Choose Your Own Marine Energy Adventure Game: Collision Risk

Lenaïg G. Hemery, Brandon T. Deguia, Martin J. Pratt, Christiana P. Tebbs, Nick Cramer, Lysel Garavelli

Abstract— **The risk of collision between marine animals and marine energy turbines continues to be the first question raised by regulators for new projects around the world, and the most significant issue slowing down consenting/permitting. The challenges stem from the difficulty in observing close encounters and interactions of marine animals with the slow-rotating turbines. To better comprehend this risk, the marine energy community and general public need to be educated on the processes and various stages involved in potential animal collisions with turbines. This project developed an interactive outreach tool for the marine energy community and general public that highlights the different stages of a collision event at various spatial scales and features a fish species of concern, the Atlantic salmon. The tool is a three-dimension educational interactive experience, accessible from any web-connected platform, and is hosted on a publicly accessible website. Throughout the experience, the player is presented with various decisions to take as the salmon approaches and interacts with a tidal turbine. At each step along the way, the player is provided with bite-size scientific information and weblinks to deepen their understanding of the topic. This short but efficient tool with expert messages is a "hands-on" experience for the players, where they are the animals and make the decisions leading up, or not, to collisions. The outcomes of this project will support broad outreach and education goals to reduce barriers to consenting/permitting for future deployment of tidal and riverine turbines.**

Keywords—**Collision risk, educational experience, environmental effects, interactive tool, tidal turbine.**

I. INTRODUCTION

COLLISION risk is the risk of marine animals getting injured or killed by entering in contact with the moving parts of a marine renewable energy (MRE) device, typically the blades of a tidal or river turbine. Collision risk remains the main environmental concern slowing down the consenting/permitting of tidal or river turbines around the world [1]. The marine animals most at risk of collision with MRE devices are marine mammals, pelagic fish, and diving seabirds that inhabit and/or use sections of the water column where the moving parts of a device are located [2]. While the outcomes of a collision, and especially the loss of individuals, could lead to damaging effects for populations of critically endangered species, collision events are rare [2].

Monitoring with acoustic and optical technologies around operational tidal or river turbines has never recorded collision events for marine mammals and diving seabirds, and only a handful of fish collisions, with unknown outcomes [1], [3], [4]. Despite the scarcity of collision events, collision risk continues to be a high concern for regulators. To better understand the risk and alleviate this concern, there is a need to communicate and engage with the general public and the MRE community (regulators, stakeholders, scientists) on the processes and stages to consider in collision risk of marine animals.

To our knowledge, only one educational video[2] exists on collision risk of marine animals with a turbine. Although this video is informative and includes different marine species, the spatial scales of the turbine and the animals and the blades' rotating speed are not accurate, scientific

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[2]https://www.youtube.com/watch?app=desktop&v=DhUzXzPVTXM&feature=emb_logo&ab_channel=PacificNorthwestNationalLaboratory

information describing the animal's behaviour is not displayed, and there is no interaction for the viewer. Other videos being developed describe the engineering side of a tidal turbine but do not include any interactions with marine animals.

This project developed an innovative type of outreach material for the MRE community and the general public to educate on the low risk of collision. The outcome is a three-dimension educational interactive experience, accessible from any web-connected platform, highlighting the different stages of collision risk at various spatial scales. Because nearshore pelagic fish, among them salmons, are likely to interact with MRE devices once deployed in suitable areas [4], [5], [6], [7], [8], the first version of the interactive tool features an Atlantic salmon approaching a bottom-mounted tidal turbine. This short but efficient interactive tool with expert messages is a "hands-on" experience for the viewers, where they are the animal and make the decisions leading up, or not, to collisions.

II. METHODS

For the first phase of the project, the team's subject matter experts developed the storyboard for the "choose your own adventure" interactive tool (Fig. 1) and implemented it with a fish example, the Atlantic salmon (*Salmo salar*). The storyboard was then shared with the team's developers to start the development of the tool. The interactive tool was created using computer game engine technology (i.e., Unity[3]) and 3D models (acquired from TurboSquid[4]) to run in a web browser. A game engine is a dynamic runtime environment for video games that allows moving objects in a 2D or 3D space, handling user inputs, and passing them to in-game objects, simulating or animating real-world events such as a collision. A collection of 3D models was purchased for the underwater scene featuring a tidal turbine, seafloor features, and marine life (fauna and flora) (see examples in Fig. 2).

