriate information in different scenarios. This includes methods of data analysis and the possible combination of different data streams to improve data interpretation. A review of the considerations in this study design will be discussed.

CONCLUSIONS

To establish an MHK energy industry, more deployments are needed to better understand the potential effects. Making more information available on the most suitable techniques and methods for monitoring will reduce environmental monitoring costs, and produce a more consistent body of information to inform environmental analysis overall. To achieve more comparable methods and interpretation, the results from existing studies should be combined with field trials on the most effective techniques to simplify the requirements for future monitoring and make this available to researchers, industry and regulators. While each study is important to add to the information available, a more strategic approach to testing monitoring techniques and analysis will lead to consensus being reached on what applications are appropriate for different scenarios, and thus enable more efficient and effective monitoring overall.

ACKNOWLEDGEMENTS

We would like to thank ORPC for providing the video data for analysis and automated processing development.

REFERENCES

[1] Copping, A., Sather, N., Hanna, L., Whiting, J., Zydlewski, G., Staines, G., Gill, A., Hutchison, I., O'Hagan, A., Simas, T., Bald, J., Sparling C., Wood, J., and Masden, E. 2016. "Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World."

[2] Verdant Power 2010 "Roosevelt Island Tidal Energy Project, Appendix B of RMEE Plans – Summary of RITE Project DIDSON Observations", http://www.theriteproject.com/uploads/VPRITE-FLAVol4-Part3of3.pdf

[3] Ocean Renewable Power Company 2013 "Cobscook Bay Tidal Energy Project 2012 Environmental Monitoring Report", http://www.orpc.co/permitting_doc/environmentalreport_Mar2013.pdf

[4] Viehman, H.A. & Zydlewski, G.B. 2015) "Fish Interactions with a Commercial-Scale Tidal Energy Device in the Natural Environment" Estuaries and Coasts **38** (Suppl 1): pp. 241-252.

[5] Offshore Renewable Energy Catapult 2016 "Tidal Turbine Collision Detection: A review of the state-of-the-art sensors and imaging systems for detecting mammal collisions", https://ore.catapult.org.uk/wp-content/uploads/2016/05/Tidal-turbine-collision-sensor-development-sensors-review-report.pdf

[6] Offshore Renewable Energy Catapult 2016 "Tidal Turbine Collision Detection: Requirements Report", https://ore.catapult.org.uk/wp-content/uploads/2016/05/Tidal-turbine-collision-sensor-development-requirements-report.pdf