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A FRAMEWORK FOR ENVIRONMENTAL RISK ASSESSMENT AND DECISION-MAKING FOR TIDAL ENERGY DEVELOPMENT IN CANADA

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ABSTRACT

In-stream tidal energy initiatives are rapidly developing in Nova Scotia, Canada, but there remains a high degree of uncertainty regarding the nature and extent (in space and time) of environmental implications of energy harvesting activities. To ensure the tidal energy industry in Nova Scotia (and elsewhere in Canada) develops in an environmentally safe and sustainable manner, regulators and industry are in need of a consistent, objective and efficient approach to assess and mitigate the risk of adverse environmental impacts of a proposed project. This paper presents a science-based environmental risk assessment and decision-making framework developed on behalf of the Nova Scotia Department of Energy and Fisheries and Oceans Canada (Federal). The framework offers key steps and considerations for identifying, assessing, and addressing the environmental risk of in-stream tidal energy projects based on the best available scientific knowledge, expert advice, and best practices for environmental risk and impact assessment. The risk assessment approach is based on a set of practical criteria and related risk indictors that are relevant, flexible and can be consistently applied to projects of any type, size or location. By following this approach, project planners and reviewers can also gain insights as to: site-appropriate project design and size consideration; the level and type of baseline studies and monitoring that may be required; methods of mitigating or reducing the level of risk of a project; and evaluation measures or trigger points for adaptive management actions. The guidance framework has been peer reviewed by scientists, industry and provincial and federal government agencies and is intended to form the basis of a joint Canada/Nova Scotia Statement of Best Practice for the management of in-stream tidal energy development.

INTRODUCTION

In a nascent field such as in-stream tidal energy (TEC), uncertainties abound: development sites are in high flow locations that may be unstudied; the waters are often important for other resource uses; and the operational characteristics and environmental effects of newly-designed devices and arrays are poorly known. Consequently, the environmental, technical and economic risks of development are difficult to forecast. This presents a challenge to regulators, proponents and the public alike. For the regulator, the risks lie in approving a development that may impact existing resource users, or that generates unacceptable environmental effects. For the proponent, the risks of technical failure may be familiar, but those associated with unusual operating or maintenance costs and absence of public acceptance can undermine confidence of financial supporters. A comprehensive process is needed to enable an adequate assessment of risk for all participants. In response to this need, in 2012, the Nova Scotia Department of Energy and Fisheries and Oceans Canada enlisted scientists at Acadia University to develop a science-based environmental risk assessment and decision-making framework [1]. This guidance has undergone peer review by scientists, industry and provincial and federal government agencies.

THE FRAMEWORK

The framework is based on the following guiding principles:

- appropriate consideration of ecosystem-scale and cumulative effects, both in the near-field and system-wide;
- acknowledging natural changes and variability;
- use of precautionary and adaptive management approaches;
- need for early initiation of baseline studies;
- consideration of site-specific and project-specific characteristics; and
- consideration of other human uses.

The framework involves seven main steps (Figure 1):

1. Define the scope of the review.
2. Evaluate the project site characteristics.
3. Evaluate the environmental risk of the project proposal based on a set of standard defined criteria and indicators (see Table)
4. Identify risks of interference with other human uses of the ecosystem (e.g. fisheries, recreation).

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5. Categorize the overall risk of the proposed project and make a management decision.
6. Propose supplementary mitigation measures to reduce the overall risk of the project, where applicable.
7. Prepare an environmental monitoring and adaptive management program for an approved project.

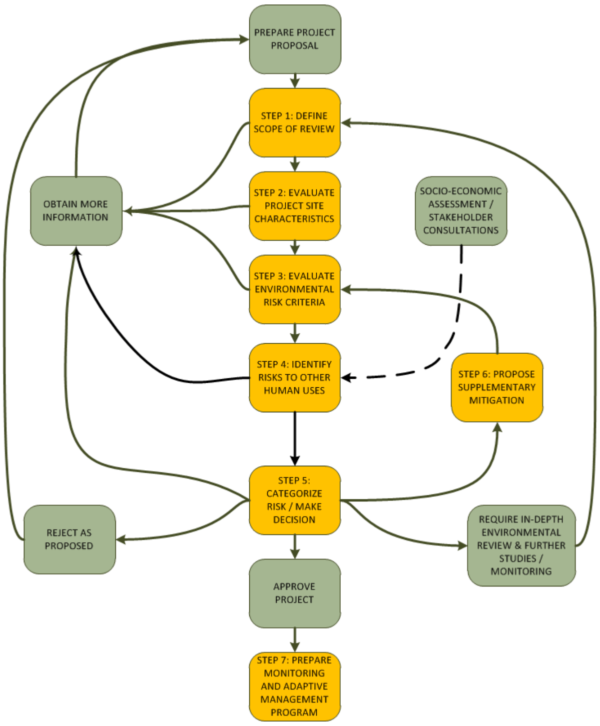

Figure 1 Decision-making Framework

EVALUATING ENVIRONMENTAL RISK

Given the high level of uncertainty and variability in the technology and site conditions, it was recognized that, at least at the present, risk and impact assessment for this industry should not rely on pre-determined trigger points. Instead, this approach is based on a set of practical criteria and related risk indictors that are relevant, flexible and can be consistently applied to projects of any type, size or location (Table 1).