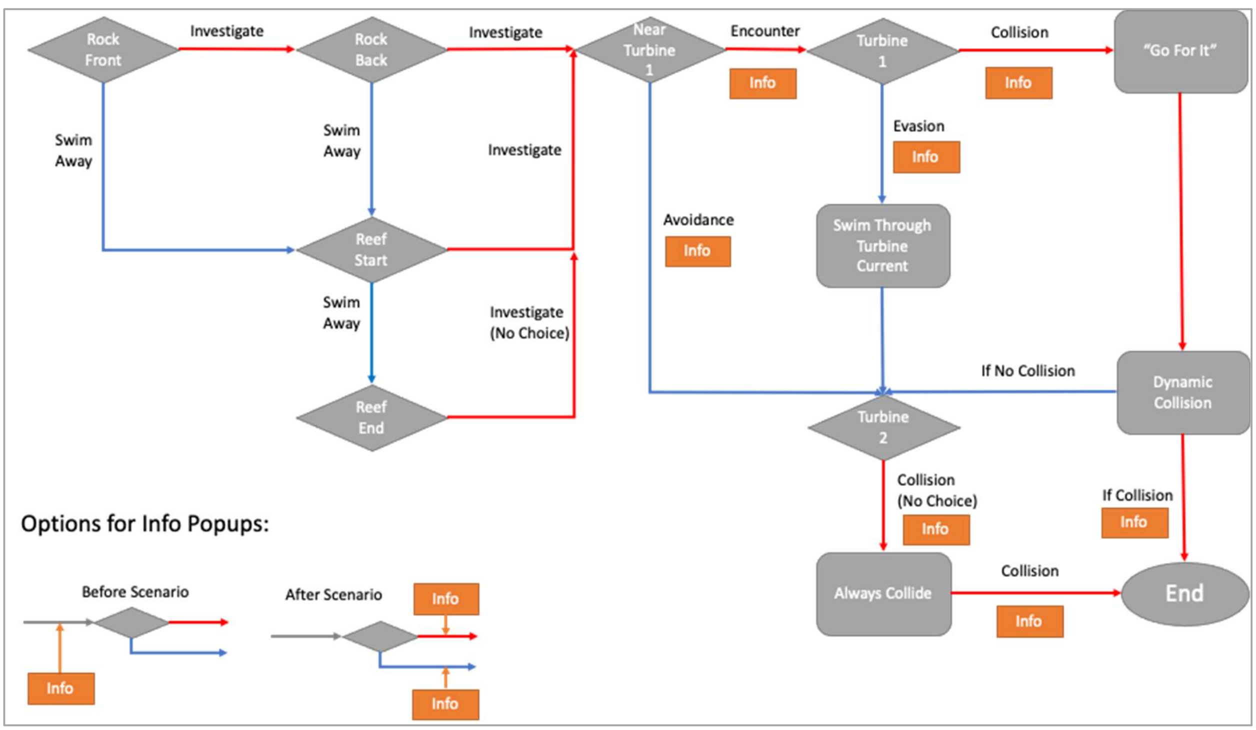


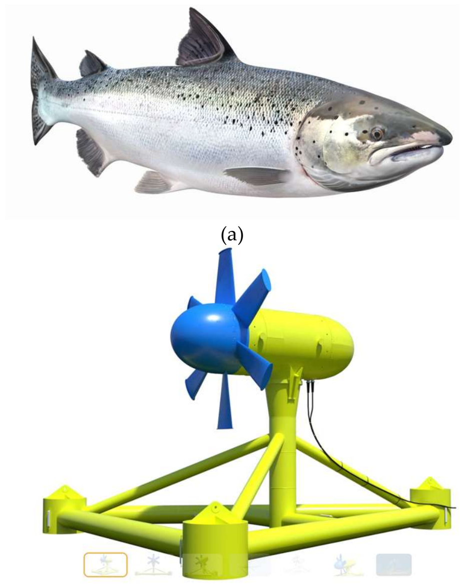
Fig. 1. Flowchart of the storyboard used for the Marine Energy Adventure Game, where the red arrows lead the path toward collision and the blue arrows lead the path away from collision.

