Workshop on Modeling Fish Interactions with Tidal Turbines

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Environmental Interactions of Marine Renewables
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Organizers

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1. Context

The *Modeling Fish Interactions with Tidal Turbines* workshop was held at the Environmental Interactions of Marine Renewables (EIMR) 2024 conference to discuss the applicability of existing marine animal-turbine interaction approaches to fish, through numerical modeling. Consenting around tidal energy projects has been slowed in some jurisdictions by concerns about the risk to fish from tidal energy turbines, particularly the likelihood and potential consequence of collision risk. Concerns are emphasized for fish species of conservation concern and those that are commercially and recreationally important, and of cultural relevance to indigenous communities (e.g., salmonids, sturgeons). Obtaining high-quality, *in situ* data around operational devices in tidal channels and developing numerical models can help answer uncertainties that remain around fish-turbine interactions.

This workshop sought to bring together expertise on encounter rate and collision risk modeling to identify current approaches, knowledge gaps, challenges, and potential solutions for applying these techniques to fish-turbine interactions in a collaborative environment. The workshop consisted of a series of presentations that provided context on collision risk, collision risk and encounter rate models, and data around fish spatiotemporal distribution, and breakout groups with guided discussions that allowed workshop participants to engage and share their thoughts about models and data gaps. There were 25 participants in attendance at the workshop.

2. Structure of the Workshop

The workshop began with five short presentations from experts focused on collision risk and collision/encounter modeling. Anna Redden gave an introduction to collision risk as it pertains to fish, including some of the challenges with monitoring fish-turbine interactions, as well as introducing the agenda for the workshop and a game plan for the discussion section. Lysel Garavelli presented existing approaches to collision risk and encounter rate models and the input data required for those models. Charles Bangley and Richard Karsten gave a joint presentation on passive acoustic tagging of fish to build static spatiotemporal distribution maps and estimate the extent of overlap with areas of planned turbine installation. Jezella Peraza provided an overview of an agent-based model to examine fish avoidance and behavior on fish-turbine interactions. And lastly, Nicholas Horne gave a presentation on collision risk assessments with a simulation-based model.

After the presentations, participants were separated into three breakout groups, along with two facilitators per group. The facilitators used a series of questions to guide the discussion around the usefulness and suitability of models and the data needed to inform collision and encounter risk models.

Questions asked during the breakout discussions are below:

- Usefulness/suitability of models
    - Are existing models sufficient for the assessment of encounter rate and collision risk?
    - Can these models be used for assessing the effects on fish populations?
- Data for collision risk & encounter rate models
    - How adequate are the various data collection methods and associated data, used separately or in combination, in delineating the risk of collision?
    - What are the specific gaps in knowledge and data in the current encounter and collision risk models?
    - What methods and data do you recommend moving forward?
    - How can these methods and associated data be used to inform encounter and collision risk models?
    - What do we need to extract from the field data to parameterize and validate the models?

3. Breakout Discussions Summary

Usefulness and Suitability of Models

Participants discussed existing encounter rate and collision risk models, their limitations, and suggestions for improvement. Models are important for informing collision risk at each site because scientists cannot monitor every single turbine. However, participants agreed that collision risk models are not suitable for very low probabilities of encounter, and that there are challenges with understanding and incorporating behavior (i.e., avoidance, evasion) into models. Current collision risk models incorrectly assume that fish exhibit naïve behavior around

turbines, when in fact field and laboratory evidence suggests that some fish species can exhibit avoidance/evasion behaviors under varying environmental conditions; it is important to incorporate these behaviors into model predictions. For example, agent-based fish models currently being developed in the US may help fine-tune models with behavioral inputs. In addition, collision risk models are sensitive to population density; however, this is often not accurately known for many fish species. Models that assume 100% mortality from collision are inaccurate and are no longer suitable for helping to contextualize the risk of fish-turbine interactions.

Participants discussed areas where monitoring and adaptive management are sufficient such as when the risk of collision is considered low (e.g., no collisions have been observed during the given study period). However, as the industry scales to arrays, monitoring and adaptive management will need to adapt.