Each criterion is assigned a risk level based on the Probability, Detectability, Spatial Extent (localized and/or system-scale), Significance, Duration and Reversibility of the forecast effect. Risk scoring follows a precautionary approach. Where uncertainty exists in a given criterion, a high risk is assumed. The overall risk category for the project is then determined based on a precautionary formula. A high risk in one criterion would place the entire project in a high risk level. With no high risk criteria, and even one moderate, the overall risk level of the project would be moderate. Only if all criteria are low risk would the project would be classified as low risk.

Table 1. Risk Criteria and Indicators

Criteria	Indicators
1. **Extent of habitat alteration due to the presence of physical infrastructure**	• Physical presence of infrastructure on benthic habitat (seabed) • Physical presence throughout the water column • Physical presence on the surface
2. **Effect on water movement and sediment dynamics**	• Amount of kinetic energy expected to be extracted by the project compared to the total available kinetic energy in the system (percentage) • Physical configuration of the site in which the development is to be located (site-scale relationship) • System characterized by seasonal or spatial fluctuations in natural flow patterns that may be affected by a regulation or disruption of current flow • Other marine renewable energy developments, in operation or planned, in the system (cumulative effects)
3. **Timing of short term projects (for projects in place <1 yr)**	• Timing of project activities in relation to known spawning, nursery, migratory or other critical time periods
4. **Physical obstacle to marine organisms**	• Capability of marine organisms to detect and actively avoid the infrastructure • Proportion of the specific pathway occupied by the project • Presence and suitability of other natural pathways available to the population to move between habitats • Presence of other developments in the area that may also present obstacles to movement of marine organisms (cumulative effects)
5. **Noise, vibrations & turbulence effects on marine organisms due to turbine operation**	• The size of the project (physical size of devices, number of turbines) • Characteristics of ambient conditions • Presence of other anthropogenic signals • Presence of species known to be sensitive • Ability of organisms to evade affected area
6. **Effects of other signals emitted by project infrastructure**	• The extent of the power cabling and lights • Characteristics of ambient conditions • Presence of other anthropogenic signals • Presence of species known to be sensitive • Ability of organisms to evade the affected area

The recommended management decisions for each risk category are:

- Low Risk - Project may proceed as planned without further review.
- Moderate or High Risk - Project as proposed will require more detailed environmental studies, additional mitigation and/or a monitoring program before receiving approval.
- Extremely High Risk - Project poses an unacceptable risk and may not proceed as proposed. Major redesign and/or relocation are required.

For large-scale commercial projects, where there may be a greater potential for an environmental impact, the risk can be managed using an adaptive, staged development approach, where the development is scaled-up in size (number of devices or production capacity) incrementally over time. Thus, a proposal incorporating an adaptive staged approach may be considered a lower risk than the same project developed all at once.

ADAPTIVE MANAGEMENT

Adaptive management is the preferred approach for dealing with projects where there is insufficient experience with the technologies and/or a lack of knowledge about the ecosystem. By developing commercial-scale projects in a staged, precautionary and adaptive manner, regulators, scientists and developers will be able to gain valuable information on baseline environmental conditions and the effects of the technology and allow more informed decisions to be made in the future. At minimum, both proponents and regulators need to work together from the outset to design a long-term adaptive environmental monitoring and management program. Such a program would include: monitoring requirements; timelines and/or conditions for re-assessment; and an adaptive response plan.

Part of the role of monitoring will be to confirm the predictions of the environmental assessment and demonstrate that mitigation is functioning as intended. If unanticipated changes are detected, the adaptive response plan should ensure that appropriate and timely actions are taken to mitigate the cause of the change and minimize the potential for a significant adverse environmental effect to result. Response(s) could include: modification of project design or expansion plans; modification or addition of mitigation measures; or, if necessary, cessation of operations and/or removal of some or all devices. Following the adaptive response plan, re-assessments would occur, at a predefined interval or condition and/or as new or improved information is gained on environmental conditions or impacts. Where new risks are identified or previously predicted risks are no longer considered probable, monitoring and mitigation requirements can be adapted.

Applications

The framework offers key steps and considerations for identifying, assessing, and addressing the environmental risk of TEC projects. A version of the framework has been published in a Toolkit for Tidal Energy Development in Nova Scotia, to provide guidance to interested developers and other stakeholders on the factors involved in the sustainable development of TEC projects [2]. The guidance is also intended as a first step by the Canadian and Nova Scotia governments in the creation of a Statement of Best Practice for the management of this emerging industry.

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