The interactive tool was built to be a dynamic experience to enable the user, as the fish, to make decisions using a mouse and keyboard or touchscreen. In the tool, the fish is fully rigged and animated to produce realistic movement as the player/fish navigates within the game environment and when any collision with a tidal turbine blade occurs. At any time in the game, the player can choose between two views of the fish: first-person view (the camera is located on the fish's dorsal fin) or third-person view (the camera is located behind the fish). Audio was incorporated to simulate the underwater environment and vary with proximity to the turbine. The tidal turbine sound clip was obtained from a publication on the underwater noise generated by a turbine of analogous design, deployed in a similar underwater environment [9]. Animated panels were created to display information at decision and outcome checkpoints throughout the experience. The scientific content was extracted from relevant publications

[3] https://unity.com/

[4] https://www.turbosquid.com/

available on *Tethys* [5] (an online knowledge base that provides information on the environmental effects of MRE) as well as from leveraging previous work by the project team [5], [10].



(a)

(b)

Fig. 2. 3D models of an Atlantic salmon and a tidal turbine (not to scale) used in the interactive tool.

During the development of the interactive tool, developers and scientists in the team were in constant communication to provide content and feedback and try out successive versions of the tool. Colleagues with a background in science education and communication reviewed the text displayed throughout the game to make sure it was accessible to a wide audience. In addition, a handful of researchers familiar with the topic but not associated with the conception of the game provided feedback on the accuracy of the scientific content.

III. IMPLEMENTATION

A. *Storyboard*

In this tool, the player is the fish and is given several choices as the fish approaches the tidal turbine at different spatial scales (Fig. 1). Along the way, information is provided to explain specific scientific terms related to collision risk as well as the probabilities of making any of the choices, based on published scientific literature. In the farfield, the fish detects the turbine because of stimuli other than visual (e.g., underwater noise) and must choose between changing direction to stay away from the stimulus and continuing toward the stimulus. If the fish (i.e., the player) decides to stay away, the fish swims away and then eventually comes back towards the noise. If the fish chooses to continue, it swims toward the noise. In the midfield, the tidal turbine becomes visible to the fish who must choose between avoiding the turbine (the concept of avoidance is explained in the tool) and continuing toward the turbine (the concept of encounter is explained in the tool). If the fish chooses to continue toward the turbine, it arrives close to the turbine (nearfield) and must choose between evading the turbine (the concept of evasion is defined in the tool) and interacting with the turbine blades (the concept of collision is explained in the tool). The actual interaction is based on the probability of a collision to happen as found in the published scientific literature (i.e., ≈ 1.5% of the fish may collide with turbine blades [4]), and the way the collision was recreated is also based on best-available science. The potential consequences of a collision are then explained: none, injury, or death, with potential implications for the species.

The terms avoidance, encounter, evasion, and collision were defined as per [2] and [10]:

- Avoidance is the behaviour of an animal actively responding to and moving away from a turbine at a distance greater than five turbine diameters (approx. 40 meters).
- Encounter is when an animal is in the proximity of a turbine (= nearfield), at about one to five turbine diameters (approx. 8-40 meters).
- Evasion is when an animal changes its behaviour to escape contact with a turbine within five turbine diameters (approx. 40 meters).
- Collision is when an animal comes into contact with the blade of a turbine or its pressure field, and may result in an injury to the animal.

B. *Design of the video game environmental background*

The first step in the development of the interactive tool was to design the underwater background (i.e., seascape) within the Unity game engine. Digitalized underwater images were used as inspiration for the initial seascape (Fig. 3) using a 3D terrain builder overlaid with textures designed specifically for underwater scenes (e.g., reducing observable distance, light variations). Following reviews from subject matter experts in the team, the seascape was updated to represent the realistic habitat of the fish with seagrass, rocky reefs, and sandy bottom (Fig. 3). Once the seascape was ready, the team's developers modified the colours and shape of the tidal turbine from the 3D model so that it would not be associated with a specific tidal developer's design.

C. *Inclusion of fish behavioural choices*

Following the storyboard, the fish behaviour was included in the interactive tool to represent the possible choices as the fish approaches the turbine. Within the game environment, the fish can swim in all directions. The player triggers the movement of the fish by choosing its behaviour such as swimming away, encountering the turbine, or avoiding the turbine (Fig. 4), then the fish

[5] https://tethys.pnnl.gov/stressor/collision

follows a pre-established path within the game engine to reach the next checkpoint.