As new data become available, experts from a variety of fields need to be involved in the development of collision risk models to ensure they provide realistic results. Participants described models as tools to instill confidence in regulatory decision-making; however, participants also cautioned that models require updating as new and better baseline and effects testing monitoring data are collected around operational turbines.

Data for Collision/Encounter Risk Models

Participants discussed data gaps for encounter rate and collision risk models, which include residency time, identification and tracking of individual animals, and turbulence measurement to determine fish school density. Detecting fish in high-flow speed areas remains challenging, as does measuring fine-scale evasion. There are few reliable estimates of fish population size, even though it is an important parameter to know when regulators ask for the expected number of fish mortality in a certain area or population-level consequences of harm or mortality stemming from collisions. Currently, there are too few datasets to create or validate fish collision models; more acoustic fish tagging studies need to be conducted, especially localized near turbines to inform an assessment of avoidance. The lack of deployed devices makes it challenging to obtain knowledge about collision risk. In addition, it was suggested multiple times throughout the discussions to conduct sensitivity analyses of the models to assess the influence of model parameters and understand which component influences the risk of collision the most (e.g., the size of a turbine blade). Some models are a little bit of a ‘black box’; understanding the key components driving each model and their relative influence on the outputs is crucial.

The biggest gap remains the lack of observations of fish-turbine interactions and actual evidence of collision events to inform models. Large amounts of data have not been processed yet and are waiting for review by trained scientists; these unprocessed data could be impeding advancements of these models. Datasets collected with video cameras or active acoustic technologies are large, so there is a need for motion detection algorithms and machine learning to speed up the post-processing, analyses, and automation of species identification.

Sharing environmental data among site developers and the scientific community will help the marine renewable energy industry progress; however, this requires increased levels of

collaboration, cooperation, and trust. Broader collaborations are needed between modelers, developers, and those designing monitoring programs, collecting the data, and analyzing the data.

4. Recommendations

To improve collision risk and encounter rate models, workshop participants recommended that the following actions are important:

- Not assume that all collisions result in mortality;
- Assess and use periods of increased species prevalence to collect data and train models;
- Improve models as new observational data on fish-turbine interactions (e.g., avoidance, behavior) becomes available and use data-rich models to inform field study designs;
- Ensure realism during model refinement by involving experts from a variety of disciplines (e.g., computational fluid dynamics, fish behavior and locomotion, computer science, etc.);
- Broaden collaborations between modelers, project developers, marine engineers, those designing monitoring programs, those collecting data, and those processing and analyzing data, and reporting monitoring results; and
- Strengthen models using data to be used as proxies for fish species of concern that behave similarly.

To better inform encounter rate and collision risk models, participants recommended the need to:

- Increase data about behavioral responses to understand what an animal does when it detects a turbine;
- Use a combination of data collection methods such as acoustic tags, visualization surveys, and multibeam sonar;
- Collect quality fish detection data over all seasons to inform model refinement;
- Understand whether collisions occur on an individual level in the first instance before focusing on population-level consequences;
- Prioritize the development of motion detection algorithms and machine learning to identify fish species for faster post-processing of large active acoustic and optical datasets; and
- Share environmental data among site developers and the scientific community.

Participants also recommended that guidance materials about collision risk be updated regularly with the best available science as they can become outdated quickly. A coalition of subject matter experts (such as this workshop) should help guide these updates. It was also suggested that a review paper be prepared about fish-turbine interaction modeling approaches applicable to tidal energy device sites. While the workshop focused on collision risk,

displacement was brought up a few times, with participants recommending that it be assessed at the same time as collision, especially as it becomes more relevant with the industry scaling up towards deploying arrays of devices.

Appendix 1: Workshop Agenda

9-9:30:

- **Anna Redden** – Introduction to collision risk
- **Lysel Garavelli** – Overview of known encounter rate and collision risk models

9:30-10:

- **Charles Bangley** and **Richard Karsten** – Using passive acoustic tracking to build fish distribution maps and calculate encounter probability

10-10:30:

- **Jezella Peraza** – Using an agent-based model to examine the effects of avoidance and behavior on fish-turbine interactions
- **Nicholas Horne** – Comprehensive collision risk assessments with a simulation-based model

10:30-10:45: Break

10:45-11:35: Breakout discussions

11:35-12:00: Report out and open discussion