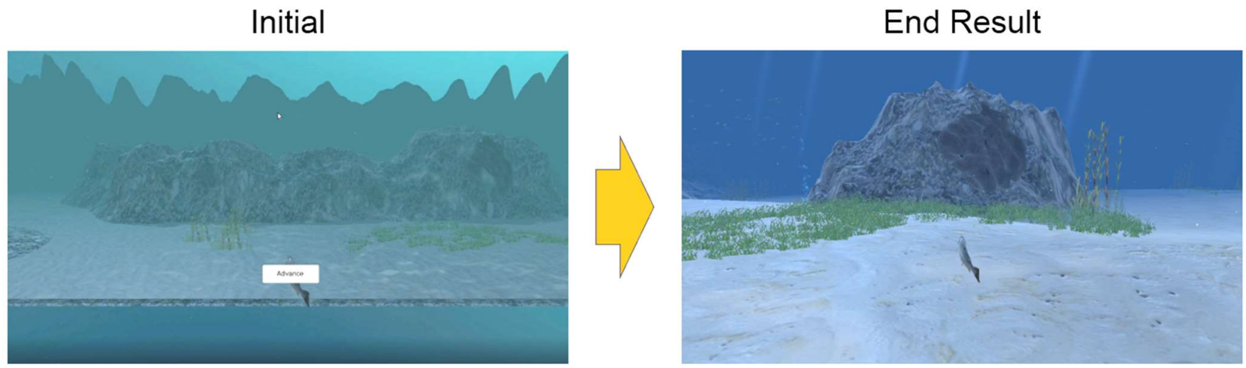
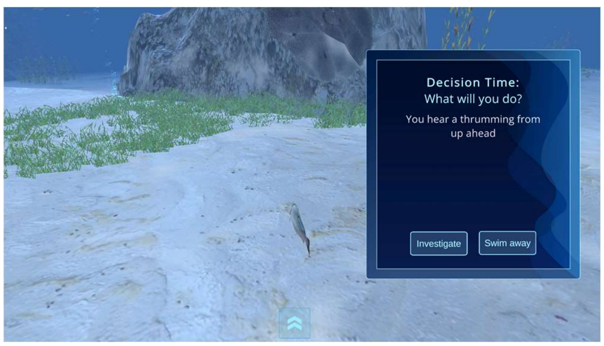


Fig. 3. Initial and final seascapes selected for the video game.



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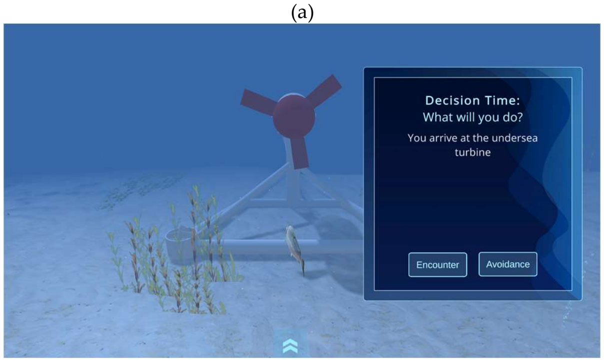


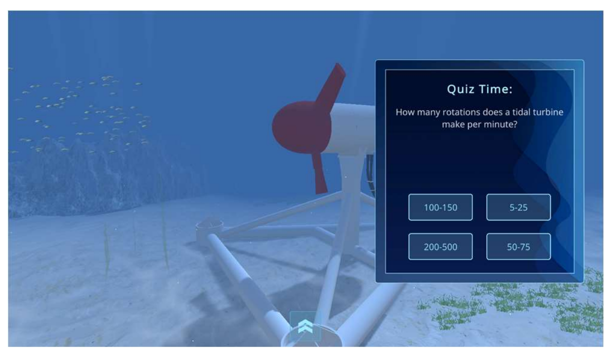
(b)

Fig. 4. Examples of fish behaviour choices included in the interactive tool: (a) in the farfield, the fish hears the turbine noise and can swim towards or away from it; (b) in the midfield, the fish sees the turbine and can decide to encounter or avoid it.

D. *Inclusion of educational content*

To educate the player on MRE technologies and the potential associated risks of collision for a fish, quizzes and descriptions of the different fish behaviours were included throughout the game. At the beginning of the game, two multiple choice questions are asked to the player (Fig. 5a): one on the average number of rotations per minute that a tidal turbine turns at, and one on how often collision events between a fish and a tidal turbine have been observed in the field. A third multiple choice question appears at the end of the game as a learning assessment, asking the player which behaviour is the most common for fish around tidal turbines. With each quiz, if the answer is wrong, the player can try again or decide to see the right answer. Each time, a brief explanation of the right answer is provided, with a link to relevant scientific literature.

During the game, at each checkpoint where the player decides on the fish behaviour, information about the decision is shown. For example, if the player decides to avoid the turbine in the midfield, the concept of avoidance is explained (Fig. 5b). This information is based on scientific literature and includes relevant hyperlinked references to the article cited hosted on *Tethys*.



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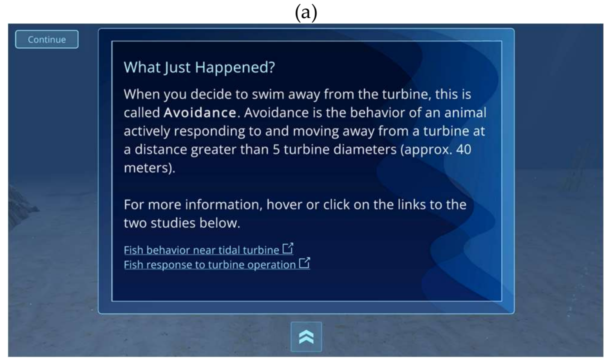
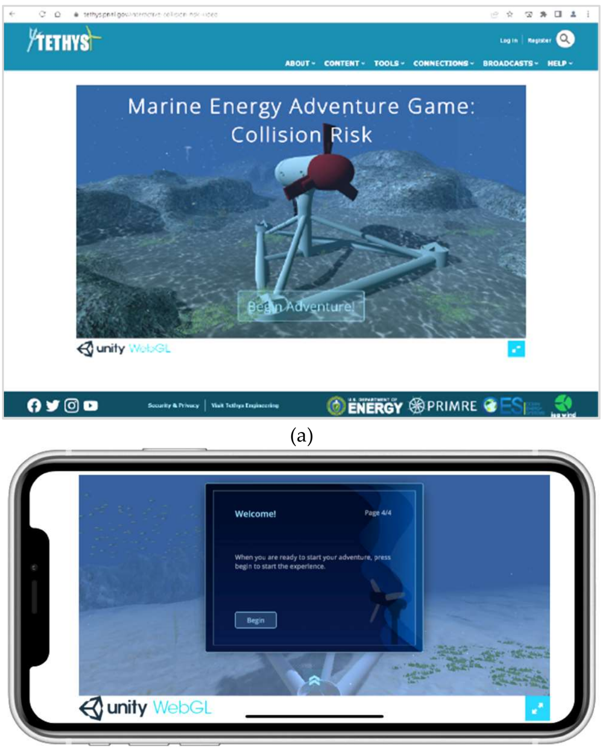


(b)

Fig. 5. Examples of educational content included in the interactive tool: (a) multiple choice question; (b) scientific information on fish behaviour.

E. *Finalization of the tool*

The interactive tool is hosted on *Tethys*. The *Tethys* webpage [6] featuring the tool can be accessed via a computer or a smartphone (Fig. 6). At the time of writing, the game is being finalized and first feedback from test users is promising: Isaac, 9 years old, "No way! Am I a fish?! That was really cool!"; Sam, 32 years old, "This is very well done! I learned a lot about how fish can interact with a turbine!".



(a)

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Fig. 6. Screenshots of the Marine Energy Adventure Game on *Tethys*: (a) on a computer web browser; (b) on a smartphone screen.

IV. CONCLUSION

Collision risk of marine animals with tidal turbines remains one of the chief concerns for regulators consenting/permitting MRE projects and for many stakeholders with interest in a project area, such as fishers or conservation groups. The scientific research has greatly progressed on this risk and results need to be communicated in accessible ways to the various interested audiences; this project developed a free interactive tool to do so. This tool will help the MRE community understand the nature of collision risk and the low probability of this event occurring when marine animals approach tidal or river turbines. The next phase of the game development will involve adding a marine mammal species and a floating tidal turbine, and promoting the game to a large audience. The use of interactive material to explain collision risk to the general public will help increase social acceptance of MRE projects, which is urgently needed for mitigating climate change effects.

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